

2023

## The Future of the Law on the Moon

Andrew Y. Lee  
*Stein Mitchell Beato & Missner LLP*

Author(s) ORCID Identifier:

 <https://orcid.org/0009-0000-0526-7757>

---

### Recommended Citation

Andrew Y. Lee, *The Future of the Law on the Moon*, 88 J. AIR L. & COM. 3 (2023)  
<https://scholar.smu.edu/jalc/vol88/iss1/2>

This Article is brought to you for free and open access by the Law Journals at SMU Scholar. It has been accepted for inclusion in Journal of Air Law and Commerce by an authorized administrator of SMU Scholar. For more information, please visit <http://digitalrepository.smu.edu>.

## THE FUTURE OF THE LAW ON THE MOON

ANDREW Y. LEE\*

### ABSTRACT

A brave new age is here, but the law is not ready.

Outer space is rapidly becoming the domain for industrial-scale private-sector innovation and entrepreneurship. By developing and maturing the unprecedented technology for vertical landing and partial reuse orbital-class rockets, Space Exploration Technologies Corporation (SpaceX) has reduced the cost of access to orbital space by a staggering factor of magnitude, i.e., to one-tenth the previous rate. SpaceX is now on the cusp of launching its next-generation launch system called Starship to orbit. Starship is designed to be fully and rapidly reusable (land, refuel, and fly like airplanes) and expected to decrease the cost of access to orbital space to a level comparable to air travel—whereby private-sector industry in outer space would become economically viable.

SpaceX is developing Starship at a breakneck speed, planning for an orbital launch in April 2023. Starship would function as the Earth–Moon transportation infrastructure for private-sector lunar activities like tourism, hospitality, mining, research, entertainment, construction, health, agriculture, and manufacturing. And the Moon is just three days away. Assuming a large fleet of reusable Starships would take flight to the Moon in the coming years, lawyers have an urgent and exciting task of laying the legal groundwork on the Moon for the complex modern gov-

---

DOI: <https://doi.org/10.25172/jalc88.1.2>

\* Stein Mitchell Beato & Missner LLP, Associate; J.D., Northwestern School of Law, 2022; B.A. Philosophy, Georgetown University, 2018. This Article was written as a senior research project. The Author would like to thank his advisors and mentors, Professors Mathew Spitzer, Yoon-Ho Alex Lee, and Joshua Kleinfeld; JALC's Editor-in-Chief Pauline Hodencq for soliciting and arranging responses published herein; JALC's editors for their hard work; and Tamar Sil and Devin Slaughaupt for their support. Please direct any inquiries to [aylee1024@gmail.com](mailto:aylee1024@gmail.com).

ernance and economy. But the legal discussion on the future of the law of the Moon has not even begun. This Article aims to fix this lacuna by first presenting specific and realistic parameters for discussion: namely, SpaceX would likely give the United States the exclusive, economic, and scalable access to the Moon within a few years, enabling a sizable private sector presence (persons and property) on the Moon engaged in commercial ventures within a decade.

A commercialized Moon would require the United States to assert legislative jurisdiction (U.S. federal law taking effect), exercise adjudicatory jurisdiction (personal jurisdiction over persons and property and subject matter jurisdiction regarding controversies that arise), and install a governing body physically on the Moon. After a brief introduction of today's space industry, Part II surveys the history of U.S. regulation of commercial space exploration. Part III summarizes the current regulatory framework that governs only the launch and landing of space vehicles on Earth. Part IV is a more detailed analysis of the space industry and the economics of space exploration. Part V shows the possibility of domestic jurisdiction in outer space, delimited by binding international space treaties and customs. Part VI focuses on two treaties as providing the foundation of domestic jurisdiction in space. As an example of the governing body, in Part VII, this Article introduces the U.S. Lunar Court and sketches the legal contours of this new adjudicatory body. The Appendix shows detailed calculations of Starship's expected capabilities and economics based on Falcon 9's historical data.

#### TABLE OF CONTENTS

I. INTRODUCTION.....	6
II. HISTORY OF COMMERCIAL SPACE REGULATION .....	9
A. NATIONAL AERONAUTICS AND SPACE ACT OF 1958 .....	10
B. COMMUNICATIONS SATELLITE ACT (CSA) OF 1962 .....	11
C. COMMERCIAL SPACE LAUNCH ACT (CSLA) OF 1984 .....	12
D. NATIONAL AERONAUTICS AND SPACE ADMINISTRATION AUTHORIZATION ACT (NSAAA) OF 1985 .....	14
E. COMMERCIAL SPACE ACT (CSA) OF 1988 AND 1998 .....	15

2023]	<i>THE FUTURE OF THE LAW ON THE MOON</i>	5
	F. COMMERCIAL SPACE LAUNCH AMENDMENTS ACT (CSLAA) OF 2004 .....	16
	G. SPURRING PRIVATE AEROSPACE COMPETITIVENESS AND ENTREPRENEURSHIP (SPACE) ACT OF 2015.	16
III.	CURRENT COMMERCIAL SPACE REGULATION .....	18
	A. REGULATORY OVERVIEW .....	18
	B. SUBSTANTIVE REGULATIONS AND THEIR SHORTCOMINGS .....	22
IV.	CURRENT AND NEAR-FUTURE DEVELOPMENTS IN THE PRIVATE SPACE INDUSTRY .....	24
	A. HISTORY OF SPACE EXPLORATION .....	24
	B. THE ECONOMICS OF A SPACE LAUNCH .....	30
	C. ADVANCEMENT IN THE LAUNCH TECHNOLOGY: SPACEX .....	34
	D. SPACEX'S COMPETITORS .....	38
	E. FUTURE SPACE INDUSTRIES .....	40
	F. WHY GO TO THE MOON? .....	42
	G. LUNAR GEOPOLITICS OF THE NEXT DECADE .....	45
V.	LIMITS OF THE POWER TO REGULATE MATTERS IN SPACE .....	46
	A. OVERVIEW OF BINDING INTERNATIONAL SPACE LAW .....	46
	B. THE MOON AGREEMENT .....	50
	C. TECHNOPOLITICS CASE STUDY 1: THE OUTER SPACE TREATY .....	50
	D. TECHNOPOLITICS CASE STUDY 2: THE INTERNATIONAL SPACE STATION .....	57
	E. TECHNOPOLITICS CASE STUDY 3: THE LAW OF THE SEA .....	62
VI.	HOW TO MOVE FORWARD .....	65
	A. THE ARTEMIS ACCORDS .....	65
	B. THE REGISTRATION CONVENTION .....	68
VII.	THE POSSIBILITY OF AN IN SITU LUNAR COURT OF LAW .....	71
	A. WHY THE U.S. COURT ON THE MOON MAY BE NECESSARY .....	72
	1. <i>The Difference Between the ISS and the Moon</i> .	73
	2. <i>The Difference Between Antarctica and the Moon</i> .....	74
	3. <i>Policy Considerations for a U.S. Lunar Court.</i> ..	75
	B. THE LOCATION .....	79

C. THE PRESCRIPTIVE JURISDICTION OF THE U.S.	
CONGRESS ON THE MOON.....	83
D. THE ADJUDICATORY JURISDICTION OF THE U.S.	
LUNAR COURT.....	85
1. <i>General Personal Jurisdiction</i> .....	86
2. <i>Specific Personal Jurisdiction</i> .....	88
3. <i>Subject Matter Jurisdiction</i> .....	89
E. THE TYPOLOGY OF A LUNAR COURT.....	90
VIII. CONCLUSION.....	92
Appendix.....	94

## I. INTRODUCTION

THE PARADIGM OF SPACE TRAVEL is changing, and the law must change with it. Traditionally, a space launch vehicle is jettisoned during ascent;<sup>1</sup> this single-use paradigm made access to space prohibitively expensive as the fixed cost of developing, producing, and operating a launch vehicle could not be spread out over multiple uses. In fact, the cost of producing a rocket now is comparable to or cheaper than producing a big airliner; for instance, a Boeing 747 can cost up to approximately \$420 million.<sup>2</sup> SpaceX's workhorse launch system, Falcon 9, costs less than \$62 million to produce.<sup>3</sup> The difference in consumer cost mostly derives from the difference in reusability.

SpaceX's Falcon 9 is capable of partial reuse; the first stage is reused, and the second stage is jettisoned.<sup>4</sup> SpaceX was the first to develop this new technology in the early 2010s (no one else has done it as of the beginning of 2023) and now has matured it, having reflown Falcon 9's first-stage booster over fifty times and having reused a single booster over ten times.<sup>5</sup> This has ena-

<sup>1</sup> Chris Woodford, *Space Rockets*, EXPLAIN THAT STUFF, <https://www.explainthatstuff.com/spacerockets.html> [<https://perma.cc/KB8W-G9BD>] (June 7, 2022).

<sup>2</sup> Erick Burgueño Salas, *Average Prices for Boeing Aircraft as of March 2022, by Type*, STATISTA (Aug. 29, 2022), <https://www.statista.com/statistics/273941/prices-of-boeing-aircraft-by-type> [<https://perma.cc/C8U7-Q3VN>].

<sup>3</sup> Michael Sheetz, *Elon Musk Touts Low Cost to Insure SpaceX Rockets as Edge Over Competitors*, CNBC, <https://www.cnbc.com/2020/04/16/elon-musk-spacex-falcon-9-rocket-over-a-million-dollars-less-to-insure.html> [<https://perma.cc/ZJV6-8NFN>] (Apr. 16, 2020, 12:25 PM).

<sup>4</sup> See Cathal O'Connell, *Reusable Rockets Explained*, COSMOS (Feb. 6, 2018), <https://cosmosmagazine.com/space/launch-land-repeat-reusable-rockets-explained> [<https://perma.cc/7DGQ-XGZX>].

<sup>5</sup> *SpaceX Missions Summary*, SPACE X INFO, <https://web.archive.org/web/20210622000151/https://spacex-info.com/launch-list/> [<https://perma.cc/S9V6-EV42>]; Amy Thompson, *SpaceX Launches 60 Starlink Satellites in Record 10th Liftoff (and Landing) of Reused Rocket*, SPACE.COM (May 9, 2021), <https://>

bled SpaceX to reduce the marginal cost of launch to \$15 million,<sup>6</sup> which is a fraction of the cost of other vehicles like Atlas V (starting at \$109 million)<sup>7</sup> or Ariane V (approximately \$175 million).<sup>8</sup>

Building on its experience in developing a partially reusable launch system, SpaceX has nearly completed developing a fully-reusable launch system, Starship.<sup>9</sup> Compared to the partial reuse paradigm of Falcon 9, every part of Starship is designed to be reused, like an airliner. Full reusability could slash the launch cost by another decimal point—as low as \$2 million.<sup>10</sup> With Starship’s tonnage standing at 100 tons, a \$2 million launch cost translates to a rate of \$20/kg, which is comparable to the roughly \$4/kg rate of airfreight.<sup>11</sup> In light of this development, in 2021, the National Aeronautics and Space Administration (NASA) awarded \$2.9 billion to SpaceX to use Starship to take America back to the Moon.<sup>12</sup> A new era of space flight, the American private commercialization of the Moon, is a question of when, not if—a question that urgently demands a legal answer.

Firstly, the launch cost of something close to \$20/kg would vastly expand the kind of enterprise possible in outer space and

[www.space.com/spacex-starlink-27-10th-falcon-9-rocket-launch-landing-success](https://www.space.com/spacex-starlink-27-10th-falcon-9-rocket-launch-landing-success) [https://perma.cc/DN3C-SEVH].

<sup>6</sup> Mike Brown, *SpaceX: Elon Musk Breaks Down the Cost of Reusable Rockets*, INVERSE (Aug. 21, 2020), <https://www.inverse.com/innovation/spacex-elon-musk-falcon-9-economics> [https://perma.cc/5MV6-4B9G].

<sup>7</sup> *Atlas V*, UNITED LAUNCH ALL., <https://www.ulalaunch.com/rockets/atlas-v> [https://perma.cc/X8BT-GDUN].

<sup>8</sup> Rich Smith, *Europe’s New Space Rocket Is Incredibly Expensive*, MOTLEY FOOL (Nov. 10, 2020, 12:25 PM), <https://www.fool.com/investing/2020/11/10/europe-space-rocket-incredibly-expensive-airbus> [https://perma.cc/V2RF-5AXM].

<sup>9</sup> *Starship*, SPACEX, <https://www.spacex.com/vehicles/starship> [https://perma.cc/AN9E-RLXK]; Ed Browne, *SpaceX’s Starship Explained as Elon Musk Shares Photo of Mars Rocket Being Built*, NEWSWEEK (Aug. 2, 2021, 7:23 AM), <https://www.newsweek.com/spacex-starship-explained-elon-musk-photo-mars-rocket-built-1615154> [https://perma.cc/EK2E-D6LN].

<sup>10</sup> Michael Sheetz, *What’s Behind SpaceX’s \$74 Billion Valuation: Elon Musk’s Two ‘Manhattan Projects’*, CNBC (Feb. 19, 2021, 3:27 PM), <https://www.cnbc.com/2021/02/19/spacex-valuation-driven-by-elon-musks-starship-and-starlink-projects.html> [https://perma.cc/LU9K-6846].

<sup>11</sup> Eric Kulisch, *Air Cargo Peak Season Evaporates on Low Demand, Higher Capacity*, FREIGHTWAVES (Oct. 7, 2022), <https://www.freightwaves.com/news/air-cargo-peak-season-evaporates-on-low-demand-high-capacity> [https://perma.cc/2X2D-9LWV].

<sup>12</sup> Kenneth Chang, *SpaceX Wins NASA \$2.9 Billion Contract to Build Moon Lander*, N.Y. TIMES, <https://www.nytimes.com/2021/04/16/science/spacex-moon-nasa.html> [https://perma.cc/3HDR-D7LM] (Oct. 22, 2021).

would increase the launch cadence. Within the next decade, we should expect entrepreneurship of every kind—like research, technology, hospitality, mining, manufacturing, heavy industry, tourism, and settlement—to flourish in Earth’s orbit and on the Moon.<sup>13</sup> Existing laws and regulations have to be reassessed to address the future, and new laws and regulations should be discussed and contingently planned to encourage and guide the U.S. private sector’s commercial activity in space.

Secondly, there will likely be massive private sector activity—controlled and led by the United States—on the Moon. This would require complex governing bodies on the Moon, and this Article explores the issues of U.S. jurisdiction on the Moon and the establishment of a lunar adjudicatory body, provisionally named the U.S. Lunar Court.

As such, this Article makes an unprecedented contribution to the body of space law scholarship. A massive commercial settlement and enterprise on the Moon is a tangible reality that seems increasingly imminent. Perhaps because SpaceX has developed Starship at a rapid pace and full reusability was science fiction just a few years ago,<sup>14</sup> legal scholars and the public have thought little of the mind-boggling implications of cheap and scalable transportation infrastructure to the Moon. Hence, scholarly commentary on the future of space law has not been based on real technological advancements in reusability but rather has relied on insipid hypotheticals such as “in future space colonies”

---

<sup>13</sup> NASA, *Why the Moon?*, YOUTUBE (Aug. 24, 2021), <https://youtu.be/bmCFwibsZg> [<https://perma.cc/C545-TAA7>]; *In 10-15 Years People Will Be Travelling to Moon: Naveen Jain, Co-Founder of Moon Express*, ECON. TIMES, <https://m.economictimes.com/small-biz/entrepreneurship/in-10-15-years-people-will-be-travelling-to-moon-naveen-jain-co-founder-of-moon-express/articleshow/54002721.cms> [<https://perma.cc/Q7RD-A99C>] (Sept. 4, 2016, 12:30 PM); Marc Vartabedian, *Space Startups See Big Payouts in New Push to the Moon: Entrepreneurs Compete for Roles in the U.S. Plan to Land Astronauts on the Moon by 2024*, WALL ST. J. (July 14, 2019, 7:26 PM), <https://www.wsj.com/articles/space-startups-see-big-payouts-in-new-push-to-the-moon-11563153990> [<https://perma.cc/7D7L-L47B>].

<sup>14</sup> NASA has not flown its new Space Launch System (SLS) since the agency began developing it in 2011. But SpaceX has developed and matured an unprecedented partially reusable Falcon 9 within that time, began developing Starship in 2019, and conducted several suborbital flights at this point. *See generally* Sissi Cao, *Which Rocket Will Return to the Moon First? Comparing SpaceX’s Starship and NASA’s SLS*, OBSERVER (Mar. 23, 2022, 4:13 PM), <https://observer.com/2022/03/spacex-starship-nasa-sls-artemis-moon-rocket-compare/> [<https://perma.cc/7ZPP-7WNY>].

or “colonies on Mars.”<sup>15</sup> And the phrase “the law of the Moon” never seems to have even entered the legal parlance.<sup>16</sup>

The times have changed. The old paradigm of space exploration—high-cost, low-volume—is at an end, and the new paradigm of space transportation—low-cost, high-volume—is just around the corner. Thus, a new kind of scholarly work is needed: one that fully canvasses and takes stock of the rapidly developing, fully reusable rocketry and rereads space law in light of Starship. This Article offers such an analysis and especially highlights the technopolitical, legal implications of SpaceX’s (a U.S. corporation’s) exclusive control of reusable rocketry.

## II. HISTORY OF COMMERCIAL SPACE REGULATION

The history of international space law and commercial space regulation shows that the interplay of technology and politics—technopolitics—has influenced the development of laws and regulations in space. The technology part makes sense because space regulations address currently used or in-development technologies. The politics part addresses how nations with technological advantage also have a political edge over other nations. Only an elite cadre of nations is capable of orbital launch. There are currently eleven spacefaring nations capable of orbital launch, ordered chronologically: Russia (the Union of Soviet Socialist Republics (U.S.S.R.) at the time),<sup>17</sup> the United States,<sup>18</sup> France,<sup>19</sup> Japan,<sup>20</sup> China,<sup>21</sup> the United Kingdom (U.K.),<sup>22</sup> In-

<sup>15</sup> See *infra* Section II.B.

<sup>16</sup> See Taylor Stanton Hardenstein, Comment, *In Space, No One Can Hear You Contest Jurisdiction: Establishing Criminal Jurisdiction on the Outer Space Colonies of Tomorrow*, 81 J. AIR L. & COM. 251, 285–86 (2016) (arguing that 1998 IGA is a good framework on which to base the laws of future spaces colonies); Brian Bozzo, *Not Because It Is Easy*, 11 DREXEL L. REV. 597 (2019) (discussing generally the aerospace regulations in America); P.J. Blount, *Jurisdiction in Outer Space: Challenges of Private Individuals in Space*, 33 J. SPACE L. 299 (2007) (analyzing states’ jurisdiction over individuals in space); Hamilton DeSaussure & P.P.C. Haanappel, 6 SYRACUSE J. INT’L L. & COM. 1 (1978) (commentating on how tort and contract principles apply in outer space). Brian Wessel, , 35 HASTINGS INT’L & COMP. L. REV. 289, 321 (2012) (“[The] rule-of-law based concerns in the field of space law are not nearly as serious as has previously been suggested.”).

<sup>17</sup> That is, October 4, 1957. Sputnik 1, NASA, <https://nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=1957-001B> [<https://perma.cc/G6KE-KMAL>].

<sup>18</sup> That is, January 31, 1958. Explorer 1, NASA, [https://www.nasa.gov/mission\\_pages/explorer/explorer-overview.html](https://www.nasa.gov/mission_pages/explorer/explorer-overview.html) [<https://perma.cc/BTB4-YFG3>] (Aug. 3, 2017).

<sup>19</sup> That is, November 26, 1965. Asterix, NASA, <https://nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=1965-096A> [<https://perma.cc/VS2V-D84A>].



dia,<sup>23</sup> Israel,<sup>24</sup> South Korea,<sup>25</sup> Iran,<sup>26</sup> and North Korea.<sup>27</sup> Only three nations—Russia, the United States, and China—are capable of *human* space flight and also happen to be global superpowers.<sup>28</sup> Non-spacefaring nations have less say in the development of law in space;<sup>29</sup> they cannot physically influence, enforce, or compete in outer space, and their impact is limited to words of protest.

#### A. NATIONAL AERONAUTICS AND SPACE ACT OF 1958

The first Space Act was passed within months of the Soviet launch of *Sputnik I*.<sup>30</sup> It was the first launch of an artificial satellite into Earth's orbit, and at the time, the U.S.S.R. was the only country to possess the requisite technology.<sup>31</sup> The United States was behind and wanted to catch up. Hence, the National Aeronautics and Space Act was passed, which established NASA and made a declaration of purpose that “activities in space should be devoted to peaceful purposes for the benefit of all mankind.”<sup>32</sup> Despite the aspirational language, the technopolitical competi-

<sup>20</sup> That is, February 11, 1970. Apollo 13, NASA (Feb. 11, 2020), <https://www.nasa.gov/feature/50-years-ago-apollo-13-two-months-from-launch> [https://perma.cc/Y2LH-KE28].

<sup>21</sup> That is, April 24, 1970. DFH 1, NASA, <https://nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=1970-034A> [https://perma.cc/9MLW-NPDU].

<sup>22</sup> That is, October 28, 1971. Prospero 1, NASA, <https://nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=1971-093A> [https://perma.cc/347R-AAYG].

<sup>23</sup> That is, July 18, 1980. Rohini 1, NASA, <https://nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=1980-062A> [https://perma.cc/NL9V-CQGT].

<sup>24</sup> That is, September 19, 1988. Ofeq 1, NASA, <https://nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=1988-087A> [https://perma.cc/2H9Q-XLX6].

<sup>25</sup> That is, August 10, 1992. DANIEL A. PINKSTON, KOR. ECON. INST. AM., JOINING THE ASIA SPACE RACE: SOUTH KOREA'S SPACE PROGRAM (2014), [http://www.keia.org/sites/default/files/publications/kei\\_aps\\_2014\\_pinkston.pdf](http://www.keia.org/sites/default/files/publications/kei_aps_2014_pinkston.pdf) [https://perma.cc/5BY7-YTSV].

<sup>26</sup> That is, February 2, 2009. Omid, NASA, <https://nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=2009-004A> [https://perma.cc/W6JW-KELA].

<sup>27</sup> That is, December 12, 2012. KMS 3-2, NASA, <https://nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=2012-072A> [https://perma.cc/2YVR-RS8L].

<sup>28</sup> , BELFER CTR. FOR SCI. & INT'L AFFS., <https://www.belfercenter.org/event/geostrategic-implications-asian-space-race> [https://perma.cc/G7PJ-TATA].

<sup>29</sup> Sophie Goguichvili, Alan Linenberger, Amber Gillette & Alexandra Novak, , WILSON CTR. (Oct. 1, 2021), <https://www.wilsoncenter.org/article/global-legal-landscape-space-who-writes-rules-final-frontier> [https://perma.cc/BVK4-LZ66].

<sup>30</sup> National Aeronautics and Space Act of 1958, Pub. L. No. 85-568, 72 Stat. 426; NASA, note 17.

<sup>31</sup> Sputnik, NAT'L GEOGRAPHIC <https://education.nationalgeographic.org/resource/ussr-launches-sputnik> [https://perma.cc/S7Z9-36QJ] (May 20, 2022).

<sup>32</sup> Space Act § 102(a).

tion lurking behind was obvious. In one meeting with an advisor, President John F. Kennedy supposedly said the following:

Kennedy . . . [said]: “Everything we do ought to be tied into getting onto the moon ahead of the Russians.”

Webb [replied], almost shouting: “Why can’t it be tied to preeminence in space?”

Kennedy . . . [bellowed]: “By God, we’ve been telling everybody for five years that we’re preeminent in space and nobody believes us!”<sup>33</sup>

And so, within eleven years of its inception, NASA landed the first man on the Moon on July 20, 1969.<sup>34</sup> The last manned lunar mission, *Apollo 17*, was in December 1972.<sup>35</sup> Kennedy’s desire for preeminence in space was more or less achieved.

Following the United States’ “victory” in the space race, NASA was hard-pressed to find a reason for the public to keep it airborne.<sup>36</sup> The “enemy” having been vanquished and the competition won, justifying the stupendous cost of the space program was politically inexpedient, unless NASA could promise to lower the cost of access to space and thereby open the new frontier for commercial space exploration.<sup>37</sup> NASA’s existential crisis begot the Space Shuttle program, which was intended as a “life preserver” for the agency but ended up being more expensive than Saturn V.<sup>38</sup>

#### B. COMMUNICATIONS SATELLITE ACT (CSA) OF 1962<sup>39</sup>

On July 10, 1962, in Cape Canaveral, NASA launched the first commercially funded communications satellite (funded by AT&T) atop a Delta rocket to low Earth orbit (LEO).<sup>40</sup> The era

---

<sup>33</sup> GREG KLERKX, *LOST IN SPACE: THE FALL OF NASA AND THE DREAM OF A NEW SPACE AGE* 154 (2004).

<sup>34</sup> *July 20, 1969: One Giant Leap For Mankind*, NASA (July 20, 2019), [https://www.nasa.gov/mission\\_pages/apollo/apollo11.html](https://www.nasa.gov/mission_pages/apollo/apollo11.html) [<https://perma.cc/QC3F-Y7P2>].

<sup>35</sup> Christopher Klein, *Apollo 17: Inside NASA’s Final Moon Landing Mission*, HISTORY (Dec. 5, 2022), <https://www.history.com/news/apollo-17-moon-landing> [<https://perma.cc/T3RG-J894>].

<sup>36</sup> See ROGER HANDBERG, *REINVENTING NASA: HUMAN SPACEFLIGHT, BUREAUCRACY, AND POLITICS* 63 (2003).

<sup>37</sup> See *id.*

<sup>38</sup> See *id.*

<sup>39</sup> Communications Satellite Act of 1962, Pub. L. No. 87-624, 76 Stat. 419.

<sup>40</sup> WHITE HOUSE, *REPORT TO THE CONGRESS FROM THE PRESIDENT OF THE UNITED STATES: UNITED STATES AERONAUTICS AND SPACE ACTIVITIES 1962*, at 20 (1963); TELSTAR 1: *The First Satellite to Relay Signals from Earth to Satellite and Back*,

of commercial satellite launches began. In response, on August 31, 1962, President Kennedy signed the Communications Satellite Act of 1962 (CSA).<sup>41</sup>

The CSA delegated to the FCC the authority and responsibility to regulate the commercial satellite industry, an arrangement that continues to this day. Title IV, Section 401 made the commercial satellite operators subject to Title II and Title III of the Communications Act of 1934.<sup>42</sup>

### C. COMMERCIAL SPACE LAUNCH ACT (CSLA) OF 1984<sup>43</sup>

CSLA's forward-looking nature is characteristic of space-related legislation. It would not be until the 2010s and SpaceX that a commercial entity would independently develop and provide launch services. But CSLA foresaw such a development in the 1980s. This is of great precedential value for the project in this Article, which urges such prospective legislation to prepare for lunar commercialization. See what CSLA says in its declaration of findings: "[T]he private sector in the United States has the capability of developing and providing private satellite launching and associated services that would complement the launching and associated services now available from the United States Government."<sup>44</sup>

The technopolitical importance of "encourag[ing]" and "regulat[ing]" commercial launches within the bounds of the United States' international obligations was not lost on the regulators.<sup>45</sup> "[T]he development of commercial launch vehicles and associated services would enable the United States to retain its competitive position internationally . . . ."<sup>46</sup> And the "provision of launch services by the private sector is consistent with the national security interests and foreign policy interests of the United States."<sup>47</sup>

---

HIST. INFO. (July 10, 1962), <https://www.historyofinformation.com/detail.php?id=797> [<https://perma.cc/PP2N-PZ2F>].

<sup>41</sup> See Communications Satellite Act of 1962 § 101; *Bill Signing, H.R. 11040 Public Law 87-624, Communications Satellite Act of 1962, 9:45AM*, JOHN F. KENNEDY PRESIDENTIAL LIBR. & MUSEUM, <https://www.jfklibrary.org/asset-viewer/archives/JFKWHP/1962/Month%2008/Day%2031/JFKWHP-1962-08-31-A> [<https://perma.cc/ZN2D-7YTL>].

<sup>42</sup> *The Communications Satellite Act of 1962*, 76 HARV. L. REV. 388, 390 (1962).

<sup>43</sup> Commercial Space Launch Act, Pub. L. No. 98-575, 98 Stat. 3055 (1984).

<sup>44</sup> *Id.* § 2(4).

<sup>45</sup> *Id.* § 2(7).

<sup>46</sup> *Id.* § 2(5).

<sup>47</sup> *Id.* § 2(6).

Substantive regulations found in CSLA were amended several times and form the basis of the current 14 C.F.R. Chapter III Regulations, which regulate only the launching and landing aspects of commercial space flight.<sup>48</sup>

Another offspring of CSLA, important for the purposes here, is the establishment of exclusive jurisdiction of federal courts on civil cases and controversies. Federal law, specifically 51 U.S.C. § 50914(g), says: “Any claim by a third party or space flight participant for death, bodily injury, or property damage or loss resulting from an activity carried out under the license shall be the exclusive jurisdiction of the Federal courts.”<sup>49</sup> The great innovation of this provision is that there is no territorial claim in outer space as a basis for jurisdiction.<sup>50</sup> In other words, the jurisdictional claim is not over a physical location, but rather “an activity carried out under the license.” The license, given out by the FAA, is for commercial launches. As such, we see a nonterritorial prescription of the jurisdiction in outer space. As the binding and well-accepted space treaties ban national appropriation of outer space,<sup>51</sup> this nonterritorial prescriptive jurisdiction should be a model for any future establishment of jurisdiction on the Moon and beyond.

Secondly, the provision does not designate a specific federal court but rather mentions federal courts generally.<sup>52</sup> It does not seem wrong for a litigant to argue for a federal district court’s jurisdiction within the bounds of other jurisdictional limitations like personal and subject matter jurisdiction. But the plain language of the provision allows for a new federal court, located on Earth or in outer space, formed under Article I or Article III, to exercise jurisdiction over parties, claims, and controversies in particular regions of outer space. This provision will indeed be an important precedent in establishing jurisdiction and a court system on the Moon and beyond.

---

<sup>48</sup> 14 C.F.R. § 400.1 (2023).

<sup>49</sup> 51 U.S.C. § 50914(g).

<sup>50</sup> *See id.*

<sup>51</sup> *See* Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies art. II, *opened for signature* Jan. 27, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205 [hereinafter *Outer Space Treaty*].

<sup>52</sup> *See* 51 U.S.C. § 50914(g).

D. NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
AUTHORIZATION ACT (NASAA) OF 1985<sup>53</sup>

The NASAA Act of 1985, for the first time, rendered the advancement of the private sector in space a statutory purpose of NASA; it provided: “[T]he general welfare of the United States requires that the National Aeronautics and Space Administration (as established by title II of this Act) seek and encourage, to the maximum extent possible, the fullest commercial use of space.”<sup>54</sup>

Bill sponsor Representative Dana Rohrabacher said: “It is my sincere hope that this bill will encourage individuals . . . to continue leading the way in pushing the boundaries of technology and safety by building and flight testing hardware, something NASA has yet to do.”<sup>55</sup>

But, NASA has never succeeded in leading the commercial industry by lowering costs; the launch cost of its vehicles has gone up over its history. For instance, the Saturn V<sup>56</sup> had a rate of about \$5,400/kg to LEO and the Space Shuttle had a rate of about \$65,400/kg.<sup>57</sup> It was not until the 2010s and SpaceX, a private company, that the cost of launch was meaningfully lowered by an order of magnitude.<sup>58</sup>

Considers the words of one commentator:

Few disagree that reusability is the key to unlocking Part Two of the Space Age promise—frequent, inexpensive and reliable popular access to near-Earth space. The point where opinions diverge, and radically, is whether the lack of a truly reusable spacecraft is due to insufficient technology or insufficient motivation. The latter charge is usually leveled at NASA and its Big Aerospace partners by those in the entrepreneurial space sector: what real incentive do Boeing and Lockheed, and by extension the shuttle’s owner, NASA, have to change the way things are?<sup>59</sup>

---

<sup>53</sup> National Aeronautics and Space Administration Authorization Act of 1985, Pub. L. No. 98-361, 98 Stat. 422.

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

<sup>55</sup> *Commercialization of Space Commercial Space Launch Amendments Act of 2004*, 17 HARV. J.L. & TECH. 619, 622 (2004) [hereinafter *Commercialization of Space*] (alteration in original).

<sup>56</sup> Thomas G. Roberts, *Space Launch to Low Earth Orbit: How Much Does It Cost?*, CTR. STRATEGIC & INT’L STUD., <https://aerospace.csis.org/data/space-launch-to-low-earth-orbit-how-much-does-it-cost/> [https://perma.cc/PP6L-3UAX] (Sept. 1, 2022). The dollar amounts here are in fiscal year 2021 dollar values. *Id.*

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

<sup>58</sup> *See id.*

<sup>59</sup> KLERKX, *supra* note 33, at 98.

E. COMMERCIAL SPACE ACT (CSA) OF 1988 AND 1998<sup>60</sup>

The 1988 CSA was a response to President Reagan's policy to encourage the growth of the domestic commercial launch market.<sup>61</sup> Executive Order 12465 was a precursor to this Act, and it empowered the Secretary of Transportation to oversee and promote the commercialization of the commercial launch market.<sup>62</sup> These efforts would lead NASA contractors like Boeing and Lockheed Martin to operate and market launches on their expendable launch vehicles (ELVs).<sup>63</sup> Those two companies would later form a joint venture called United Launch Alliance (ULA) in 2006 that still provides launches on their reliable Atlas V and Delta IV heavy rockets.<sup>64</sup> But because those rockets are expendable and therefore cost hundreds of millions of dollars per launch, the commercial launch market did not expand beyond the traditional market of communications satellites, military contracts, and NASA contracts. But the prospective nature of the 1988 CSA and the subsequent development of the ELV industry should be noted.

The 1998 CSA came after nearly a decade-long operation of the *International Space Station (ISS)*. Yet other prospective legislation, the 1998 CSA, paved the way for commercial ventures related to the *ISS*. We are seeing the fruits of this policy now: SpaceX delivers cargo and astronauts to the *ISS*; for the past twenty years, a bevy of commercial experiments were conducted onboard the *ISS*,<sup>65</sup> and Made in Space, a private company, developed a manufacturing technique for zero-g fiber optic cable.<sup>66</sup>

---

<sup>60</sup> Commercial Space Act of 1998, Pub. L. No. 105-303, 112 Stat. 2843.

<sup>61</sup> Kim G. Yelton, *Evolution, Organization and Implementation of the Commercial Space Launch Act and Amendments of 1988*, 4 J.L. & TECH. 117, 118, 125 (1989).

<sup>62</sup> *Id.* at 119, 125–26.

<sup>63</sup> U.S. GOV'T ACCOUNTABILITY OFF., GAO-14-259T, EVOLVED EXPENDABLE LAUNCH VEHICLE: INTRODUCING COMPETITION INTO NATIONAL SECURITY SPACE LAUNCH ACQUISITIONS (2014).

<sup>64</sup> *Rockets*, UNITED LAUNCH ALL., <https://www.ulalaunch.com/rockets> [<https://perma.cc/S7GB-6LQX>]; *United Launch Alliance*, BOEING, <https://www.boeing.com/space/united-launch-alliance/> [<https://perma.cc/XY4M-G98F>].

<sup>65</sup> *20 Breakthroughs from 20 Years of Science Aboard the International Space Station*, NASA (Oct. 26, 2020), [https://www.nasa.gov/mission\\_pages/station/research/news/iss-20-years-20-breakthroughs](https://www.nasa.gov/mission_pages/station/research/news/iss-20-years-20-breakthroughs) [<https://perma.cc/9AMU-R2LC>].

<sup>66</sup> *Made in Space—Building a Better Optical Fiber*, NASA (Mar. 6, 2019), [https://www.nasa.gov/mission\\_pages/station/research/news/b4h-3rd/eds-mis-building-better-optical-fiber](https://www.nasa.gov/mission_pages/station/research/news/b4h-3rd/eds-mis-building-better-optical-fiber) [<https://perma.cc/C62Z-88BJ>].

F. COMMERCIAL SPACE LAUNCH AMENDMENTS ACT (CSLAA) OF 2004<sup>67</sup>

In a near-perfect bipartisanship, the House of Representatives passed the CSLAA by a vote of 402 to 1.<sup>68</sup> The CSLAA was designed to promote the emerging suborbital human space flight industry by defining the industry targeted by regulation, vesting all regulatory authority in the FAA, and removing regulatory obstacles.<sup>69</sup> Several entrepreneurial ideas such as hotels, theme parks, and zero-g healthcare facilities for LEO have been floated since as early as the 1990s.<sup>70</sup> This Act paved the way for the suborbital space tourism industry led by Blue Origin and Virgin Galactic, which started commercial operations in 2022.<sup>71</sup>

G. SPURRING PRIVATE AEROSPACE COMPETITIVENESS AND ENTREPRENEURSHIP (SPACE) ACT OF 2015<sup>72</sup>

The changing technopolitics have already influenced how the United States interprets international space law, thereby setting state precedent. In the latest installment of prospective legislation, under President Barack Obama, the U.S. Commercial Space Launch Competitiveness Act (SPACE Act) was passed in 2015.<sup>73</sup> Title IV § 51302 bestows private property rights: “[t]he President, acting through appropriate Federal agencies, shall . . . promote *the right of United States citizens to engage in commercial exploration for and commercial recovery of space resources* . . . in accordance with the international obligations of the United States.”<sup>74</sup>

---

<sup>67</sup> Commercial Space Launch Amendments Act of 2004, Pub. L. No. 108-492, 118 Stat. 3974.

<sup>68</sup> *Commercialization of Space*, *supra* note 55, at 619.

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

<sup>70</sup> ROBERT ZUBRIN, ENTERING SPACE: CREATING A SPACEFARING CIVILIZATION 58–69 (1999).

<sup>71</sup> Amanda Stevens, *SpaceX vs. Blue Origin vs. Virgin Galactic: What’s the Difference?*, TECHTARGET (Dec. 21, 2021), <https://www.techtargget.com/whatis/feature/SpaceX-vs-Blue-Origin-vs-Virgin-Galactic-Whats-the-difference> [https://perma.cc/GBU8-PJCN].

<sup>72</sup> U.S. Commercial Space Launch Competitiveness Act, Pub. L. No. 114-90, 129 Stat. 704 (2015).

<sup>73</sup> Stephan Hobe & Kuan-Wei Chen, *Legal Status of Outer Space and Celestial Bodies*, in ROUTLEDGE HANDBOOK OF SPACE LAW 29–30 (Ram S. Jakhu and Paul Stephen Dempsey eds., 2017) (showing how the authors recognize that the question of ownership over mined resources is “a subject of further interpretation,” and how they call the SPACE Act “an unprecedented detraction from international space law.”).

<sup>74</sup> 51 U.S.C. § 51302(a)(3) (2015) (emphasis added).

Section 51303 further clarifies the right of private ownership in space:

A United States citizen engaged in commercial recovery of an asteroid resource or a space resource under this chapter shall be *entitled to any asteroid resource or space resource obtained*, including to possess, own, transport, use, and sell the asteroid resource or space resource obtained in accordance with applicable law, including the international obligations of the United States.<sup>75</sup>

“Space resource,” of course, includes resources found on the Moon. The Outer Space Treaty (OST) includes a provision against the national appropriation of celestial “real estate.”<sup>76</sup> The SPACE Act interprets that provision as inapplicable to individual claims of property rights on the Moon. When the U.S. private sector starts mining and commercializing the Moon later in this decade, this provision will be the legal basis for that activity. And if the United States is the first to commercialize the Moon and no other nations have lunar transportation capability, which seems to be the highly likely scenario soon, they have no actionable interests or technopolitical leverage to prohibit or foil the United States from mapping out the multiplanetary future of humanity.

The recognition of and advocacy for the legalization of the U.S. commercial activity in outer space have been traditionally bipartisan. On April 6, 2020, President Donald Trump signed Executive Order 13914, which states:

Americans should have the *right to engage in commercial exploration, recovery, and use of resources in outer space*, consistent with applicable law. Outer space is a legally and physically unique domain of human activity, and the *United States does not view it as a global commons*. Accordingly, it shall be the policy of the United States to encourage international support for the *public and private recovery and use of resources in outer space*, consistent with applicable law.<sup>77</sup>

---

<sup>75</sup> *Id.* § 51303 (emphasis added).

<sup>76</sup> See Outer Space Treaty, *supra* note 51, art. II (“Outer space, including the Moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means.”). It is, however, unclear whether land is considered a resource. Because the SPACE Act provision considers “recovery,” it seems to limit the individual claim of property rights to movable property. However, land may be “recovered.” This is beyond the scope of this Article and ultimately would not matter.

<sup>77</sup> Executive Order 13914, 85 Fed. Reg. 20381 (Apr. 10, 2020) (emphasis added).



The Order goes further than the SPACE Act. It says *public* recovery and use of resources in outer space, not “national appropriation.” Hence, if NASA or a new federal agency takes, say, water from the Moon (or other celestial body) to sustain its regulatory operations on the Moon, such activity would not be an act of appropriation under the OST. When there are many settlements on the Moon engaged in commercial activity, it is beyond question that governmental infrastructure should and would be present. This will require the utilization of lunar resources and a permanent station or facility on the Moon. Executive Order 13914 clarifies that such activities are legal under international law.<sup>78</sup>

### III. CURRENT COMMERCIAL SPACE REGULATION

#### A. REGULATORY OVERVIEW

Currently, commercial launch and reentry are regulated by the Office of Commercial Space Transportation (AST) under the Federal Aviation Administration (FAA) (together, FAA-AST),<sup>79</sup> headed by the Associate Administrator for the AST.<sup>80</sup>

The AST regulates by issuing permits and licenses without which commercial entities may not launch a space object in an orbital or suborbital trajectory or reenter a space object back into Earth’s atmosphere.<sup>81</sup> The AST’s regulatory power starts and ends respectively at launch and reentry.

The AST defines launch as an act of placing or trying to place a launch vehicle (LV) or a reentry vehicle (RV) and any payload therein in a suborbital trajectory, in outer space, or in Earth orbit.<sup>82</sup> Reentry is the return or the attempt to return an RV or a

---

<sup>78</sup> *Id.*

<sup>79</sup> 14 C.F.R. § 401.1 (2023).

<sup>80</sup> *Id.* § 401.3.

<sup>81</sup> *See id.* § 400.2.

<sup>82</sup> *See id.* § 401.5. Getting to outer space is a function of the vertical distance from sea level, i.e., altitude, wherein 100 km above the sea level, i.e., above the Kármán Line, is “outer space.” Daisy Dobrijevic & Andrew May, *The Kármán Line: Where Does Space Begin?*, SPACE.COM, <https://www.space.com/karman-line-where-does-space-begin> [<https://perma.cc/4A5D-246W>] (Nov. 14, 2022). Reaching orbit is a function of horizontal velocity, or velocity tangent to the Earth’s surface, whereby the velocity of about 11 km/s or 25,000 mph is required. *What Is Escape Velocity?*, NW. UNIV., <https://www.qrg.northwestern.edu/projects/vss/docs/space-environment/2-whats-escape-velocity.html> [<https://perma.cc/Y395-M99P>]. There are two helpful ways to understand this concept. The first is to imagine a ballistic trajectory (like a cannonball) stretching further and further out until it goes around Earth and comes back to the launching spot. Without air friction, an

payload *from Earth* back to Earth from outer space.<sup>83</sup> The prepositional phrase “from Earth” makes clear that the FAA only regulates launches from Earth. One could imagine a launch from an orbital platform, a station, or a launch from another celestial body such as the Moon. There are plans to install orbital refueling stations in LEO.<sup>84</sup> Some vehicles that launch from these platforms and fly to the Moon or Mars would not be regulated by the AST under the present regime. In fact, there is no regulation or regulatory body for this activity. Similarly, a launch from the Moon is also unregulated.

Reentry by an ELV is conducted to burn up in the heat of reentry or to crash-land in an unpopulated area,<sup>85</sup> while the reentry of a reusable launch vehicle (RLV), like the Space Shuttle Falcon 9 first-stage booster or the Dragon 2 capsule, is meant to come back in one piece, to be reused (relaunched) again.<sup>86</sup>

Federal law available at 14 C.F.R. § 400.1 establishes that the CSLA of 1984 empowers and enables the FAA to create and en-

object placed in that trajectory will stay up—and rockets first go up and then go sideways to get out of the dense atmosphere. *See* W. Dean Pesnell, *The Flight of Newton’s Cannonball*, 86 AM. J. PHYSICS 338, 338 (2018).

The other helpful way to understand orbit is to imagine a funnel. *See* KEVIN R. GRAZIER & STEPHEN CASS, *The Gravity of the Situation: Orbits*, in HOLLYWEIRD SCIENCE: THE NEXT GENERATION 284 (2017). The effects of gravity are similar to spiraling down a funnel. *Id.* An object falling down a funnel may escape it by traveling fast enough to spiral out of the funnel—the exact mechanics of an orbital launch. *Id.*

Then, being in a suborbital trajectory means the horizontal velocity is lower than 11 km/s. For example, Virgin Galactic’s *SpaceShipTwo* is suborbital. Jeff Foust, *Virgin Galactic Pushes Back Commercial Suborbital Flights to 2023*, SPACE NEWS (May 6, 2022), <https://spacenews.com/virgin-galactic-pushes-back-commercial-suborbital-flights-to-2023> [<https://perma.cc/MQ3E-3BY8>]. To simply reach outer space, the object needs to go up high enough, and the velocity or speed is irrelevant. Blue Origin’s New Shepard rocket, on the other hand, simply goes up and comes down, and has negligible horizontal velocity. *New Shepard*, BLUE ORIGIN, <https://www.blueorigin.com/new-shepard> [<https://perma.cc/U8JV-GZ58>].

<sup>83</sup> 14 C.F.R. § 401.5.

<sup>84</sup> *Refueling Satellites in Space*, LOCKHEED MARTIN, <https://www.lockheedmartin.com/en-us/news/features/2021/refueling-satellites-in-space.html> [<https://perma.cc/4F6Q-8VBR>].

<sup>85</sup> Unless you are China. Ed Browne, *Chinese Rocket Reportedly Rained Metal on Ivory Coast Last Time One Fell to Earth*, NEWSWEEK (May 5, 2021), <https://www.newsweek.com/chinese-rocket-rained-metal-ivory-coast-earth-orbit-1588865> [<https://perma.cc/TL8G-AZDU>].

<sup>86</sup> Mike Wall, *SpaceX Fires up Falcon Heavy Rocket Ahead of Saturday Launch (Photo)*, SPACE.COM (Jan. 10, 2023), <https://www.space.com/spacex-fifth-falcon-heavy-launch-static-fire> [<https://perma.cc/6B2G-4HNH>].

force regulations contained in the chapter.<sup>87</sup> However, international treaties and agreements to which the United States is a party limit the scope of the FAA's regulatory power.<sup>88</sup>

The FAA-AST is empowered to regulate commercial space transportation activities conducted in the United States' territory *or* by a U.S. natural person or a corporation anywhere in the world. The power to regulate launches by a foreign person or corporation on U.S. soil is consistent with the Convention on Registration of Objects Launched into Outer Space (Registration Convention). Article II of the Registration Convention provides that the launching state shall maintain a registry of objects launched into Earth orbit or beyond.<sup>89</sup> The launching state may be any of the following four categories: state that launches, state that procures the launch, state from whose territory the object is launched, or state from whose facility the object is launched.<sup>90</sup>

However, the Registration Convention disallows concurrent jurisdiction on the object launched<sup>91</sup> while the OST makes registration a prerequisite of jurisdiction.<sup>92</sup> In conjunction with the provisions of 14 C.F.R. Chapter III, the FAA may *exclusively* oversee any launch by a U.S. corporation anywhere on Earth, as well as any launch by conducted anyone from a U.S. territory.<sup>93</sup>

Lastly, the Regulation targets commercial companies and does not apply to launches, reentries, or any other space activity by the U.S. government.<sup>94</sup> However, it does regulate commercial launches on behalf of the U.S. government.<sup>95</sup> When SpaceX, for example, launches reconnaissance satellites on behalf of the

---

<sup>87</sup> 14 C.F.R. § 400.1 (2023).

<sup>88</sup> There are four binding international space law treaties that are applicable to the launch and reentry of vehicles. *See infra* Section IV.A.

<sup>89</sup> Convention on Registration of Objects Launched into Outer Space art. II, Jan. 14, 1975, 28 U.S.T. 695, 1023 U.N.T.S. 15.

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

<sup>91</sup> *Id.* art. II(2) ("Where there are two or more launching States in respect of any such space object, they shall jointly determine which one of them shall register the object in accordance with paragraph 1 of this article.").

<sup>92</sup> Outer Space Treaty, *supra* note 51, art. VIII ("A State Party to the Treaty on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object, and over any personnel thereof, while in outer space or on a celestial body.").

<sup>93</sup> *See* 14 C.F.R. § 400.2 (2023) (AST authorizes and supervises "commercial space transportation activities conducted in the United States *or by a U.S. Citizen*") (emphasis added); *id.* § 401.5 (defining "U.S. Citizen" to include corporations); *id.* § 413.3.

<sup>94</sup> *Id.* § 400.2(a).

<sup>95</sup> *Id.* § 401.3.

U.S. Space Force, the FAA's approval is needed with regards to the launch itself and the subsequent reentry of the Falcon 9 booster.

The general public may petition the Associate Administrator to issue, amend, or repeal a regulation pertaining to commercial space launch and reentry.<sup>96</sup> The rulemaking procedure for commercial launch is governed by the FAA's general rulemaking procedure.<sup>97</sup> Moreover, a commercial space launch entity can petition the Associate Administrator to waive some or every requirement in a particular license or permit.<sup>98</sup> This petition for a waiver must present a compelling case that balances factors such as public interest served by the waiver; a threat to the public health, safety, and property; national security; foreign policy interests; and so on.<sup>99</sup> The FAA-AST does not grant a wholesale waiver of a permit or license if a person is on board.<sup>100</sup> The FAA reserves practically plenary power to modify, suspend, or revoke any permit or license.<sup>101</sup> The Associate Administrator may also issue an emergency order immediately terminating a licensed or permitted launch or reentry, or the operation of a launch or reentry site.<sup>102</sup> Violations may result in civil penalties of a maximum of \$283,009 for each violation.<sup>103</sup> The affected party is entitled to a hearing before an administrative law judge,<sup>104</sup> but the final decision-making power is exclusively vested in the Associate Administrator.<sup>105</sup>

---

<sup>96</sup> *Id.* § 404.3(a)(1).

<sup>97</sup> *Id.* § 404.13(a); *see also id.* §§ 11.1–11.103 (setting out the rulemaking procedures for the FAA).

<sup>98</sup> *Id.* § 404.3(a)(2)–(3).

<sup>99</sup> *Id.* § 404.5(b)(3).

<sup>100</sup> *Id.* § 404.7(b).

<sup>101</sup> *Id.* § 405.3(b) (“The FAA may suspend or revoke any license or permit issued to such licensee or permittee under this chapter if the FAA finds that a licensee or permittee has substantially failed to comply with any requirement of the Act, any regulation issued under the Act, the terms and conditions of a license or permit, or any other applicable requirement; or that public health and safety, the safety of property, or any national security or foreign policy interest of the United States so require.”).

<sup>102</sup> *Id.* § 405.5.

<sup>103</sup> *Id.* § 406.9(a).

<sup>104</sup> *Id.* § 406.1; *see also id.* §§ 406.101–.79 (details of the procedure for the hearing).

<sup>105</sup> *Id.* § 406.5.

## B. SUBSTANTIVE REGULATIONS AND THEIR SHORTCOMINGS

The AST regulates launch, reentry, and other relevant activities, such as the operation of the launch and reentry sites, by requiring and issuing licenses and experimental permits.<sup>106</sup> The AST requires a license for foreign and domestic persons to launch or reenter vehicles in the United States' territory or to engage in the operation of launch and reentry sites.<sup>107</sup> A U.S. citizen must obtain a license for the launch and reentry of vehicles or the operation of launch and reentry sites anywhere in the world.<sup>108</sup>

The language "outside the United States"<sup>109</sup> may seem to suggest that launches from or reentries to the Moon or an orbital platform might fall under the regulatory ambit of the FAA. But that is not so, at least currently, as the regulatory authority of the FAA is limited to Earth by its own rules and definitions. For instance, "launch" only pertains to launches "from Earth," and "reentry" only means "return . . . to Earth."<sup>110</sup> Launch and reentry sites are also "on Earth."<sup>111</sup>

The United States does not assert regulatory jurisdiction over foreign entities that launch or reenter foreign territory, even if a U.S. citizen has a controlling interest in the foreign entity.<sup>112</sup> The AST, however, regulates foreign entities in which a U.S. citizen has a controlling interest if the launch or reentry happens in international territory or waters.<sup>113</sup>

The application process for licenses and experimental permits goes through, in order: preapplication consultation, acceptance, completion, review, any applicable supplementation or amendment, and issuance of a license or permit.<sup>114</sup> If the application is denied, the applicant may petition to submit a revised application or request a hearing.<sup>115</sup> The license or permit can be renewed.<sup>116</sup>

---

<sup>106</sup> A "permit" always means experimental permit.

<sup>107</sup> *Id.* § 413.3(a)-(b).

<sup>108</sup> *Id.* § 413.3(c).

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

<sup>110</sup> *Id.* § 401.5.

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

<sup>112</sup> Controlling interest does not simply mean over fifty percent ownership but also enough stake to exercise managerial control. *Id.*

<sup>113</sup> *Id.* § 413.3(d)-(e).

<sup>114</sup> *Id.* §§ 413.1-23.

<sup>115</sup> *Id.* § 413.21(b)(1).

<sup>116</sup> *Id.* §§ 413.21(b)(2), 413.23(d).

The launch site encompasses the location *on Earth* where a launch takes place and the necessary facilities are located.<sup>117</sup> Launches from the Moon are not regulated.<sup>118</sup> A federal launch range is a type of launch site that is owned and operated by the federal government.<sup>119</sup> The FAA further regulates the license to operate a reentry site;<sup>120</sup> experimental permit for experimental vehicles;<sup>121</sup> launch license;<sup>122</sup> launch safety;<sup>123</sup> launch and reentry of a (RLV);<sup>124</sup> reentry of a reentry vehicle other than a reusable launch vehicle;<sup>125</sup> and human space flight requirements.<sup>126</sup>

Current commercial space flight regulations do not regulate commercial activity in outer space or on the Moon. Regulations also say nothing of the production or activity that takes place on the Moon.

By regulating objects and personnel launched from Earth—assuming the launch falls within the current regulatory jurisdiction—the FAA may be able to extend its regulatory power under the current empowering legislation. But if a substantial activity is to take place on the lunar surface utilizing resources *in situ*, like launching a lunar satellite from the Moon, new legislation would be necessary. Legislation establishing regulatory and general jurisdiction on the Moon can and should be prospective, as space-related legislation tended to be in the past, given the breakneck speed of development in full reusability, which brings us ever closer to the commercialization of the Moon. But as will be discussed in the rest of this Article, extending jurisdiction to celestial bodies is a complicated question of international law. But the United States should have no problem in doing so in practice, given its imminent technopolitical dominance on the Moon and careful interpretation of existing international law, as will be discussed now.

---

<sup>117</sup> *Id.* § 401.5.

<sup>118</sup> *See id.*

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

<sup>120</sup> *Id.* § 433.

<sup>121</sup> *Id.* § 437.

<sup>122</sup> *Id.* § 415.

<sup>123</sup> *Id.* § 417.

<sup>124</sup> *Id.* § 431.

<sup>125</sup> *Id.* § 450.

<sup>126</sup> *Id.* § 460.

#### IV. CURRENT AND NEAR-FUTURE DEVELOPMENTS IN THE PRIVATE SPACE INDUSTRY

##### A. HISTORY OF SPACE EXPLORATION

The following is a précis of the history of human access to space<sup>127</sup> mainly centered around three launch vehicles of import: the R-7 rocket family, Saturn V, and the Space Shuttle.

The U.S.S.R. achieved the first-ever human access to space using its R-7 rocket, which placed the first artificial satellite, *Sputnik 1*, in Earth's orbit on October 4, 1957.<sup>128</sup> The United States and U.S.S.R. were already in the thick of the Cold War by that point, and the R-7 was indeed first developed as an Intercontinental Ballistic Missile (ICBM) to carry nuclear warheads.<sup>129</sup> Yet for this historical launch, the payload was swapped for a small radio signal emitting satellite.<sup>130</sup> *Sputnik 1* sent out regular beeps as it orbited Earth once every ninety-six minutes, which anyone with a radio could confirm.<sup>131</sup> After a few months, on November 3, 1957, the Soviets launched a dog named Laika in *Sputnik II* atop another R-7 rocket.<sup>132</sup>

The R-7 is noteworthy for having sent America into a frenzy regarding space exploration, starting the so-called Space Race chapter of the Cold War.<sup>133</sup> In 1957, America was not capable of launching satellites into orbit.<sup>134</sup> This meant that the United States also had an inferior nuclear-strike capability (ICBMs require orbital insertion), which implicated national security.

But the seldom-mentioned fact is that the R-7 family of rockets is still used and is the most prolific launch vehicle in the

---

<sup>127</sup> "Outer space": In this Article, the Kármán Line, 100 km (62.14 mi) in altitude, is considered to demarcate the start of outer space. See *supra* note 82 for more on the Kármán Line and the differences between "outer space" and "orbit."

<sup>128</sup> James J. Harford, *Korolev's Triple Play: Sputniks 1, 2, and 3*, NASA HIST. OFF. (1997), <https://history.nasa.gov/sputnik/harford.html> [<https://perma.cc/3PDT-X723>].

<sup>129</sup> *Id.*; Freddie Wilkinson, *The History of Space Exploration*, NAT'L GEOGRAPHIC (Oct. 24, 2022), <https://www.nationalgeographic.org/article/history-space-exploration> [<https://perma.cc/8RA5-DV7S>].

<sup>130</sup> Wilkinson, *supra* note 129.

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

<sup>132</sup> *Id.* But sadly, Laika almost immediately died during launch. Alice George, *The Sad, Sad Story of Laika, the Space Dog, and Her One-Way Trip into Orbit*, SMITHSONIAN MAG. (Apr. 11, 2018), <https://www.smithsonianmag.com/smithsonian-institution/sad-story-laika-space-dog-and-her-one-way-trip-orbit-1-180968728> [<https://perma.cc/W8JB-JUWJ>].

<sup>133</sup> Wilkinson, *supra* note 129.

<sup>134</sup> See NASA, *supra* note 18.

history of human space flight.<sup>135</sup> One of its many variants, called Soyuz-U, has launched successfully approximately 765 times—the most of any vehicle.<sup>136</sup> Cosmonauts<sup>137</sup> still launch atop an R-7 to get to the ISS. And after the retirement of the Space Shuttle in 2011, the United States also relied on the Russian R-7 to send astronauts to the ISS.<sup>138</sup> The history of R-7 shows how space technology has remained largely stagnant since the 1950s, whereby the *first-ever* launch system to access space is *still* the workhorse of the space industry—that is, until SpaceX arrived at the scene, as explained below.

Returning to history, the United States responded to the *Sputnik* crisis by consolidating space research efforts into a new agency, NASA. Spearheaded by Wernher von Braun,<sup>139</sup> a host of German engineers “brought” to America after WWII worked hard in Huntsville, Alabama, at the Redstone Arsenal.<sup>140</sup> But the Soviet cosmonaut Yuri Gagarin became the first human to orbit around Earth, albeit only once, on April 12, 1961, in a flight lasting 108 minutes.<sup>141</sup> Three weeks later, NASA achieved a human sub-orbital space flight (“touching space,” i.e., briefly flying beyond the Kármán line but not reaching orbit) by sending

---

<sup>135</sup> See *Soyuz Launch Vehicle: The Most Reliable Means of Space Travel*, EUR. SPACE AGENCY [ESA], [https://www.esa.int/Science\\_Exploration/Human\\_and\\_Robotic\\_Exploration/Delta\\_Mission/Soyuz\\_launch\\_vehicle\\_The\\_most\\_reliable\\_means\\_of\\_space\\_travel](https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Delta_Mission/Soyuz_launch_vehicle_The_most_reliable_means_of_space_travel) [https://perma.cc/86FN-T7VG].

<sup>136</sup> See *id.*; Gunter D. Krebs, Soyuz-U (11A511U), GUNTER’S SPACE PAGE, [https://space.skyrocket.de/doc\\_lau\\_det/soyuz-u.htm](https://space.skyrocket.de/doc_lau_det/soyuz-u.htm) [https://perma.cc/L4EC-TKAH].

<sup>137</sup> This is the name for astronauts trained in Russia and certified as a space pilot by Roscosmos. See generally Elizabeth Howell, *Roscosmos: Russia’s Space Agency*, SPACE.COM (Jan. 29, 2018), <https://www.space.com/22724-rosocosmos.html> [https://perma.cc/F5UY-PTJC].

<sup>138</sup> See *Space Shuttle Transition and Retirement*, NASA, [https://www.nasa.gov/mission\\_pages/transition/placement/index.html](https://www.nasa.gov/mission_pages/transition/placement/index.html) [https://perma.cc/NP2F-VUH4]; Joey Roulette, *NASA, Russian Space Agency Sign Deal to Share Space Station Flights – Roscosmos*, REUTERS (July 15, 2022, 9:57 AM), <https://www.reuters.com/business/aerospace-defense/nasa-russian-space-agency-sign-deal-share-space-station-flights-rosocosmos-2022-07-15/> [https://perma.cc/37TJ-D5PT].

<sup>139</sup> Yes, he is the one who designed the first-ever liquid-fuel rocket V-2 that terrorized the citizens of London during World War II. *Wernher von Braun*, NASA EARTH OBSERVATORY, (May 2, 2001), [https://earthobservatory.nasa.gov/features/vonBraun/vonbraun\\_3.php](https://earthobservatory.nasa.gov/features/vonBraun/vonbraun_3.php) [https://perma.cc/6VA7-4MDD].

<sup>140</sup> *Biography of Wernher Von Braun*, NASA, <https://www.nasa.gov/centers/marshall/history/vonbraun/bio.html> [https://perma.cc/PR6J-B6YM] (Aug. 3, 2017).

<sup>141</sup> *Yuri Gagarin: First Man in Space*, NASA, [https://www.nasa.gov/mission\\_pages/shuttle/sts1/gagarin\\_anniversary.html](https://www.nasa.gov/mission_pages/shuttle/sts1/gagarin_anniversary.html) [https://perma.cc/7CS8-NESA] (Apr. 13, 2011).



Alan Shepard, a NASA astronaut, on a meager fifteen-minute flight.<sup>142</sup>

The United States had had enough of the humiliation, and President Kennedy announced that year, on May 25, that NASA would land a man on the Moon and bring him back before 1970.<sup>143</sup> This was very ambitious, if not fantastical, considering that NASA had not even succeeded in placing a person *in Earth's orbit*.

But this trump card was the only card left because every other space-exploration milestone was taken by the Soviets: the first artificial satellite; the first living animal, the first human, and the landing of the first human-made object on the Moon;<sup>144</sup> the second human orbital flight (that lasted about twenty-four hours);<sup>145</sup> the first spacewalk;<sup>146</sup> and the first woman in space.<sup>147</sup>

Throughout the 1960s, NASA worked on other minor launch vehicles like the Atlas rocket family<sup>148</sup> for sending artificial satellites into orbit and Gemini rockets for testing manned space flight.<sup>149</sup> But the prize was on the Moon, and von Braun de-

---

<sup>142</sup> *60 Years Ago: Alan Shepard Becomes the First American in Space*, NASA, <https://www.nasa.gov/image-feature/60-years-ago-alan-shepard-becomes-the-first-american-in-space> [<https://perma.cc/FHS2-Z6JM>] (May 5, 2021); Michael Neufeld, *First American in Space: The Flight of Alan B. Shepard*, NAT'L AIR & SPACE MUSEUM (May 5, 2021), <https://airandspace.si.edu/stories/editorial/first-american-space-flight-alan-b-shepard> [<https://perma.cc/J9JF-4FLA>].

<sup>143</sup> Steve Garber, *The Decision to Go to the Moon: President John F. Kennedy's May 25, 1961 Speech Before a Joint Session of Congress*, NASA HIST. OFF., <https://history.nasa.gov/moondec.html>. [<https://perma.cc/E3DP-9BPE>] (Oct. 29, 2013).

<sup>144</sup> *Luna 2 in 1959*. *Luna 2*, NASA, <https://nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=1959-014A> [<https://perma.cc/L3JJ-FBLL>].

<sup>145</sup> In 1961. See generally Doug Millard, *Gherman Titov*, GUARDIAN (Sept. 21, 2000, 9:58 PM), <https://www.theguardian.com/news/2000/sep/22/guardianobituaries1> [<https://perma.cc/P6WR-8YWX>]; John Uri, *60 Years Ago: Astronaut Glenn Meets Cosmonaut Titov*, NASA (May 3, 2022), <https://www.nasa.gov/feature/60-years-ago-astronaut-glenn-meets-cosmonaut-titov> [<https://perma.cc/J5X7-VWFL>].

<sup>146</sup> Extra-Vehicular Activity (EVA) in outer space, wearing a spacesuit. John Uri, *Space Station 20th: Spacewalking History*, NASA (June 3, 2020), <https://www.nasa.gov/feature/space-station-20th-spacewalking-history> [<https://perma.cc/8C48-HZLN>].

<sup>147</sup> Valentina Tereshkova in the *Vostok 6* mission. *Vostok 6*, NASA, <https://nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=1963-023A> [<https://perma.cc/DG3T-NLCY>].

<sup>148</sup> Atlas V is still used today, just like the R-7 rocket family. The first flight of Atlas V was on December 17, 1957. See *On Atlas' Shoulders*, LOCKHEED MARTIN, <https://www.lockheedmartin.com/en-us/news/features/history/atlas.html> [<https://perma.cc/MCY2-7DUN>].

<sup>149</sup> Wilkinson, *supra* note 129.

signed the legendary Saturn V moon rocket, which to this date is the most powerful rocket that has launched successfully.<sup>150</sup> In 1969, the *Apollo 11* mission took to the Moon astronauts Michael Collins, Buzz Aldrin, and Neil Armstrong (the first man to walk on the Moon).<sup>151</sup> They landed on July 24, 1969, in keeping with President Kennedy's vow to land a man before the decade was over.<sup>152</sup>

But the Apollo missions were largely symbolic: trying to get to the Moon and plant the flag; they were not designed to "stay" on the Moon. For one, the vehicle that cost about \$1.3 billion *per launch* was entirely expended and could only send two or three persons at a time.<sup>153</sup> That comes to about \$400 to \$650 million per person for a week-long excursion on the Moon—not exactly a model for settlement or economically viable private enterprise on the Moon. Not surprisingly shortly after the flag-planting, the Apollo program ended in 1972, and the mighty Saturn V has not flown since 1973.<sup>154</sup>

The Soviets' idea of one-upmanship after the Moon landing was the first space station *Salyut 1*, launched in 1971.<sup>155</sup> The United States responded by launching the *Skylab* space station atop a Saturn V in its last flight.<sup>156</sup> Hence, since the 1970s, space exploration has remained largely in the LEO<sup>157</sup> in various space

---

<sup>150</sup> *The First Person on the Moon*, NASA, <https://www.nasa.gov/audience/for-students/k-4/stories/first-person-on-moon.html> [https://perma.cc/PN6Z-HFBT] (Apr. 9, 2009).

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

<sup>152</sup> *Id.*

<sup>153</sup> Inflation adjusted. *Information Summaries: The Early Years: Mercury to Apollo-Soyuz*, NASA 3 (Sept. 1991), [https://www.nasa.gov/sites/default/files/167718main\\_early\\_years.pdf](https://www.nasa.gov/sites/default/files/167718main_early_years.pdf) [https://perma.cc/CC9V-7S3G].

<sup>154</sup> *Id.* at 12; Ben Evans, *The Day the Saturn V Almost Failed: 50 Years Since Apollo 6*, AMERICASPACE, <https://www.americaspace.com/2018/04/01/the-day-the-saturn-v-almost-failed-50-years-since-apollo-6> [https://perma.cc/6Z23-997X].

<sup>155</sup> *Salyut 1*, NASA SPACE SCI. DATA COORDINATED ARCHIVE, <https://nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=1971-032A> [https://perma.cc/UL6T-UNYH].

<sup>156</sup> Cliff Lethbridge, *Saturn V Skylab Fact Sheet*, SPACELINE, <https://www.spaceline.org/saturn-v-skylab-fact-sheet> [https://perma.cc/H3T6-HEXF].

<sup>157</sup> A geocentric orbit is an orbit around the Earth; a low Earth orbit, or LEO, is a geocentric orbit of less than 2,042 km (approximately 1,200 mi) in altitude. See Zainab Reza, *What Is Geocentric Orbit?*, WORLDATLAS (Dec. 19, 2017), [https://www.worldatlas.com/articles/what-is-geocentric-orbit.html#:~:text=the%20most%20commonly%20used%20classification,low%20Earth%20orbit%20\(LEO\)](https://www.worldatlas.com/articles/what-is-geocentric-orbit.html#:~:text=the%20most%20commonly%20used%20classification,low%20Earth%20orbit%20(LEO)) [https://perma.cc/6SWC-3MXH].

stations just a few hundred miles above.<sup>158</sup> It is quite a downturn compared to walking on the Moon.

The Space Shuttle was a vehicle designed in the 1960s and 1970s for supposedly cheap access to LEO by reusing the launch system.<sup>159</sup> The aim of reusability was undeniably correct: to decrease the cost of launch by spreading out the fixed costs of development and manufacturing throughout many launches and to increase the rate of launch—refurbishment or system check-ups would be faster than making a new launch system for every launch.<sup>160</sup>

Long story short, the Shuttle was, in hindsight, a failure.<sup>161</sup> It launched 135 times and failed twice, making the launch-failure

---

<sup>158</sup> See generally *History of Space Exploration*, BRITANNICA, <https://www.britannica.com/science/space-exploration/Space-stations> [<https://perma.cc/37MS-PYZ5>]. Currently, the ISS has been operational since 1998, at a price tag of \$1.5 billion or so per year. Jeff Foust, *NASA Outlines Cost Savings from ISS Transition*, SPACENEWS (Feb. 6, 2022), <https://spacenews.com/nasa-outlines-cost-savings-from-iss-transition> [<https://perma.cc/GSY4-6LPV>]. China launched its first manned space station in 2021. Ryan Woo & Lianping Gao, *Chinese Astronauts Board Space Station in Historic Mission*, REUTERS (Nov. 29, 2022, 8:38 PM), <https://www.reuters.com/lifestyle/science/china-launches-crewed-spacecraft-chinese-space-station-state-television-2022-11-29> [<https://perma.cc/23ZE-8B53>].

<sup>159</sup> Cliff Lethbridge, *Space Shuttle*, SPACELINE, <https://www.spaceline.org/united-states-manned-space-flight/space-shuttle-program-history/> [<https://perma.cc/6TA7-DWD3>].

<sup>160</sup> *Space Shuttle: Shuttle Basics*, NASA, [https://www.nasa.gov/returntoflight/system/system\\_STS\\_prt.htm](https://www.nasa.gov/returntoflight/system/system_STS_prt.htm) [<https://perma.cc/9B4K-4PW2>]; Nilopal Ojha, *Reusable Launch Systems — Revolutionizing the Future of Space Travel and Exploration*, SATMAGAZINE (Dec. 2020), [www.satmagazine.com/story.php?number=651485507](http://www.satmagazine.com/story.php?number=651485507) [<https://perma.cc/F4DW-FXHG>].

<sup>161</sup> The Shuttle had 28,000 heat shields on its belly that protected the vehicle from the intense heat of atmospheric reentry. See Peter N. Spotts, *Troubled from the Start: The Tale of the Tiles*, CHRISTIAN SCI. MONITOR (Feb. 6, 2003), <https://www.csmonitor.com/2003/0206/p01s01-usgn.html> [<https://perma.cc/BTF8-JMDB>]. The tiles proved to be the downfall of the Shuttle. See *id.* The belly side of the Shuttle was attached to the tanker, which contained liquid hydrogen and oxygen. See William J. Broad & David E. Sanger, *Loss of the Shuttle: Insulation; NASA Was Told in 1990 About Vulnerable Tiles*, N.Y. TIMES (Feb. 5, 2003), <https://www.nytimes.com/2003/02/05/us/loss-of-the-shuttle-insulation-nasa-was-told-in-1990-about-vulnerable-tiles.html> [<https://perma.cc/2GGZ-YFUB>]. These fuels being very cold, ice formed around the tanker, which caused insulation foam to fall on the Shuttle's belly. See *id.* The weak tiles were always bombarded by fragments of ice and insulation during launch. See *id.* This made the return journey extremely dangerous, and notoriously resulted in the Columbia disaster. See *id.* But see *Missing Tiles 'Not Responsible' for Columbia Crash*, GUARDIAN (Feb. 14, 2003, 6:40 AM), <https://www.theguardian.com/world/2003/feb/14/columbia.spaceexploration> [<https://perma.cc/H74H-S7UD>]. But in terms of reusability, it meant that NASA engineers had to painstakingly inspect every single tile. See Spotts, *supra*. Most of the tiles were uniquely shaped and were glued

rate of 1.5%, or one in every 67 launches, the highest launch failure of any operational launch system in history.<sup>162</sup> It killed fourteen astronauts in those two failures,<sup>163</sup> making it the deadliest launch system in history—the only launch system to have killed anybody during flight.<sup>164</sup> For a vehicle intended to fly hundreds of times a year, it only flew 135 times in its forty-year history, which was extended by twenty years from its initially slated retirement in the 1990s.<sup>165</sup> What is more, after the Shuttle retired in 2011, the United States had no rocket to send astronauts to the *ISS* and had to pay \$90 million *per astronaut* to get NASA astronauts to the *ISS* atop a R-7 rocket, which, as said earlier, is still used after some sixty years.<sup>166</sup>

---

to the Shuttle, making the inspection and refurbishment incredibly expensive and slow. *See id.* This made the reusable Shuttle cost even more than the expended Saturn V. *See id.*; *Why the Space Shuttle Program Was a Disaster*, MOONDAWG'S SPACE NEWS (Nov. 29, 2021), <https://sites.psu.edu/mooneypassionblog/2021/11/29/why-the-space-shuttle-program-was-a-disaster/> [<https://perma.cc/UY32-TPL2>].

<sup>162</sup> Cheryl L. Mansfield, *STS-135: The Final Voyage*, NASA, [https://www.nasa.gov/mission\\_pages/shuttle/shuttlemissions/sts135/launch/sts-135\\_mission-overview.html](https://www.nasa.gov/mission_pages/shuttle/shuttlemissions/sts135/launch/sts-135_mission-overview.html) [<https://perma.cc/RW69-B2QD>] (Aug. 7, 2017); Tom Hartsfield, *How the Space Shuttle Program Nearly Ended in Disaster*, BIG THINK: THE PAST (Aug. 12, 2022), <https://bigthink.com/the-past/space-shuttle-program-near-disaster> [<https://perma.cc/8HEP-EFZA>].

<sup>163</sup> John A. Logsdon, *Return to Flight: Richard H. Truly and the Recovery from the Challenger Accident*, in *FROM ENGINEERING SCIENCE TO BIG SCIENCE* 345 (1998), <https://history.nasa.gov/SP-4219/Chapter15.html> [<https://perma.cc/B877-UZPJ>]; Ronald Kotulak, *Key Differences Seen in Columbia, Challenger Disasters*, CHI. TRIB. (Feb. 2, 2003, 2:00 AM), <https://www.chicagotribune.com/nation-world/chi-0302020335feb02-story.html> [<https://perma.cc/EW36-M9QD>].

<sup>164</sup> Rodney Rocha, *Accident Case Study of Organizational Silence & Communication Breakdown: Shuttle Columbia, Mission STS-107*, NASA 4 (Jan. 27, 2011), [https://www.nasa.gov/pdf/553084main\\_Case\\_Study\\_Silence\\_Breakdown\\_Columbia\\_Rocha.pdf](https://www.nasa.gov/pdf/553084main_Case_Study_Silence_Breakdown_Columbia_Rocha.pdf) [<https://perma.cc/5THX-QXPH>]; Mathew Heck, *The Competitive Advantage: Competitive Space Groups Are Coercing Cooperative Agencies into Efficiency*, GATE (Dec. 3, 2018, 7:20 AM), <http://uchicogate.com/articles/2018/12/3/competitive-advantage-competitive-space-groups-are-coercing-cooperative-agencies-efficiency/> [<https://perma.cc/P6GF-MFNM>].

<sup>165</sup> Brian Jirout, *Lessons of Landsat—From Experimental Program to Commercial Land Imaging, 1969-1989*, in *SEEDS OF DISCOVERY: CHAPTERS IN THE ECONOMIC HISTORY OF INNOVATION WITHIN NASA*, NASA 164, 166 (2016), [https://www.nasa.gov/sites/default/files/atoms/files/seeds\\_of\\_discovery\\_ms-space-portal.pdf](https://www.nasa.gov/sites/default/files/atoms/files/seeds_of_discovery_ms-space-portal.pdf) [<https://perma.cc/H2V9-6THV>].

<sup>166</sup> Jamie Carter, *Sorry, SpaceX. Watch This Week as NASA Pays \$90 Million to Launch U.S. Astronaut on a Russian Rocket*, FORBES (Oct. 12, 2020, 10:00 PM), <https://www.forbes.com/sites/jamiecartereurope/2020/10/12/sorry-spacex-watch-this-week-as-nasa-pays-90-million-to-launch-us-astronaut-on-a-russian-rocket/?sh=51284a1d1f52> [<https://perma.cc/YK4P-H38C>].

Space is hard. In fact, it is so hard that the two superpowers poured tens of billions of dollars into it for over seven decades and still could not achieve reusability.<sup>167</sup> Rockets from the 1950s and 1960s are still used, albeit upgraded.<sup>168</sup> The best moment was planting a flag on the Moon and getting a few rock samples back, never to return.<sup>169</sup> Mighty NASA's venture into cutting the cost of access to LEO resulted in a catastrophe called the Space Shuttle.<sup>170</sup> It seemed like sending robots to Mars was the best space exploration would ever get in our lifetime. If NASA, which has had a \$650 billion budget in nominal dollars over its sixty-years history<sup>171</sup> (\$23 billion in 2020 alone),<sup>172</sup> could not achieve reusability, who could? It seemed like humanity would be forever Earth-bound. This was the depressing state of space technology until a South African software engineer founded a private aeronautics company that designed a *partially* reusable system for about \$300 million and started launching rockets at a fraction of the traditional cost (a marginal cost of \$15 million per launch).<sup>173</sup>

## B. THE ECONOMICS OF A SPACE LAUNCH

Before SpaceX, space had been the province of a select subset of developed nations because, among other things, it was expen-

---

<sup>167</sup> *Nasa Budgets: US Spending on Space Travel Since 1958 Updated*, GUARDIAN, <https://www.theguardian.com/news/datablog/2010/feb/01/nasa-budgets-us-spending-space-travel> [<https://perma.cc/ZT7C-GT68>].

<sup>168</sup> LOCKHEED MARTIN, *supra* note 148.

<sup>169</sup> John Noble Wilford, *Astronauts Land on Plain; Collect Rocks, Plant Flag*, N.Y. TIMES (July 21, 1969), <https://archive.nytimes.com/www.nytimes.com/library/national/science/nasa/072169sci-nasa.html> [<https://perma.cc/S6ZZ-MAK8>].

<sup>170</sup> See Stephen M. Walt & Martin Walt IV, *The Space Shuttle Program: Stunning Success or Dismal Failure*, FOREIGN POL'Y (Mar. 22, 2011, 12:50 PM), <https://foreignpolicy.com/2011/03/22/the-space-shuttle-program-stunning-success-or-dismal-failure/> [<https://perma.cc/W73U-9KX5>].

<sup>171</sup> GUARDIAN, *supra* note 167.

<sup>172</sup> *NASA's FY 2021 Budget*, PLANETARY SOC'Y, <https://www.planetary.org/space-policy/nasas-fy-2021-budget> [<https://perma.cc/X5D3-GFSR>].

<sup>173</sup> NASA, COMMERCIAL MARKET ASSESSMENT FOR CREW AND CARGO SYSTEMS PURSUANT TO SECTION 403 OF THE NASA AUTHORIZATION ACT OF 2010 (P.L. 111-267), at 40 (2011), [https://www.nasa.gov/sites/default/files/files/Section403\(b\)CommercialMarketAssessmentReportFinal.pdf](https://www.nasa.gov/sites/default/files/files/Section403(b)CommercialMarketAssessmentReportFinal.pdf) [<https://perma.cc/XB7T-E3RV>]; Mike Brown, *SpaceX: Elon Musk Breaks Down the Cost of Reusable Rockets*, INVERSE (Aug. 21, 2020), <https://www.inverse.com/innovation/spacex-elon-musk-falcon-9-economics> [<https://perma.cc/69WL-K5YP>].

sive.<sup>174</sup> The Apollo program cost, adjusted for inflation, was about \$257 billion (in 2020 dollars), and the Space Shuttle program was over \$200 billion (in 2010 dollars).<sup>175</sup> The high cost was due to the difficulty of developing a launch vehicle and the inability to reuse such expensive vehicles.<sup>176</sup> SpaceX, having developed Falcon 9 for about \$300 million, proved that technology has matured enough for private-funded development to be possible at a fraction of the traditional governmental cost.<sup>177</sup> Without a doubt, the private sector's operational efficiency also helped lower the cost.<sup>178</sup>

The single-use regime of ELVs also made space expensive and inaccessible to private commercial entities. Imagine if Boeing 747s were not reused.<sup>179</sup> Considering a 747 costs around \$418 million and may fly about 450 passengers, the minimum per flight cost would be nearly \$1 million per person.<sup>180</sup> In terms of cargo, it would cost \$1,463 for every pound.<sup>181</sup> By reusing aircraft many times with minimal checkups in between, airliners drastically bring down the cost of air travel. Reusability is the holy grail of space flight, whereby achieving airplane-esque *full* reusability may lower the cost of space flight so much as to finally enable commercial activities in LEO, the Moon, and beyond.

Hence, the cost-per-unit-weight-to-orbit is an important variable in analyzing the economics of a space launch. For purposes

<sup>174</sup> See Bruno Venditti, *The Cost of Space Flight Before and After SpaceX*, VISUAL CAPITALIST (Jan. 27, 2022), <https://www.visualcapitalist.com/the-cost-of-space-flight/> [https://perma.cc/E2V8-YQGE].

<sup>175</sup> See *How Much Did the Apollo Program Cost?*, PLANETARY SOC'Y, <https://www.planetary.org/space-policy/cost-of-apollo> [https://perma.cc/UJT7-D7M5]; Mike Wall, *NASA's Shuttle Program Cost \$209 Billion – Was It Worth It?*, SPACE.COM (July 5, 2011), <https://www.space.com/12166-space-shuttle-program-cost-promises-209-billion.html> [https://perma.cc/VF7B-7S9U].

<sup>176</sup> Vidya Sagar Reddy, *The SpaceX Effect*, 6 NEW SPACE 125, 125 (2018).

<sup>177</sup> NASA, *supra* note 173, at 40.

<sup>178</sup> Reddy, *supra* note 176, at 125.

<sup>179</sup> See Amy Shira Teitel, *How Does SpaceX Build Its Falcon 9 Reusable Rocket?*, BBC: SCI. FOCUS, <https://www.sciencefocus.com/space/how-does-spacex-build-its-falcon-9-reusable-rocket/> [https://perma.cc/QEV5-ZZ7C].

<sup>180</sup> See *id.*; Jake Hardiman & Luke Bodell, *Money Talks: A Look at the List Prices of Boeing Aircraft*, SIMPLE FLYING, <https://simpleflying.com/how-much-do-boeing-aircraft-cost> [https://perma.cc/R2H5-WVP6] (July, 26, 2022).

<sup>181</sup> Cargo capacity is 307,600 pounds. David A. Mann, *Take a Look Inside UPS' Newest, Biggest Boeing 747-8F Cargo Jet*, PUGET SOUND BUS. J. (Feb. 5, 2018), <https://www.bizjournals.com/seattle/news/2018/02/05/ups-boeing-747-8f-cargo-jet-photos-video.html> [https://perma.cc/33QM-VHUE].

of this Article, I concretize it to “dollars per kilogram,” or \$/kg, to LEO or the Moon.

By partially reusing Falcon 9, SpaceX has achieved the rate of \$2,600/kg to LEO, one of the lowest in history (second only to the Falcon Heavy).<sup>182</sup> In comparison, the Saturn V had the rate of about \$5,400/kg to LEO, and the Space Shuttle had a rate of \$65,400/kg to LEO.<sup>183</sup> This means that every sip of water that astronauts drank on the *ISS* cost about \$5,000.<sup>184</sup> Even United Launch Alliance’s (ULA’s) Delta IV Heavy, which flies today, has the rate of \$11,600/kg,<sup>185</sup> and the famously efficient Russian space program’s modern Proton-M costs \$2,800/kg.<sup>186</sup> Even with just the partial reusability of the Falcon family (reusing the first stage, but not the second stage or fairings), SpaceX cut the \$/kg to a fraction of the traditional rate.<sup>187</sup>

However, the \$/kg measure is insufficient for a full analysis of the economics of space flight. For, as is the case in any economic analysis, the rate of supply is an indispensable variable. Only with a high rate of volume and low cost can economies of scale be achieved and enable commercial space.<sup>188</sup>

Three factors seem to adequately explain the rate of supply<sup>189</sup> in space flight: the cargo capacity, rate of manufacturing, and turnaround time of the vehicle. To put it differently, creating a vehicle that can carry a lot and be reused shortly after flying will lead to the rate of supply sufficient to sustain efforts to settle and commercialize the Moon. For this Article, I use cargo capacity

---

<sup>182</sup> See Roberts, *supra* note 56. The Falcon Heavy comes in at an unprecedented \$1,500/kg. *Id.*

<sup>183</sup> *Id.*

<sup>184</sup> See generally Larry Greenemeier, *New Menu Item on Space Station: Drinking Water Made from Recycled Urine*, SCI. AM. (Oct. 26, 2007), <https://www.scientificamerican.com/article/new-menu-item-on-space-st/> [<https://perma.cc/G4VQ-GAK6>].

<sup>185</sup> See Roberts, *supra* note 56; see also Danny Paez, *SpaceX Falcon Heavy vs. Delta IV Heavy: 4 Key Differences*, INVERSE (May 10, 2016), <https://www.inverse.com/article/44728-falcon-heavy-vs-delta-iv-heavy> [<https://perma.cc/P7CV-UVBW>].

<sup>186</sup> U.S. GOV’T ACCOUNTABILITY OFF., GAO-17-609, SURPLUS MISSILE MOTORS: SALE PRICE DRIVES POTENTIAL EFFECTS ON DOD AND COMMERCIAL LAUNCH PROVIDERS tbl.4 (2017).

<sup>187</sup> Tom Nardi, *SpaceX’s Next Giant Leap: Second Stage Recovery*, HACKADAY (May 23, 2018), <https://hackaday.com/2018/05/23/spacexs-next-giant-leap-second-stage-recovery/> [<https://perma.cc/H3R5-R6AS>].

<sup>188</sup> Eric Berger, *SpaceX May Finally Be Reaching a Nirvana of High Flight Rates*, ARS TECHNICA (May 12, 2017, 8:28 AM), <https://arstechnica.com/science/2017/05/with-a-launch-set-for-monday-spacex-closing-in-on-high-flight-rate-goals/> [<https://perma.cc/ZZ7K-8HCY>].

<sup>189</sup> I address the issue of demand in later sections.

per unit time, concretized to tons per year, or ton/year. This unit takes into account the gross weight of cargo that can be carried by a family of rockets per year. This in turn will depend on how many rockets can be produced per year and how often they can reflly (if at all). This variable is also closely related to the first variable, dollars per kilogram. More frequent reflights spread out the cost of manufacturing, decreasing the marginal cost per launch.

SpaceX was capable of producing a Falcon 9 every two weeks in 2016, which amounts to about twenty-six vehicles per year.<sup>190</sup> Since 2012, SpaceX has launched a total of 1,272 tons into various orbits using the Falcon 9 and Falcon Heavy rockets.<sup>191</sup> In comparison, in 2019 alone, around 61.3 million tons of airfreight were carried by commercial airlines globally.<sup>192</sup> Using the analytical tools developed in the Appendix, one may attribute the high tons/year of commercial airlines to the fact that Boeing, alone, could deliver 806 planes in 2018<sup>193</sup> (high rate of production), and airfreight costs about \$4/kg.<sup>194</sup> This means that the holy grail of space flight would require SpaceX to achieve something like a production capacity greater, and the freight cost cheaper, by an order of magnitude. Only a launch vehicle design that could be manufactured in much greater quantity and could provide a two-digit \$/kg and could carry hundreds of thousands of tons of cargo to the Moon would enable the settlement and commercialization of the Moon. Starship fits the bill.<sup>195</sup>

---

<sup>190</sup> Jeff Foust, *SpaceX Seeks to Accelerate Falcon 9 Production and Launch Rates This Year*, SPACE NEWS (Feb. 4, 2016), <https://spacenews.com/spacex-seeks-to-accelerate-falcon-9-production-and-launch-rates-this-year> [<https://perma.cc/X68T-7TT4>].

<sup>191</sup> SPACE X STATS, <https://www.spacexstats.xyz/#upcoming-next> [<https://perma.cc/XVB9-7GY4>].

<sup>192</sup> Jim Currier, *The Aviation Industry in 2021 – The Road to Recovery*, HONEYWELL, <https://aerospace.honeywell.com/us/en/about-us/blogs/aviation-industry-2021-road-to-recovery> [<https://perma.cc/T7MX-2X79>].

<sup>193</sup> Erick Burgueño Salas, *Boeing's Aircraft Deliveries from 1998 to 2021*, STATISTA (Aug. 29, 2022), <https://www.statista.com/statistics/273968/number-of-delivered-aircraft-by-boeing/> [<https://perma.cc/GF9T-KM9U>].

<sup>194</sup> Kulisch, *supra* note 11.

<sup>195</sup> See *infra* Appendix for further discussion.



## C. ADVANCEMENTS IN THE LAUNCH TECHNOLOGY: SPACE X

SpaceX is a private, American aerospace corporation founded in 2002.<sup>196</sup> It has achieved numerous singular milestones and produced paradigm-changing innovation.<sup>197</sup> SpaceX is the only private commercial entity that has launched humans into orbit.<sup>198</sup> Today, this makes SpaceX and Roscosmos (the Russian space agency) the only entities capable of transporting humans to and from the *ISS*.<sup>199</sup>

---

<sup>196</sup> Alison Eldridge, *SpaceX*, BRITANNICA, <https://www.britannica.com/topic/SpaceX> [<https://perma.cc/Y3HV-HL2L>] (Jan. 3, 2023).

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

<sup>198</sup> *Id.* The human space flight achieved by other private entities Blue Origin and Virgin Galactic is completely different and much easier. See Stuart Fox, *6 Private Companies That Could Launch Humans into Space*, SPACE.COM (June 4, 2010), <https://www.space.com/8541-6-private-companies-launch-humans-space.html> [<https://perma.cc/WB8Q-AMEJ>]. Their “space flight” involves putting persons or payload above the 100 km Kármán Line that demarcates the beginning of outer space. See *id.* LEO insertion requires a speed close to 32,400 km/h. See Sabine Stanley, *Achieving Escape Velocity: Launching Rockets into Space*, WONDRIUM DAILY (Dec. 30, 2020), <https://www.wondriumdaily.com/achieving-escape-velocity-launching-rockets-into-space/> [<https://perma.cc/7J4P-RN5V>]. Virgin Galactic’s suborbital vehicle, SpaceShipOne, only reaches the speed of 3,800 km/h, and Blue Origin’s New Shepard only reaches a speed of 3,600 km/h. See Gunter D. Krebs, *SpaceShipOne (SS1)*, GUNTER’S SPACE PAGE, [https://space.skyrocket.de/doc\\_lau/spaceshipone.htm](https://space.skyrocket.de/doc_lau/spaceshipone.htm) [<https://perma.cc/RPN9-2TDB>]; Michael Sheetz, *Jeff Bezos Reaches Space on Blue Origin’s First Crewed Launch*, CNBC, <https://www.cnn.com/2021/07/20/jeff-bezos-reaches-space-on-blue-origins-first-crewed-launch.html> [<https://perma.cc/ER6E-CYPY>] (July 20, 2021, 2:21 PM). The energy required to accelerate the same payload to 25,000 km/h is about fifty times greater than to 3,600 km/h. See generally Jim Clash, *The Astronomical Difference Between Orbital and Suborbital Space Flight*, FORBES (June 16, 2022, 1:20 PM), <https://www.forbes.com/sites/jimclash/2022/06/16/the-astronomical-differences-between-orbital-and-suborbital-space-flight/?sh=7ffa69317c1a> [<https://perma.cc/8AWU-5SH6>]. Reentering the atmosphere from orbit generates a massive amount of heat, and that heat is not as significant in suborbital flights. See ELIZABETH MARBLE, NASA, MEASURING THE SPECTRAL EMISSIVITY OF THERMAL PROTECTION MATERIALS DURING ATMOSPHERIC REENTRY SIMULATION, at S-2-3 (1995), <https://ntrs.nasa.gov/api/citations/19960050124/downloads/19960050124.pdf> [<https://perma.cc/H87A-VWRB>] (temperatures upon orbital reentry can reach 2,900 degrees Fahrenheit); Marti Sarigul-Klijn & Nesrin Sarigul-Klijn, *Flight Mechanics of Manned Sub-Orbital Reusable Launch Vehicles with Recommendations for Launch and Recovery*, AM. INST. AERONAUTICS & ASTRONAUTICS (2003) (suborbital flight can momentarily reach temperatures of 1,000 degrees Fahrenheit). Thus, suborbital and orbital flights are not in the same technological category.

<sup>199</sup> See Joey Roulette, *NASA Mulls SpaceX Backup Plan for Crew of Russia’s Leaky Soyuz Ship*, REUTERS (Dec. 28, 2022, 9:19 AM), <https://www.reuters.com/business/aerospace-defense/nasa-mulls-spacex-backup-plan-crew-russias-leaky-soyuz-ship-2022-12-28/> [<https://perma.cc/U249-734D>].

SpaceX is gearing up to conduct the first orbital test launch of its fully reusable launch system, Starship.<sup>200</sup> Fully reusable denotes the capability of a vehicle to be reused continuously with minimal refurbishment between uses.<sup>201</sup> Commercial airplanes and cars, for example, are fully reusable vehicles. They occasionally require refurbishment (e.g., engine oil change, gear replacement, etc.); otherwise, cars and airplanes can be reused indefinitely until they are no longer serviceable, and the everyday upkeep amounts to simple refueling.

Full reusability has never been achieved in the history of space flight.<sup>202</sup> Orbital launch vehicles have always been single-use.<sup>203</sup> On the ascent, launch vehicles jettison parts that are no longer needed, which fall into the ocean or unpopulated areas.<sup>204</sup> If the mission objective is to place a payload in orbit, like a GPS satellite, every part of the launch vehicle will have been jettisoned by the time the payload is in orbit.<sup>205</sup> If the objective is to send humans into space and bring them back, like the Apollo lunar missions, only the reentry vehicle will make it back to Earth, and it will not be reused.<sup>206</sup>

---

<sup>200</sup> Mike Wall, *SpaceX Could Launch 1st Starship Orbital Flight in February, Elon Musk Says*, SPACE.COM (Jan. 9, 2023), <https://www.space.com/spacex-starship-first-orbital-launch-february-2023> [<https://perma.cc/WL69-D9XY>].

<sup>201</sup> Eric Berger, *Stoke Space Aims to Build Rapidly Reusable Rocket with a Completely Novel Design*, ARS TECHNICA (Oct. 10, 2022, 6:30 AM), <https://arstechnica.com/science/2022/10/stoke-space-aims-to-build-rapidly-reusable-rocket-with-a-completely-novel-design/3/> [<https://perma.cc/YM64-XCY3>].

<sup>202</sup> See Kristin Houser, *First-of-Its-Kind Rocket Engine Nears First Flight Test*, FREETHINK (Oct. 14, 2022), <https://www.freethink.com/space/reusable-rocket> [<https://perma.cc/D9RE-UY34>]; Beatrice Murray, *How SpaceX Successfully Designed the World's First Reusable Rocket*, DESIGNBOOM (Mar. 31, 2017), <https://www.designboom.com/technology/space-x-falcon-9-reusable-rocket-04-01-2017/> [<https://perma.cc/86SM-FQ4F>]. For the purposes of this Section, only orbital-class launch vehicles are considered.

<sup>203</sup> See Victor Tangermann, *NASA Employee Says SpaceX's Starship Is About to Change Everything*, FUTURISM (Oct. 28, 2021), <https://futurism.com/nasa-employee-spacex-starship> [<https://perma.cc/QC5D-4PP7>]; Edd Gent, *SpaceX Rocket Flies 10 Times as Reusability Gets Surprisingly Routine*, SINGULARITY HUB (May 17, 2021), <https://singularityhub.com/2021/05/17/spacex-milestone-signals-reusable-rockets-are-becoming-mainstream> [<https://perma.cc/2LPZ-4BHW>].

<sup>204</sup> See Reddy, *supra* note 176, at 125.

<sup>205</sup> See *id.*

<sup>206</sup> See Tim Sharp, *Saturn V Rockets & Apollo Spacecraft*, SPACE.COM, <https://www.space.com/16698-apollo-spacecraft.html> [<https://perma.cc/459J-Z22T>] (Apr. 29, 2022). The Space Shuttle was an attempt at partial reuse, but due to various fatal design errors, which caused the death of fourteen astronauts, the refurbishment of the Shuttles ended up costing more than making a new launch vehicle. See discussion *supra* Section IV.A.

SpaceX, however, successfully implemented partial reusability in Falcon 9.<sup>207</sup> Falcon 9 is a two-stage rocket that can carry a payload or a reentry vehicle called the Dragon spacecraft into LEO.<sup>208</sup> When Falcon 9 is configured to carry a payload into orbit, the second stage and the two fairings that house the payload atop the rocket are jettisoned.<sup>209</sup> When it is configured to carry humans or cargo in Dragon, the second stage is jettisoned, but Dragon is refurbished and reused upon reentry.<sup>210</sup>

The Falcon 9 first stage booster is currently the only reusable orbital-class booster.<sup>211</sup> What is more, SpaceX matured the technology—reusing one booster more than ten times and reflying a booster within twenty-nine days.<sup>212</sup> This partial reusability is still a long shot from commercial airplanes, but it is a welcome innovation in the right direction in an industry that has remained in the same paradigm since its inception.

Partial reusability has enabled SpaceX to cut the cost of launch significantly. By one metric, a Falcon Heavy system with a reused first stage booster costs about \$100 million per launch, which is roughly one-tenth of the cost of the launch of SpaceX's competitors such as the United Launch Alliance and the European Space Agency (ESA).<sup>213</sup> SpaceX's drastic reduction in

---

<sup>207</sup> Mike Wall, *Amazing SpaceX Reusable Rocket Test Caught on Video*, SPACE.COM (July 22, 2014), <https://www.space.com/26610-amazing-spacex-reusable-rocket-video.html> [<https://perma.cc/54DJ-HZWL>].

<sup>208</sup> Kenneth Chang, *Recycled Rockets Could Drop Costs, Speed Space Travel*, N.Y. TIMES (Mar. 30, 2017), <https://www.nytimes.com/2017/03/30/science/spacex-reuseable-rockets-launch.html> [<https://perma.cc/2EGM-Z6K2>].

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

<sup>210</sup> See Joey Roulette, *Exclusive: SpaceX Ending Production of Flagship Crew Capsule*, REUTERS (Mar. 28, 2022, 6:30 AM), <https://www.reuters.com/lifestyle/science/exclusive-spacex-ending-production-flagship-crew-capsule-executive-2022-03-28/> [<https://perma.cc/7QWS-VL2E>].

<sup>211</sup> See Tim Fernholz, *Blue Origin Is Still Catching Up to Elon Musk's SpaceX*, QUARTZ (July 22, 2021), <https://qz.com/2037008/blue-origin-is-still-catching-up-to-elon-musks-spacex> [<https://perma.cc/XE5W-22T2>].

<sup>212</sup> See Lee Kanayama, *Falcon 9 B1051 Makes Final Flight on Galaxy-31 & 32 Mission*, NASA SPACEFLIGHT.COM (Nov. 12, 2022), <https://www.nasaspaceflight.com/2022/11/galaxy-31-32> [<https://perma.cc/T4WA-F83S>]; Trevor Sesnic, *SpaceX Continues to Break Reuse Records and Reach New Milestones in 2021*, NASA SPACEFLIGHT.COM (Dec. 28, 2021), <https://www.nasaspaceflight.com/2021/12/spacex-reuse-records-milestones> [<https://perma.cc/XE2V-JPRV>].

<sup>213</sup> See John K. Strickland, Jr., *The SpaceX Falcon Heavy Booster: Why Is It Important?*, NAT'L SPACE SOC'Y (Sept. 2011), <https://space.nss.org/the-spacex-falcon-heavy-booster-why-is-it-important> [<https://perma.cc/98FR-L2V5>].

price per launch has enabled it to acquire sixty percent of the U.S. commercial launch market in 2021.<sup>214</sup>

SpaceX started developing partially reusable rockets in 2011 and demonstrated the first reflight of a booster in 2017.<sup>215</sup> It has since matured the reuse of the first stage booster such that every launch in 2021 and 94% of launches in 2022 involved a reused booster.<sup>216</sup> It is surprising that other aerospace entities, commercial or governmental, are just now starting to develop reusable orbital-class rocket boosters.<sup>217</sup>

It is hard to believe that a private company is so technologically ahead of governmental space juggernauts such as Europe, China, Russia, and even NASA.<sup>218</sup> What is more, in 2023, SpaceX plans to conduct the first orbital test launch of Starship, a new generation launch system designed to be fully reusable.<sup>219</sup>

Starship is a two-stage launch system like Falcon 9, but unlike Falcon 9, the second stage of Starship is designed to be reused.<sup>220</sup> SpaceX has already successfully conducted the suborbital flight and soft-landing of the second stage.<sup>221</sup> It has already built the prototype for the first and second stages for the up-

<sup>214</sup> See Matthew Weinzierl & Mehak Sarang, *The Commercial Space Age Is Here*, HARV. BUS. REV. (Feb. 12, 2021), <https://hbr.org/2021/02/the-commercial-space-age-is-here> [<https://perma.cc/3Y8F-R7SJ>]; Denise Chow, *To Cheaply Go: How Falling Launch Costs Fueled a Thriving Economy in Orbit*, NBC NEWS (Apr. 8, 2022, 10:52 AM), <https://www.nbcnews.com/science/space/space-launch-costs-growing-business-industry-rcna23488> [<https://perma.cc/R3NL-98UT>].

<sup>215</sup> *A Brief Recap of Reusable Rockets*, ZLSA DESIGN (July 11, 2018, 12:00 AM), <https://zlsadesign.com/article/ Recap-of-reusable-rockets> [<https://perma.cc/E495-ALW2>].

<sup>216</sup> *Launch History - Per Year*, SPACE X STATS, <https://www.spacexstats.xyz/#launchhistory-per-year> [<https://perma.cc/LH3H-D6HM>]; Mike Wall, *61 Rocket Launches! SpaceX Celebrates Record-Breaking 2022*, SPACE.COM (Jan. 4, 2023), <https://www.space.com/spacex-celebrates-2022-61-launches> [<https://perma.cc/N7S2-ZNNZ>].

<sup>217</sup> See, e.g., Andrew Jones, *China Launches Secretive Reusable Test Spacecraft*, SPACE NEWS (Aug. 4, 2022), <https://spacenews.com/china-launches-secretive-reusable-test-spacecraft/> [<https://perma.cc/2BL6-RM3J>].

<sup>218</sup> See, e.g., *id.*

<sup>219</sup> See Mike Wall, *SpaceX Could Launch 1st Starship Orbital Flight in February, Elon Musk Says*, SPACE.COM (Jan. 9, 2023), <https://www.space.com/spacex-starship-first-orbital-launch-february-2023> [<https://perma.cc/RL6E-U9GD>].

<sup>220</sup> See Andy Law, *The Definitive Guide To Starship: Starship vs Falcon 9, What's New and Improved?*, EVERYDAY ASTRONAUT (Nov. 6, 2020), <https://everydayastronaut.com/definitive-guide-to-starship/> [<https://perma.cc/5A2Y-P94Y>].

<sup>221</sup> See Valius Venckunas, *SpaceX: Starship to Launch Starlink Gen2 in March 2022*, AEROTIME HUB (Jan. 11, 2022), <https://www.aerotime.aero/articles/29922-space-x-starship-to-launch-starlink-gen2-in-march-2022> [<https://perma.cc/S7ZE-Y7Y9>].

coming launch.<sup>222</sup> SpaceX demonstrated the proof of concept of the launch system designed to be fully reusable.<sup>223</sup> It also has the track record, technology, and funding to mature that design.<sup>224</sup>

It is difficult to overstate the implications of an operational, fully reusable launch system. Starship could cut the dollars per kg to a rate comparable to airfreight, or about \$10/kg to LEO.<sup>225</sup> Airfreight, in comparison, averages about \$4/kg.<sup>226</sup> The low cost of access to space would finally allow industrial-scale private sector activity in outer space, in LEO, and on the Moon in the near future.

Lastly, in conducting legal analysis of SpaceX's success, one must consider the technopolitical implications of Starship. If successful, Starship will be the only fully reusable launch system.<sup>227</sup> Considering that foreign aerospace entities are at best in the earliest stages of *blueprinting partial* reusability, the United States will likely maintain its monopoly over industrial and commercial access to space in the foreseeable future. This technopolitical reality would give the federal government much latitude and responsibility in setting out the first legal and regulatory precedent in the era of commercialized Moon and outer space.

#### D. SPACEX'S COMPETITORS

There are no near-term competitors. The only other known entities *planning* to develop a fully reusable launch vehicle are an American startup named Relativity Space<sup>228</sup> and Blue Ori-

---

<sup>222</sup> See Mike Wall, *SpaceX Fires Up Starship Prototype Again Ahead of Test Flight*, SPACE.COM (Dec. 15, 2022), <https://www.space.com/spacex-starship-static-fire-ship-24-december-15> [<https://perma.cc/8CLW-ZX3P>].

<sup>223</sup> See *id.*

<sup>224</sup> See generally Q.ai, *Elon Musk's SpaceX Valued at \$137 Billion in Latest Funding Round*, FORBES (Jan. 3, 2023, 7:32 AM), <https://www.forbes.com/sites/qai/2023/01/03/elon-musks-spacex-valued-at-137-billion-in-latest-funding-round/?sh=495f248c3b36> [<https://perma.cc/KZ3N-45MF>].

<sup>225</sup> See Benzinga, *Elon Musk's Starship Launch to Cost Just \$10 Per Kg: How It Compares With 'Heavy Lifters' From 5 Decades Ago*, EPOCH TIMES, [https://www.theepochtimes.com/elon-musks-starship-launch-to-cost-just-10-per-kg-how-it-compares-with-heavy-lifters-from-5-decades-ago\\_4743017.html](https://www.theepochtimes.com/elon-musks-starship-launch-to-cost-just-10-per-kg-how-it-compares-with-heavy-lifters-from-5-decades-ago_4743017.html) [<https://perma.cc/58S8-RTXQ>] (Sept. 21, 2022).

<sup>226</sup> See Kulisch, *supra* note 11.

<sup>227</sup> See Wall, *supra* note 200.

<sup>228</sup> Michael Sheetz, *Relativity Space Unveils a Reusable, 3D-Printed Rocket to Compete with SpaceX's Falcon 9*, CNBC (Feb. 25, 2021, 3:05 PM), <https://www.cnbc.com/2021/02/25/relativitys-reusable-terran-rocket-competitor-to-spacexs-falcon-9.html> [<https://perma.cc/SYC3-74MP>].

gin.<sup>229</sup> However, considering that neither company has even reached orbit, there is no historical data to predict, as I did in the Appendix, when and to what extent these companies will be capable of offering a reusable launch system. At any rate, as both companies are American companies, the technopolitics of affordable and scalable access to the Moon falling in the sole hands of the United States would not change, even if both companies develop a fully reusable vehicle in the near future.

In terms of *partially* reusable launch systems like Falcon 9, several national space agencies have published plans to develop one in the coming years. China has a plan to make its Long March 7 rocket boosters land like Falcon 9 boosters.<sup>230</sup> The partial reusability regime, as we have seen in Falcon 9, is revolutionary but not paradigm-changing. The ESA also plans to launch its partially reusable system in 2023.<sup>231</sup> Russia's Roscosmos plans to launch its partially reusable rocket in 2026.<sup>232</sup>

All in all, considering that SpaceX landed its partially reusable Falcon 9 in 2015, these space agencies are at least ten years behind in developing partial reusability. Some of the mighty space agencies in Europe and Russia are seemingly not even in the discussion stage of developing a fully reusable system.<sup>233</sup> China is only in the early planning stages.<sup>234</sup> Meanwhile, SpaceX has conducted suborbital flights of Starship and plans to launch orbital

---

<sup>229</sup> Eric Berger, *Blue Origin Has A Secret Project Named "Jarvis" to Compete with SpaceX*, ARS TECHNICA (July 27, 2021, 8:00 AM), <https://arstechnica.com/science/2021/07/blue-origin-is-developing-reusable-second-stage-other-advanced-projects/> [<https://perma.cc/8JTS-TQ8H>].

<sup>230</sup> Andrew Jones, *China Prepares to Launch New Rockets as Part of Push to Boost Space Program*, SPACE.COM (Feb. 14, 2020), <https://www.space.com/china-space-program-new-long-march-rockets.html> [<https://perma.cc/555X-P52P>].

<sup>231</sup> *ESA Plans Demonstration of a Reusable Rocket Stage*, ESA (Dec. 15, 2020), [https://www.esa.int/Enabling\\_Support/Space\\_Engineering\\_Technology/ESA\\_plans\\_demonstration\\_of\\_a\\_reusable\\_rocket\\_stage](https://www.esa.int/Enabling_Support/Space_Engineering_Technology/ESA_plans_demonstration_of_a_reusable_rocket_stage) [<https://perma.cc/L52Z-S5QZ>].

<sup>232</sup> Mike Wall, *Russia Planning to Go Reusable in 2026 with New Amur Rocket*, SPACE.COM (Oct. 14, 2020), <https://www.space.com/russia-announces-reusable-rocket-amur> [<https://perma.cc/MYX5-XY5Q>].

<sup>233</sup> *Cf. id.*; Chris Young, *Europe's New Reusable Spacecraft Is More Like a 'Large Crew Dragon' than Starship*, INTERESTING ENG'G (Sept. 20, 2022, 9:41 AM), <https://interestingengineering.com/innovation/europe-new-reusable-spacecraft-starship> [<https://perma.cc/BP9J-D4WT>].

<sup>234</sup> Andrew Jones, *China Could Shift to Fully Reusable Super Heavy-Launcher in Wake of Starship*, SPACENEWS (July 21, 2022), <https://spacenews.com/china-could-shift-to-fully-reusable-super-heavy-launcher-in-wake-of-starship> [<https://perma.cc/F242-8WRP>].

flights early in 2023.<sup>235</sup> SpaceX has also contracted with NASA to land astronauts on the Moon using Starship in 2024.<sup>236</sup> In all likelihood, SpaceX will have perfected Starship by the time national space agencies finish developing Falcon 9-esque reusable rockets. All this is to say that cheap and scalable transportation to the Moon will only be forthcoming from Starship in the near and foreseeable future (this decade), and that will endow the United States with technopolitical dominance in shaping the future of the Moon.

#### E. FUTURE SPACE INDUSTRIES

The space industry is thriving with an estimated \$366 billion in revenue in 2019, 95% of which involved just the traditional LEO satellite business.<sup>237</sup> This market includes satellites for telecommunication, internet, remote sensing, Earth observation, weather, national security, reconnaissance, and so on. This market is growing but has certain inherent limitations. Low Earth orbits and geosynchronous orbits in which these satellites are parked are limited.<sup>238</sup> Because these satellites travel at many times the speed of a bullet, the safety margin for the distance between the satellites is thin.<sup>239</sup> The increasing amount of space debris further decreases the availability of orbital planes.<sup>240</sup> Broadcast frequencies for the satellites are also limited and are distributed to companies (of which there is a growing monopolized concentration) via bilateral and multilateral agreements.<sup>241</sup> Lastly, there is no natural resource to be mined or otherwise collected in Earth's orbits.<sup>242</sup>

---

<sup>235</sup> Wall, *supra* note 200.

<sup>236</sup> Elon Musk says it will probably be sooner. Elizabeth Howell, *Elon Musk Says SpaceX Could Launch a Starship to the Moon 'Probably Sooner' than 2024: Report*, SPACE.COM (Aug. 24, 2021), <https://www.space.com/elon-musk-spacex-starship-to-moon-sooner-2024> [<https://perma.cc/QM3T-B4DC>].

<sup>237</sup> Weinzierl & Sarang, *supra* note 214.

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

<sup>239</sup> See Mike Wall, *Kessler Syndrome and the Space Debris Problem*, SPACE.COM, <https://www.space.com/kessler-syndrome-space-debris> [<https://perma.cc/9L5E-D2SU>] (July 14, 2022).

<sup>240</sup> See *id.*

<sup>241</sup> See Sabine Neschke, *Exploring the Potential of LEO Satellites for Broadband Access*, BIPARTISAN POL'Y CTR. (Dec. 21, 2022), <https://bipartisanpolicy.org/blog/leo-satellites-broadband-access/> [<https://perma.cc/QHX9-4J5V>].

<sup>242</sup> See Weinzierl & Sarang, *supra* note 214.

In contrast, in-space production of goods and services has nearly unlimited growth potential.<sup>243</sup> Mining raw materials on the Moon or asteroids for refining and producing goods in outer space has the potential for growth (arguably limitless) that dwarfs the possibilities of Earth.<sup>244</sup> Mars's surface area is comparable to the solid land on Earth, and the Moon's surface is nearly twice as big as North America.<sup>245</sup> There is no biosphere or scene of nature on those two bodies to protect, which make them ideal for polluting heavy industry.<sup>246</sup> The commercialization of the Moon, considering its proximity to Earth (a three-day journey with Starship), is within our grasp.<sup>247</sup> Looking further into the future, large platforms for habitation or manufacturing can be built anywhere in the vast emptiness of space within the solar system, which increases the possible surface area for human activity indefinitely.

The in-space manufacturing industry is infantile, but there is already a strong private sector interest, which will only grow substantially with the arrival of Starship. Made In Space, Inc. has already shown the proof of concept of zero-g 3D printing in 2014 when it printed a wrench on the *ISS*.<sup>248</sup> In 2018, the company had manufactured fiber optic cables on the *ISS*.<sup>249</sup> This has a strong promise of commercial success because the strong gravitational pull on Earth causes tiny crystals that significantly increase signal loss to form in the cable.<sup>250</sup> The quality of fiber optics manufactured in low-g is vastly superior to their terres-

---

<sup>243</sup> See *id.*; see also Michael Sheetz, *Space Industry Is on Its Way to Reach \$1 Trillion in Revenue by 2040, Citi Says*, CNBC (May 21, 2022, 7:00 AM), <https://www.cnbc.com/2022/05/21/space-industry-is-on-its-way-to-1-trillion-in-revenue-by-2040-citi.html> [<https://perma.cc/QZ3Q-GLXA>].

<sup>244</sup> See Weinzierl & Sarang, *supra* note 214.

<sup>245</sup> See Michael C. Malin, *Mars*, BRITANNICA, <https://www.britannica.com/place/Mars-planet> [<https://perma.cc/K5XQ-RWRG>] (Dec. 20, 2022).

<sup>246</sup> *Earth-Mars-Moon Comparison*, DIGIPAC, <https://www.digipac.ca/chemical/mtom/contents/chapter1/marsfacts.htm> [<https://perma.cc/N4WH-QZBC>].

<sup>247</sup> Paul D. Spudis, *The Moon: Point of Entry to Cislunar Space*, in TOWARD A THEORY OF SPACEPOWER ch. 12 (Charles D. Lutes & Peter L. Hays eds., 2011), <https://apps.dtic.mil/sti/pdfs/ADA546585.pdf> [<https://perma.cc/R6LK-26PJ>].

<sup>248</sup> Gregory Barber, *The Best Place to Make Undersea Cables Might Be . . . in Space*, WIRED (Sept. 11, 2019, 7:00 AM), <https://www.wired.com/story/the-best-place-to-make-undersea-cables-might-be-in-space> [<https://perma.cc/4KP7-PL76>].

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

<sup>250</sup> *Fiber Optics*, REDWIRE SPACE, <https://redwirespace.com/products/fiber-optics/?rdws=nnn.xffxcv.tfd&rdwj=44203> [<https://perma.cc/J6LK-YSCJ>]; Sarah Lewin, *Making Stuff in Space: Off-Earth Manufacturing Is Just Getting Started*, SPACE.COM (May, 11, 2018), <https://www.space.com/40552-space-based-manufacturing-just-getting-started.html> [<https://perma.cc/BHV6-B8MT>].



trial-made counterparts.<sup>251</sup> High-tech and banking industries are in the market for ever-faster data transfer and are poised with wealthy customers.<sup>252</sup> Made In Space has already acquired the capability to produce large quantities of fiber optic cables in zero-g; with Starship's airfreight-equivalent dollar per kg, industrialization of production would finally be possible.<sup>253</sup> In February 2020, NASA awarded \$142 million to Maxar Technologies to develop a manufacturing infrastructure in LEO.<sup>254</sup> "Astrolab is building a rover capable of completing tasks such as construction, transporting supplies to build a lunar base, research and exploration, as well as ferrying astronauts around the moon's surface."<sup>255</sup>

With enough material and human resources in outer space, the space economy would be able to snowball on its own, independently from Earth. To enter this closed-positive-loop economy, there must be enough infrastructure in outer space.

#### F. WHY GO TO THE MOON?

We know that the Moon is rich in rare-earth minerals (REMs), which are indispensable in many industries: electronics, catalysts, chemical engineering, agriculture, and so on.<sup>256</sup> Now, 97% of the global supply of REMs is controlled by China.<sup>257</sup> When the Moon is open for commercialization, mining REMs on the Moon would impinge on national security for the United States.

<sup>251</sup> Lewin, *supra* note 250.

<sup>252</sup> See generally, e.g., Angelo D'Andrea & Nicola Limodio, *High-Speed Internet, Financial Technology, and Banking*, EUR. CENT. BANK (2020), [https://www.ecb.europa.eu/pub/conferences/ecbforum/shared/pdf/2020/DAndrea\\_paper.en.pdf](https://www.ecb.europa.eu/pub/conferences/ecbforum/shared/pdf/2020/DAndrea_paper.en.pdf) [<https://perma.cc/YK6E-ZQ35>] (explaining some key benefits from high-speed data transfer).

<sup>253</sup> Emily Calandrelli, *Made in Space Plans to Create a Superior Optical Fiber in Microgravity*, TECHCRUNCH (July 16, 2016, 6:48 PM), <https://techcrunch.com/2016/07/13/made-in-space-plans-to-create-a-superior-optical-fiber-in-microgravity/> [<https://perma.cc/KL76-7CQS>].

<sup>254</sup> *NASA Funds Demonstration of Assembly and Manufacturing in Space*, NASA (Jan. 31, 2020), <https://www.nasa.gov/press-release/nasa-funds-demonstration-of-assembly-and-manufacturing-in-space> [<https://perma.cc/975J-B7RY>].

<sup>255</sup> Samantha Masunaga, *'We Want to Be the UPS or FedEx of the Moon': A Hawthorne Company's Big Moonshot*, L.A. TIMES (Mar. 10, 2022, 3:30 PM), <https://www.latimes.com/business/story/2022-03-10/la-fi-astrolab-lunar-rover-truck-hawthorne-aerospace-moon-exploration> [<https://perma.cc/SEK4-UVYJ>].

<sup>256</sup> See Cécile Bontron, *Rare-Earth Mining in China Comes at a Heavy Cost for Local Villages*, GUARDIAN (Aug. 7, 2012, 8:59 PM), <https://www.theguardian.com/environment/2012/aug/07/china-rare-earth-village-pollution> [<https://perma.cc/2TWC-Y7AE>].

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

The REM market stood at \$4 billion in 2020 and is projected to reach \$6.6 billion by 2027.<sup>258</sup> Also, note that REM mining is extremely polluting.<sup>259</sup>

NASA is currently seeking to contract with a private company to mine on the lunar surface.<sup>260</sup> Contractors would use robots to collect 50 to 500 grams of lunar regolith and rocks from any location on the Moon.<sup>261</sup> NASA will take possession of the samples and reimburse the companies.<sup>262</sup> The focus of the program is to mine and map the lunar south pole, where there are permanently shaded craters with sizable water-ice deposits.<sup>263</sup>

Goldman Sachs released a report saying that mining in outer space has costs “comparable to traditional mines” and that technological barriers are getting lower.<sup>264</sup> It described the challenge as merely a “psychological barrier.”<sup>265</sup> The Government of Luxembourg invested \$227 million in 2017 in a space-resources initiative.<sup>266</sup> Lunar mining would first focus on the *in situ* manufacturing of rocket propellants and potable water for human settlers.<sup>267</sup> Investors will also look to the potential of creating securitized stakes in lunar infrastructure.<sup>268</sup>

The Moon is *the* stepping stone to other celestial bodies; it is the bridge to the inexhaustible riches of the solar system.<sup>269</sup> Two

<sup>258</sup> *Insights on the Rare Earth Metals Global Market to 2027 – Metallurgy & Alloys Segment to Record 8.4% CAGR*, PR NEWSWIRE (Jan. 7, 2021, 4:45 PM), <https://www.prnewswire.com/news-releases/insights-on-the-rare-earth-metals-global-market-to-2027—metallurgy—alloys-segment-to-record-8-4-cagr-301202761.html> [<https://perma.cc/84XZ-DKRN>].

<sup>259</sup> See Bontron, *supra* note 256.

<sup>260</sup> Eric Berger, *NASA Says It Will Pay Private Companies to Gather Moon Rocks*, ARS TECHNICA (Sept. 10, 2020, 9:40 AM), <https://arstechnica.com/science/2020/09/nasa-says-it-will-pay-private-companies-to-gather-moon-rocks/> [<https://perma.cc/H7LJ-NFXF>].

<sup>261</sup> *Id.*

<sup>262</sup> *Id.*

<sup>263</sup> *NASA CubeSat Will Shine a Laser Light on the Moon’s Darkest Craters*, JPL NASA (Apr. 27, 2020), <https://www.jpl.nasa.gov/news/nasa-cubesat-will-shine-a-laser-light-on-the-moons-darkest-craters> [<https://perma.cc/GJ9C-HPNC>].

<sup>264</sup> Joe Landon & Etienne Schneider, *These 5 Industries Will Be First to Do Business in Space*, WORLD ECON. F. (Nov. 24, 2017), <https://www.weforum.org/agenda/2017/11/industries-will-make-money-in-space/> [<https://perma.cc/BZM2-T65U>].

<sup>265</sup> *Id.*

<sup>266</sup> *Id.*

<sup>267</sup> *Id.*

<sup>268</sup> *See id.*

<sup>269</sup> See Bryan Palaszewski, *Solar System Exploration Augmented by in Situ Resource Utilization: Lunar Base Issues*, in LUNAR SCIENCE 1, 2 (Yann- Henri Chemin ed., 2019), <https://pdfs.semanticscholar.org/bf39/08336bfc91993b38>

facts illustrate the importance of the industrialization and settlement of the Moon: (1) Earth is a deep gravity well, requiring enormous energy to escape;<sup>270</sup> (2) other celestial bodies contain riches beyond reckoning: a single asteroid named 16 Psyche is worth an estimated \$10 quintillion,<sup>271</sup> and the asteroid belt is worth an estimated \$700 quintillion (enough for every person on Earth to have \$100 billion).<sup>272</sup> These two facts suggest that we want to supply few flights from Earth (preferably only humans leaving Earth, and not resources), produce as much *in situ* as possible, and only send finished products from space down to Earth. The Moon, having only one-sixth the gravity of Earth<sup>273</sup> and being located very close to our home planet, is the best candidate for the burgeoning space industry. Spaceships can land and launch with substantially less fuel and reach lunar orbit in a single-stage rocket (nearly impossible on Earth), making the to-and-from other celestial bodies extraordinarily easy and cheap.<sup>274</sup> Also, there is little concern for pollution or environmental regulation,<sup>275</sup> thus saving cost. Finally, propellant production coupled with *in situ* production of materials on the Moon would also broaden access to Mars and other celestial bodies.<sup>276</sup>

---

995e0f5086c3392c2a25.pdf?\_ga=2.212945492.1127766251.1674712757-1733133127.1674712757 [https://perma.cc/K5KZ-3HSA].

<sup>270</sup> See discussion *supra* Section IV.C.

<sup>271</sup> Elizabeth Gamillo, *This Metal-Rich, Potato-Shaped Asteroid Could Be Worth \$10 Quintillion*, SMITHSONIAN MAG. (Jan. 4, 2022), <https://www.smithsonianmag.com/smart-news/asteroid-16-psyche-may-be-worth-more-than-planet-earth-at-10-quintillion-in-fine-metals-180979303/> [https://perma.cc/F26H-4VX3].

<sup>272</sup> India Bureau, *Asteroids Contain Metals Worth Quintillions of Dollars—But Mining Them Won't Necessarily Make Your Richer than Bezos or Musk*, BUS. INSIDER (June 30, 2021, 7:42 PM), <https://www.businessinsider.in/science/space/news/spacex-had-to-reschedule-its-rocket-launch-because-an-aircraft-entered-the-keep-out-zone/articleshow/83970868.cms> [https://perma.cc/56J3-YD7D].

<sup>273</sup> See Tim Sharp & Daisy Dobrijevic, *How Big Is the Moon?*, SPACE.COM, <https://www.space.com/18135-how-big-is-the-moon.html> [https://perma.cc/Q9Z7-AHEJ] (Feb. 7, 2022).

<sup>274</sup> Jatan Mehta, *Launching Rockets from the Moon Is Our Ticket to a Home on Mars*, MEDIUM (Dec. 23, 2017), <https://medium.com/teamindus/why-launching-rockets-from-the-moon-is-our-ticket-to-a-home-on-mars-30bba878e9d8> [https://perma.cc/L4N4-SFPJ].

<sup>275</sup> *But see Scientists Concerned About Moon Pollution*, N.Z. GEOGRAPHIC (Aug. 20, 2020), <https://www.nzgeo.com/audio/scientists-concerned-about-moon-pollution/> [https://perma.cc/2SCU-QYQR] (explaining that recent studies suggest Moon pollution could inhibit the study of the solar system).

<sup>276</sup> See Palaszewski, *supra* note 269, at 15–16.

Lastly, investors would consider the implication of the maturation of *in situ* production on the Moon, enough to render it self-sufficient—meaning, no supply shipments from Earth would be required for continued operation. The tremendous expenses, even with Starship, stem from the energy required to escape Earth’s gravity well. Once that limitation is gone, the lunar economy can snowball on its own. The return on an early investment in lunar infrastructure would be tremendous when that happens. These should be enough grounds for private investment in Moon colonization and industrialization.

#### G. LUNAR GEOPOLITICS OF THE NEXT DECADE

Starship will change nations’ interests in space fundamentally, and space law must adapt.<sup>277</sup> Consider the reality now: every land on Earth is taken and no country may acquire new territory through settlement on Earth; natural resources are running out and industry faces ever-increasing regulatory costs; certain resources are controlled by geopolitical rivals and enemies; globalization leads to uncomfortable dependencies; developed nations cannot expand their economies like developing nations. The multiplanetary age represents the negation of these propositions. There are new lands (although they cannot be claimed, they can be exploited) in space; inexhaustible natural resources; no regulation (yet) over the ecosystem, climate, or environment; a new source of indispensable resources (e.g., REMs); new supply chains for such resources, independent of global trade; completely new sectors with manufacturing needs for creating new infrastructures, allowing for a new arena of economic expansion. The commercialization of space has unimaginable promise. Just as the Moon landing was imminent in the 1960s and required the creation of the binding international space law treaties, lunar settlement and commercialization are imminent now and necessitate a rethinking of space law.

In this decade, SpaceX’s Starship will likely be the only space launch vehicle capable of offering the rate and scale of transportation for supporting private settlement on and commercializa-

---

<sup>277</sup> See Hobe & Chen, *supra* note 73, at 26 (“As outer space provides great socio-economic, political and strategic value, and with the shift away from State-led and government-funded space missions to commercial space ventures conducted by an increasing number of private space actors, the formation of space law is naturally thereby shaped by concerns and interests from the public, private and techno[ ]logical, economic, security and political domains.”) (internal citation omitted).

tion of the Moon.<sup>278</sup> Starship would allow settlers to establish the first permanent manned stations and engage in the first commercial activities on the Moon.<sup>279</sup> Lunar industries of mining, manufacturing, and tourism would start to take form. These new ventures would, however, be under the exclusive control of the United States, giving it significant leverage in developing the law of the Moon. Likely, most people and corporations on the Moon will fall under U.S. jurisdiction in one way or another—by federal legislation or through bilateral and multilateral treaties.

The complicated, unprecedented, and dangerous nature of lunar ventures requires the development of an authoritative legal regime that clarifies legal relationships and obligations: contractual principles, safety regulations, property rights (intellectual, real, and personal), and civil and criminal liability of natural and artificial persons. It makes sense to export the existing legal regime to the Moon and adapt it as necessary, and because the stakeholders in these relationships would likely fall under American jurisdiction, it only makes sense that a U.S. legal system will be the first to take root on the Moon.

## V. LIMITS OF THE POWER TO REGULATE MATTERS IN SPACE

### A. OVERVIEW OF BINDING INTERNATIONAL SPACE LAW

Binding international space law comes from international space agreements that came to effect in roughly three different eras.<sup>280</sup> The first period, from the 1960s and 1970s, saw the ratification of the four and only binding international space law trea-

---

<sup>278</sup> See generally discussion *supra* Part IV.

<sup>279</sup> See generally discussion *supra* Section IV.C. But see Edward Helmore, 'We're in a Space Race': NASA Sounds Alarm at Chinese Designs on Moon, *GUARDIAN* (Jan. 2, 2023, 9:13 AM), <https://www.theguardian.com/science/2023/jan/02/china-moon-nasa-space-race> [<https://perma.cc/4MWC-EN2R>] (noting that China has "an autonomous lunar research station" planned for 2025 and has announced visions for lunar infrastructure and governance). We can expect lunar landers from India and China, but those countries are still lagging behind private American companies. See *id.*; Andrew Jones, *India Continuing Work on Moon Landing and Crewed Spaceflight Plans Despite Delays*, *SPACE.COM* (Apr. 24, 2022), <https://www.space.com/india-moon-lander-crewed-spaceflight-progress> [<https://perma.cc/6SPY-KUBM>]; Andrew Jones, *Here's What China's 1st Moon Landing with Astronauts Might Look Like (Video)*, *SPACE.COM* (Jan. 3, 2023), <https://www.space.com/china-moon-landers-astronauts-renderings> [<https://perma.cc/2HBK-YUS4>].

<sup>280</sup> See Wessel, *supra* note 16, at 291–94.

ties.<sup>281</sup> The second period from the 1980s through the 1990s saw the establishment of nonbinding agreements concerning the practical and fair use of LEO (orbital planes are limited) for communication satellites (the broadcast spectrum is also limited).<sup>282</sup> And the third period, since the 2000s, is marked by various nonbinding technical instruments negotiated through the U.N. Committee on the Peaceful Uses of Outer Space (COPUOS) or passed by the General Assembly as nonbinding resolutions.<sup>283</sup>

The history of international space agreements started in the 1960s, on the eve of the American Apollo missions to the Moon.<sup>284</sup> The first among the four binding treaties of the 1960s and 1970s was the OST, which is often called the “constitution for outer space”<sup>285</sup> and “is really [the] only one important piece of international legislation [regarding space].”<sup>286</sup> It incorporates the entire body of international law as space law, which has important implications in the laws of war, and it also lays down certain axiomatic principles of space law: prohibition on the national appropriation of celestial real estate (Article II); prohibition on the placement of weapons of mass destruction in space (Article III); declaration that space exploration should be carried out for the benefit of all nations and aspiration that space is the “province of all mankind” (Article I); the nations’ duty to render assistance to foreign astronauts (Article V); the liability of nations to the international community for their space activities (Article VI); and the launching nation’s jurisdiction over objects that do not disappear as objects reach space (Article

---

<sup>281</sup> *Id.*

<sup>282</sup> *Id.*

<sup>283</sup> *Id.* COPUOUS, with seventy-one member states, has two subcommittees: the Scientific and Technical Subcommittee and the Legal Subcommittee. *Id.* at 291. These are all standing committees of the U.N. *Id.*

<sup>284</sup> *Id.* at 292.

<sup>285</sup> *Id.* The OST is the most-influential space agreement, being the first, as others either refer to it or expand on its provisions. *See id.* For the purposes of this Article, the Rescue Agreement and Liability Agreement are not of much importance; they require that states, respectively, rescue astronauts in space or when returned to Earth irrespective of their nationality and reimburse for any harm caused to other nations by objects they put into orbit. *See id.* at 292–93. The Registration Convention is very important to our discussion below. *See id.* at 293; discussion *infra* Section VI.B.

<sup>286</sup> Rory Bennett, *Property Rights in a Vacuum: A Moon Anarchist’s Guide to Prospecting*, 64 ARIZ. L. REV. 229, 234 (2021); *see also* Goguichvili et al., *supra* note 29.

VIII).<sup>287</sup> The Treaty has been ratified by all spacefaring nations<sup>288</sup> and a total of 112 states.<sup>289</sup>

The next three binding treaties were elaborations on different provisions of the OST.<sup>290</sup> The Rescue Agreement (1968) expounds on Article VI of the OST and requires that state parties provide assistance to astronauts of whatever nationality—in case they perform an emergency landing in their territories—and return the astronauts to their homes.<sup>291</sup> The Liability Convention (1972) expands on Article VI of the OST, makes the launching state strictly liable for the damage its space objects cause to persons and properties on Earth (including airspace), and establishes a negligence standard for damage to space objects.<sup>292</sup> The Registration Convention (1975) develops Article VIII of the OST and requires that launching states register objects that they launch nationally with the U.N.<sup>293</sup>

These four treaties are all well-ratified, build on each other, and have not been disputed since their adoption.<sup>294</sup> These factors place the four treaties squarely within the category of binding international law.<sup>295</sup> Further, as of January 1, 2022, the OST has been ratified or accepted by 112 states; the Rescue Agreement by 99, the Liability Convention by 98, and the Registration Convention by 72.<sup>296</sup> In the technopolitical discussion of international space law, however, nations that are capable of orbital space flight matter more in the establishment of customary in-

---

<sup>287</sup> Wessel, *supra* note 16, at 292.

<sup>288</sup> That is, states that are capable of launching something into orbit. Henry R. Hertzfeld, Brian Weeden & Christopher D. Johnson, *Outer Space: Ungoverned or Lacking Effective Governance? New Approaches to Managing Human Activities in Space*, 36 SAIS REV. INT'L AFFS. 15, 15–17 (2016).

<sup>289</sup> *Status of International Agreements Relating to Activities in Outer Space as at 1 January 2020*, UNOOSA, [https://www.unoosa.org/res/oosadoc/data/documents/2022/aac\\_105c\\_22022crp/aac\\_105c\\_22022crp\\_10\\_0\\_html/AAC105\\_C2\\_2022\\_CRP10E.pdf](https://www.unoosa.org/res/oosadoc/data/documents/2022/aac_105c_22022crp/aac_105c_22022crp_10_0_html/AAC105_C2_2022_CRP10E.pdf) [<https://perma.cc/3NKL-VAR2>].

<sup>290</sup> Wessel, *supra* note 16, at 292.

<sup>291</sup> *Id.* The Treaty's full name is the "1968 Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space." *See id.*

<sup>292</sup> *Id.* at 292–93. The Treaty's full name is the "1972 Convention on International Liability for Damage Caused by Space Objects." *Id.* at 292.

<sup>293</sup> *Id.* at 293. The Treaty's full name is the "1975 Convention on Registration of Objects Launched into Outer Space." *Id.*

<sup>294</sup> *Id.*

<sup>295</sup> I take this to mean a lot of political capital is needed to violate the respective treaties.

<sup>296</sup> UNOOSA, *supra* note 289.

ternational space law, or “a general practice accepted as law”<sup>297</sup> as it relates to outer space, for the simple reason that non-spacefaring nations cannot set any “practice” in outer space.<sup>298</sup>

There are a total of eleven spacefaring nations. In the order of their first orbital launches, this includes the following nations: Russia (the U.S.S.R. at the time),<sup>299</sup> the United States,<sup>300</sup> France,<sup>301</sup> Japan,<sup>302</sup> China,<sup>303</sup> the U.K.,<sup>304</sup> India,<sup>305</sup> Israel,<sup>306</sup> South Korea,<sup>307</sup> Iran,<sup>308</sup> and North Korea.<sup>309</sup> The four binding treaties are ratified by the eleven spacefaring nations,<sup>310</sup> which is why the treaties are technopolitically “binding,” as they bind nations that are capable of either following or disobeying the provisions of the four treaties.<sup>311</sup>

The technological differential makes the power dynamic behind the development of space law quite different than, for example, the law of the sea for the simple reason that every nation is capable of marine navigation.<sup>312</sup> We must think of capability- and domain-specific terms in discussing the legal potency of space law: the more access a nation has to a specific domain of outer space (the Moon, Mars, LEO, etc.), the more influence it has in the development of space law there. On the other hand, if a nation has no access to a domain of outer space, its opinions as to the interpretation of space law carry little weight; more literally, a non-spacefaring nation cannot set any precedent in outer space or even break an already-existing convention.<sup>313</sup>

---

<sup>297</sup> *Customary Law*, INT’L COMM. RED CROSS, <https://www.icrc.org/en/war-and-law/treaties-customary-law/customary-law> [<https://perma.cc/82GM-9Z4R>].

<sup>298</sup> See Hjalte Osborn Frandsen, *Customary International Law as a Vessel for Global Accord: The Case of Customary Rules of the Road for Governing the Orbital Highways of Earth*, 87 J. AIR. L. & COM. 705, 727–35 (2022).

<sup>299</sup> October 4, 1957. NASA, *supra* note 17.

<sup>300</sup> January 31, 1958. NASA, *supra* note 18.

<sup>301</sup> November 26, 1965. NASA, *supra* note 19.

<sup>302</sup> February 11, 1970. NASA, *supra* note 20.

<sup>303</sup> April 24, 1970. NASA, *supra* note 21.

<sup>304</sup> October 28, 1971. NASA, *supra* note 22.

<sup>305</sup> July 18, 1980. NASA, *supra* note 23.

<sup>306</sup> September 19, 1988. NASA, *supra* note 24.

<sup>307</sup> August 10, 1992. PINKSTON, KOR. ECON. INST. AM., *supra* note 25.

<sup>308</sup> February 2, 2009. NASA, *supra* note 26.

<sup>309</sup> December 12, 2012. NASA, *supra* note 27.

<sup>310</sup> UNOOSA, *supra* note 289.

<sup>311</sup> See INT’L COMM. RED CROSS, *supra* note 297.

<sup>312</sup> For a discourse on the parallels between the customary law of the sea and the developing customary law of space, see generally Frandsen, *supra* note 298, *passim*.

<sup>313</sup> See *id.* at 725, 731–32.



## B. THE MOON AGREEMENT

Technopolitically, the Moon Agreement (1979)<sup>314</sup> has no real legal significance.<sup>315</sup> The Moon Agreement has been ratified by eighteen states, and none are spacefaring nations.<sup>316</sup> Then, the Moon Agreement is not a “binding” treaty in outer space because spacefaring nations are not bound to it.<sup>317</sup>

## C. TECHNOPOLITICS CASE STUDY 1: THE OUTER SPACE TREATY

The four binding space treaties were borne out of the old paradigm of space flight: only the United States was able to plant a flag on the Moon but it could not do much more; spacefaring nations have been largely limited to LEO. Only the United States, Russia, and China have been capable of human space flight, and space launch vehicles are single-use, launch rate is low, and \$/kg is not economical.

In the 1960s, when the OST was on the table at the U.N., lunar settlement or exploitation was not the main objective; rather simply getting there was the ultimate goal.<sup>318</sup> After 1972, the focus shifted to LEO (hence, the Space Shuttle was designed to be capable of only LEO flights) and building the *ISS*.<sup>319</sup> The four treaties and subsequent development of nonbinding space laws occurred in the technopolitical context where at least two pow-

---

<sup>314</sup> See 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>315</sup> See Cassandra Steer, *Sources and Law-Making Processes Relating to Space Activities*, in ROUTLEDGE HANDBOOK OF SPACE LAW 3, 6–7 (Ram S. Jakhu & Paul Stephen Dempsey eds., 2017); Wessel, *supra* note 280, at 293–94. Several U.N. General Assembly nonbinding resolutions have been passed: the 1982 Principles Governing the Use by States of Artificial Earth Satellites for International Direct Television Broadcasting; the 1986 Principles Relating to Remote Sensing of Earth from Outer Space; the 1992 Principles Relevant to the Use of Nuclear Power Sources in Outer Space; the 1996 Declaration on International Cooperation in the Exploration and Use of Outer Space for the Benefit and in the Interest of All States, Taking into Particular Account the Needs of Developing Countries. See Wessel, *supra* at 294. But these nonbinding agreements “are unlikely to evolve into binding customary rules” and therefore will be of vanishing significance to the Moon in the late 2020s. See *id.* at 297–98.

<sup>316</sup> See UNOOSA, *supra* note 289.

<sup>317</sup> Wessel, *supra* note 280, at 298.

<sup>318</sup> The UN Ad Hoc Committee on the Peaceful Uses of Outer Space (Ad Hoc COPUOS) report reads: “[H]uman settlement and extensive exploitation of resources were not likely in the near future. For this reason the Committee believed that problems relating to the settlement and exploitation of celestial bodies did not require priority treatment.” Rep. of the Ad Hoc Comm. on the Peaceful Uses of Outer Space, U.N. Doc. A/4141 (1959), at 25, para. 31.

<sup>319</sup> See discussion *supra* Section II.A.

ers had more or less equal access to LEO. As we study the history of the Treaty, it is important to understand that the United States was losing the Space Race and it had no monopoly (far from it) over access to space.<sup>320</sup>

The OST was a remarkable treaty for its day considering how many prospective issues it addressed and how prolific it was in producing subsequent treaties based on it.<sup>321</sup> It was bound to succeed as it was enthusiastically agreed to by the only two spacefaring nations at the time, the United States and the U.S.S.R., and was forwarded by the unanimous recommendation of the Political Committee at the U.N. and unanimously passed in the General Assembly.<sup>322</sup>

The OST was passed at the height of the Cold War and Space Race when the United States and the U.S.S.R. human missions to the Moon seemed imminent.<sup>323</sup> Absent legal frameworks concerning sovereignty in outer space, states were rightfully concerned about the implications of the first human touchdown on the Moon: Would any of the traditional grounds for terrestrial sovereign claims—discovery, occupation, annexation, and contiguity—be valid on the Moon?<sup>324</sup> Soviets did crash a vehicle carrying the red flag onto the Moon but claimed no sovereign rights.<sup>325</sup> Still, a human presence, however transient, could have allowed for a sovereign claim based on discovery or occupation.<sup>326</sup> Claims of sovereignty implied exclusivity, which in turn would allow for claims of trespass, hampering free exploration

---

<sup>320</sup> For a detailed history of the events leading up to the adoption of the OST, see BIN CHENG, *STUDIES IN INTERNATIONAL SPACE LAW* 215–226 (1997). See also Bin Cheng, *The 1967 Outer Space Treaty: Thirtieth Anniversary*, 23 *AIR & SPACE L.* 156, 160 (1998).

<sup>321</sup> See CHENG, *supra* note 320, at 264; Jill Stuart, *The Outer Space Treaty Has Been Remarkably Successful – but Is It Fit for the Modern Age?*, CONVERSATION (Jan. 27, 2017, 11:59 AM), <https://theconversation.com/the-outer-space-treaty-has-been-remarkably-successful-but-is-it-fit-for-the-modern-age-71381> [<https://perma.cc/H9JB-DERQ>].

<sup>322</sup> Paul G. Dembling & Daniel M. Arons, *The Evolution of the Outer Space Treaty*, 33 *J. AIR L. & COM.* 419, 429 (1967).

<sup>323</sup> Steven Freeland, *What Sort of Space “Race” Should We Be Pursuing?*, *AUSTL. INST. INT’L AFFS.* (Dec. 15, 2021), <https://www.internationalaffairs.org.au/australianoutlook/what-sort-space-race-should-we-be-pursuing/> [<https://perma.cc/8TXG-QHW3>].

<sup>324</sup> Dembling & Arons, *supra* note 322, at 421; LEON LIPSON & NICHOLAS DEB. KATZENBACH, *REPORT TO NASA ON THE LAW OF OUTER SPACE* 4 (1960); see also Hardenstein, *supra* note 16, at 259–60 (discussing the importance of OST delineating the consequence of a human moon landing before *Apollo 11*).

<sup>325</sup> Dembling & Arons, *supra* note 322, at 421.

<sup>326</sup> See Hardenstein, *supra* note 16, at 259.

of outer space and punishing latecomers; this concerned the United States and U.S.S.R., as well as nations with hopes of space exploration.<sup>327</sup>

The springboard for the non-appropriation principle of the OST was *Sputnik I*.<sup>328</sup> For no country claimed trespass when the radio-emitter orbited Earth and traversed its heavens.<sup>329</sup> The first customary international space law was born: space objects in Earth's orbit do not trespass on any state's territory, and therefore no state has a territorial claim in outer space.<sup>330</sup> President Eisenhower expanded this custom in 1960 when he proposed: "We agree that celestial bodies are not subject to national appropriation by any claims of sovereignty."<sup>331</sup> This was also an apt statement for a U.S. President at the time because the United States was, at worst, losing the space race and, at best, in a tight competition with the U.S.S.R.<sup>332</sup> Neither country had the technological means to commercialize any celestial body but could cause legal troubles by getting there first and claiming the right to exclude.<sup>333</sup> So, the technopolitics panned out nicely for the unanimous adoption of the non-appropriation principle.

Probably because it was losing the Space Race, the United States first proposed the outer space non-appropriation principle.<sup>334</sup> On December 20, 1961, the General Assembly adopted

---

<sup>327</sup> Dembling & Arons, *supra* note 322, at 421. It seems to me that the United States and U.S.S.R. did not want to risk the other party getting there first and making claims, and other nations feared the two powers would take everything before they acquire the technology. In 1959, the U.N. Ad Hoc Committee on the Peaceful Uses of Outer Space said that "serious problems could arise if States claimed, on one ground or another, exclusive rights over all or part of a celestial body." *Id.* (quoting Report of the Ad Hoc Committee on the Peaceful Uses of Outer Space, U.N. Doc. A 141/25 (1959)).

<sup>328</sup> Wessel, *supra* note 16, at 291.

<sup>329</sup> See Carl Q. Christol, *Judge Manfred Lachs and the Principle of Jus Cogens*, 22 J. SPACE L. 33, 35 (1994) (arguing that access to space, passage through another state's airspace to reach space, and the principle that space is the province of all humankind are non-derogable international law).

<sup>330</sup> *Id.* at 42; see Steer, *supra* note 315, at 8 ("[M]any principles of the Outer Space Treaty are considered binding as a matter of customary law . . .").

<sup>331</sup> Dembling & Arons, *supra* note 322, at 421–22.

<sup>332</sup> See Hardenstein, *supra* note 16, at 264.

<sup>333</sup> See *id.* at 263; see also Jonathan Arenson, *Apocalyptic Imagined Futures as Securitizing Speech Acts in the Reconceptualization of Outer Space as a Private Domain: Applied to Discourse from the Pro-Privitized Outer Space Epistemic Community*, CHARLES UNIV. PRAGUE 17 (2015), <https://dspace.cuni.cz/bitstream/handle/20.500.11956/75999/120211427.pdf?sequence=1&isAllowed=Y> [https://perma.cc/95Q2-C8HX].

<sup>334</sup> Dembling & Arons, *supra* note 322, at 421.

the following language by Resolution: “Outer space and celestial bodies are free for exploration and use by all States in conformity with international law and are not subject to national appropriation.”<sup>335</sup> President Lyndon B. Johnson’s remarks in 1966 give us a glimpse of the sense of urgency around the development of a legal framework before a state reached the Moon: “[T]ake action now . . . to be sure that our astronauts . . . can freely conduct scientific investigations of the moon.”<sup>336</sup> The President suggested that the treaty adopted include the following: “No country should be permitted to advance a claim of sovereignty.”<sup>337</sup>

Both the U.S.S.R. and the United States submitted drafts of the Treaty that shared many provisions, including the non-appropriation principle.<sup>338</sup> Hence, Article II of the OST “provoked only a few minutes of debate.”<sup>339</sup> Article II provides: “Outer space, including the Moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means.”<sup>340</sup> Drafters were concerned about the broad claims of sovereignty based on the firstcomers’ rights.<sup>341</sup> Indeed, the provision does not say future permanent installments on the Moon, for instance, amount to national appropriation. This accords with the logical reading of the sentence, for “use or occupation” itself is not banned, but rather national appropriation based on “use or occupation.”<sup>342</sup> “Appropriation” immediately became a target of academic criti-

---

<sup>335</sup> *Id.* at 424 (quoting G.A. Res. 1721 (XVI) (Dec. 20, 1961)).

<sup>336</sup> *Id.* at 425.

<sup>337</sup> *Id.* at 426.

<sup>338</sup> *Id.* at 431.

<sup>339</sup> *Id.*

<sup>340</sup> Outer Space Treaty, *supra* note 51, art. II.

<sup>341</sup> Dembling & Arons, *supra* note 322, at 431.

<sup>342</sup> See Stephen Gorove, *Interpreting Article II of the Outer Space Treaty*, 37 FORDHAM L. REV. 349, 353 (1969); see, e.g., Steer, *supra* note 315, at 13. Steer argues that it is unlawful under the OST for a commercial entity or an individual “to claim property rights over celestial bodies.” *Id.* However, a claim over unmovable celestial real estate is quite different than that over recovered movable property, e.g., mined resources. For a dubious argument that non-appropriation means no property rights for any entity, see MANFRED LACHS, THE LAW OF OUTER SPACE: AN EXPERIENCE IN CONTEMPORARY LAW-MAKING 41–42 (Tanja Masson-Zwaan & Stephan Hobe eds., Martinus Nijhoff Publishers 2010) (1972). Deep seabed is also subject to non-appropriation, but UNCLOS and customary law in the area allow all sorts of commercial mining. See also Hobe & Chen, *supra* note 73, at 29 (“[I]t is a subject of further interpre[ ]tation whether only the surface of the celestial bodies or also what lies underneath (such as resources) is protected by this provision.”).

cism for vagueness.<sup>343</sup> However it created no trouble for the United States or the U.S.S.R. as the primary motivation was building a legal framework for free exploration of the Moon, not for settlement or commercialization of the Moon.<sup>344</sup>

Accordingly, Article VI of the U.S. draft and Article I of the U.S.S.R. draft provided for free access to outer space and celestial bodies.<sup>345</sup> The final agreed-upon OST provides in Article XII: "All stations, installations, equipment and space vehicles shall be open to representatives of other States Parties to the Treaty on a basis of reciprocity."<sup>346</sup>

The OST explicitly contemplates *all* stations, which would include temporary and permanent, to be legal.<sup>347</sup> However, when read in conjunction with Article II, providing that a state owning a permanent base provides a certain degree of access to other nations, the base would not amount to "national appropriation" of the lunar real estate on which it sits.<sup>348</sup>

At first, the United States, unsurprisingly, wanted absolute free access as it was losing the Space Race;<sup>349</sup> if the pattern held, the Soviets would get to the Moon first and might install a manned base while claiming sovereignty over the entire Moon or some locations of interest.<sup>350</sup> Article VI of the U.S. draft provided that "All areas of celestial bodies, including all stations, installations, equipment and space vehicles on celestial bodies, shall be open at all times to representatives of other States conducting activities on celestial bodies."<sup>351</sup>

However, the Soviets felt that an absolute right of passage is absurd because it may pose a danger to astronauts or interfere with normal operations.<sup>352</sup> When the United States agreed to

---

<sup>343</sup> See Hobe & Chen, *supra* note 73, at 29.

<sup>344</sup> Rep. of the Ad Hoc Comm. on the Peaceful Uses of Outer Space, U.N. Doc. A/4141, at 25, para. 31 (1959).

<sup>345</sup> See Dembling & Arons, *supra* note 322, at 430 ("[T]here shall be free access to all areas of celestial bodies.").

<sup>346</sup> See *id.* at 431 (quoting Outer Space Treaty, *supra* note 51, art. XII).

<sup>347</sup> See *id.*

<sup>348</sup> See *id.*

<sup>349</sup> See *id.* at 447.

<sup>350</sup> See *id.* at 431.

<sup>351</sup> *Id.* at 447. It is of note that this language is borrowed from the Antarctic Treaty, Article VII, paragraph 3: "All areas of Antarctica, including all stations, installations, and equipment within those areas and all ships and aircraft at points of discharging or embarking cargoes or personnel in Antarctica shall be open at all times to inspection by any observers designated . . ." *Id.* at 447 n.133 (quoting Antarctic Treaty art. VII(3), Dec. 1, 1959, 5778 U.N.T.S. 72).

<sup>352</sup> See *id.* at 448.

the “reciprocity” provision, its delegate said: “[I]f the first State had denied access to representatives of the second State then the latter was not required on the principle of reciprocity to grant access to representatives of the first State.”<sup>353</sup> This legislative history suggests that forbidding passage, and therefore exercising the right to exclude foreign nationals from a lunar base, would not amount to the national appropriation of the real estate on which the base sits.<sup>354</sup>

At this point, it is of tremendous importance to underscore the technopolitical context behind the passage of the OST. The United States was losing the Space Race, and therefore its interests lay with the adoption of international space law that would allow for second comers to explore the Moon or other areas of space as freely as possible.<sup>355</sup> The United States failed to achieve any first milestones in space; the Soviets had the honor of the first artificial satellite, first living animal, first human and human-made object on the Moon, second orbital flight that lasted about twenty-four hours, first spacewalk, and first woman in space.<sup>356</sup> In the 1960s, the years leading to the 1967 adoption of the Treaty, NASA was busy playing catch-up and wanted to claim a Hail Mary victory in the Space Race by achieving a then-fantastical goal of landing humans on the Moon.<sup>357</sup> The Soviets, having achieved so much in space, were also developing a new rocket, N1, for manned lunar missions.<sup>358</sup> No one nation had or expected exclusive access to space or the Moon.<sup>359</sup>

The situation presented by Starship is starkly different than that of the Apollo era.<sup>360</sup> No national or private space entity has even come close to reusability other than SpaceX, which is still the only entity capable of reusing orbital rockets.<sup>361</sup> Moreover,

---

<sup>353</sup> *Id.* at 449.

<sup>354</sup> *Id.*

<sup>355</sup> See CHENG, *supra* note 320, at 215–16, 220; Cheng, *supra* note 320, at 160.

<sup>356</sup> See *supra* Section I.B for exact dates.

<sup>357</sup> See Abby McGanney Nolan, ‘How We Got to the Moon’ Tells the Story of NASA’s 1960s Venture in Rich Detail, WASH. POST (Oct. 12, 2020, 10:14 AM), [https://www.washingtonpost.com/lifestyle/kidspost/2020/10/11/29e6152e-052e-11eb-a2db-417cddf4816a\\_story.html](https://www.washingtonpost.com/lifestyle/kidspost/2020/10/11/29e6152e-052e-11eb-a2db-417cddf4816a_story.html) [<https://perma.cc/X852-Y4CG>].

<sup>358</sup> Mark Garcia, 50 Years Ago: Soviet’s Moon Rocket’s Rollout to Pad Affects Apollo Plans, NASA, <https://www.nasa.gov/feature/50-years-ago-soviet-s-moon-rocket-s-rollout-to-pad-affects-apollo-plans> [<https://perma.cc/Q7K8-LCC5>] (Nov. 27, 2017).

<sup>359</sup> See Cheng, *supra* note 320, at 160.

<sup>360</sup> Or the ISS era, as will be discussed below.

<sup>361</sup> See discussion *supra* Sections IV.C–D.

no one is currently developing a *fully reusable* launch system.<sup>362</sup> SpaceX is not just blue-printing Starship but has already flight-tested many full-scale prototypes and aims for an orbital flight in early 2023.<sup>363</sup> In the immediate and foreseeable future, the United States, by way of SpaceX, will have exclusive commercial access to the Moon.<sup>364</sup> The first settlement and commercial activity on the Moon will be an endeavor controlled and led by the United States.<sup>365</sup> Such monopolized control of a domain of space has never been seen in the history of space flight. Starship implies a new paradigm of technopolitics of space law, and as we saw in the 2015 Space Act, the United States will, and should, continue to interpret and adapt space law to serve its technological interests.<sup>366</sup>

It is also worth noting that the OST failed to provide for an enforcement mechanism of any kind, be it a court of law or an arbitral tribunal, nor are there any international judicial decisions regarding the space treaties.<sup>367</sup> During the drafting stage of the OST, the United States wanted the International Court of Justice to hear claims arising out of disputes over the OST.<sup>368</sup> The Soviets wanted concerned state parties to simply “consult together with a view to their settlement.”<sup>369</sup> Due to the sense of urgency behind passing the Treaty, or the political reality of the Cold War, the two space powers seemed to have simply glossed over enforcement.<sup>370</sup> No court or tribunal whatsoever has jurisdiction over cases and controversies between private parties arising out of the provisions of the four binding treaties.<sup>371</sup> The

---

<sup>362</sup> See Eric Ralph, *SpaceX Testing Ceramic Starship Heat Shield Tiles on Flight-Proven CRS-18 Cargo Dragon*, TESLARATI (July 24, 2019), <https://www.teslarati.com/spacex-starship-heat-shield-cargo-dragon-testing/> [https://perma.cc/49C3-4DKE].

<sup>363</sup> See *id.*

<sup>364</sup> Of course, other entities are capable of landing on the Moon. But the “access” here means cheap and scalable access.

<sup>365</sup> See discussion *supra* Section IV.G.

<sup>366</sup> See U.S. Commercial Space Launch Competitiveness Act, H.R. 2262, 114th Cong. (2015), <https://www.congress.gov/bill/114th-congress/house-bill/2262> [https://perma.cc/7VAN-2EXB]; cf. Kurt Taylor, *Fictions of the Final Frontier: Why the United States SPACE Act of 2015 Is Illegal*, 33 EMORY INT’L L. REV. 653, 661–64 (2019).

<sup>367</sup> Dembling & Arons, *supra* note 322, at 453; Steer, *supra* note 315, at 11.

<sup>368</sup> See Dembling & Arons, *supra* note 322, at 453.

<sup>369</sup> *Id.*

<sup>370</sup> *Id.*

<sup>371</sup> See Michael J. Listner & Joshua T. Smith, *A Litigator’s Guide to the Galaxy: A Look at the Pragmatic Questions for Adjudicating Future Outer Space Disputes*, 23 VAND. J. ENT. & TECH. L. 53, 59 (2020).

OST is also not a self-executing treaty under *Medellin v. Texas*; so without additional congressional legislative enactment, private U.S. entities cannot be regulated or legally bound on the Moon based on the OST.<sup>372</sup> This would have the effect of further empowering the United States on the Moon in the next decade. What the U.S. public and private sectors do on the Moon will indubitably and exclusively affect the development of the law of the Moon, and no entity may challenge it in any international court or tribunal,<sup>373</sup> but only in U.S. tribunals.<sup>374</sup>

#### D. TECHNOPOLITICS CASE STUDY 2: THE *INTERNATIONAL SPACE STATION*

The *ISS* is a permanently manned space station about the size of a football field that orbits around Earth in LEO, only about 250 miles above sea level.<sup>375</sup> It is a science lab for conducting experiments in a microgravity environment and is capable of normally supporting six to ten people.<sup>376</sup> The first module was launched in 1998 atop a Russian rocket, and the station has been continuously manned since 2000 by over 200 scientists, researchers, and military pilots from 15 nations.<sup>377</sup> The *ISS* continued to add modules, growing in size and capability, as NASA

<sup>372</sup> Phoebe T. Clewley, *Newspace: The Rise of the Private Space Industry Is Threatening the Current Legal Framework Governing Outer Space*, 21 J. HIGH TECH. L. 354, 389 (2021).

<sup>373</sup> See generally Listner & Smith, *supra* note 371. Of course, U.S. persons on the Moon may agree to international arbitration but will not be hailed to any non-U.S. court. See *id.* at 60–61.

<sup>374</sup> See *id.* at 76–77. Ratified international treaties are federal law, and therefore U.S. District Courts have jurisdiction to hear challenges under them. See *id.*; *About Treaties*, U.S. SENATE, <https://www.senate.gov/about/powers-procedures/treaties.htm#:~:text=treaties%20are%20binding%20agreements%20between,supreme%20Law%20of%20the%20Land.> [https://perma.cc/3JQ5-CKDY]. But it is difficult to imagine a federal court entertaining a suit to enjoin some U.S. endeavor on the Moon. How is it justiciable? How is this not a political question of the most extreme kind—national efforts on the Moon? How would international parties have standing when they do not even have the capability to get to the Moon, and when any harm they could complain about is hypothetical and distant, and not immediate? See Listner & Smith, *supra* note 371, at 78–79; *Lujan v. Defs. of Wildlife*, 504 U.S. 555 (1992).

<sup>375</sup> Elizabeth Howell, *International Space Station: Facts About the Orbital Laboratory*, SPACE.COM (Aug. 24, 2022), <https://www.space.com/16748-international-space-station.html> [https://perma.cc/CWS7-C6VB]; Flint Wild, *What Is the International Space Station?*, NASA, <https://www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-is-the-iss-58.html> [https://perma.cc/6JWQ-K4GL] (Nov. 2, 2020).

<sup>376</sup> Wild, *supra* note 375; Howell, *supra* note 375.

<sup>377</sup> Howell, *supra* note 375.



commissions foreign space agencies to contribute modules and instruments.<sup>378</sup> All the launches of people to the *ISS* were conducted by Russia or the United States.<sup>379</sup>

Back in the 1980s when the *ISS* was first planned, the U.S.S.R. was not one of the partners—Russia only joined after the fall of the U.S.S.R. in the mid-1990s.<sup>380</sup> Initially the *ISS*, despite its namesake, was a U.S.-led international project, as the United States was the only country that could carry modules and astronauts up to LEO.<sup>381</sup>

The 1998 Intergovernmental Agreement (1998 IGA)<sup>382</sup> is the primary law that governs the *ISS*.<sup>383</sup> The *ISS* presented the contracting parties with a unique legal situation such as: when a crime happens on the *ISS*, which country would have jurisdiction (Article 22);<sup>384</sup> if a new piece of technology is invented, which country's intellectual property law governs (Article 21);<sup>385</sup> and which country has general jurisdiction over which module (Article 5).<sup>386</sup>

Going back in history a little to 1988, not 1998, the Intergovernmental Agreement (1988 IGA)<sup>387</sup> (the one the U.S. partnering states negotiated *before* Russia joined), showcases the technopolitical underpinning of international space law. The

---

<sup>378</sup> Wild, *supra* note 375.

<sup>379</sup> David M. Harland, International Space Station, BRITANNICA, <https://www.britannica.com/topic/International-Space-Station> [<https://perma.cc/J8E4-CGBL>]. Furthermore, only three nations are capable of human space flight: the United States, Russia, and China. Meghan Bartels, *From Yuri Gagarin's Launch to Today, Human Spaceflight Has Always Been Political*, SPACE.COM, <https://www.space.com/yuri-gagarin-human-spaceflight-history-politics> [<https://perma.cc/6E8P-7S3T>] (Apr. 12, 2021).

<sup>380</sup> Hardenstein, *supra* note 16, at 278.

<sup>381</sup> *See id.*

<sup>382</sup> Agreement Among the Government of Canada, Governments of Member States of the European Space Agency, the Government of Japan, the Government of the Russian Federation, and the Government of the United States of America Concerning Cooperation on the Civil International Space Station, Jan. 29, 1998, 1998 U.S.T. LEXIS 303, T.I.A.S. No. 12927 [hereinafter 1998 IGA].

<sup>383</sup> Hardenstein, *supra* note 16, at 277–78.

<sup>384</sup> 1998 IGA, *supra* note 382, art. 22.

<sup>385</sup> *Id.* art. 21.

<sup>386</sup> *Id.* art. 5.

<sup>387</sup> Agreement Among the Government of the United States of America, Governments of Member States of the European Space Agency, the Government of Japan, and the Government of Canada On Cooperation in the Detailed Design, Development, Operation, and Utilization of the Permanently Manned Civil Space Station, Sept. 29, 1988, Temp. State Dep't. No. 92-65, 1992 WL 466295 [Jan. 30, 1992] [hereinafter 1988 IGA].

1988 IGA was the first international treaty to consider extraterritorial criminal jurisdiction, filling the lacuna of the Antarctic Treaty, which failed to address criminal jurisdiction.<sup>388</sup> For our purposes here, Article 22 of the 1988 IGA is of interest, as it gave the United States primary criminal jurisdiction over every person onboard the *ISS*.<sup>389</sup> Partner states were given secondary criminal jurisdiction: “1. The United States, the European Partner States, Japan, and Canada may exercise criminal jurisdiction over the flight elements they respectively provide and over personnel in or on any flight element who are their respective nationals.”<sup>390</sup> Under this regime, for instance, a Japanese astronaut on a European module would be subject to concurrent Japanese and European criminal jurisdiction. This clause utilized both the nationality principle (jurisdiction attaching to the person) and quasi-territorial flag jurisdiction from maritime law (jurisdiction attaching to the ship bearing the flag).<sup>391</sup>

But the jurisdiction granted to state partners was secondary to the United States’ extraordinary primary jurisdiction:

In addition, the United States may exercise criminal jurisdiction over . . . a non-U.S. national in or on a non-U.S. element . . . provided that . . . the United States . . . consult[ed] with the Partner State . . . concerning the prosecutorial interests of both States . . . [and] either (1) received the concurrence . . . in the continuation of the prosecution; or (2) if such concurrence is not forthcoming, failed to receive assurances from such Partner State that it intends to prosecute its national on commensurate charges supported by the evidence.<sup>392</sup>

In a concretized hypothetical under this regime, if a Canadian astronaut committed a crime in a Japanese module, the United States could still unilaterally assert jurisdiction over the Canadian astronaut. The operative phrase “failed to receive assurances,” gave the United States jurisdiction primacy: partners either had to (1) concur to the U.S. prosecution of their nationals; or (2) promise the United States that it will prosecute to the extent satisfactory to the United States.<sup>393</sup> But the power of evaluating the adequacy assurance was given to the receiver, the

---

<sup>388</sup> Hardenstein, *supra* note 16, at 271–74, 278–80.

<sup>389</sup> *See id.* at 278–79, 281.

<sup>390</sup> 1988 IGA, *supra* note 387, art. 22(1).

<sup>391</sup> Hardenstein, *supra* note 16, at 276–77.

<sup>392</sup> 1988 IGA, *supra* note 387, art. 22(2) (emphasis added).

<sup>393</sup> *See id.*; Hardenstein, *supra* note 16, at 278–79, 281.

United States, not the sender.<sup>394</sup> Under this regime, the United States could declare that it failed to receive adequate assurances and assert criminal jurisdiction unilaterally.<sup>395</sup>

In the 1990s, Russia joined the partnership with experience in building and maintaining a multi-module space station, something the United States had not done.<sup>396</sup> Capable of transporting station modules and astronauts/cosmonauts into LEO, Russia was an equal partner to the United States, unlike previous U.S. partners.<sup>397</sup> Indeed, the Station is even to this day divided into two large sections: a U.S.-led international section and a Russian section.<sup>398</sup> This new technopolitical reality eradicated the extraordinary grant of primary criminal jurisdiction to the United States in the 1988 IGA.<sup>399</sup> The language of the 1998 IGA changed accordingly.

Rather than creating a regime where the United States and Russia vie for jurisdiction, the technopolitical reality of the U.S.–Russia collaboration resulted in criminal jurisdiction equally concurrent among all partnering states.<sup>400</sup> In relevant parts, Article 22 of the 1998 IGA provides:

[T]he Partner State whose national is the alleged perpetrator shall, at the request of any affected Partner State, consult with such State concerning their respective prosecutorial interests. An affected Partner State *may*, following such consultation, exercise criminal jurisdiction over the alleged perpetrator provided that . . . the Partner State whose national is the alleged perpetrator either: (1) concurs . . . or (2) *fails to provide* assurances that it will submit the case to its competent authorities for the purpose of prosecution.<sup>401</sup>

---

<sup>394</sup> See Hardenstein, *supra* note 16, at 279.

<sup>395</sup> See *id.*; see generally Hans P. Sinha, *Criminal Jurisdiction on the International Space Station*, 30 J. SPACE L. 85, 111–15 (2004); Stacy J. Ratner, *Establishing the Extraterrestrial: Criminal Jurisdiction and the International Space Station*, 22 B.C. INT'L & COMP. L. REV. 323, 333 (1999).

<sup>396</sup> *Mir Space Station*, NASA, <https://history.nasa.gov/SP-4225/mir/mir.htm>. [<https://perma.cc/HM8T-9DNX>].

<sup>397</sup> Todd Harrison & Nahmyo Thomas, *NASA in the Second Space Age: Exploration, Partnering, and Security*, 10 STRATEGIC STUD. Q., Winter 2016, at 7–9.

<sup>398</sup> Kristin Fisher, *Russia's Space Agency Warns US Sanctions Could 'Destroy' Cooperation on the International Space Station*, CNN POLITICS (Feb. 24, 2022, 10:46 PM), <https://www.cnn.com/2022/02/24/politics/russian-space-agency-us-sanctions-international-space-station/index.html>. [<https://perma.cc/A9B5-P89R>].

<sup>399</sup> Hardenstein, *supra* note 16, at 280–81.

<sup>400</sup> See *id.*

<sup>401</sup> 1998 IGA, *supra* note 382, art. 22(2) (emphasis added).

The change of language from “failed to receive” to “fails to provide” is noteworthy. Prosecution by the affected state is not contingent on its having *received* assurances but on the state having failed to *provide* assurances.<sup>402</sup> The power of evaluation is given to the sender, not the receiver. The receiver is any affected nation, irrespective of the nationality of the flight element, reducing needless complexity (removing the territorial principle in favor of the nationality principle).<sup>403</sup> In other words, the receiver’s complaint that it had failed to receive adequate assurance can be overcome by the sender’s rejoinder that it has provided assurance adequate in its domestic law. Any mention of U.S. primary jurisdiction was also removed<sup>404</sup> and the 1998 IGA stands today.<sup>405</sup>

Unlike with the *ISS*, the first decade or so on the Moon would be a thoroughly exclusive U.S. endeavor, with no other country even remotely capable of commercial flights to the Moon, presenting a wholly different technopolitical reality.<sup>406</sup> Unlike LEO in the 1990s, the United States will likely be the only nation in the 2020s—and possibly in the better part of the 2030s—with the capability to transport commercial cargo and personnel to the Moon cost-effectively and at scale.<sup>407</sup> SpaceX will have developed Starship without any international support.<sup>408</sup> Regardless, the U.S. government has and will have control over SpaceX’s operations through the weapons export control powers.<sup>409</sup>

---

<sup>402</sup> See Hardenstein, *supra* note 16, at 280–81.

<sup>403</sup> *Id.*; Mark J. Sundahl, *Legal Status of Spacecraft*, in *ROUTLEDGE HANDBOOK OF SPACE LAW* 42, 50 (Ram S. Jakhu & Paul Stephen Dempsey eds., 2017).

<sup>404</sup> Hardenstein, *supra* note 16, at 281.

<sup>405</sup> *20 Years Ago: Station Partners Sign Intergovernmental Agreement (IGA)*, NASA, (Jan. 29, 2018), <https://www.nasa.gov/feature/20-years-ago-station-partners-sign-intergovernmental-agreement-iga>. [<https://perma.cc/DPN5-LPBZ>].

<sup>406</sup> See discussion *supra* Section IV.G.

<sup>407</sup> See discussion *supra* Section IV.G.

<sup>408</sup> See discussion *supra* Section IV.G.

<sup>409</sup> See generally Michael J. Noble, *Export Controls and United States Space Power*, 6 *ASTROPOLITICS* 251, 253 (2008). SpaceX is the only entity in history to have landed a rocket back on Earth and reused it. See discussion *supra* Section IV.C. The China National Space Administration (CNSA) has plans for developing reusability for its brand-new Long March 8. *China’s New Long March 8 Rocket Makes Maiden Flight*, REUTERS, (Dec. 22, 2020, 12:14 AM), <https://www.reuters.com/article/space-exploration-china-idUKKBN28W0J7> [<https://perma.cc/H6CR-YY4C>]. China and India have the capacity to use lunar rovers weighing a few hundred pounds and may develop an Apollo-esque capacity of sending people for a week-long lunar expedition at the cost of hundreds of millions of dollars per person. See Mir Sadat, *Space: New Threats, New Service, New Frontier*, 14 *STRATEGIC STUD. Q.*, Winter 2020, at 7; James Clay Moltz, *Commercial Space Developments*, in

Partnering states would most certainly be more than happy to be part of the endeavor and provide some modules and personnel, but the power to control the logistics, regulation, training, and transport would be firmly in the United States' hands.

The United States' technopolitical control on the Moon would surpass that over the 1988 IGA. Back then, Russia had the same or better capabilities than the United States and some partnering states were capable of orbital launches.<sup>410</sup> Hence, the technopolitics presented by Starship would give the United States unprecedented latitude in developing the law of the Moon and the first governing bodies (federal agencies) of the Moon from its laws.

#### E. TECHNOPOLITICS CASE STUDY 3: THE LAW OF THE SEA

Let us consider the technopolitics of the law of the sea. High seas are global commons that must be maintained for the benefit of all humanity, but parts of them are exclusively claimed and commercialized by nations.<sup>411</sup> The United States is notoriously not a party to the U.N. Convention on the Law of the Sea (UNCLOS), but many highly qualified commentators consider certain principles codified in UNCLOS as customary international law.<sup>412</sup> For instance, Article 136 provides: "The Area and its resources are the common heritage of mankind."<sup>413</sup> Article 137 continues: "No State shall claim or exercise sovereignty or sovereign rights over any part of the Area or its resources . . . No such claim or exercise of sovereignty or sovereign rights nor such appropriation shall be recognized."<sup>414</sup> UNCLOS and the OST

---

CROWDED ORBITS 91, 108 (2014). But nothing in development now would be capable of Starship's tonnage per year (hundreds of thousands of tons) or dollar per kilogram (\$50-500). See *The Countries Launching Missions to the Moon and Beyond in 2023*, BBC (Dec. 24, 2022), <https://www.bbc.com/news/science-environment-64002977> [<https://perma.cc/5QC8-URFG>].

<sup>410</sup> See discussion *supra* Part IV.

<sup>411</sup> United Nations Convention on the Law of the Sea arts. 57-58, Dec. 10, 1982, 1833 U.N.T.S. 397 [hereinafter UNCLOS].

<sup>412</sup> See, e.g., James L. Malone, *The United States and the Law of the Sea After UNCLOS III*, 46 L. & CONTEMP. PROBS. 29, 33-35 (1983).

<sup>413</sup> See UNCLOS, *supra* note 411, art. 136. UNCLOS provides the definition: "'Area' means the seabed and ocean floor and subsoil thereof, beyond the limits of national jurisdiction." *Id.* art 1(1). Article 3 and Article 5 provide that national jurisdiction extends "up to a limit not exceeding 12 nautical miles, measured from" "the low-water line along the coast." *Id.* arts. 3, 5. One nautical mile is about 1.15 miles or 1.852 km. Similar language of common heritage is also found in the Antarctic Treaty. See Antarctic Treaty, *supra* note 351, art. 4.

<sup>414</sup> See UNCLOS, *supra* note 411, art. 136.

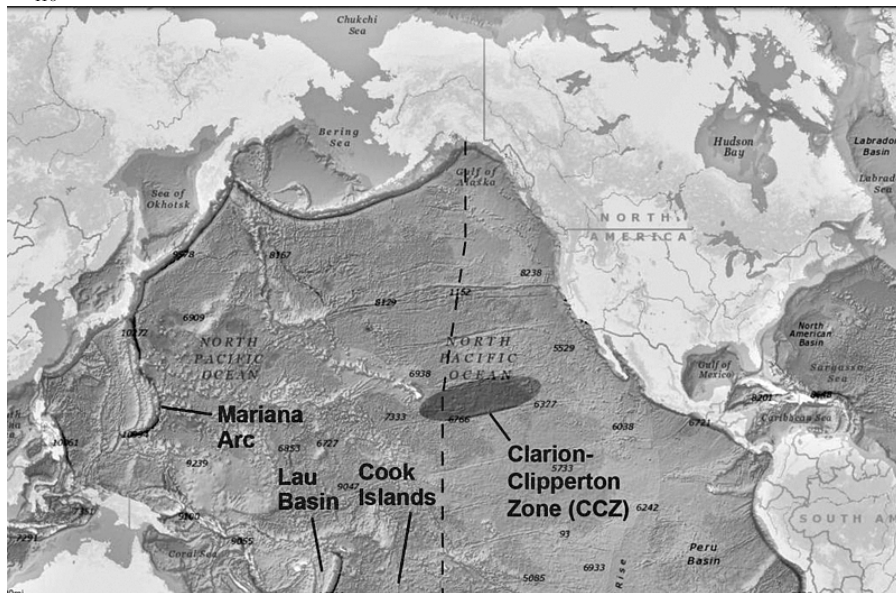
share the non-appropriation principle<sup>415</sup>: the former prohibits the national appropriation of the high seas, and the latter does so for outer space and celestial bodies.

However, the high seas are replete with resources such as fish, minerals, precious metals like cobalt and gold, and, of course, crude oil. Both the United States and state parties to UNCLOS claim exclusive mining rights over, for instance, parts of the Clarion-Clipperton Zone (CCZ), located between Hawaii and Mexico.<sup>416</sup> China, Germany, Japan, South Korea, Nauru, Russia, Tonga, and the U.K. all claim the right to mine certain areas of CCZ, while the United States claims and controls the largest areas subdivided into four zones.<sup>417</sup>

At first glance, exclusive mining rights over a piece of land (seabed) that is only good for mining seems a straightforward exercise of sovereign rights in practice. One subdivision of CCZ under U.S. control is even leased to a Belgian company, with the United States seemingly exercising ownership rights.<sup>418</sup> But on

<sup>415</sup> See Hobe & Chen, *supra* note 73, at 27; Dembling & Arons, *supra* note 322, at 423.

<sup>416</sup>



Location of the Clarion Clipperton Zone, WIKIMEDIA, [https://commons.wikimedia.org/wiki/File:Location\\_of\\_the\\_Clarion\\_Clipperton\\_Zone.png](https://commons.wikimedia.org/wiki/File:Location_of_the_Clarion_Clipperton_Zone.png) [<https://perma.cc/2G59-PWWG>].

<sup>417</sup> Clarion Clipperton Fracture Zone, Int'l SEABED AUTH., <https://isa.org.jm/polymetallic-nodules-exploration-areas-clarion-clipperton-fracture-zone> [<https://perma.cc/X767-ZW2T>].

<sup>418</sup> But see sources cited *infra* note 420.

the high seas, the technopolitical reality seems to have preceded abstract legal ideals like non-appropriation. For instance, we have the technology to mine 5.95 billion tons (bt) of manganese, and 0.27 bt of Nickel is buried in the CCZ.<sup>419</sup> Notwithstanding the customary-law status of the non-appropriation of the high seas, through bilateral and multilateral agreements and domestic legislation, the United States has “legally” mined from the CCZ, and so have other states.<sup>420</sup> The Artemis Accords would be a space version of such a multilateral agreement by which the United States will claim the legality of its citizen’s commercial activities and the exercise of property rights on the Moon.<sup>421</sup>

There are, however, technopolitical differences between the deep sea and the Moon that forbid drawing a straightforward analogy from the sea to the Moon. First, many nations have the technology to conduct deep seabed mining, whereas only the United States will likely have the technology to commercialize the Moon in this decade. As it stands, other spacefaring nations are far behind in developing a fully reusable vehicle like Starship.<sup>422</sup> Thus, it is a fair assumption that in the 2020s and well into the 2030s, no nation other than the United States is likely to have the capacity to develop commercial transportation infrastructure to the Moon.

The realistic and logical conclusion is that the United States would regulate itself and its partners’ activities on the Moon, just as NOAA oversees U.S. deep-sea exploration and mining. There are no other meaningful international stakeholders that can establish a precedential practice in the lunar domain.

---

<sup>419</sup> INT’L SEABED AUTH., TECHNICAL STUDY 6: A GEOLOGICAL MODEL OF POLYMETALLIC NODULE DEPOSITS IN THE CLARION CLIPPERTON FRACTURE ZONE 4 (2010).

<sup>420</sup> See Ian Bezpalko, *The Deep Seabed: Customary Law Codified*, 44 NAT. RES. J. 867, 871–72 (2004). Because the United States is not a party to UNCLOS, its deep-sea exploration and mining endeavors do not fall under the authority of the International Seabed Authority (the Authority). See *id.* at 873–74. Rather domestic legislation, the Deep Seabed Hard Mineral Resources Act (DSHMRA) empowers the National Oceanic and Atmospheric Administration (NOAA) to give permits to explore and mine deep seabed. See *id.* at 873; 15 C.F.R. § 970.100(a) (2023). When the United States faces potential disputes regarding areas of exploration and mining, it has entered into agreements with interested stakeholders. See Bezpalko, *supra*, at 881; see also Deep Seabed Hard Mineral Resources Act, 30 U.S.C. §§ 1401–73.

<sup>421</sup> See *infra* Section VI.A.

<sup>422</sup> See discussion *supra* Sections IV.C.–D.

## VI. HOW TO MOVE FORWARD

A. THE ARTEMIS ACCORDS<sup>423</sup>

The Artemis Accords were drafted by NASA under Administrator Jim Bridenstine in 2020 and signed by eight nations, most of them capable of orbital flight: Australia, Canada, Italy, Japan, Luxembourg, the United Arab Emirates, the United Kingdom, and the United States.<sup>424</sup> Commentators agree that the Artemis Accords and SPACE Act, respectively, multilaterally and legally, affirm that private ownership over resources extracted and utilized on the Moon or in outer space generally is not national appropriation forbidden by the OST.<sup>425</sup> This is in direct contradiction with the Moon Agreement.<sup>426</sup> But the Artemis Accords reflect the technopolitical reality, and the first instance of private ownership on the Moon by U.S. persons would permanently set the customary law of private ownership in space.

Few commentators realize the legal significance of a novel concept that appears in the Artemis Accords: “safety zones,” which are “area[s] in which nominal operations of a relevant activity or an anomalous event could reasonably cause harmful interference.”<sup>427</sup> In theory, safety zones could give the state operating on a piece of lunar land the power to exclude other states and to enforce its laws and regulations.<sup>428</sup> Declaring a

---

<sup>423</sup> NASA, THE ARTEMIS ACCORDS: PRINCIPLES FOR COOPERATION IN THE CIVIL EXPLORATION AND USE OF THE MOON, MARS, COMETS, AND ASTEROIDS FOR PEACEFUL PURPOSES (2020), <https://www.nasa.gov/specials/artemis-accords/img/Artemis-Accords-signed-13Oct2020.pdf> [<https://perma.cc/9RM7-EFAE>].

<sup>424</sup> Press Release, NASA, International Partners Advance Cooperation with First Signings of Artemis Accords (Oct. 13, 2020).

<sup>425</sup> Bennett, *supra* note 286, at 247; Megan Alexa MacKay, *Property Rights in Celestial Bodies: A Question of Pressing Concern to All Mankind*, 104 MARQ. L. REV. 575, 600 (2020) (“[The SPACE] Act gives United States-based corporations ownership rights over resources mined from space objects.”).

<sup>426</sup> See discussion *supra* Section V.B.

<sup>427</sup> NASA, *supra* note 423, sec. 11, para. 7.

<sup>428</sup> See Christopher D. Johnson, *Renewed Ambitions in Space-Exploration Lawmaking*, 33 AIR & SPACE LAW. 19, 21 (2020) (recognizing the physical necessity of establishing safety zones because the lunar horizon is only 1.5 miles in radius, and landings and launches create a plume of sharp, corrosive regolith); Rossana Deplano, *The Artemis Accords: Evolution or Revolution in International Space Law*, 70 INT’L & COMPAR. L.Q. 799, 808–09 (2021); Hunter Sutherland, *The Stakes Are out of This World: How to Fix the Space Act of 2015*, 22 VT. J. ENV’T L. 100, 121–22 (2021) (citing space lawyer Christopher Johnson in stating that because the safety zones are not permanent, they are not sovereign territory and therefore do not contravene the OST). *But see* Ben McKeown, Andrew G. Dempster & Serkan Saydam, *Artemis Accords: Are Safety Zones Practical for Long Term Commercial Lunar Resource Utilisation?*, 62 SPACE POL’Y, 2022, at 14–15 (arguing that “it is not clear how the



piece of lunar real estate a safety zone comes very close to national appropriation, but it is not because there is no claim of ownership of the land itself.<sup>429</sup> But it will entitle the United States to regulate and enforce its laws on the Moon not only for U.S. nationals but for foreign nationals as well.<sup>430</sup>

The extension of jurisdiction need not necessarily stop at safety zones properly. Pursuant to customary international law, strict territorial construction of legislative jurisdiction is a thing of the past. Consider the Permanent Court of International Justice (PCIJ) case, *The S.S. Lotus (France v. Turkey)* (1927).<sup>431</sup> A French vessel collided with a Turkish vessel killing several onboard the latter, and Turkey wished to apply its criminal laws to a French officer's action on the French vessel.<sup>432</sup> The PCIJ ruled that the French sailor's actions had sufficient effects on the Turkish vessel, sustaining Turkish jurisdiction.<sup>433</sup> This was one of the earlier premier cases that expanded the strict reading of territoriality as a prerequisite of jurisdiction, whereby national laws have authority only within the borders of its territory with the "effects" doctrine.<sup>434</sup>

Restatement (Third) of Foreign Relations Law of the United States § 402 clarifies that "a state has jurisdiction to prescribe law with respect to . . . conduct outside its territory that has or is intended to have substantial effect within its territory."<sup>435</sup> In the lunar context, "territory" can be substituted with "safety zones."

Section 403 further states that "[w]hether exercise of jurisdiction over a person or activity is unreasonable is determined by evaluating all relevant factors." Reasonableness of extraterritorial legislative jurisdiction—applying the effects doctrine—is based on a factors test looking at the totality of circumstances:

- (a) [T]he extent to which the [foreign] activity . . . has *substantial, direct, and foreseeable effect* upon or in the [domestic] territory;

---

Safety Zones alone would provide sufficient legal and governance certainty to encourage commercial space resource extraction operations").

<sup>429</sup> See Sutherland, *supra* note 428, at 122.

<sup>430</sup> See Johnson, *supra* note 428, at 21; Deplano, *supra* note 428, at 808–09; Sutherland, *supra* note 428, at 121.

<sup>431</sup> The Case of the S.S. *Lotus* (Fr. v. Turk.), Judgment, 1927 P.C.I.J. (ser. A) No. 10 (Sept. 7).

<sup>432</sup> *Id.* at 5.

<sup>433</sup> *Id.* at 23.

<sup>434</sup> *Id.* at 25; Najeeb Samie, *The Doctrine of "Effects" and the Extraterritorial Application of Antitrust Laws*, 14 U. MIAMI INTER-AM. L. REV. 23, 30–31 (1982).

<sup>435</sup> RESTATEMENT (THIRD) OF FOREIGN RELATIONS LAW OF THE UNITED STATES § 402(1)(c) (AM. L. INST. 1983).

- (b) the *connections*, such as nationality, residence, or economic activity, between the regulating state and the person principally responsible for the activity to be regulated, or between that state and those whom the regulation is designed to protect;
- (c) the character of the activity to be regulated, *the importance of regulation to the regulating state*, the extent to which other states regulate such activities, and the degree to which the desirability of such regulation is generally accepted;
- (d) the existence of *justified expectations* that might be protected or hurt by the regulation;
- (e) the *importance of the regulation* to the international political, legal, or economic system;
- (f) the extent to which the regulation is consistent with the traditions of the international system;
- (g) the extent to which another state may have an interest in regulating the activity; and
- (h) the likelihood of *conflict with regulation by another state*.<sup>436</sup>

This grab bag of factors makes for a perfect recipe for the technopolitical extension of jurisdictional reach. With the United States being the sole technopolitical power on the Moon, “the importance of regulation to the regulating state” will be high, and there will be “justified expectation” of its exercise of jurisdiction.

The effects doctrine should be applied broadly as a basis of Congress’s jurisdictional reach on the Moon because the novelty, unknowns, and extreme danger of the environment present heightened concern for regulatory conformity, whether the parties or property concerned are foreign or domestic.<sup>437</sup> The low fracture tolerance of a small community in the hostile and lethal lunar environment would likely more acutely present itself in the early stages of lunar commercialization. The lunar surface will be the harshest environment humans have ever confronted, and the nearest safe harbor is 240,000 miles of vacuum away. Hence, any conduct that impinges on the interest or safety of a U.S. national or entity on the Moon would have a “substantial effect” and “connection” on U.S. lunar settlements; the U.S. lunar governance framework would have tremendous regulatory interests.

---

<sup>436</sup> *Id.* § 403 (emphasis added).

<sup>437</sup> See Sundahl, *supra* note 403, at 44 (“Under customary law, a state may have the jurisdiction to regulate a space object if . . . the operation of the object ha[s] significant effects on the state . . . or . . . pose[s] a security threat to a state . . .”).

Furthermore, because the first lunar settlements will likely be an American endeavor, the responsibility to ensure law and order falls squarely on the United States, pursuant to Article VI of the OST.<sup>438</sup> Furthermore, as the only nation with commercial access to the Moon, only the United States would be able to afford to send governing presence on the Moon. The United States' responsibility for regulating activities on the Moon would become a basis for Congress to assert jurisdiction over foreign nationals and entities.

Ultimately, the international law limits on U.S. legislative jurisdiction do not trump U.S. federal law. Even if Congress passes legislation extending prescriptive jurisdiction over properties and individuals on the Moon that otherwise violates international law limits on the jurisdiction, the U.S. tribunals must ignore the customary international law and apply the domestic law.<sup>439</sup> Coupled with the technopolitics of early lunar settlement that would likely endow the United States with unprecedented latitude, Congress is legally extremely well-equipped to extend its jurisdiction on the Moon.

#### B. THE REGISTRATION CONVENTION

Another way to extend jurisdiction is found under the Registration Convention, requiring every launched object to be registered to a "launching state's" registry. Article II provides: "When a space object is launched into earth orbit or beyond, the launching State shall register the space object by means of an entry in an appropriate *registry which it shall maintain*."<sup>440</sup> Every object and person launched from Earth to outer space under the authority of state parties to the Treaty must be registered to some launching state, over which (and the personnel therein),

---

<sup>438</sup> Outer Space Treaty, *supra* note 51, art. VI ("States Parties to the Treaty shall bear international responsibility for national activities in outer space, including the Moon and other celestial bodies, whether such activities are carried on by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty.")

<sup>439</sup> *United States v. Aluminum Co. of Am.*, 148 F.2d 416, 443 (2d Cir. 1945).

<sup>440</sup> The Registration Convention of Objects Launched into Outer Space art. II(1), Jan. 14, 1975, 28 U.S.T. 695, [hereinafter Registration Convention] (emphasis added).

Article VIII of the OST grants jurisdiction<sup>441</sup> to those objects properly registered and persons on board.<sup>442</sup>

Article I of the Registration Convention expands on the OST and defines the “launching state”: “(a) The term ‘launching State’ means: (i) A State which *launches* or *procures* the launching of a space object; (ii) A State from whose *territory* or *facility* a space object is launched[.]”<sup>443</sup> Thus, the Convention tells us that any of the following four types of states can be considered a launching state and have a right to register the launched object, thereby acquiring prescriptive jurisdiction over the same<sup>444</sup>:

- (1) The state that has jurisdiction over the launch vehicle.<sup>445</sup>  
For instance, a lunar module that came from Japan but launched aboard Starship, which is a U.S. launch vehicle, may be entered into the U.S. registry of launched objects.
- (2) The state that procures the launch. Here, following the previous example, Japan would be the country that pro-

---

<sup>441</sup> See Outer Space Treaty, *supra* note 51, art. VIII (“A State Party to the Treaty on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object, and over any personnel thereof, while in outer space or on a celestial body. Ownership of objects launched into outer space, including objects landed or constructed on a celestial body, and of their component parts, is not affected by their presence in outer space or on a celestial body or by their return to the Earth. Such objects or component parts found beyond the limits of the State Party to the Treaty on whose registry they are carried shall be returned to that State Party, which shall, upon request, furnish identifying data prior to their return.”).

<sup>442</sup> The Registration Convention, however, may or may not allow concurrent jurisdiction. Article II says: “Where there are two or more launching States in respect of any such space object, they shall jointly determine *which one of them* shall register the object in accordance with paragraph 1 of this article.” Registration Convention, *supra* note 440, art. II(2) (emphasis added). The phrase “*which one of them*” seems to imply that a spacecraft may only appear in the registry of one state, and thereby fall under its exclusive jurisdiction. However, according to Article 6, states have a duty to supervise actions of their nationals in space. *Id.* art. VI. So, if a spacecraft belonging to a state’s national causes damage to property of another state, the first state bears liability whether or not it is registered to it. This may be interpreted as allowing concurrent jurisdiction under Article 2. See Sundahl, *supra* note 403, at 43. But this nicety is of little consequence for my purposes because it does not affect the United States’ power to pass my proposed legislation.

<sup>443</sup> Registration Convention, *supra* note 440, art. I (emphasis added).

<sup>444</sup> This mimics the language in the Liability Convention as well. See Arnel Kerrest & Caroline Thro, *Liability for Damage Caused by Space Activities*, in ROUTLEDGE HANDBOOK OF SPACE LAW 59, 61 (Ram S. Jakhu & Paul Stephen Dempsey eds., 2017).

<sup>445</sup> For an argument that only the state that actually launches should have jurisdiction, see Stephen Gorove, *Liability in Space Law: An Overview*, 8 ANNALS AIR & SPACE L. 373, 377 (1983).

cured the launch and would have a claim to register the lunar module.

- (3) The state in whose territory the launch took place. If Starship was launched from New Zealand carrying a Japanese module, New Zealand would have a claim to register the Japanese module.
- (4) The state that owns the facility that launched the vehicle. If Australia owned that facility in New Zealand that launched Starship carrying a Japanese module to the Moon, Australia would have a claim.

Using the powers of the weapons export control authority, domestic legislation requiring registration of every spacecraft launched aboard a U.S. spacecraft (e.g., Starship) to a U.S. registry would be a sufficient basis for asserting legislative jurisdiction to anything put on the Moon by Starship or any other U.S.-based commercial flyer. And on the Moon, similar to the maritime flag jurisdiction, U.S. jurisdiction need only extend to lunar safety zones or some similar legal concept.<sup>446</sup>

Simple domestic legislation pursuant to Article II(a)(i) of the Registration Convention and Article VII of the OST would be sufficient to bring every lunar space object launched onboard Starship under U.S. lunar jurisdiction. The relevant provision could look something like this:

Every space object, vehicle, instrument, craft, installment, facility, module, habitat, and satellite bound to the lunar surface, selenocentric orbit, cislunar space, or Earth–Moon LaGrange points that is partially or wholly launched aboard a United States spacecraft must be registered to the United States registry of launched objects and subject to the laws, rules, and regulations of the United States.

The authority to compel private aerospace companies to include the registry provision in their launch contracts is found in 15 C.F.R. § 730 *et seq.*, the Export Administration Regulations (EAR)<sup>447</sup> power given to the Bureau of Industry and Security, and in the International Traffic in Arms Regulations (ITAR) implemented by the Directorate of Defense Trade Controls (DDTC).<sup>448</sup> The DDTC, especially, is authorized to impose controls on military-related articles.<sup>449</sup> The U.S. Munitions List iden-

---

<sup>446</sup> See Hardenstein, *supra* note 16, at 275–76.

<sup>447</sup> 15 C.F.R. pt. 730.

<sup>448</sup> 22 C.F.R. pt. 120.

<sup>449</sup> See 22 C.F.R. § 121.1.

tifies such instruments, and Category XV includes “Spacecraft and Related Articles.”<sup>450</sup> “Spacecraft, including satellites and space vehicles, whether designated developmental, experimental, research, or scientific, or having a commercial, civil or military end-use”<sup>451</sup> falls under DDTC’s authority. Starship falls under Category XV.

Domestic legislation requiring U.S. registration of all lunar-bound payloads onboard U.S. vessels is an application of the already-existing executive authority to control exports. That authority compels that when companies like SpaceX enter a launch contract with a foreign entity, the contract must include terms that say the latter will register its lunar-bound payload to the U.S. registry of space objects.<sup>452</sup> Then, in conjunction with Article VIII of the OST, relevant U.S. federal law is wholly applicable to foreign objects and personnel launched aboard Starship bound for the Moon.

## VII. THE POSSIBILITY OF AN IN SITU COURT OF LAW

In this Section, I sketch the international and domestic legal contours of a U.S. jurisdictional body on the Moon. I use what I call the U.S. Lunar Court (USLC) as an example, but much of the legal discussion here would also be applicable to other adjudicatory bodies.

To summarize, in this decade, the United States will likely have the technopolitical edge to establish its substantive laws and legal customs as the law of the Moon under federal jurisdiction. An agency of the federal government would likely take the role of the lunar executive, and the U.S. Congress would take on the mantle of the lunar legislature like it is for the District of Columbia. As explored in detail below, the Lunar Court cannot be a state court, a territorial court, or a U.S. District Court. It would be a legislative court—an Article I court—but one that has the general jurisdiction of a state court and the Article III power to hear federal cases. Yesteryear’s courts of the District of Columbia provide precedent.

As I begin this discussion, it must be noted that international law applies wholly to outer space, as provided by the OST and customary international law. The basic principle of law, *lex*

---

<sup>450</sup> *Id.*

<sup>451</sup> *Id.*

<sup>452</sup> *See id.* § 122.1.

*specialis derogat legi generali*, applies to international law.<sup>453</sup> In the lunar context, the four binding international space law treaties and customary international space law *qua lex specialis* override other doctrines of general international law, *lex generalis*. The legality of establishing a U.S. federal court on the Moon, then, must be tested against the provisions of the OST, Rescue Agreement, Liability Convention, Registration Convention, and other applicable customary international space law. Only in cases of lacunae in *lex specialis*, i.e., space law, would general international law be controlling in lunar jurisprudence.<sup>454</sup> Then the corollary is, if the establishment of the Lunar Court is legal under international space law, *a fortiori* it is legal under international law.

With that in mind, Section VII.A discusses, as a matter of policy, why a court on the Moon is needed. Section VII.B discusses whether it is consistent with international space law for a U.S. federal court to be physically located on the surface of the Moon. Section VII.C is about whether, consistent with international space law, the U.S. Congress may legislate for the Moon—i.e., whether Congress may exercise prescriptive jurisdiction on the Moon. Section VII.D shows that consistent with international space law, USLC may exercise adjudicatory jurisdiction—subject matter jurisdiction over matters legislated by Congress and personal jurisdiction over persons and properties on the Moon. Finally, Section VII.E discusses the typology of the USLC, pursuant to U.S. domestic law.

#### A. WHY THE U.S. COURT ON THE MOON MAY BE NECESSARY

The following are possible party alignments in lunar disputes: (a) civil disputes between two individuals of the same or different nationality; (b) criminal disputes; (c) disputes with elements of (a) and (b); (d) disputes between states concerning the application or interpretation of space law treaties or customary space

---

<sup>453</sup> Special-purpose law has priority over general-purpose law. Michael Akehurst, *The Hierarchy of the Sources of International Law*, 47 BRIT. Y.B. INT'L L. 273, 273 (1975); JAMES CRAWFORD, BROWNLIE'S PRINCIPLES OF PUBLIC INTERNATIONAL LAW 654 (2012).

<sup>454</sup> See Outer Space Treaty, *supra* note 51, art. III ("States Parties to the Treaty shall carry on activities . . . in accordance with international law, including the Charter of the United Nations . . .").

law; (e) disputes between individuals and states.<sup>455</sup> We should expect disputes of all five kinds to arise in a commercialized and massively settled Moon that is 240,000 miles away from Earth. Legal scholarship on space law, however, has failed to imagine this new paradigm of space exploration led by commercial entities and on a massive scale—i.e., hundreds or thousands of civilians engaging in business transactions in space. The old paradigm of highly specialized experts' limited excursion (only a few astronauts going to the *ISS* and the Moon) did not encourage scholars to envision an *in situ* court of general jurisdiction, empowered and capable of hearing all five kinds of disputes. But the quickly developing Starship not just inspires but urgently necessitates a new kind of legal discussion that envisions a complex civil society that could take root on the Moon.

### 1. *The Difference Between the ISS and the Moon*

Civil disputes arising in outer space have not been considered in international law. IGA only deals with criminal disputes, for which there is no uniform procedure, as countries share jurisdiction.<sup>456</sup> Moreover, it assumes the availability of courts on Earth. Until now, the low population in LEO (mostly single-digit) and proximity to Earth has allowed for international law to assume the availability of terrestrial courts of respective countries of which astronauts are nationals.<sup>457</sup>

Virtually every astronaut, except for a handful of tourists to the *ISS*, has been highly trained. They live a life continuously monitored by hundreds of people in mission control in NASA, ESA, and Roscosmos and are required to carry out a highly regimented schedule conducting scientific experiments or performing maintenance on the Station.<sup>458</sup> This is not an environment in which you expect a civil dispute or criminal activity. Astro-

---

<sup>455</sup> See Tare Brisibe, *Settlement of Disputes and Resolution of Conflicts*, in ROUTLEDGE HANDBOOK OF SPACE LAW 90, 92 (Ram S. Jakhu & Paul Stephen Dempsey eds., 2017).

<sup>456</sup> See discussion *supra* Section V.D.

<sup>457</sup> For instance, no one seems to have raised the potential of legal disputes among the four-civilian crew in SpaceX's Inspiration4 mission. There are only four people, and they will be back to Earth in three days. There is no need for an *in situ* adjudicatory body in LEO for that mission. See Scott Dutfield & Vicky Stein, *Inspiration4: The First All-Civilian Spaceflight on SpaceX Dragon*, SPACE.COM (Jan. 5, 2022), <https://www.space.com/news/live/spacex-inspiration4-updates> [<https://perma.cc/4WLU-6UXF>].

<sup>458</sup> See discussion *supra* Section V.D.



nauts and cosmonauts do not stay in orbit for longer than a few months, and at any rate, it is only a few hours away from Earth.

The Moon is 240,000 miles away from Earth, a distance equivalent to flying ten times around the Earth at the equator.<sup>459</sup> A one-way trip to or from the Moon takes three days, not to forget the danger, cost, and inconvenience of such a trip. Moreover, to expect commercialization of the Moon is to expect settlement by legions of civilians in the private sector. They will live in a highly stressful environment, likely consuming rehydrated foods, with rationed water, and having little or no showers or baths.<sup>460</sup> Outside is cosmic, with solar radiation and a lethal vacuum with temperatures ranging from -414 to 253 degrees Fahrenheit.<sup>461</sup> It is as apt an environment as any for civil and criminal disputes to arise. Complex business transactions in lunar commercialization would also beget civil disputes requiring damages payments, declaration of rights, or injunctive orders.

## 2. *The Difference Between Antarctica and the Moon*

Article I of the Antarctic Treaty<sup>462</sup> and the Preamble of the OST<sup>463</sup> both require states to use these domains “for peaceful purposes only.” Article V of the Antarctic Treaty<sup>464</sup> and Article IV of the OST<sup>465</sup> ban the placement of weapons of mass destruction in either domain. Article VII of the Antarctic Treaty<sup>466</sup> and Article XII of the OST<sup>467</sup> call for freedom of access by all nationals to stations, installations, equipment, and such. Importantly, Article II of the OST<sup>468</sup> and Article IV<sup>469</sup> of the Antarctic Treaty ban claims of territorial sovereignty, making the Moon, a speci-

---

<sup>459</sup> See *How Far Away Is the Moon*, NASA SCI., <https://spaceplace.nasa.gov/moon-distance/en/> (Mar. 3, 2023).

<sup>460</sup> See Liz Treadwell, *Living on the Moon – How to Make It Possible*, HEROX, <https://www.herox.com/blog/957-3-problems-we-need-to-solve-before-we-can-live-on#:~:text=because%20of%20the%20Moon's%20sparse,need%20to%20live%20in%20shelters> [<https://perma.cc/S5WZ-FACM>].

<sup>461</sup> *Id.*; *NASA Science: Earth's Moon*, NASA, <https://moon.nasa.gov/inside-and-out/overview/> [<https://perma.cc/G7XF-KDPC>].

<sup>462</sup> Antarctic Treaty, *supra* note 351, art. I.

<sup>463</sup> Outer Space Treaty, *supra* note 51, pmbl.

<sup>464</sup> Antarctic Treaty, *supra* note 351, art. V.

<sup>465</sup> Outer Space Treaty, *supra* note 51, art. IV.

<sup>466</sup> Antarctic Treaty, *supra* note 351, art. VII.

<sup>467</sup> Outer Space Treaty, *supra* note 51, art. XII.

<sup>468</sup> *Id.* art. II.

<sup>469</sup> Antarctic Treaty, *supra* note 351, art. IV.

men of celestial bodies considered by the OST, and Antarctica legally analogous.

The provisions of the 1998 IGA, OST, and the Antarctic Treaty regarding general jurisdiction are founded on the same assumption and principles. The assumption is the availability of national courts for adjudicating cases and controversies that arise, respectively, in the *ISS*, outer space, and Antarctica. Built on this assumption is the scheme whereby the state parties to the treaty retain general jurisdiction over modules (broadly construed) registered to their state and their nationals.

The 1998 IGA provides: “Pursuant to Article VIII of the Outer Space Treaty . . . each Partner shall retain jurisdiction and control over the elements it registers . . . and over personnel in or on the [International] Space Station who are its nationals.”<sup>470</sup> The Antarctic Treaty Provides: “[T]o facilitate the exercise of their functions under the present treaty . . . observers . . . and scientific personnel . . . shall be subject only to the jurisdiction of the Contracting Party of which they are nationals . . . while they are in Antarctica.”<sup>471</sup> The idea is that disputes can be worked out in a country’s home courts because both *ISS* and Antarctica are only a few hours away. This assumption, however, fails on the Moon for the simple reason that it is 240,000 miles away. Disputes arising on the Moon would have to be dealt with on the Moon by a legitimate and competent tribunal.

### 3. Policy Considerations for a U.S. Lunar Court

*Promoting the rule of law*—For efficient and orderly development of the lunar society, there must be an authoritative and dependable source of law. A court on the Moon, by applying laws and regulations, would clarify the rights and duties of settlers on the Moon.<sup>472</sup>

*Litigation cost and convenience*—The stupendous distance (240,000 miles) from Earth and potentially high and growing lunar population call for a local court, among other governing entities. The availability of a local court and the low cost of litigation are essential in preempting private justice and thereby ensuring law and order. The cost of moving evidence and witnesses to Earth would be millions of dollars—then only extreme high-stakes lawsuits would see a day in court. A local court, on

<sup>470</sup> 1998 IGA, *supra* note 382, art. 5(2).

<sup>471</sup> Antarctic Treaty, *supra* note 351, art. VIII.

<sup>472</sup> See, e.g., Sundahl, *supra* note 403, at 46–47.

the other hand, would allow for small claims to be adjudicated and make trials more cost-effective and efficient generally. It is difficult to imagine producing real evidence from the Moon to a terrestrial court. Lastly, an Earth–Moon video conference (i.e., a virtual court) is likely not ideal. The Earth–Moon distance amounts to 2.6 light-seconds roundtrips, which, coupled with processing delays, would create a lag of at least 3 seconds.<sup>473</sup>

*Local knowledge*—Local courts are privy to the unique culture of the community and may play a big role in shaping the community in turn. A terrestrial court sitting 240,000 miles away will be disconnected from the lunar community. Deciding on legal standards in a tort suit on the Moon would consider the uniquely dangerous lunar environment. Also, lunar settlements will have different internal standards for safety. Perhaps money damages might not mean too much in an environment where resources mean too much. Fraud concerning water, for instance, might have a life-or-death consequence. Certain aspects about the lunar setting that cannot even be imagined today would be of first impression to the justice system, rendering it imprudent for a distant court without local knowledge or expertise to adjudicate lunar matters.

*Building lunar precedent and jurisprudence*—We must operate with the assumption that the population on the Moon will only grow. A local court on the Moon would serve as a depository of lunar precedent and jurisprudence. This accumulation of expertise and experience will allow the lunar courts of tomorrow to handle increasingly complex disputes that are unique to the Moon.

---

<sup>473</sup> *But see* Hardenstein, *supra* note 16, at 287 (claiming that the enforcement of jurisdiction on Mars is “not a problem the legal field can fix. Instead, science and technology will solve this conundrum by continuing to develop faster and more convenient technology that allows for a better link between the colony and Earth.”). This is nonsense because technology literally cannot make the connection between colonies and Earth faster than the speed of light—several seconds to the Moon, and several minutes to Mars. *See* Chad Orzel, *The Real Reasons Quantum Entanglement Doesn’t Allow Faster-Than-Light Communication*, FORBES (May 4, 2016, 9:46 AM), <https://www.forbes.com/sites/chadorzel/2016/05/04/the-real-reasons-quantum-entanglement-doesnt-allow-faster-than-light-communication/?sh=5d9770983a1e> [<https://perma.cc/CB69-TZK4>]. This is because according to Einstein, nothing travels faster than light, which is a fundamental axiom of physics. *See id.*

*Jury*<sup>474</sup>—A trial by jury is a constitutional right in the United States. Jury trials are rarer in civil disputes, but litigants still retain the right to a jury trial in many cases. In criminal trials, defendants have an absolute right to a trial by twelve jurors in federal cases. But the jury trial is a trial by peers. New Yorkers do not serve as jurors in California cases because New Yorkers do not represent the people of California and are not privy to the lived experience of the Californian culture and custom. It is a natural corollary that terrestrial residents perhaps could not serve as jurors for lunar cases. Without a lunar court, trying lunar cases by jury would be almost certainly impossible.

*Limits of agency courts*—An arm of the federal government will initially regulate safety and environmental issues on the Moon. However, agency courts are not sufficient because they cannot constitutionally hear cases that belong to the judiciary. For instance, an agency court may not hear general common law claims that lie beyond the agency's narrowly tailored expertise or suits arising from the so-called private rights. It also has no general criminal jurisdiction. Lastly, an Article III court has to oversee Article I courts in some fashion—i.e., by providing a forum for appeal and legally requiring the former to enter judgments rendered by the latter. A lunar court would be the most natural way to oversee lunar agency courts.

*Ensuring prosecution of crimes*—A deadlock caused by overlapping jurisdictions is perhaps most egregious when it comes to the prosecution of crimes. A rather famous story of Dr. Rodney Mark, a scientist in Antarctica, is a tragedy of multiple jurisdictions.<sup>475</sup> Dr. Mark was an Australian astrophysicist working at a U.S. research station in Antarctica.<sup>476</sup> He became ill and suddenly died within a few days, but because the weather did not permit air travel, he was preserved frozen for six months.<sup>477</sup> When a coroner in New Zealand eventually conducted an au-

---

<sup>474</sup> Disclaimer: a discussion regarding which rights U.S. nationals on the Moon within U.S. jurisdiction enjoy would amount to an article unto itself. However, it is difficult to imagine that a U.S. national facing criminal charges in any U.S. court would not have a right to a trial by jury, as criminal jury is an absolute right enjoyed by a criminal defendant. See U.S. CONST. amend. VI.

<sup>475</sup> Todd F. Chatham, Comment, *Criminal Jurisdiction in Antarctica: A Proposal for Dealing with Jurisdictional Uncertainty and Lack of Effective Enforcement*, 24 EMORY INT'L L. REV. 331, 331 (2010).

<sup>476</sup> *Id.* at 332.

<sup>477</sup> *Id.*

topsy, lethal levels of methanol were found in his system.<sup>478</sup> Investigations could not rule out the possibility of foul play.<sup>479</sup>

The United States had prosecutorial interest because the supposed crime occurred on a U.S. base, and Dr. Mark was a U.S. contractor.<sup>480</sup> However, the U.S. base was in Ross Dependency, a region over which New Zealand claims sovereignty. As one of its nationals, Australia also had a prosecutorial interest.<sup>481</sup> The Antarctic Treaty tragically is silent on the procedure for criminal jurisdiction.<sup>482</sup> The resulting unprincipled overlap of jurisdictional interests resulted in a stalemate, and the circumstance of his death has been left unresolved to this day.<sup>483</sup> Having one law administered in one jurisdiction by one court would avoid a tragedy similar to that of Dr. Marks, drawing a macabre shadow in an exciting new world. The presence of a robust justice system would encourage conformity to the law and deter criminal and civil wrongdoing.

*Ease of enforcement*—Safety regulation would be key to the sustainable development of lunar infrastructure. A new U.S. agency, perhaps under the Department of Transportation or as an independent agency like NASA, would easily be able to enforce infractions through the Lunar Court. An agency court on the Moon would be a nice alternative, but without a court of law, an executive tribunal would likely not pass constitutional muster. An international tribunal is infamously incapable of enforcing judgments, especially on U.S. nationals.<sup>484</sup> Even if it were to pass a judgment, an international tribunal would be unable to directly enforce it on U.S. lunar residents, as the decision must be recognized or enforced by a U.S. court. This amounts to an unnecessary procedural triplicate: a lunar international court's decision has to be recognized by a terrestrial U.S. court and enforced against a U.S. lunar resident 240,000 miles away. This is impracticable.

*Simple and efficient resolution of disputes*—Consider the regime under the Liability Convention. Individuals harmed by foreign

---

<sup>478</sup> *Id.*

<sup>479</sup> *Id.* at 333.

<sup>480</sup> *Id.*

<sup>481</sup> *Id.* at 331, 333.

<sup>482</sup> *Id.* at 339.

<sup>483</sup> *Id.* at 341.

<sup>484</sup> See *Enforcement of Judgments*, TRAVEL.STATE.GOV, <https://travel.state.gov/content/travel/en/legal/travel-legal-considerations/international-judicial-assst/Enforcement-of-Judges.html> [<https://perma.cc/3E97-J93H>].

space objects must contact their state's foreign affairs department, which then reaches out to its counterpart in the launching state's government, which in turn will use its domestic laws to decide how to proceed.<sup>485</sup> Any international regime on the Moon would be necessarily similar, requiring multiple procedural legs. The Lunar Court, on the other hand, will proceed directly against the tortfeasor and enter judgment.

*International tribunals are inadequate*<sup>486</sup>—International law is not directly applicable to individuals.<sup>487</sup> International tribunals<sup>488</sup> have no compulsory jurisdiction<sup>489</sup> that can force a U.S. national to appear before them. The international Permanent Court of Arbitration lacks general jurisdiction and criminal jurisdiction over private individuals.<sup>490</sup> Lastly, it is frankly silly to think that the United States, despite the technopolitical advantage afforded by Starship, would agree to have its lunar affairs be controlled by some third-party international institution.

## B. THE LOCATION

For a U.S. court on the Moon to be legitimate, it needs to overcome two legal hurdles. First, physically establishing a permanent seat of government on the lunar surface must be legal under international law. The second hurdle is the United States' assertion of prescriptive jurisdiction (legislating for people and

---

<sup>485</sup> See Kerrest & Thro, *supra* note 444, at 68. And the judgment by the Lunar Court is enforceable and legitimate under the Liability Convention. Article XI provides: "Nothing in this Convention shall prevent a State, or natural or juridical persons it might represent, from pursuing a claim in the courts or administrative tribunals or agencies of a launching State." Convention on International Liability for Damage Caused by Space Objects art. XI(2), Mar. 29, 1972, 24 U.S.T. 2389, 961 U.N.T.S. 187 [hereinafter Liability Convention]. This is important as the United States is a party to the Liability Convention. See UNOOSA, *supra* note 289.

<sup>486</sup> Brisibe, *supra* note 455, at 95 (arguing that "the international legal system is inadequate at providing suitable institutions, means or procedures for settlement of disputes arising from outer space activities.").

<sup>487</sup> Hobe & Chen, *supra* note 73, at 37; Sundahl *supra* note 403, at 47.

<sup>488</sup> There is an Inter-Agency Space Debris Coordination Committee (IADC) under UNCOPUOS. U.S. Mission Unvie, 2022 COPUOS STSC – U.S. on Space Debris, U.S. MISSION TO INT'L ORGS. VIENNA (Feb. 10, 2022), <https://vienna.usmission.gov/2022-copuos-stsc-space-debris/> [https://perma.cc/H7L5-JMK4]. But it has no lawmaking power. See *id.* It only makes recommendations, which the U.N. General Assembly may or may not adopt. See *id.* We will need a binding and authoritative legal institution on the Moon for the first American settlers.

<sup>489</sup> Brisibe, *supra* note 455, at 92.

<sup>490</sup> *Id.* at 93.

property on the Moon under U.S. law) and adjudicatory jurisdiction (the court's authority to hear the case and make a binding judgment on parties). Firstly, under the OST, the physical presence of a U.S. court on the surface of the Moon must not amount to the national appropriation of (1) the ground on which the court sits and (2) the region of lunar land under the court's jurisdiction. The United States, or any other spacefaring nation per the OST to which they are all parties, may not appropriate any celestial body or parts thereof.<sup>491</sup> Hence, the United States' establishment of federal courts must not amount to national appropriation: not by the physical presence or by jurisdictional assertion. And it will not.

First, it must be legal under international law for a court building to be physically located on the Moon. For this, we look to the OST and find that a permanent seat of an adjudicatory body on the Moon is consistent with the OST. Article II of the OST says, "Outer space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means."<sup>492</sup> The question is whether, within the meaning of the OST, the United States would *appropriate* the plot of land on the Moon by placing a court there. Article II is written broadly to preempt national appropriation by ending the clause with a catch-all phrase: "by any other means." This phrase can be interpreted as rendering the list preceding it illustrative, not exhaustive. This can seem problematic as a permanent court may be deemed an "other means" by which the United States asserts territorial sovereignty over the Moon or parts thereof.

This interpretation fails to read the OST as a whole and appreciate the spirit of it because the OST quite explicitly contemplates permanent manned stations. For instance, Article XII says:

*All stations, installations, equipment and space vehicles on the moon and other celestial bodies shall be open to representatives of other States Parties to the Treaty on a basis of reciprocity. Such representatives shall give reasonable advance notice of a projected visit, in order that appropriate consultations may be held and that maximum precautions may be taken to assure safety and to avoid interference with normal operations in the facility to be visited.*<sup>493</sup>

---

<sup>491</sup> Outer Space Treaty, *supra* note 51, art. II.

<sup>492</sup> *Id.*

<sup>493</sup> *Id.* art. XII (emphasis added).

The universal quantifier “all” stations necessarily includes both permanently manned stations and those that are the seat of government. A station housing a lunar court, or any regulatory body for that matter, is included as one such example of “all stations, installations, . . . and space vehicles” and may be legally placed on the Moon or other celestial bodies so long as it is reasonably open to “representatives of other States Parties.”<sup>494</sup>

Moreover, Article II must be read in light of the spirit of the OST and other provisions therein like Article III, which *encourages* installing a court of law on the Moon. Article III provides: “States Parties to the Treaty shall carry on activities . . . in the interest of maintaining international peace and security and promoting international co-operation and understanding.”<sup>495</sup> Establishing an independent lunar court promotes the rule of law on the Moon and is “in the interest of maintaining international peace and security.” A court that imports from Earth equality and justice to the Moon “promot[es] international co-operation and understanding.”

Article IV of the OST further permits and promotes a court on the Moon: “The use of any equipment or *facility* necessary for peaceful exploration of the moon and other celestial bodies shall also not be prohibited.”<sup>496</sup> There is little need to rehearse the indispensability of an independent and fair court in keeping peace and order. When there are thousands of people working in a dangerous and extremely stressful environment, we cannot assume the absence of disputes. Placing the nearest court of law 240,000 miles away from the venue encourages disorderly conduct and does little to deter criminal acts. Hence, a lunar court is a “facility necessary for peaceful exploration of the moon . . . [that] shall . . . not be prohibited.”

Article VI of the OST further strengthens the legality of a lunar court:

States Parties . . . bear international responsibility for national activities in outer space, including the moon . . . , whether such activities are carried on by governmental agencies or by non-governmental entities, and for *assuring that national activities are carried out in conformity with the provisions* set forth in the present Treaty.<sup>497</sup>

---

<sup>494</sup> See *id.*; Hardenstein, *supra* note 16, at 266.

<sup>495</sup> Outer Space Treaty, *supra* note 51, art. III.

<sup>496</sup> *Id.* art. IV (emphasis added).

<sup>497</sup> *Id.* art. VI (emphasis added).



The Treaty explicitly requires the United States to regulate the activities of its nationals on the Moon. Regulation of conduct requires a system of justice that may promote law and order. Thus, the OST quite obviously contemplates and allows for a justice system on the Moon for regulating the conduct of individuals. A court on the Moon that would “assur[e] that national activities are carried out in conformity with the provisions set forth” pursuant to Article VI of the OST.

Perhaps most importantly, Article VIII says: “A State Party to the Treaty on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object, and over any personnel thereof, while in outer space or on a celestial body.”<sup>498</sup> To “retain jurisdiction and control” over objects and persons on the Moon would be impracticable without an enforcement mechanism on the Moon with the necessary attendant adjudicatory body. Especially as the lunar population grows and transactions on the Moon become more complicated, retaining jurisdiction and control from 240,000 miles away will be rendered increasingly difficult. Hence, establishing a federal court on the Moon is pursuant to the rights of state parties to retain jurisdiction and control as explicitly delineated by Article VIII.

Looking at the Moon Agreement is helpful as it represents a very stringent interpretation of the OST, decreasing the latitude of the spacefaring nation as much as possible. Indeed, only eighteen nations ratified it and four signed it, none of them being capable of space flight.<sup>499</sup> The provision that parties establish an international regime with plenary power to regulate human activities on the Moon was likely the source of its failure.<sup>500</sup> At any rate, even the Moon Agreement provides: “States Parties may pursue their activities in the exploration and use of the moon anywhere on or below its surface . . . [and] [p]lace their personnel, space vehicles, equipment, facilities, stations and installations anywhere on or below the surface of the moon.”<sup>501</sup> Additionally, “States Parties may establish manned and unmanned stations on the moon.”<sup>502</sup> A lunar court, being a facility or a station with personnel, may be installed on the Moon—

---

<sup>498</sup> *Id.* art. VIII.

<sup>499</sup> UNOOSA, *supra* note 289; see Wessel, *supra* note 16, at 293.

<sup>500</sup> Moon Agreement, *supra* note 314, art. 11(5)–(7); Wessel, *supra* note 16, at 293.

<sup>501</sup> Moon Agreement, *supra* note 314, art. 8.

<sup>502</sup> *Id.* art. 9.

even the Moon Agreement says such actions do not amount to national appropriation.

C. THE PRESCRIPTIVE JURISDICTION OF THE U.S. CONGRESS ON THE MOON

Next, could the United States assert prescriptive (legislative) and adjudicatory jurisdiction over U.S. nationals, non-U.S. nationals, and U.S. property on the Moon? On its face, the proposition seems to face many legal hurdles. Usually, territoriality is the foremost justification for legislative jurisdiction, especially in common law; a person or property's physical presence within the borders of a court's jurisdiction endows it with the power to bring it under its domestic laws. A nation also may not ordinarily legislate extraterritorially or internationally.<sup>503</sup> Furthermore, establishing jurisdiction based on territorial claims over lunar land would be a straightforward violation of Article II of the OST.<sup>504</sup> For if annexation of the territory is not national appropriation, what is? Territorial justification in the lunar context conflicts with the non-appropriation clauses of the OST.

However, sovereignty/territory is a bundle of a state's prerogatives; the concept of quasi-territory is an expression of this understanding and has been used elsewhere in law to justify state actions such as extraterritorial taxation or criminal prosecution.<sup>505</sup> It is then well-established state practice to assert prescriptive jurisdiction (therefore, limited sovereign prerogative) over "territory" over which the state has no full territorial sovereignty.

High seas, or international waters, are also not open to appropriation by claim of sovereignty.<sup>506</sup> It is true that, under UNCLOS, state parties may explore and recover sea resources.<sup>507</sup> However, even under international customary law that forbids national appropriation of the high seas, the United States, which is not a party to UNCLOS, claims exclusive mining rights and installs semi-permanent and permanent oil rigs *legally under international law*. Because these permanent and semi-permanent oil rigs are installments but also ships flying the flag of the nation, the so-called flag jurisdiction applies.<sup>508</sup> Not the ocean

<sup>503</sup> See Steer, *supra* note 315, at 4.

<sup>504</sup> See Outer Space Treaty, *supra* note 51, art. II.

<sup>505</sup> Stacey L. Lowder, *A State's International Legal Role: From the Earth to the Moon*, 7 TULSA J. COMPAR. & INT'L L. 253, 260-61 (1999).

<sup>506</sup> See discussion *supra* Section V.E.

<sup>507</sup> See discussion *supra* Section V.E.

<sup>508</sup> See discussion *supra* Section V.E.

floor underneath the floors, but the vessel or installation itself becomes a territory of sorts—a quasi-territory. What is important is a state's ability to bind its laws on the individuals and semi-moveable property, not on the immovable property on which they sit.<sup>509</sup>

Lunar bases are similarly semi-permanent fixtures that “fly” the American flag. They are spacecraft in outer space that are registered in the United States. If there is no claim to the land on which these objects sit, an exercise of prescriptive jurisdiction to a lunar base is consistent with the OST and preceded in the law of the sea. Indeed, as discussed above, several provisions of the OST are consistent with the physical placement of a lunar judiciary.

Space law treaties as controlling *lex specialis* also provide ample avenues for the United States to legislate, binding foreign persons and objects on the Moon. The Registration Convention requires every launched object to be registered to a “launching state's” registry.<sup>510</sup>

Soon the United States will likely possess heretofore unprecedented technopolitical dominance on the lunar surface. The United States may simply choose to enter into a bilateral or multilateral agreement with partner states to acquire jurisdiction, as it did in Article 22 of the 1988 IGA. The Artemis Accords is one such example where the concept of “safety zones” provides ample means of jurisdictional assertion.<sup>511</sup>

Although Starship likely will be the only commercial transportation to the Moon in the near and foreseeable future, it is certainly conceivable that other space superpowers like China and Russia would fashion their own fully reusable launch vehicle.<sup>512</sup> Would U.S. federal lunar law extend to vehicles and persons not registered to the United States and not on the Moon pursuant to some agreement that gives the United States jurisdiction? I believe there is enough ground to do so under the effects doctrine and the safety zone jurisdiction.<sup>513</sup>

---

<sup>509</sup> See Yun Zhao, *Law Related to Intellectual Property and Transfer of Technology*, in ROUTLEDGE HANDBOOK OF SPACE LAW 321, 327 (Ram Jakhu & Paul Stephen Dempsey eds., 2017).

<sup>510</sup> See discussion *supra* Section V.B.

<sup>511</sup> See discussion *supra* Section V.A.

<sup>512</sup> See discussion *supra* Section V.A.

<sup>513</sup> See discussion *supra* Section V.A.

D. THE ADJUDICATORY JURISDICTION OF THE U.S. LUNAR COURT

This Article provides, using established U.S. procedural law, the legal foundation for the U.S. Lunar Court's general and specific personal jurisdiction (whether the court in question can issue a binding judgment over a litigant) over domestic and foreign individuals and properties on the Moon, and proposes legislation to endow the U.S. Lunar Court with adequate subject matter jurisdiction (whether the court in question is empowered and competent to rule on the issue or controversy at hand).

A matter common to the discussion below must first be addressed: the question of, yet again, territory. The legal discourse of personal jurisdiction makes use of the "forum state" or the state in which the forum, i.e., the court at issue, is physically located.<sup>514</sup> For instance, as will be detailed below, whether a litigant lives in the forum state is an important factor in the analysis of personal jurisdiction. This is deeply problematic for the Lunar Court as there can be no state, or any territory for that matter, on the Moon.<sup>515</sup> Hence, this Article proposes the use of a "forum zone," an extension of the "safety zone," instead of a "forum state."

It is obvious that "forum state" cannot be used as it wrongly implies the illegal assertion of territorial sovereignty over a piece of lunar land. But as discussed previously, the prescriptive jurisdiction over persons and properties on the Moon need not be based on territorial sovereignty, and at least three avenues for congressional lunar jurisdiction were identified.<sup>516</sup> Thus, in the lunar context, there is no reason to adhere to the ill-sounding term "state," which has all the wrong implications.

Moreover, a lunar settlement likely will be physically or operationally interconnected modules, similar to the *ISS*. This network of modules would constitute a safety zone. Then, rather than an enclosed boundary line defining jurisdiction, the adaptive and flexible conception of "connection" could define the jurisdictional boundary. This change of conception allows for a functional and totality-of-the-circumstances, on-the-ground analysis of jurisdictional reach.

---

<sup>514</sup> See, e.g., *Daimler AG v. Bauman*, 571 U.S. 117, 137–39 (2014); *Goodyear Dunlop Tires Operations, S.A. v. Brown*, 564 U.S. 915, 919 (2011).

<sup>515</sup> See discussion *supra* Section V.A.

<sup>516</sup> See discussion *supra* Section V.D.

Although the specific application of this approach would have to wait for the actual developments on the Moon, certain factors could be analyzed a priori. The physical connection would be a strong factor in favor of the jurisdictional reach; meaning, modules that are physically connected to the module housing the governing bodies would seem to indicate the presence of jurisdiction. The functional connection would be another strong factor in favor of jurisdiction. Modules that are not connected physically may still depend on each other for essential operations, such as the supply of breathable air, water, food, transportation, power, communication, and so on. There may be other on-the-ground factors like whether there is a lot of traffic between the modules, information exchange, and so on.

### 1. *General Personal Jurisdiction*

General personal jurisdiction is an unlimited, all-purpose power of the court for issuing a judgment that binds litigants.<sup>517</sup> To put it differently, even if the transaction at issue transpired outside the forum state, the court with general personal jurisdiction over the litigant may issue binding judgments. General jurisdiction is unlimited in the sense that the defendant's actions are irrelevant.<sup>518</sup>

The easiest way for the Lunar Court to find the basis for asserting personal jurisdiction, however, is by having every individual going to the Moon onboard Starship consent to the jurisdiction of the Lunar Court. "[B]ecause the personal jurisdiction requirement is a waivable right, there are a 'variety of legal arrangements' by which a litigant may give 'express or implied consent to the personal jurisdiction of the court.'"<sup>519</sup> However, this method only applies to the near future where Starship is the sole commercial means of lunar transport. A more general base of jurisdictional assertion would be preferable.

For that, this Article looks to the traditional test as to whether a court may exercise jurisdiction over a defendant as to any claim. For example, the exercise of general jurisdiction looks at whether the defendant is domiciled in the forum state or, in legal parlance, whether the defendant is "at home."<sup>520</sup> A person

---

<sup>517</sup> *Daimler*, 571 U.S. at 137–39; *Goodyear*, 564 U.S. at 919.

<sup>518</sup> See Stephen E. Sachs, *The Unlimited Jurisdiction of the Federal Courts*, 106 VA. L. REV. 1703, *passim* (2020).

<sup>519</sup> *Burger King Corp. v. Rudzewicz*, 471 U.S. 462, 472 n.14 (1985) (quoting *Ins. Corp. of Ir. v. Compagnie des Bauxites de Guinee*, 456 U.S. 694, 703 (1982)).

<sup>520</sup> *Daimler*, 571 U.S. at 127; *Goodyear*, 564 U.S. at 919.

is domiciled in the forum state if he or she resides there with the intent to remain indefinitely or make it his or her home.<sup>521</sup> A corporation is “at home” or “domiciled” in a forum state if it is incorporated under the law of the state or headquartered there.<sup>522</sup>

In the lunar context, however, it is too early to conceive of the traditional notion of domicile for both natural and artificial persons. At least in the initial stages of the lunar settlement, it is difficult to imagine a person going to the Moon to stay there indefinitely. It is unclear if that will even be allowed by the government as the health effects of the high-radiation, low-gravity environment of the Moon is yet to be tested, and the government has an interest in ensuring the safety of its citizens. Moreover, for a corporation to incorporate, there must be a developed body of lunar law, which we cannot know a priori how it would be. Lastly, a Moon-based corporation, i.e., a corporation headquartered on the Moon, seems even further down the future.

But this Article is concerned with the near and foreseeable future, the early lunar settlement that Starship is very likely to enable. Indeed, whether a defendant is at home or domiciled is a special case of a more general doctrine: namely, whether a continuous and systematic contact with the forum renders the defendant essentially at home in the forum state.<sup>523</sup> For lunar purposes, we alter the language as proposed above: whether a lunar court may exercise general jurisdiction over a defendant is a function of whether a continuous and systematic contact with the forum renders the defendant essentially at home in the forum zone. It is difficult to say a priori what a continuous and systematic contact would look like on the Moon—a contact based on which enabling general jurisdiction “does not offend ‘traditional notions of fair play and substantial justice.’”<sup>524</sup> However, the concept of a “forum zone” proves itself useful here as the flexibility latent in the notion of a “zone”—ambiguous, at any rate—compared to the concrete notion of a territorial boundary. This allows for a flexible consideration of factors that the Supreme Court instructed courts to apply in determining

---

<sup>521</sup> *Daimler*, 571 U.S. at 137; *Sonera Holding B.V. v. Cukurova Holding A.S.*, 750 F.3d 221, 225 (2d Cir. 2014).

<sup>522</sup> *Daimler*, 571 U.S. at 137–39; *Martinez v. Aero Caribbean*, 764 F.3d 1062, 1070 (9th Cir. 2014).

<sup>523</sup> *See Daimler*, 571 U.S. at 126–27.

<sup>524</sup> *Int’l Shoe Co. v. Washington*, 326 U.S. 310, 316 (1945) (quoting *Milliken v. Meyer*, 311 U.S. 457, 463 (1940)).

the existence of general jurisdiction: continuous and systematic contact with the forum zone; and whether the suit thusly commenced offends the traditional notions of fair play and substantial justice in light of the unique lunar context.<sup>525</sup>

The exercise of personal jurisdiction, however, also requires a substantive body of law that enables the court's arm to grab onto the defendant.<sup>526</sup> As Congress would have prescriptive jurisdiction over a lunar system, it would have to pass a Lunar long-arm statute that empowers the Lunar Court to exercise personal jurisdiction. This provision can be short and simple, leaving the specifics to natural development through the common law process:

**Lunar Long-Arm Statute**

Jurisdiction Exercisable

A U.S. Lunar Court may exercise jurisdiction on any basis not inconsistent with the U.S. Constitution and the laws of the lunar zones enacted by Congress.<sup>527</sup>

2. *Specific Personal Jurisdiction*

A more common form of personal jurisdiction, in contrast to general jurisdiction, is specific personal jurisdiction—where the bases of exercising personal jurisdiction arise from the defendant's specific contact with the forum state as it relates to the plaintiff's causes of action, i.e., transactions that form the basis of the complaint.<sup>528</sup> Specific jurisdiction relies on an "activity or an occurrence that takes place in the forum State and is therefore subject to the State's regulation."<sup>529</sup>

Whether an activity or occurrence "takes place" in the forum state is broadly and functionally construed and tested under the "purposeful availment" test: this looks at whether the foreign defendant purposefully directed its activities at residents of the forum, whether the litigation arises out of those activities, and whether the defendant purposefully availed himself or herself of

---

<sup>525</sup> *See id.*

<sup>526</sup> *See Daimler*, 571 U.S. at 125.

<sup>527</sup> Based on California's long-arm statute. CAL. CIV. PROC. CODE § 410.10 ("A court of this state may exercise jurisdiction on any basis not inconsistent with the Constitution of this state or of the United States.").

<sup>528</sup> *Daimler*, 571 U.S. at 127–29; *Walden v. Fiore*, 571 U.S. 277, 283–85 (2014); Donald L. Doernberg, *Resolving International Shoe*, 2 TEX. A&M L. REV. 247, 290 (2014).

<sup>529</sup> *Goodyear Dunlop Tires Operations, S.A. v. Brown*, 564 U.S. 915, 919 (2011).

privileges of the forum state's law, thus subjecting himself or herself to the forum law.<sup>530</sup> But the court's exercise of specific personal jurisdiction must still meet the constitutional muster—it must be consistent with the traditional understanding of “fair play and substantial justice.”<sup>531</sup>

Imagine different systems on the Moon, where they have traffic in between them but no requisite interdependence to deem them as forming a single system. This situation is not unlike where the defendant's activity in, say, Florida injures the plaintiff in California. The question is whether the plaintiff can force the defendant to defend himself or herself in the California court, i.e., whether the California court may exercise specific jurisdiction over the Florida defendant over the conduct that forms the basis of the suit. There is an overflowing amount of case law and commentary regarding similar situations that were litigated in the United States. That depository of precedent and knowledge would be helpful as the lunar courts wrestle with the question of whether they can bring a foreign national under their jurisdiction in a foreign system.

### 3. *Subject Matter Jurisdiction*

“[S]ubject matter jurisdiction ‘refers to a tribunal's power to hear a case, a matter that can never be forfeited or waived.’”<sup>532</sup> When a suit is filed, the plaintiff complains to the court that an action by the defendant caused harm. Then the plaintiff alleges that the defendant's action was illegal under a statute or common law (raising an issue) and that the court is empowered to adjudicate on that issue. Subject matter jurisdiction refers to whether the court is empowered to adjudicate the issue at hand, and it cannot be consented to or waived by the parties because subject matter jurisdiction is a constitutional and statutory grant and requirement.<sup>533</sup>

The constitutional source is the following: “The judicial Power shall extend to all Cases, in Law and Equity, arising under

---

<sup>530</sup> *Burger King Corp. v. Rudzewicz*, 471 U.S. 462, 472–73 (1985).

<sup>531</sup> *Id.* at 476 (quoting *Int'l Shoe Co. v. Washington*, 326 U.S. 310, 320 (1945)).

<sup>532</sup> *Adkison v. Comm'r*, 592 F.3d 1050, 1055 (9th Cir. 2010) (quoting *Union Pac. R.R. v. Bhd. of Locomotive Eng'rs & Trainmen Gen. Comm. of Adjustment*, 558 U.S. 67, 81 (2009)).

<sup>533</sup> *Ins. Corp. of Ir. v. Compagnie des Bauxites de Guinee*, 456 U.S. 694, 702 (1982).



this Constitution, the Laws of the United States, and Treaties made, or which shall be made, under their Authority.”<sup>534</sup>

Two statutes empower federal district courts. First, 28 U.S.C. § 1331 confers to U.S. district courts federal question jurisdiction—“original jurisdiction of all civil actions arising under the Constitution, laws, or treaties of the United States.”<sup>535</sup> Second, 28 U.S.C. § 1332 gives district courts subject matter jurisdiction through diversity jurisdiction over non-federal, i.e., state law cases, if there is complete diversity among the parties and the amount in controversy exceeds \$75,000.<sup>536</sup>

In the same vein, a federal statute would need to confer subject matter jurisdiction to the Lunar Court. This law may be as simple as 28 U.S.C. § 1331, which is one sentence long. Something like:

**28 U.S.C. § XXXX – Lunar Jurisdiction**

The U.S. Lunar Courts shall have original jurisdiction of all civil actions arising under the Constitution, laws, or treaties of the United States and exclusive jurisdiction of all civil and criminal actions arising under the laws of the Moon of the United States.

The first clause mimics 28 U.S.C. § 1331 verbatim. The second clause confers the Lunar Courts exclusive subject matter jurisdiction over cases and controversies arising under the laws of the Moon adopted by Congress, sitting as a lunar legislature as it sits as the District of Columbia legislature.

E. THE TYPOLOGY OF A LUNAR COURT

No piece of lunar real estate should be understood as a territory of a terrestrial government, but space objects on the lunar surface may be quasi-territories of the United States. Here, Congress has ample means, pursuant to the OST, Registration Convention, and other pertinent international law, to legislate and confer adjudicatory jurisdiction to the U.S. Lunar Court. Now that the policy considerations and legality of the United States’ prescriptive and adjudicatory jurisdiction have been considered, I address what kind of court the U.S. Lunar Court could or should be under U.S. law.

There are very different types of tribunals possible under the U.S. Constitution: Article I legislative courts, Article III judiciary

---

<sup>534</sup> U.S. CONST. art. III, § 2.

<sup>535</sup> 28 U.S.C. § 1331.

<sup>536</sup> 28 U.S.C. § 1332.

courts,<sup>537</sup> and Article IV territorial courts. The Lunar Court cannot be a territorial court under Article IV because the Moon cannot make up territory under the OST. Territorial courts sometimes are federal courts with a state-court-like general jurisdiction.<sup>538</sup> But as the United States may not claim any part of the Moon as its territory, territorial courts do not fit the bill. So, an Article IV tribunal is completely out of the picture. Article III U.S. district courts, on the other hand, are courts of limited jurisdiction that may hear only cases arising under federal law or based on diversity of citizenship. This is too limited for a lunar court, which needs a state-court-like general jurisdiction to hear tort and contract cases. Agency courts, unable to hear general common law cases, are also problematic. Lunar courts would need to hear cases arising from common law, such as contract and tort cases and criminal cases, as the civilian population grows on the Moon and business transactions get increasingly complex, i.e., as the lunar civil society matures. So, it seems the Lunar Court must be a hybrid court formed under both Articles I and III—simultaneously a court of general jurisdiction like state trial courts but with the full powers of the federal district court.

Imbuing the Lunar Court formed under Article I with Article III powers, many constitutional challenges would be preempted because Article I courts may not hear common law causes of action.<sup>539</sup> Article I courts may apply authoritative constitutional

---

<sup>537</sup> James E. Pfander, *Article I Tribunals, Article III Courts, and the Judicial Power of the United States*, 118 HARV. L. REV. 643, 650 (2004) (“Just as Article III mandates a hierarchical judicial department with a single superior court, the constitutional requirements of supremacy and inferiority establish an important limit on the power of Congress to establish Article I tribunals. The Inferior Tribunals Clause of Article I expressly empowers Congress to ‘constitute’ such tribunals, but it qualifies the grant of power by mandating that any such tribunals be ‘inferior to the [S]upreme Court.’ The Clause requires more than inferiority in the abstract; it requires concrete inferiority in relationship to the Supreme Court. This subjects inferior tribunals to the oversight of the Supreme Court and requires them to give effect to supreme federal law. The complementary texts of Article III and Article I, in short, establish a firm rule: all tribunals that Congress constitutes, including both Article III courts and Article I tribunals, must remain inferior to the Supreme Court.”).

<sup>538</sup> *Territorial Courts in the Federal Judiciary*, U.S. CTS., [https://web.archive.org/web/20141020154533/https://www.uscourts.gov/news/TheThirdBranch/11-02-01/Territorial\\_Courts\\_in\\_the\\_Federal\\_Judiciary.aspx](https://web.archive.org/web/20141020154533/https://www.uscourts.gov/news/TheThirdBranch/11-02-01/Territorial_Courts_in_the_Federal_Judiciary.aspx) [https://perma.cc/JCM6-GTYT].

<sup>539</sup> *N. Pipeline Constr. Co. v. Marathon Pipe Line Co.*, 458 U.S. 50, 80–81 (1982).

precedents, but they may not develop new ones.<sup>540</sup> Precedent-setting authority is needed for the U.S. Lunar Court to spread civil liberties and constitutional rights to the Moon.

Consider an analogous precedent: the U.S. District Court for the District of Columbia used to be fully Article I and fully Article III.<sup>541</sup> This should be a model for the U.S. Lunar Courts.<sup>542</sup> The U.S. Congress is the local legislature for D.C., enacting criminal laws for the capital.<sup>543</sup> The Reform Act of 1970 made the Superior Court the local court of D.C. and stripped the D.C. District Court of its general jurisdiction.<sup>544</sup> Now its relationship with the Superior Court parallels that between federal district courts and state courts.<sup>545</sup> But before 1963, the federal district court in D.C. assumed the roles of both a federal and local court.<sup>546</sup> This made D.C. federal district courts a duality: fully constitutional and fully local.

## VIII. CONCLUSION

Massive, commercial U.S. ventures on the Moon will mark a new era in the history of law, where the law lands on a celestial body for the first time in human history. But as the history of prospective space legislation shows and prudence dictates, the law must land before people. Now the next lunar missions are just around the corner, and the likelihood of economic and scalable Earth–Moon transportation infrastructure (e.g., Starship) should be taken seriously. This Article was a first attempt in envisioning and preparing for the likely impending future where hundreds, if not thousands, of commercial actors are engaged in complicated transactions on the lunar surface. There need to be regulations, laws, and governing bodies. This Article described and argued that the extension of U.S. federal jurisdiction and installation of governing bodies on the Moon are

---

<sup>540</sup> See Pfander, *supra* note 537, at 686.

<sup>541</sup> See Theodore Voorhees, *The District of Columbia Courts: A Judicial Anomaly*, 29 CATH. U. L. REV. 917 (1980).

<sup>542</sup> U.S. military courts would not serve us here because they are created under Article I, Section 8, which gives Congress the power to “make Rules for the Government and Regulation of the land and naval Forces.” U.S. CONST. art. I, § 8, cl. 14.

<sup>543</sup> *Metro. R.R. v. District of Columbia*, 132 U.S. 1, 16 (1889).

<sup>544</sup> See District of Columbia Court Reform and Criminal Procedure Act of 1970, § 11-901, 84 Stat. 473, 482.

<sup>545</sup> See *id.*

<sup>546</sup> *History of the DC Courts*, D.C. Cts., <https://www.dccourts.gov/about/history-dccourts> [<https://perma.cc/E3ZN-EEPC>].

consistent with every binding international agreement. This Article sketched out the legal contours of one such governing body: the U.S. Lunar Court. I hope this Article brings excitement and awareness to the legal community of the equally exciting and somewhat unnerving future that is quickly approaching us.

**APPENDIX—DATA, METHODOLOGY, AND FULL RESULTS OF THE  
STARSHIP DEVELOPMENT TIMELINE AND STARSHIP  
CAPACITY PROJECTION**

**FALCON 9 HISTORICAL DATA**

SpaceX started developing Falcon 9 in 2006. Six years later in 2012, Falcon 9 delivered cargo to the *ISS* for the first time. Using Falcon 9's publicly available historical data (Table 1), regression analysis, and SpaceX's media releases regarding its plans for Starship, this Article will attempt to predict the expected timeline for Starship's development and capabilities.

SpaceX first demonstrated the suborbital vertical landing of the Falcon 9 booster in 2012. Three years later in 2015, SpaceX demonstrated an orbital vertical landing. Two years later in 2017, SpaceX began reflighting landed boosters. Reused boosters represented 28% of launches in 2017, 57% in 2018, 69% in 2019, and 81% in 2020.

Years	Timeline
2002	SpaceX founded <sup>1</sup>
2006	Start of the Falcon 9 development <sup>2</sup>
2012	Falcon 9 delivers cargo to the ISS <sup>3</sup>
2015	First booster landing <sup>4</sup>
2018	Start of the Starship development <sup>5</sup>
2020	First human flight on the Falcon 9 <sup>6</sup>

**Table 1 — A Brief History of Falcon 9.**<sup>7</sup>

<sup>1</sup> SPACEX, <https://www.spacex.com/> [<https://perma.cc/K2F4-TN6F>].

<sup>2</sup> *Space Launch Report: SpaceX Falcon 9 Data Sheet*, NASA, <https://sma.nasa.gov/LaunchVehicle/assets/spacex-falcon-9-data-sheet.pdf> [<https://perma.cc/M87W-3XHS>] (May 1, 2017).

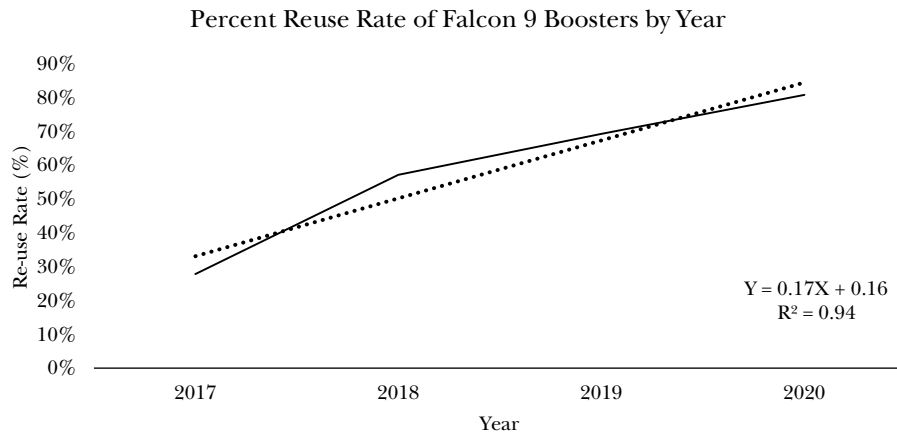
<sup>3</sup> Press Release, NASA, First Contracted SpaceX Resupply Mission Launches with NASA Cargo to Space Station (Oct. 7, 2012), [https://www.nasa.gov/home/hqnews/2012/oct/HQ\\_12-355\\_SpaceX\\_CRS-1\\_Launch.html](https://www.nasa.gov/home/hqnews/2012/oct/HQ_12-355_SpaceX_CRS-1_Launch.html) [<https://perma.cc/8FX2-HVPB>].

<sup>4</sup> Keith Wagstaff & Devin Coldewey, *SpaceX Makes History: Falcon 9 Launches, Lands Vertically*, NBC, <https://www.nbcnews.com/tech/innovation/spacex-makes-history-successfully-launches-lands-falcon-9-rocket-n483921> [<https://perma.cc/MC4J-5G3V>] (Dec. 22, 2015, 4:11 AM).

<sup>5</sup> *Elon Musk Renames His BFR Spacecraft Starship*, BBC (Nov. 20, 2018), <https://www.bbc.com/news/business-46274158> [<https://perma.cc/6KES-AMBJ>].

<sup>6</sup> Mike Wall, *With SpaceX's First Astronaut Launch, a New Era of Human Spaceflight Has Dawned*, SPACE.COM, <https://www.space.com/spacex-astronaut-launch-new-spaceflight-era.html> [<https://perma.cc/P3F5-W4QL>] (May 31, 2020).

<sup>7</sup> *Falcon's User Guide*, SPACEX (Sept. 2021), <https://www.spacex.com/media/falcon-users-guide-2021-09.pdf> [<https://perma.cc/2MK6-T5Z4>].



**Figure 2 — Percent Actual Reuse Rate of Falcon 9 Boosters by Year from 2017–2020 and Simple Linear Regression Model Building.**

The dashed line represents the fitted linear regression model ( $Y = \beta_0 + \beta_1 X$ ) to the Falcon 9's booster reuse historical data.  $\beta_0$ : 0.16.  $\beta_1$ : 0.17. Coefficient of Determination ( $R^2$ ): 0.94.

SpaceX's Falcon 9 production capacity—the number of rockets that SpaceX can produce each year—is not publicly available.<sup>8</sup> However, the yearly number of flights of new Falcon 9s is the floor for the yearly Falcon 9 production capacity. So, Falcon 9's flight capacity—the number of flights per year—is used to approximate the production capacity. SpaceX produced as many Falcon 9s as it flew them when no Falcon 9 was reflown. The resulting Falcon 9 production capacity is a conservative estimate considering that a SpaceX executive said in 2015 that SpaceX could produce one Falcon 9 every two weeks.

<sup>8</sup> This is in fact an underestimate of the production capacity.

<b>Year</b>	<b>Total Number of Falcon 9 Launches Per Year<sup>9</sup></b>
2010	2
2011	0
2012	2
2013	3
2014	6
2015	7
2016	8
2017	18
2018	21
2019	13
2020	26
2021	35

**Figure 3 — Total Number of Falcon 9 Launches Per Year.**

From 2010 to 2016, SpaceX increased Falcon 9's rate of vehicle production by 30.16% yearly on average (Figure 3). Data from 2017 to 2020 includes Falcon 9's launches by new and reused vehicles (Figure 3). Thus, the flight capacity from 2017 onward becomes an unreliable estimation of the production capacity of Falcon 9. Data from 2017 to 2020 is omitted in calculating the rate of increase in production capacity (30.16%) of Falcon 9.

SpaceX has prepared Falcon 9 for human spaceflight. In 2020, SpaceX launched astronauts to the *ISS* on its Dragon 2 capsule atop Falcon 9. It took SpaceX nine years to develop Dragon 2 and human-rate (through NASA) Falcon 9. Three Dragon 2 capsules were launched in 2020 out of twenty-six total Falcon 9 launches; that is, about 12% of the launches were human-rated in 2020, the first year of Falcon 9's human spaceflight. Using the historical Falcon 9 data, we can model Starship's expected development timeline and capabilities.

---

<sup>9</sup> *Falcon 9*, SPACE X, <https://www.spacex.com/vehicles/falcon-9/> [<https://perma.cc/3K5Y-PWLY>]; SPACE X STATS, <https://www.spacexstats.xyz/#upcoming-next> [<https://perma.cc/GBX5-HD92>].



## METHODS

Starship is expected to become gradually more reused just like Falcon 9. To model Starship's reuse rate, a linear regression model (Figure 2) for Falcon 9's historical reuse rate is fitted.

$$S = 0.17Y + 0.16 \text{ Eq. 1.}$$

*S*: Starship's booster reuse rate, *Y*: *n*<sup>th</sup> year of booster reuse.  
SpaceX's predicted production capacity of Starship (how many Starships SpaceX can produce each year) is based on the historical data from 2010 to 2016 of Falcon 9's production capacity.

$$PC_n = 1.30(PC_{n-1}) \text{ Eq. 2.}$$

*PC<sub>n</sub>*: Production Capacity of Starship.

*n*: the year where *n* = 1 is when Starship production starts.

For a robust estimation of Starship's flight capacity (total number of Starship flights in a year), we assume that Starships produced in a year will only be reflown in that year and will not be reflown in subsequent years because there is no available data on how many years a Starship vehicle can last.

Starship's anticipated flight capacity when vehicles start getting reused can be modeled as follows:

$$FC_n = PC_n + PC_n \times R \text{ Eq. 3.1.}$$

*FC<sub>n</sub>*: Flight Capacity of Starship; *R*: Reuse Rate of Starship.

When a vehicle's reuse rate is 0%, flight capacity equals its production capacity because every flying vehicle is a new, single-use article. However, when the reuse rate is greater than 0%, the flight capacity is greater than the production capacity. For instance, if the production capacity of Starship is 10 with the reuse rate of 30%, the flight capacity of Starship will be 13 that year.

Eq. 3.1. assumes that the vehicle can only be reused once. If Starship can be reused not just once in a year, but many times in a year depending on the turnaround time (how long it takes to refurbish a flown vehicle to make it flight-ready again) of the vehicle, we can further modify Eq. 3.1. to reflect this change.

$$FC_n = PC_n + PC_n \times R \times N_{\text{reflight}} \text{ Eq. 3.2.}$$

*N<sub>reflight</sub>* (Number of Reflights of a Starship Per Year) = 12/Turnaround Time of Starship in Months.

For instance, if the turnaround time of a vehicle is less than 182 days (approximately six months), it may fly two times a year (fly once and reflly once again). Falcon 9 had a 120-day turnaround time in 2018, only a year after its first reuse. A 120-day (4-month) turnaround time means the capacity to fly 3 times per year. In 2020, four years after its first reflight, SpaceX achieved a turnaround time of twenty-seven days (approximately

one month) for Falcon 9. One month turnaround translates into twelve flights per year.

For example, if the production capacity of a Starship is ten and Starship has a reuse rate of 30% with a turnaround time of 30 days, the flight capacity will be  $10 + 10 \times 0.3 \times (12/1) = 46$ .

Similar to Falcon 9, Starship will ultimately be human-rated for lunar transportation. Human-rating Falcon 9 took nine years. When Falcon 9 started flying humans (in 2020), it launched three human-rated missions, which translates into 12% of all 26 launches in 2020. Assuming that a similar percentage of Starships would be human-rated nine years after its development, i.e., in 2027, the production capacity of human-rated Starship can be estimated as follows:

$$PC \text{ of Human-Rated Starship} = 0.12 \times PC, \text{ Eq. 4.}$$

Now we discuss Starship's predicted capabilities, i.e., tonnage. Each Starship is designed to carry at least 100 tons to LEO and the Moon.<sup>10</sup> Hence, we get a simple equation that the yearly tonnage of Starships is 100 tons times its flight capacity.

$$\text{Total Tonnage Per Year to LEO or the Moon (t/yr)} = 100 \times FC \text{ Eq. 5.}$$

The anticipated tonnage of a vehicle to LEO is ordinarily different than the tonnage to the Moon. The more fuel required to go from LEO to the Moon translates into less cargo. However, Starship is designed to be refueled in LEO, not unlike how fighter jets are refueled in midair. This would enable cargo in LEO to be taken to the Moon. Hence, for Starship, the anticipated tonnage to LEO is the anticipated tonnage to the Moon.

But what does the tonnage mean in terms of human transportation? Because the Moon is inhospitable to humans, significant infrastructure is required to support human life. This situation is not new, as the *ISS* enables humans to live and work in the vacuum of outer space. The *ISS* weighs 420 tons and can support up to 10 crew members. We use this data to estimate the weight of an overall system needed for a person on the Moon: 42 tons (420 tons divided by 10 people). Thus, Starship's lunar tonnage can be used to derive the number of people it can transport to the Moon each year.

---

<sup>10</sup> LEO cargo capacity of 100 tons means the Starship uses all of its fuel to put 100 tons to LEO. The additional fuel needed to go from LEO to the Moon, however, is expected to be supplied by orbital refueling. SpaceX and NASA are developing technology to mate two spacecraft in orbit to transfer fuel from one spacecraft to another.

***Number of Humans Transported to the Moon Per Year = Total Tonnage Per Year to the Moon x (1 person/42 tons) Eq. 6.***

In discussing Starship's capabilities, we also need to consider the cost-effectiveness of its production and flights to find out whether Starship will be economically viable. When the reuse rate of a launch system is zero, the cost of manufacturing approximates the cost of launch. The dollar per kilogram to LEO (\$/kg-LEO) can be calculated by dividing the per-launch cost by the cargo capacity (tonnage) in kilograms of the vehicle. The \$/kg-LEO of Starship when it is not reflown is, then, its cost of manufacturing divided by 100,000 kg.

Starship's cost of manufacturing is estimated using Falcon 9's cost of manufacturing and cargo capacity. Falcon 9 costs \$62 million and can carry 22.8 tons to LEO. We assume that the increase in the cost of manufacturing parallels the increase in the cargo capacity. Starship's manufacturing cost (MC) comes out to  $\$62,000,000 \times 100 / 22.8 = \$272,000,000$ . Then, Starship's dollar-per-kg cost to LEO can be calculated as:

$$\$/\text{kg-LEO} = \$272,000,000 / 100,000\text{kg} = \$2,720/\text{kg. Eq. 7.1.}$$

When Starship is reused, the overall launch cost is reduced. According to Elon Musk, the cost of launching a reused Falcon 9 is \$15 million, \$10 million of which is represented by the second stage. That puts service costs—inspecting, refurbishing, fueling, etc.—at around \$5 million. When Starship is reused, Eq. 7.1. needs to be modified to represent the cost savings when it starts reflighting:

$$\$/\text{kg-LEO} = \frac{(PC \times MC + N_{\text{Total Reflight}} \times SC \text{ Per Reflight})}{\text{Total Tonnage to LEO Per Year}} \quad \text{Eq. 7.2}$$

$$\text{Total Tonnage to LEO Per year} = \frac{\text{Number of Total Starship Flights}}{\text{Year}} \times 100 \text{ tons}$$

$N_{\text{Total Reflight}}$ : Total number of reflights in a given year.

When the reuse rate of Starships is 100%, the fixed cost of production is spread throughout so many reflights that it may be considered negligible, as is the case of airlines.

Starship's \$/kg-LEO at 100% Reuse Rate:

$$\frac{\text{Service Cost of 100\% Reusable Starships}}{\text{Total Tonnage to LEO Per Year}} \quad \text{Eq. 7.3.}$$

As mentioned previously, flights to the Moon would require orbital refueling. Thus, the service costs for launches to the Moon increase due to multiple launches required to transport fuel to LEO. We assume that the fuel Starship needs for lunar missions requires

three Starship flights to LEO. The \$/kg-Lunar is calculated by multiplying the \$/kg-LEO by four.

$$\$/\text{kg-Lunar } (L) = 4 \times \$/\text{kg-LEO} \quad \text{Eq. 7.4.}$$

### **STARSHIP'S PROJECTED DEVELOPMENT**

SpaceX started developing Starship in 2018. If Starship follows the developmental timeline of Falcon 9, Starship would be expected to deliver cargo to LEO by 2022. In 2021, Starship demonstrated suborbital landing. Starship's orbital vertical landing is then expected to be in 2024, and its first year of reuse is expected to be in 2026.

Figures 4a and 4b demonstrate the yearly projections of cargo-only Starship and human-rated Starship development, respectively, based on Falcon 9's historical data. In the year 2030, SpaceX is expected to reach a yearly production capacity of 112 Starships with a flight capacity of 1,340, assuming 100% reusability of the vehicles. In 2030, \$/kg-LEO may be lowered to approximately \$50 (or \$20 according to Elon Musk).

In 2027, nine years after Starship's development began, we project that the first human-rated Starship will fly humans to the Moon. In 2030, we project that thirteen human-rated Starships will send 397 people to the Moon.

**a. Yearly Projections of Cargo-Only Starship**

Year	PC <sup>11</sup>	FC	Reuse Rate (%)	Tons to LEO <sup>12</sup>	\$/kg-LEO
2020	8	—	—	—	—
2021	10	—	—	—	—
2022	14	14	0	1,400	\$2,720 <sup>13</sup>
2023	18	18	0	1,800	\$2,720
2024	23	23	0	2,300	\$2,720
2025	30	30	0	3,000	\$2,720
2026	39	52 <sup>14</sup>	33 <sup>15</sup>	5,200	\$2,047 <sup>16</sup>
2027	51	177 <sup>17</sup>	50	17,700	\$814
2028	66	287	67	28,700	\$663
2029	86	592	84	59,200	\$437
2030	112	1,451 <sup>18</sup>	100	145,100	\$50 <sup>19</sup>

**b. Yearly Projections of Human-Rated Starship to the Moon**

Year	PC <sup>20</sup>	FC	Tons to Moon <sup>21</sup>	\$/kg-L	People to Moon <sup>22</sup>	People on Moon	Total Freight Cost in Millions
2027	6 <sup>23</sup>	20 <sup>24</sup>	2,000	\$3,256 <sup>25</sup>	47	47	\$6,521
2028	8	33	3,300	\$2,653	78	125	\$8,754
2029	10	68	6,800	\$1,748	161	286	\$11,883
2030	13	167 <sup>26</sup>	16,700	\$200	397	683	\$3,340

**Figure 4 — Starship's projected development from 2020 to 2030**<sup>11</sup> Eq. 2.<sup>12</sup> Eq. 5.<sup>13</sup> Eq. 7.1.<sup>14</sup> Eq. 3.1.<sup>15</sup> Eq. 1.<sup>16</sup> Eq. 7.2.<sup>17</sup> Eq. 3.2.<sup>18</sup> Eq. 3.3.<sup>19</sup> Eq. 7.3.<sup>21</sup> Eq. 2.<sup>22</sup> Eq. 5.<sup>23</sup> Eq. 6.<sup>24</sup> Eq. 4.

## DISCUSSION

In 2027, it would cost \$6.5 billion and twenty Starship flights to transfer forty-seven people to the Moon 240,000 miles away along with the entire infrastructure to support them on the Moon. Compare this to the Space Shuttle, which costs \$500 million per launch,<sup>27</sup> and it took thirty-six Shuttle launches to build the *ISS* that supports six people at a time; this alone comes out to \$18 billion. Also NASA on average spent \$4 billion per year to station three Americans on the *ISS*. Compare that number to forty-seven people on the Moon for \$6.5 billion.

By 2030, when Starship matures its full reusability, it can deliver the infrastructure needed for 397 people for \$3.1 billion, which comes out to about \$7.75 million per person. Although still expensive, on the aerospace scale, this is stupendously cheap. It is for this projected economics of Starship that this article predicts that a new paradigm of space exploration is imminent. If the U.S. government had the will to spend \$4 billion per year to fund the *ISS*, where two to three Americans stay at a given time, imagine what it would do when it can send forty-seven people to the Moon for \$6.5 billion. In commercial terms, companies invest on average about \$650 million for an oil rig. Sending 400 people to the Moon for \$3.1 billion is squarely and securely within the cost range of the private sector. As such, SpaceX's Starship will finally allow for massive commercial activity on the Moon in the next few years.

---

<sup>25</sup> Eq. 3.2.

<sup>26</sup> Eq. 7.4.

<sup>27</sup> Eq. 3.3.