Michigan Journal of International Law

Volume 40 | Issue 1

2018

Space, the Final Frontier of Enterprise: Incentivizing Asteroid Mining Under a Revised International Framework

Jack Heise
University of Michigan Law School

SPACE, THE FINAL FRONTIER OF ENTERPRISE: INCENTIVIZING ASTEROID MINING UNDER A REVISED INTERNATIONAL FRAMEWORK

*Jack Heise**

INTRODUCTION

The Restaurant at the End of the Universe, a novel by Douglas Adams, describes a torture device called the Total Perspective Vortex. This virtual reality machine permits the being inside to grasp, for an instant, "the entire unimaginable infinity of creation" and their size within it, denoted by a "microscopic dot on a microscopic dot, which says 'You are here.' "[1] The resulting sense of insignificance and smallness has the power to completely annihilate a sentient being's brain.[2]

Humans occupy and harness the resources of a miniscule percentage of the known universe. Stated broadly, the exploration of the universe presents challenges of both physics and engineering. The former refers to limits based on our current understanding of physics: travel at or faster than the speed of light, for example, would violate the general theory of relativity.[3] The latter describes challenges with respect to building the instruments that do not defy the laws of physics and ought to be possible to create.

Asteroid mining—the extraction of raw materials from rocks in outer space—is a problem of engineering rather than physics. This endeavor both depends upon and tends to facilitate an increasingly robust industry of space exploration, tourism, and utilization of outer space resources–a collective group of business entities termed the "space economy."[4] Various studies

---

* Managing Notes Editor, Michigan Journal of International Law; J.D. Candidate, University of Michigan Law School, 2019. I would like to the thank the many editors at MJIL who worked on this piece for their thoughtful feedback and keen attention to detail. I would also like to thank my friends and roommates at Michigan Law, family, and girlfriend for their support throughout law school and the writing of this note: my universe would be cold and lonely without you.

1. Douglas Adams, The Restaurant at the End of the Universe 70 (1980).

2. *Id.* at 77.

3. Put plainly, this Theory posits that "as an object approaches the speed of light, its mass reaches infinity. So, in other words, a spacecraft couldn't physically go as fast as light." Elizabeth Howell, *Engage Warp Drive! Why Interstellar Travel's Harder Than It Looks*, SPACE.COM (May 7, 2018), https://www.space.com/40507-interstellar-space-travel-and-science-fiction.html.

4. *See* ORG. FOR ECON. CO-OPERATION AND DEV., THE SPACE ECONOMY AT A GLANCE 2007, at 13 (2007) (defining the space economy as: "All public and private actors

show asteroid mining to be possible and even financially lucrative.[5] Private sector companies are scrambling to tackle this challenge, with the goal of extracting water to be used in space to sustain life and used as propellant.[6] Because this propellant would be available in space, it ameliorates one challenge of space travel, which is the extraordinary cost associated with launching each pound of cargo. By removing the need to carry all fuel associated with the voyage at the point of launch, asteroid mining could dramatically reduce the cost of space travel.[7]

The existing international legal framework governing asteroid mining is a product of the Cold War era.[8] The Outer Space Treaty (the "OST") prohibits "national appropriation" of celestial objects like asteroids "by claim of sovereignty, by means of use or occupation, or by any other means."[9] A literal reading of this passage tends to prohibit the practice of asteroid mining. The OST does, however, posit that "the exploration and use of outer space for peaceful purposes" is in the common interest of all mankind.[10] While the terms of the OST prohibit asteroid mining, it is an endeavor that is wholly within the spirit of the treaty as a practice that tends to facilitate space travel.

This Note argues that the OST should be modified to provide explicit permission for private entities to engage in asteroid mining while maintaining the principles of international peace and cooperation that the treaty espouses as the core of the framework governing outer space. Part I explores the current state of asteroid mining with reference to the current objectives of companies conducting missions in this realm. Part II examines the OST as applied to the enterprise of asteroid mining by private companies. Part III considers the benefits and drawbacks of various regulatory schemes to govern asteroid mining. It argues for a solution based on the historical development of the whaling industry that retains the principles and international character of the OST while still incentivizing asteroid mining.

---

involved in developing and providing space-enabled products and services. It comprises a long value-added chain, starting with research and development actors and manufacturers of space hardware . . . and ending with the providers of space-enabled products . . . and services . . . to final users.").

5. *See, e.g.*, KECK INST. FOR SPACE STUDIES, ASTEROID RETRIEVAL FEASIBILITY STUDY (2012), http://kiss.caltech.edu/final_reports/Asteroid_final_report.pdf.

6. *See infra* Section I(a).

7. *See infra* Section I(c).

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

9. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies art. 2, Jan. 27, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205 [hereinafter Outer Space Treaty].

10. *Id.* pmbl.

I. The Who, What, How, and Why of Asteroid Mining

The premise of asteroid mining at first glance may not seem like it needs further explanation: the point is to extract material from big rocks in space. However, the nature of the actors involved in this endeavor warrants discussion given the difference between the spacefaring climate as the framers of the OST saw it and the present one. Moreover, the objective of asteroid mining companies—providing fuel and materials in space—tends to reduce costs associated with launch. Reduced launch costs facilitate space travel, in and of itself an evident purpose of the OST; facilitated space travel, in turn, could deliver substantial benefits to all mankind, furthering another stated purpose of the OST.[11]

A. *The Business of Asteroid Mining*

A casual Internet search for asteroid mining is likely to turn up sky-high dollar value estimates of asteroids. From Neil deGrasse Tyson saying that asteroid mining will make the first trillionaire,[12] to a Goldman Sachs note stating that a single asteroid could contain $25–$50 billion worth of platinum relative to a $2.6 billion cost of an asteroid-grabbing spacecraft,[13] to reports that NASA is sending a probe to an asteroid worth $10,000 quadrillion, the profit element of this enterprise is not lost on observers.[14] However, these estimates depend on the extraction of metals like platinum, their return to Earth, and sale at the current market price, which, as the aforementioned Goldman Sachs note concedes, would "crater the global price of platinum . . . ."[15]

---

11. *See id.* (stating "the common interest of all mankind in the progress of the exploration and use of outer space for peaceful purposes," as well as the belief that "the exploration and use of outer space should be carried on for the benefit of all peoples irrespective of the degree of their economic or scientific development . . . .").

12. Joanna Rothkopf, *Neil deGrasse Tyson Reveals How the World's First Trillionaires Will Make Their Fortunes*, SALON (May 4, 2015), https://www.salon.com/2015/05/04/neil_degrasse_tyson_the_first_trillionaire_will_be_whoever_figures_out_how_to_mine_asteroids.

13. Jim Edwards, *Goldman Sachs: Space-Mining for Platinum Is 'More Realistic Than Perceived,'* BUS. INSIDER (Apr. 6, 2017), http://www.businessinsider.com/goldman-sachs-space-mining-asteroid-platinum-2017-4.

14. Brid-Aine Parnell, *NASA Will Reach Unique Metal Asteroid Worth $10,000 Quadrillion Four Years Early*, FORBES (May 26, 2017), https://www.forbes.com/sites/bridaineparnell/2017/05/26/nasa-psyche-mission-fast-tracked/#5dfa4f754ae8.

15. Edwards, *supra* note 13. Asteroid mining companies have a "ready made market if [they] take[] advantage of the fact that it costs roughly $20,000/Kg to launch something in to space[,]" not to mention that the "costs [of] getting a Kg of platinum just from orbit to ground level are pretty high . . . ." Alex Hern, *If You're Going to Mine in Space, the Last Thing to Do Is Bring Minerals Back Down to Earth*, NEW STATESMAN AMERICA (Jan. 23, 2013), https://www.newstatesman.com/technology/2013/01/if-youre-going-mine-space-last-thing-do-bring-minerals-back-down-earth.

Instead of attempting to mine metals, the initial step in asteroid mining proposed by Planetary Resources, the most prominent asteroid mining company in existence today, is to mine asteroids for water.[16] By making propellant available in space, asteroid mining "increases the payload capacity of rockets, enables the creation of a space highway with fuel depots located at various points of need throughout the Solar System, and allows spacecraft to travel much farther."[17] In other words, the business of asteroid mining, at least in its infancy, is not about harvesting valuable metals and returning them to Earth,[18] but rather about providing raw materials to enable the growth of the space economy.

The impetus to provide in-space materials to the space economy is a matter of physics. Launching an object into space is expensive: SpaceX's Falcon 9—with the capacity to carry just over 50,000 pounds of payload into low Earth orbit[19]—costs an estimated $36.7 million to launch and uses between $200,000 and $300,000 in fuel each trip.[20] If asteroid mining companies were able to provide some of the propellant in space, that would not only reduce fuel costs, but would reduce the overall launch weight, freeing up more space for payload.[21]

In sum, should asteroid mining companies be able to provide fuel in space, it could dramatically reduce the costs of transporting rockets and cargo into space—both into low Earth orbit and to more distant targets, like Mars. Having this infrastructure in place could also reduce the long-term costs of the asteroid mining business itself, given that the business model involves launching objects into space. While a 2012 study estimated the total cost of an asteroid retrieval mission at $2.6 billion,[22] a substantial reduction in launch costs would result in meaningful savings.[23] This model of as-

16. *Products*, PLANETARY RESOURCES, https://www.planetaryresources.com/products (last visited Nov. 28, 2018); *see also Why Asteroids*, PLANETARY RESOURCES, https://www.planetaryresources.com/why-asteroids/ (last visited Nov. 28, 2018).

17. *Products*, *supra* note 16.

18. Planetary Resources does see mineral extraction as a long-term goal; however, there is currently an emphasis on providing construction materials to the in-space economy. *See id.* (stating that metals extracted from asteroids "will be used for in-space manufacturing of high-end electronics, laboratory equipment and spacecraft components.").

19. *Falcon 9*, SPACEX, http://www.spacex.com/falcon9 (last visited Nov. 28, 2018).

20. Peter B. de Selding, *SpaceX's Reusable Falcon 9: What Are the Real Cost Savings for Customers?*, SPACENEWS (Apr. 25, 2016), http://spacenews.com/spacexs-reusable-falcon-9-what-are-the-real-cost-savings-for-customers.

21. *See id.* (noting that for reusable rockets, "[r]eserving fuel in the first stage for landing adds mass to the vehicle and deprives it of performance, effectively carrying fuel instead of extra payload . . . .").

22. KECK INST. FOR SPACE STUDIES, *supra* note 5, at 13, 40–41.

23. *Id.* at 13 (noting that "[t]he recurring cost for subsequent [asteroid capture and return] missions is estimated at approximately $1B so subsequent missions would improve that cost savings to a factor of 20.").

teroid mining as a provider of in-space resources, then, can facilitate the growth of the space economy: future forays into space would have their costs greatly reduced by a "space highway with fuel depots."[24]

B. *Public and Private Actors in the Asteroid Mining Space*

Both private companies and the space agencies of sovereign governments bear mentioning in a full discussion of asteroid mining. The role of the private sector in space has expanded substantially in the past decade, leading some commentators to suggest that the private sector has eclipsed the public sector in this arena.[25] The asteroid mining industry, as detailed above, both depends upon and tends to facilitate this development. Sovereign space agencies, by contrast, conduct a waning share of activity in space and increasingly operate by way of public-private partnerships as an investor in the space economy.[26] This marks an important shift from the factual backdrop of the original OST in that private, independent companies are increasingly taking the wheel.

As explored above, the asteroid mining business facilitates the growth of the space economy by reducing launch costs. However, the future of asteroid mining as a lucrative industry also *depends upon* the existence and growth of a robust space economy. The symbiotic relationships that could develop between private companies deserves emphasis. The viability of asteroid mining depends on a space economy to which asteroid mining companies can sell fuel and metals: the lack of a current market in asteroid resources should resolve itself "when the space population hits critical mass, demanding infrastructure."[27] For spaceflight companies,[28] a crucial component to reduce costs is access to propellant in space.[29]

---

24. *Products*, *supra* note 16.

25. *See, e.g.*, Kristin Houser, *Private Companies, Not Governments, Are Shaping the Future of Space Exploration*, FUTURISM (June 12, 2017), https://futurism.com/private-companies-not-governments-are-shaping-the-future-of-space-exploration (noting the substantial expansion of the space economy in recent years and the shift toward the private sector); *The New Space Race*, ECONOMIST (Jan. 18, 2018), https://www.economist.com/news/leaders/21735023-events-space-reflect-those-back-home-new-space-race (describing the growing role of the private sector in space).

26. *See* Elton Lossner, *The New Space Race*, HARV. POL. REV. (May 26, 2017), http://harvardpolitics.com/covers/the-new-space-race/; *see also* Thomas Heath, *Space-Mining May Be Only a Decade Away. Really.*, WASH. POST (Apr. 28, 2017), https://www.washingtonpost.com/business/space-mining-may-be-only-a-decade-away-really/2017/04/28/df33b31a-29ee-11e7-a616-d7c8a68c1a66_story.html?utm_term=.bc9e52036305.

27. Heath, *supra* note 26. The "space population" referred to in this article includes space travelers—tourists and scientists—as well as satellite companies. *See id.*

28. SpaceX, Blue Origin, and Virgin Galactic are among the best-known companies that seek to send people into space. *See generally* Monica Grady, *Private Companies Are Launching A New Space Race – Here's What To Expect*, PHYS.ORG: CONVERSATION (Oct. 3, 2017), https://phys.org/news/2017-10-private-companies-space.html. Satellite companies like

Sovereign governments continue to play a significant, albeit declining, role in the space economy. NASA's share of the national budget decreased from 4.4% in 1966 to 0.5% in 2014.[30] Its current strategy centers on partnership with the private space economy: "NASA helps mitigate financial risk, while the private sector conducts research and innovation more efficiently than NASA can . . . ."[31] Similarly Luxembourg, which lacks its own space agency,[32] opened a 200 million Euro fund in 2016 to bring asteroid mining companies to the country.[33] Planetary Resources has availed itself of opportunities offered by both NASA and Luxembourg, performing contract work with the former and securing funding from the latter.[34]

While sovereign governments do hold some of the purse strings relevant to asteroid mining companies and the space economy as a whole, private companies are increasingly displacing national space agencies.[35] A pri-

---

Société Européenne des Satellites, based in Luxembourg, also require launch services to place their devices into orbit and could thus benefit from reduced launch costs. *See* Dana Hull, *SpaceX Launches Satellite for SES in Its 11th Mission This Year*, BLOOMBERG (June 4, 2018), https://www.bloomberg.com/news/articles/2018-06-04/spacex-launches-satellite-for-ses-in-its-11th-mission-this-year.

29. *Asteroid Mining Is The Key To Our Future Expansion Into Space*, PLANETARY RESOURCES (Nov. 30, 2017), https://www.planetaryresources.com/2017/11/asteroid-mining-is-the-key-to-our-future-expansion-into-space/ (noting that "Earth's gravity well is so deep that the cost of bringing propellant from Earth to fuel that economy in space will be prohibitive.").

30. Lossner, *supra* note 26. In the 2019 fiscal year, NASA received 0.4% of the total federal budget. Kimberly Amadeo, *NASA Budget, Current Funding, History, and Economic Impact*, BALANCE, https://www.thebalance.com/nasa-budget-current-funding-and-history-3306321 (last updated Sept. 7, 2018).

31. Lossner, *supra* note 26.

32. *Aerospace Industry*, GRAND DUCHY LUX., http://www.luxembourg.public.lu/en/investir/secteurs-cles/industrie-aerospatiale/index.html (last updated Mar. 21, 2018).

33. Approximately $227 million US. David Z. Morris, *Luxembourg to Invest $227 Million in Asteroid Mining*, FORTUNE (June 5, 2016), http://fortune.com/2016/06/05/luxembourg-asteroid-mining.

34. *See* David Coldeway, *Planetary Resources Mines Luxembourg for $28M in Asteroid Hunting Funds*, TECHCRUNCH (Nov. 3, 2016), https://techcrunch.com/2016/11/03/planetary-resources-mines-luxembourg-for-28m-in-asteroid-hunting-funds; *Planetary Resources Moves Closer to Mining Asteroids*, PLANETARY RESOURCES (July 15, 2015), https://www.planetaryresources.com/2015/07/planetary-resources-moves-closer-to-mining-asteroids.

35. *See, e.g.*, Loren Grush, *How the Private Space Industry Could Take Over Lower Earth Orbit—and Make Money Off It*, VERGE (Feb. 16, 2018), https://www.theverge.com/2018/2/16/17014176/nasa-iss-commercial-space-industry-budget-2025-privatization ("NASA hopes to transition the domain of lower Earth orbit . . . to the commercial space industry over the next seven years."); Sintia Radu, *The Global Race to Space*, U.S. NEWS & WORLD REP. (Aug. 27, 2018), https://www.usnews.com/news/best-countries/articles/2018-08-27/60-years-after-nasa-a-global-space-race (noting that "experts say the future of space activity may rest with private corporations . . . ."); Alan Yuhas, *The New Space Race: How Billionaires Launched the Next Era of Exploration*, GUARDIAN (Feb. 9, 2018), https://www.theguardian.com/science/2018/feb/09/new-space-race-billionaires-elon-musk-jeff-bezos

vate space economy that is increasingly independent from sovereign governments tends to undermine the factual framework upon which the original OST relied.[36] Specifically, Article VI assigns responsibility for non-governmental entities to national governments, the implicit assumption likely being that private entities would be acting at the behest of a sovereign.[37] This concern is increasingly unsubstantiated in an environment in which private, independent companies are ascendant.[38]

C. *Global Benefits of Asteroid Mining*

Asteroid mining has the potential to facilitate space travel, an outcome the OST holds to be in the interest of humanity as a whole.[39] The potential of asteroid mining to reduce the cost of spaceflight, moreover, could facilitate the growth of the space economy. Asteroid mining thus aligns with another stated purposes of the OST in the sense that an expanded space economy could provide substantial benefits to all mankind.[40] First, in seeking to face the challenges posed by space travel, the public sector space race gave rise to numerous technological innovations, ranging from LEDs to emergency blankets to memory foam.[41] It seems likely that the private space race would result in a similar degree of innovation, the products of which could benefit people across the globe.

Second, a successful mission to Mars could provide benefits beyond a mere sense of interplanetary accomplishment. NASA suggests that, given the parallels between the formation and evolution of Mars and Earth, a voyage there could help "us learn more about our own planet's history and future."[42] The scientific advancements from such a mission cannot currently

---

(quoting Jeff Manber, CEO of the space company Nanoracks: "We're finally reaching the point where there's a robust marketplace . . . . It won't just be on the one pillar of government-organized or government-funded.").

36. *See* Jason Krause, *The Outer Space Treaty Turns 50: Can It Survive a New Space Race?*, ABA J., Apr. 2017, at 44 (noting that the OST is a "product of the Cold War and primarily addresses concerns of that era, including nuclear war[,]" and that at that time "only the United States and Soviet Union were even capable of launching vehicles into space . . . .").

37. *See* Outer Space Treaty, *supra* note 9, art. 6.

38. *See* articles cited *supra* note 35.

39. *See* Outer Space Treaty, *supra* note 9, at pmbl. ("[T]he common interest of all mankind in the progress of the exploration and use of outer space for peaceful purposes . . . .").

40. *See* Outer Space Treaty, *supra* note 9, at pmbl.

41. *Jet Propulsion Laboratory*, NASA, https://www.jpl.nasa.gov/infographics/infographic.view.php?id=11358.

42. *NASA's Journey to Mars*, NASA, https://www.nasa.gov/content/nasas-journey-to-mars (last updated Aug. 7, 2017).

be anticipated and are difficult to predict, but "expand[ing] the frontiers of knowledge" in this manner could well bring benefits to all mankind.[43]

Third, the development of asteroid mining technology could also help advance asteroid diversion tactics. The development of the technology required to conduct successful asteroid mining operations could "help us to divert any incoming asteroids."[44] This is of great importance since NASA recently eliminated its Asteroid Redirect Mission due to funding cuts;[45] NASA's project was hailed by some scientists as a "critical step in demonstrating we can protect our planet from a future asteroid impact . . . ."[46] Asteroid mining could step in and fill an important void. While the probability of an Armageddon-causing impact is low, the effects of an impact would be extremely severe.[47] Even some mitigation of this risk as a byproduct of asteroid mining would be a benefit to humanity as a whole.

Finally, reduced launch costs could facilitate measures to combat global climate change. One proposed solution for canceling out predicted increases in average worldwide temperature is to "prevent[] . . . about 1% of incoming solar radiation—insolation—from reaching the Earth. This could be done by scattering into space from the vicinity of Earth an appropriately small fraction of total insolation."[48] Asteroid mining could facilitate such measures in that "[t]echnologies that could greatly decrease the cost of space-launch

---

43. NAT'L AERONAUTICS & SPACE ADMIN., FY 2017: AGENCY FINANCIAL REPORT, at 20 (2017).

44. Ian Sample, *Asteroid Mining: US Company Looks to Space for Precious Metal*, GUARDIAN (Jan. 23, 2013, 2:40), https://www.theguardian.com/science/2013/jan/22/space-mining-gold-asteroids. The Keck study, *supra* note 5, at 11–12, states the synergies asteroid mining would have with planetary defense as 1) developing "reliable robotic anchoring capability[,]" 2) "structural characterization, especially of the surface layers[,]" 3) understanding the "dust environment[,]" and 4) "[t]echniques for proximity operations and NEO [near-Earth object] navigation . . . ."

45. Jeff Foust, *NASA Closing Out Asteroid Redirect Mission*, SPACENEWS (June 14, 2017), http://spacenews.com/nasa-closing-out-asteroid-redirect-mission.

46. Geoff Brown, *NASA Plans to Test Asteroid Deflection Technique Designed to Present Earth Impact*, PHYS.ORG (July 4, 2017), https://phys.org/news/2017-07-nasa-asteroid-deflection-technique-earth.html (referring to the Double Asteroid Redirection Test program, a part of the Asteroid Redirection Mission).

47. *See* Milton Kazmayer, *Long Term Effects of an Asteroid Impact on Earth*, SEATTLE PI, https://education.seattlepi.com/long-term-effects-asteroid-impact-earth-4601.html (last visited Nov. 28, 2018) ("A massive asteroid impact would create long-term changes in the atmosphere and climate of the planet. Upon impact, vaporized dirt and rock would fill the atmosphere, blocking sunlight and creating a state of near-permanent darkness and winter-like conditions . . . . [A] large asteroid, one at least five kilometers in diameter, could cause enough damage to threaten life on this planet.").

48. EDWARD TELLER ET AL., GLOBAL WARMING AND ICE AGES: I. PROSPECTS FOR PHYSICS-BASED MODULATION OF GLOBAL CHANGE 2 (1997). In other words, this method proposes reflecting incoming sunlight back into space by sending material from Earth into orbit to block that sunlight, thus reducing the incoming amount of heat that would warm the Earth's surface.

could make a telling difference in the practicality of all types of space-deployed scattering systems of scales appropriate to insolation modulation."[49] There are certainly intermediate measures to combat climate change that ought to be taken first, but asteroid mining would facilitate this expedited solution. While some of the benefits of asteroid mining would doubtless accrue primarily to those nations with asteroid mining companies within their borders, the benefits noted in this section—space exploration as a general proposition, technological and scientific development, improvement of asteroid diversion technology, and facilitated means of swiftly countering climate change—would inure substantially to the benefit of all mankind.

II. THE LEGAL AMBIGUITIES OF THE OUTER SPACE TREATY

The emergence of asteroid mining as a feasible business possibility presents a legal question: whether asteroid mining by private companies is legal under the OST, which prohibits "national appropriation . . . by means of use or occupation" of "celestial bodies . . . ."[50] The United States endorsed the view that asteroid mining is legal under existing international law through the passage of the U.S. Commercial Space Launch Competitiveness Act of 2015.[51] Luxembourg similarly sanctioned asteroid mining with its own legislation.[52] On the other hand, Russia and Brazil are both of the opinion that asteroid mining "constitute[s] de facto national appropriation[,]" in violation of the OST.[53]

---

49. *See id.* at 7.

50. Outer Space Treaty, *supra* note 9, art. 2.

51. U.S. Commercial Space Launch Competitiveness Act, Pub. L. No. 114-90, § 402(a) 129 Stat. 704, 721 (2015) ("A United States citizen engaged in commercial recovery of an asteroid resource or a space resource . . . 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 according to applicable law, including the international obligations of the United States."). The bill subsequently states, "It is the sense of Congress that by the enactment of this Act, the United States does not assert sovereignty or sovereign or exclusive rights or jurisdiction over, or ownership of, any celestial body." § 403, 129 Stat. at 722.

52. *See* Loi du 20 juillet 2017 sur l'exploration et l'utilisation des ressources de l'espace [Law of July 20, 2017 on the exploration and utilization of space resources], MÉMORIAL A N° 674 DE 2017 (enacted July 28, 2017) (Lux.).

The authoritative French version begins by stating "Les ressources de l'espace sont susceptibles d'appropriation," or in English, "Space resources are capable of being appropriated." It goes on to state that "L'exploitant agréé ne peut exercer l'activité . . . qu'en conformité avec . . . les obligations internationales du Luxembourg," which is a mandate that the operator may only perform the activity "in accordance with the international obligations of Luxembourg." This highlights an interpretation of the Outer Space Treaty that appropriation of space resources is not in violation of international law.

53. Kyle Evanoff, *The Outer Space Treaty's Midlife Funk*, COUNCIL ON FOREIGN REL.: INTERNATIONALIST (Oct. 10, 2017), https://www.cfr.org/blog/outer-space-treatys-midlife-funk; *see also* Mark Kaufman, *Luxembourg's Asteroid Mining is Legal Says Space Law Ex-*

Article II of the OST states, "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."[54] The treaty further provides that individual countries "shall bear international responsibility for national activities in outer space . . . whether such activities are carried on by governmental agencies or by non-governmental entities" and must further "assur[e] that national activities are carried out in conformity with the provisions set forth in the present Treaty."[55] Taken together, these provisions provide the textual basis for arguing that asteroid mining by private companies is either permissible under or in violation of the OST.

International law provides an interpretive framework relevant for answering this question that places emphasis on the purpose of treaties. The Vienna Convention on the Law of Treaties (the "Vienna Convention") provides principles for the interpretation of treaties. For the purposes of asteroid mining, the United States is not a party to the Vienna Convention and is thus not bound by its terms; nevertheless, the United States "considers many of the provisions of the Vienna Convention on the Law of Treaties to constitute customary international law on the law of treaties."[56] The Vienna Convention itself provides the following guidance to those interpreting treaties: "A treaty shall be interpreted in good faith in accordance with the ordinary meaning to be given to the terms of the treaty in their context and in the light of its object and purpose."[57] International law states an interpretive method that, while starting with ordinary meaning, explicitly sanctions consideration of the framers' purpose.

A literal textual interpretation of the treaty's ordinary meaning suggests its terms prohibit asteroid mining. However, purposive arguments—particularly given the nature of asteroid mining as a business that tends to facilitate space travel and exploration—generally point to an interpretation that grants permission to private companies to mine asteroids.

---

pert, INVERSE (Aug. 1, 2017), https://www.inverse.com/article/34935-luxembourg-s-asteroid-mining-is-legal-says-space-law-expert (noting the explanation of the Russian and Brazilian point of view on asteroid mining by space law expert Frans von der Dunk, that these countries "don't view these mining operations as meeting the non-ownership standards of the Outer Space Treaty . . . .").

54. Outer Space Treaty, *supra* note 9, art. 2.

55. Outer Space Treaty, *supra* note 9, art. 6.

56. *Vienna Convention on the Law of Treaties*, U.S. DEP'T ST., https://www.state.gov/s/l/treaty/faqs/70139.htm.

57. Vienna Convention on the Law of Treaties art. 31, May 23, 1969, 1155 U.N.T.S. 331.

A. *Textual Interpretation Prohibiting Asteroid Mining Under the Outer Space Treaty*

A private asteroid mining company most likely qualifies as a non-governmental entity under the OST and is thus bound by the prohibitions stated in Article II.[58] Article VI of the OST, as noted above, mandates that "States Parties to the Treaty shall bear international responsibility for national activities in outer space . . . whether such activities are carried on by governmental agencies or by non-governmental entities . . . ."[59] A preliminary question to answer before assessing whether the prohibitions stated in Article II preclude asteroid mining is whether a private asteroid mining company would fall within this category specified in Article VI. Based on the plain meaning of the treaty, as well as the potential for circumvention of the terms of the treaty under an alternate interpretation discussed below, the answer is likely yes.

To begin, a private company literally meets the plain meaning definition of "non-governmental entity" as an entity that is not the government. If not a private company, what non-governmental entity capable of spaceflight could the framers of the OST have had in mind?[60] Moreover, an alternative interpretation could open the door to unscrupulous government circumvention of the treaty, allowing nations to dodge responsibility under international law by forming shell corporations and then freely engaging in activities otherwise prohibited by Article II.[61] Even assuming the private entities engaging in asteroid mining were truly private, they would remain under the "authorization and continuing supervision" of the government under whose laws they are incorporated.[62] Numerous academic commentators have pointed out that "[s]tates are unable to authorize their non-governmental entities to conduct activities that international law prohibits the state, itself, from conducting."[63] The actions of private space companies, then, must create

---

58. Outer Space Treaty, *supra* note 9, art. 2 (prohibiting "national appropriation by claim of sovereignty, by means of use or occupation, or by any other means.").

59. Outer Space Treaty, *supra* note 9, art. 6.

60. Outer Space Treaty, *supra* note 9, art. 6.

61. *See* Ricky J. Lee, *Article II of the Outer Space Treaty: Prohibition of State Sovereignty, Private Property Rights, or Both?*, 11 AUSTL. INT'L L.J. 128, 130 (2004) (noting that Article II must have at least some application to private entities, or else "it may be possible for States to circumvent the prohibitions contained in the Outer Space Treaty simply by 'privatising' the contravening activity.").

62. Outer Space Treaty, *supra* note 9, art. 6.

63. Leslie I. Tennen, *Enterprise Rights and the Legal Regime for Exploitation of Outer Space Resources*, 47 U. PAC. L. REV. 281, 287 (2016); *see also* C. WILFRED JENKS, SPACE LAW 201 (1965) (stating that "what is forbidden to a State is not permitted to a chartered company created by a State or to one of its nationals acting as a private adventurer . . . .").

"international responsibility" for sovereign parties to the treaty; a violation of terms by the former is a violation by the latter.[64]

Having determined that the prohibitions in Article II likely apply to private companies, the next question is whether asteroid mining is a prohibited means of "national appropriation [of a celestial body] by claim of sovereignty, by means of use or occupation, or by any other means." First, it seems far more likely than not that asteroids fall within the scope of celestial bodies defined by this treaty. The Oxford Living Dictionary defines "celestial" as "[p]ositioned in or relating to the sky, or outer space as observed in astronomy."[65] This points to a rather all-encompassing definition that would seem to include all bodies beyond the terrestrial scope of Earth capable of astronomical observation and study; asteroids are plainly bodies of matter in space that are observable from Earth.

The treaty uses the phrase "the moon and other celestial bodies,"[66] which might support an *ejusdem generis* inference that the celestial bodies envisioned by the treaty must be moon-like; that is to say, a celestial body must be very large and in predictable orbit around a planet or star, including planets and moons, but excluding asteroids and comets. However, this more exclusive definition would create a celestial line-drawing dilemma given that asteroids can become moons[67] and asteroids can have their own moons.[68] This difficulty, coupled with the broad definition of "celestial," points to a broad definition of "celestial body" that includes asteroids.

The crux of the question, then, is whether asteroid mining as an activity constitutes "national appropriation . . . by means of use or occupation . . . ."[69] To "appropriate" something means to "take exclusive possession of,"[70] or to "[t]ake (something) for one's own use . . . ."[71] In the case of

64. *But see* Stephen Gorove, *Interpreting Article II of the Outer Space Treaty*, 37 FORDHAM L. REV. 349, 351 (1969) (suggesting that the treaty "appears to contain no prohibition regarding individual appropriation or acquisition by a private association . . . ."); *see also* Wayne N. White, Jr., *Real Property Rights in Outer Space*, PROC. 40 COLLOQUIUM ON L. OUTER SPACE 370 (1998) (arguing that Article II of the Outer Space Treaty prohibits territorial sovereignty but does not prohibit private appropriation).

65. *Celestial*, OXFORD LIVING DICTIONARIES: ENG., https://en.oxforddictionaries.com/definition/celestial (last visted Nov. 28, 2018); *see also Celestial*, MERRIAM-WEBSTER ONLINE DICTIONARY, https://www.merriam-webster.com/dictionary/celestial (last visited Nov. 28, 2018) ("of or relating to the sky of visible heavens").

66. Outer Space Treaty, *supra* note 9, art. 2.

67. *See Mars Moons*, NASA, https://solarsystem.nasa.gov/moons/mars-moons/in-depth (last updated Mar. 29, 2018) (noting that the moons of Mars, Phobos and Deimos, "may be captured asteroids.").

68. *See 243 Ida*, NASA, https://solarsystem.nasa.gov/small-bodies/asteroids/243-ida/in-depth (last updated Dec. 5, 2017) (noting that Ida is the first asteroid found to have its own moon).

69. Outer Space Treaty, *supra* note 9, art. 2.

70. *Appropriate*, MERRIAM-WEBSTER ONLINE DICTIONARY, https://www.merriam-webster.com/dictionary/appropriate#h2 (last visited Nov. 28, 2018).

the OST, "national" modifies "appropriation[,]" illustrating that exclusive use of celestial objects that is sovereign in nature constitutes a violation of the treaty.[72] A plain reading of the text of Article II indicates that "use or occupation" is one avenue through which a country can engage in national appropriation and, due to Article VI, that use or occupation can be the product of a private company's actions.[73]

The passage of the U.S. Commercial Space Launch Competitiveness Act endorses an interpretation that extraction of space resources by commercial actors is a use that does not amount to a claim of sovereignty, absent a claim of sovereignty by the actor's host nation.[74] Congress stated in the Act that, "by enactment . . . the United States does not thereby assert sovereignty or sovereign or exclusive rights or jurisdiction over . . . any celestial body."[75] In making this disclaimer, Congress treated making a claim of sovereignty as a *necessary* component of achieving national appropriation of a celestial body. It gave private actors permission to exploit celestial resources, subject to the authorization and supervision of the federal government, "in accordance with the international obligations of the United States," while disclaiming that this amounted to a claim of sovereignty or jurisdiction.[76] In other words, Congress effectively interpreted the OST to prohibit only national appropriation by claim of sovereignty *and* by use or occupation, an interpretation it understands to be in conformity with international law.

---

71. *Appropriate*, OXFORD LIVING DICTIONARIES: ENG., https://en.oxforddictionaries.com/definition/appropriate (last visited Nov. 28, 2018).

72. Outer Space Treaty, *supra* note 9, art. 2.

73. Outer Space Treaty, *supra* note 9, arts. 2, 6.

74. The passage of this Act may in and of itself constitute a violation of the Outer Space Treaty: the Draft Articles on Responsibility of States for internationally Wrongful Acts states, "There is a breach of an international obligation by a State when an act of that State is not in conformity with what is required of it by that obligation, regardless of its origin or character." Int'l Law Comm'n, Rep. of the on the Work of Its Fifty-Third Session, U.N. Doc. A/56/10, at 54 (2001). The commentary to this Article states that "[c]ertain obligations may be breached by the mere passage of incompatible legislation." *Id.* at 57. On the other hand, given circumstances in which "it is open to the State concerned to give effect to the legislation in a way which would not violate the international obligation in question[,]" then "whether there is a breach will depend on whether and how the legislation is given effect." *Id.* In this case, the Act at least pays lip service to conformity with international obligations when it disclaims that it is an assertion of sovereignty: it states that Congress did not understand this Act to amount to "sovereignty or sovereign or exclusive rights or jurisdiction over, or ownership of, any celestial body." U.S. Commercial Space Launch Competitiveness Act, Pub. L. No. 114-90, § 403 129 Stat. 704, 722 (2015). This disclaimer may well place this Act in the latter category envisioned by the commentary to the Draft Articles, that the violation depends on how the Act is given effect. This in turn requires a more thorough reading of the Treaty itself.

75. U.S. Commercial Space Launch Competitiveness Act, § 403.

76. U.S. Commercial Space Launch Competitiveness Act, § 403.

The more persuasive textual interpretation of Article II of the OST points toward the opposite conclusion. The disjunctive nature of Article II suggests that national appropriation can occur *either* by "claim of sovereignty," *or* by "use or occupation . . . ."[77] Under this interpretation, a private company could certainly violate the terms of the OST through use or occupation of a celestial body.

The counterargument to this interpretation is based more on experience with the treaty than the terms of the document itself. First, some use or occupation of celestial bodies, whether by sovereign governments or by private industry, has not been legally contested over the course of the OST's existence. The United States, the U.S.S.R., and China have all "soft-landed" on the moon, placing astronauts or lunar rovers on the surface, thus occupying, if only temporarily, the surface of a celestial body specifically enumerated by the OST.[78]

Moreover, as noted in the House Report prior to passing the Commercial Space Launch Competitiveness Act, "[t]he United States, Russia, and Japan have all removed, taken possession, and used in-situ natural resources. These activities have never been protested by a State party to the treaty or judged in a court of law to be in violation of the Outer Space Treaty."[79] The OST, by its own terms, condones some use of celestial bodies by sovereign governments. Article IV states, "[t]he moon and other celestial bodies shall be used by all States Parties to the Treaty exclusively for peaceful purposes."[80] While military use of space and celestial objects is clearly *verboten*, the implication of this provision is permission for peaceful use. It is certainly accurate that the "use or occupation" of a celestial body has not previously amounted to a *per se* violation of the treaty. The argument that asteroid mining does not violate the OST, then, seems to be that use or occupation alone is not enough; violation requires an additional claim of sovereignty.

However, a lack of prior implementation or legal enforcement does not foreclose the interpretation that some kinds of use or occupation by a private actor could amount to violation of the treaty, even absent the assertion of sovereignty or jurisdiction. Moreover, given the history of partnerships between the commercial space sector and sovereign governments,[81] an interpretation making a claim of sovereignty necessary to national appropriation by private use creates a loophole large enough to swallow all the prohibi-

77. Outer Space Treaty, *supra* note 9, art. 2.

78. Connor Simpson, *China Becomes Third Country to Ever 'Soft-Land' on the Moon*, ATLANTIC (Dec. 14, 2013), https://www.theatlantic.com/international/archive/2013/12/china-becomes-third-country-ever-soft-land-moon/356151/.

79. H.R. REP. NO. 114-153, at 8 (2015).

80. Outer Space Treaty, *supra* note 9, art. 4.

81. *See supra* Section I(b) (noting the history of financial partnerships between private space companies and sovereign governments).

tions stated in the OST. For example, the colonization of Mars by a private company is an action that would likely violate the treaty as it currently stands in that it would almost by definition require exclusive possession of a celestial body that is meant to be the "province of all mankind."[82] However, were colonization not accompanied by the explicit assertion of national sovereignty or jurisdiction, it would be permissible under the U.S. interpretation of the OST.

The degree of occupation and use also might well exceed previous examples in the history of the OST. Asteroid mining is perhaps a more fleeting occupation than a permanent colony, but if the asteroid mining industry becomes a fully mobilized component of the new space economy, the degree of extraction and use would far exceed the scattered lunar samples in terms of volume, making those a tenuous precedent upon which to rely. These arguments based on experience with the OST do not rely on the terms of the treaty anyway. Focusing on the plain meaning of the text, asteroid mining by a private company, even if unaccompanied by a claim of sovereignty, violates the OST.

B. *Asteroid Mining is in Line with the Purposes of the Outer Space Treaty*

Despite the preceding plain text reading, asteroid mining by private companies squares with the purposes of the OST.[83] A major purpose of the treaty is to maintain the international character of space, to ensure that the vast realm beyond Earth's atmosphere remains "the province of all mankind[,]" and that the benefits of space exploration flow to all states "irrespective of their degree of economic or scientific development . . . ."[84] This Note argues that asteroid mining is an enterprise that is in the interest of all mankind and brings benefits to all nations regardless of their current state of development.

Commercial asteroid mining is private, profit-driven in character, and arguably distinguishable from the more wholly scientific objectives of sov-

---

82. Outer Space Treaty, *supra* note 9, art. 1. For more detailed explanation as to why a Mars colony would likely violate the Outer Space Treaty, see Michael J. Listner, *A Legal Look at Elon Musk's Plan to Colonize Mars*, SPACE REV. (July 17, 2017), http://www.thespacereview.com/article/3286/1; Caroline Haskins, *The Legal Battle to Colonize Mars*, OUTLINE (Mar. 15, 2018), https://theoutline.com/post/3739/mars-colony-settlement-spacex-elon-musk-trump?zd=1&zi=mmhbqxps.

83. The Vienna Convention, Article 31, explicitly sanctions the consideration of the purpose of a treaty in the interpretation of the document—this seemingly condones purposive interpretation in a way that is arguably more out of vogue in the American judiciary. Vienna Convention on the Law of Treaties, *supra* note 57, art. 31.

84. Outer Space Treaty, *supra* note 9, art. 1.

ereign space agencies like NASA.[85] However, given the waning funding for and role of sovereign space agencies,[86] the development of the asteroid mining industry could deliver important benefits to all mankind that simply may not otherwise come into existence. Asteroid mining could contribute to the common good by producing benefits that have global effect, as they pertain to the survival of the human species. These include enhanced asteroid diversion capability[87] and facilitation of climate change mitigation measures.[88] Advancements in technology to address the challenges of asteroid mining and improving our collective scientific understanding of the universe could bring as yet unknown benefits to all humanity.[89] Finally, by reducing costs of launch, asteroid mining could effectively open the door to the space economy to nations that might otherwise find this prospect cost-prohibitive.[90]

The purposive arguments presented above in favor of the permissibility of asteroid mining are not immune to criticism. The United States, Luxembourg, and whatever other nations are able to attract asteroid mining companies in the future would benefit disproportionately from asteroid mining in the form of taxable corporate income and job creation. For the roughly 99% of countries currently without asteroid mining companies within their borders, there would be no share of those benefits, which are effectively being extracted from a space that is meant to be the "province of all mankind."[91] Moreover, given that spaceflight is currently the exclusive province of a few wealthy, industrialized nations, there is at least an argument to be made that asteroid mining may accelerate the gap between the first and third world rather than act as a rising tide that lifts all ships.

However, an argument that disproportionate benefit makes asteroid mining at odds with the purpose of the OST misunderstands the treaty and overlooks the nature of the benefits asteroid mining could deliver. First, the OST endorses the view that human space travel and exploration, as a gen-

---

85. *See* NAT'L AERONAUTICS & SPACE ADMIN., *supra* note 43, at 6 (stating agency objectives).

86. *See* Lossner, *supra* note 26; *see also* Marina Koren, *NASA's Next Frontier is Washington*, GOV'T EXECUTIVE (Feb. 17, 2017), https://www.govexec.com/technology/2017/02/nasas-next-frontier-washington/135553/.

87. *See* KECK INST. FOR SPACE STUDIES , *supra* note 5, at 11–12 (describing how asteroid mining would enhance asteroid diversion capabilities).

88. *See* TELLER ET AL., *supra* note 48, at 7 (noting that technology decreasing the cost of launch would facilitate solar insolation modulation).

89. *See supra* Section I(c).

90. *See supra* Section I(a). for why asteroid mining reduces cost of launch. Moreover, this growth of the "space population" is in the interest of asteroid mining companies since that is their future market for in-space materials. *See* Heath, *supra* note 26.

91. Outer Space Treaty, *supra* note 9, art. 1.

eral proposition, is in the interest of humanity.[92] Asteroid mining would facilitate space travel by reducing launch costs and would do so in an indiscriminate manner—assuming private asteroid mining companies are able to sell propellant to entities from all nations, as would surely be in their best interest.[93]

Second, while the financial fruits of the endeavor may reflect preexisting terrestrial inequality, many benefits of asteroid mining would, by definition, extend to all mankind.[94] The OST does not demand that all benefits derived from outer space be shared equally across nations, but rather that outer space activity "should be carried on for the benefit of all peoples irrespective of the degree of their economic or scientific development . . . ."[95] Improved asteroid diversion technology and facilitation of climate change mitigation measures provide benefits pertaining to the continued habitability of Earth that are spread evenly across the globe.[96] Scientific and technological developments,[97] depending on their content, could eventually flow to all nations by way of sale through global markets. Because asteroid mining could simultaneously facilitate space travel and bring substantial benefits to all mankind—notwithstanding an uneven distribution of those benefits—it is in harmony with the stated objectives of the OST.

III. A New International Framework to Govern the Space Economy

Asteroid mining creates tension within the OST as an activity that is prohibited by the treaty's terms but largely in line with the treaty's purpose. As such, the OST should be modified to allow for greater certainty and predictability with respect to asteroid mining. The possibility that asteroid mining could be illegal under international law likely disincentivizes entry into this new endeavor by adding risk and uncertainty. This section outlines what a revised framework should look like. First, the law governing space should remain international in nature to further the interests of peaceful cooperation and facilitate dispute resolution. Second, this framework should present minimal regulatory barriers for entry given the benefits that asteroid mining could bring to all mankind. The development of whaling law provides a use-

92. *See* Outer Space Treaty, *supra* note 9, pmbl. (recognizing "the common interest of all mankind in the progress of the exploration and use of outer space for peaceful purposes . . . .").

93. *See supra* Section I(c).

94. *See supra* Section I(c).

95. Outer Space Treaty, *supra* note 9, pmbl.

96. *See* Keck Inst. for Space Studies, *supra* note 5, at 11–12 (noting that asteroid mining could have a possible effect on asteroid diversion technology); Teller, *supra* note 50, at 7 (stating that reducing cost of launch could facilitate solar insolation management).

97. *See NASA's Journey to Mars*, *supra* note 42.

ful historical example of how norms and rules for the asteroid mining industry could evolve in a way that facilitates efficient governance of this endeavor.

A. *The Desirability of an International Framework*

The preservation of space as a zone governed by international law, in contrast to a system predicated on national jurisdiction, is desirable in that it promotes peace, facilitates dispute resolution, and allows for more coordinated efforts in addressing issues relevant to all entities operating in space.[98] As illustrated by the recent legislative activity in the United States and Luxembourg, the risk of inaction is the resultant domination of the extraterrestrial environment by individual nations rather than by international agreement.[99] It would take only minor changes to the OST to resolve some of the ambiguities in the status quo and help bring the benefits of asteroid mining to humanity as a whole. A revision of this treaty rather than a wholesale abandonment of the agreement—whether that abandonment is in fact or merely in practice—would better maintain the international character of space.

The OST reflects Cold War era concerns about the militarization of space.[100] Private companies, now ascendant in the growing space economy, simply do not have the military capacity or intention of sovereign governments. In short, the factual backdrop for the signing of the OST has changed. One straightforward means of authorizing private companies to extract space resources would be to revise the OST to clarify that the language in Article II prohibiting national appropriation does not apply to private companies. This could be achieved by simply adding a sentence to the end of Article VI: *Under the revised treaty, companies shall remain under the supervision of the countries in which they are based but are not capable of national appropriation by use or occupation.* This revision would create something of a line-drawing problem given the partnerships between sovereign space agencies and private companies,[101] as well as a possible loophole by which unscrupulous nations could take advantage of the corporate form. Additional safeguards might be necessary to prevent this possibility. This revision could, however, promote peaceful coexistence and uniformity in space law, as well as create certainty as to the legality of asteroid mining by private companies.

---

98. The OST, *supra* note 9, espouses many of these ideals in the preamble.

99. The passage of the U.S. Space Launch and Competitiveness Act and the Loi de 20 julliet 2017 illustrate that given lack of international consensus, there is a risk that individuals nations will act unilaterally in accord with the interpretation of the OST most favorable to their interests. For more on the enactment of these laws, see *supra* notes 51–52.

100. Not only military activity, but the nuclear arms race specifically helped prompt the signing of the OST. *See* Krause, *supra* note 36, at 46; Grush, *supra* note 8.

101. *See supra* Section I(b).

Another possibility is to create a new set of international rules for extraction of space resources. Assignment of such property rights could take the form of a first-come, first-served system[102] or it could depend on an Earth-side registration process.[103] Arguably, extraction is different than the forbidden uses enumerated in the OST in that it is a temporary occupation and not inherently an exercise of military might or the flexing of sovereign muscle.[104] While the United States and Luxembourg both interpret asteroid mining to be legal under the existing treaty,[105] the promulgation of rules governing the endeavor would add clarity as to the legality of the enterprise. This approach would have the advantage of treating sovereign actors and private companies alike, but would require more substantial revision of the OST, or a new international agreement altogether.

An amended OST or a new treaty governing the extraction of space resources would have the benefit of maintaining the peaceful order of space. While admittedly the product of a different era, the post-national and peaceable foundation of the OST is still desirable in an international environment where many nations are armed to the proverbial nuclear teeth. Peaceful use of outer space is a laudable objective and one served most effectively by international agreement rather than by competing national claims of sovereignty.[106]

An international system would also facilitate dispute resolution. In a borderless and extra-jurisdictional realm like outer space, a system predicated on national sovereignty and ownership is not instructive as to whose

---

102. Wayne White, *Proposal for a Multilateral Treaty Regarding Jurisdiction and Real Property Rights in Outer Space*, SPACE FUTURE (2001), http://www.spacefuture.com/archive/proposal_for_a_multilateral_treaty_regarding_jurisdiction_and_real_property_rights_in_outer_space.shtml ("Entities may occupy and use locations in outer space on a first-come, first-served basis, so long as said occupation and use will not interfere with other entities [sic] activities.").

103. Alison Morris, Note, *Intergalactic Property Law: A New Regime for a New Age*, 19 VAND. J. ENT. & TECH. L. 1085, 1112 (2017).

104. In Article 4, the Outer Space Treaty forbids "establishment of military bases, installations and fortifications . . . ." See articles cited *supra* note 82 for a more detailed explanation as to why a permanent government-sponsored colony would violate art. 2 of the Outer Space Treaty.

105. The language used in these laws, suggests that the legislative bodies of both countries interpreted the laws being passed as in conformity with international law. See *supra* notes 51–52 for more discussion of the specific language these laws used to indicate their conformity with international law.

106. U.N. Convention on the Law of the Sea and the Antarctic Treaty, both examples of treaties governing areas outside of the jurisdictional reach of any sovereign, emphasize the fundamental importance of peaceful use. *See* U.N. Convention on the Law of the Sea pmbl., *opened for signature* Dec. 10, 1982, 1833 U.N.T.S. 397 (stating the desirability of a treaty that will "promote the peaceful uses of the seas and oceans . . . ."); Antarctic Treaty pmbl., Dec. 1, 1959, 12 U.S.T. 794, 402 U.N.T.S. 71 (noting the objective that Antarctica "shall not become the scene or object of international discord . . . .").

laws—or whose choice of law rules—would control in the event of disputed title of an asteroid or the commission of a tort between two actors from different nations.[107] The United Nations Convention on the Law of the Sea (the "UNCLOS") established the International Tribunal for the Law of the Sea (the "ITLOS") as a means of providing a venue in which similar disputes could be adjudicated between actors with conflicting legal regimes.[108] Outer space has a great deal of similarity to the high seas: both are vast, both are easily treated as a non-appropriable international commons, and both are an in-between space in the sense of existing between bodies of *terra firma*.[109] An international mechanism like ITLOS ought to be established for resolving space disputes such that parties can seek a neutral arbiter to resolve conflict and laws can be uniformly applied to all entities irrespective of their country of origin.[110]

Finally, an international system could more easily allow for cooperation between nations and private entities in addressing issues that affect the spacefaring community as a whole. The emergence of space debris and the use of nuclear power sources in space are examples of developing issues that bear on the ease and safety of space travel for all.[111] Left to national governments or individual corporations, it seems plausible that lack of oversight could result in a tragedy of the commons.[112] By contrast, an interna-

---

107. The Outer Space Treaty, *supra* note 9, is currently not instructive in this respect, either: it provides that states retain jurisdiction over their objects and personnel (art. 8), and that they are internationally liable for damage to another state party (art. 7).

108. *See* U.N. Convention on the Law of the Seas, *supra* note 106, at Annex VI; *see also* Helmut Tuerk, *The Contribution of the International Tribunal for the Law of the Sea to International Law*, 26 PENN ST. INT'L L. REV. 289 (2007).

109. *See* M.J. Peterson, *The Use of Analogies in Developing Outer Space Law*, 51 INT'L ORG 245, 252 (1997) (noting that the vastness and in-between quality of the seas and space made this analogy appealing); Nina Tannenwald, *Law Versus Power on the High Frontier: The Case for a Rule-Based Regime for Outer Space*, 29 YALE J. INT'L L. 363, 374 (2004) (noting that the decision to treat outer space as a nonappropriable international commons arose by analogy to the high seas).

110. ITLOS has been used relatively few times since coming into existence, leading some commentators to conclude that its effectiveness is limited. *See* Rosemary Rayfuse, *The Future of Compulsory Dispute Settlement Under The Law of the Sea Convention*, 36 VICT. U. WELLINGTON L. REV. 683, 709–10 (2005) (noting that ITLOS has heard relatively few cases, has proven to be "circumscribed in scope," and that "if the past is prologue, the future does not look overly bright."). On the other hand, other commentators have interpreted the brief history of ITLOS as supporting a more positive vision of the tribunal's future, and that its mere existence has been a beneficial development. *See* Tuerk, *supra* note 108, at 316 (noting that the tribunal's record "does not compare unfavourably to that of other international judicial bodies in the initial stages of their existence[,]" and that "a choice of forum . . . is more beneficial than harmful . . . .").

111. *See* David Tan, *Towards a New Regime for the Protection of Outer Space as the "Province of All Mankind,"* 25 YALE J. INT'L L. 145, 149–55 (2000).

112. *See* Joseph S. Imburgia, *Space Debris and Its Threat to National Security: A Proposal for a Binding International Agreement to Clean Up the Junk*, 44 VAND. J. TRANSNAT'L

tional framework is well-suited to consider the problems of the space ecosystem in a way that transcends national boundaries. The UNCLOS Preamble, for example, demonstrates an awareness that "problems of ocean space are closely interrelated and need to be considered as a whole."[113] The compelling interests of peace, uniformity, and cooperation in outer space illustrate the desirability of an international framework to govern asteroid mining; to tweak rather than jettison the existing law. The resulting clarity and predictability would incentivize asteroid mining through reducing legal risk and uncertainty.

A counterproposal to an international framework is a system in which nations assign property rights according to domestic law. It would be possible to take a *terra nullius* approach to property rights relating to celestial bodies.[114] In the *Western Sahara* advisory opinion, the International Court of Justice defined *terra nullius* as "a legal term of art employed in connection with 'occupation' as one of the accepted legal methods of acquiring sovereignty over territory."[115] For a nation to peaceably acquire sovereignty through occupation, the land must be "*terra nullius*—a territory belonging to no-one—at the time of the act alleged to constitute the 'occupation[.]' "[116] This legal approach was prevalent during the colonial era: explorers and emigrants acting in the name of European sovereigns declared ownership of territory by right of discovery and occupation.[117] By authorizing U.S. citizens to extract materials from asteroids through the Commercial Space Launch Competitiveness Act, the United States has started down a path in which property rights in space flow from the jurisdiction of individual sov-

---

L. 589, 592 (2011) (noting that "[w]ithout legal consequences, including appropriate international sanctions for treaty violations, little international influence exists to compel space-faring nations to find a viable solution to this problem.").

113. U.N. Convention on the Law of the Sea, *supra* note 106.

114. Numerous commentators have suggested that something along the lines of *terra nullius*, adverse possession, or right of first possession—all sounding in domestic law—ought to apply to celestial resources. *See, e.g.*, Brandon C. Gruner, *A New Hope for International Space Law: Incorporating Nineteenth Century First Possession Principles into the 1967 Space Treaty for the Colonization of Outer Space in the Twenty-First Century*, 35 SETON HALL L. REV. 299, 344–56 (2004); Lauren E. Shaw, *Asteroids, the New Western Frontier: Applying Principles of the General Mining Law of 1872 to Incentivize Asteroid Mining*, 78 J. AIR L. & COM. 121, 143–54 (2013).

115. Western Sahara, Advisory Opinion, 1975 I.C.J. Rep. 12, ¶ 79 (Oct. 16).

116. *Id.* (italicization in original).

117. *See, e.g.*, Johnson v. M'Intosh, 21 U.S. (8 Wheat.) 543, 587 (1823) ("[D]iscovery gave an exclusive right to extinguish the Indian title of occupancy . . . ."); Mabo v. Queensland [No. 2] (1992) 175 CLR 1, ¶ 33 (Austl.) ("International law recognized . . . occupation of territory that was terra nullius as [one] of the effective ways of acquiring sovereignty.").

ereign nations.[118] Luxembourg has taken a similar approach through its own legislation.[119]

There are some notable advantages to this approach. The absence of an international policing or enforcement mechanism in space arguably points in favor of regulation by nations with spaceflight capacity. Given the generally acknowledged challenges of enforcing international law,[120] one might wonder whether domestic governments might be better positioned to monitor and control private entities based within their borders. A nation-centric approach would also likely incentivize investment in asteroid mining, prompting countries and private actors to invest more aggressively so as not to lose the new space race.[121] Assuming, as this Note does, that the development of the asteroid mining industry is in the interest of humanity as a whole, this approach has some appeal.

However, a nation-centric, first possession framework has drawbacks that highlight the desirability of an international governance regime for asteroid mining. First, the experience of colonization was one that prompted conflict between colonizers.[122] The peaceful character of space is one of the great achievements of the OST, and it should not be jettisoned. Second, a regime characterized by national actors could spark a race to the bottom with respect to domestic regulation, leading to the same "flags of convenience" problem present in the maritime context as asteroid mining and spaceflight companies relocate to avoid taxes, labor and safety standards, and tort liability.[123] An international framework, by contrast, could more

---

118. *See* U.S. Commercial Space Launch Competitiveness Act of 2015, Pub. L. No. 114-90, 129 Stat. 704.

119. *See* Loi du 20 juillet 2017 sur l'exploration et l'utilisation des ressources de l'espace [Law of July 20, 2017 on the exploration and utilization of space resources], MÉMORIAL A N° 674 DE 2017 (enacted July 28, 2017) (Lux.).

120. *See, e.g.*, Frederic L. Kirgis, *Enforcing International Law*, ASIL INSIGHTS, Jan. 22, 1996, (providing an overview of challenges of enforcement of international law).

121. *See* Ross Myers, *The Doctrine of Appropriation and Asteroid Mining: Incentivizing the Private Exploration and Development of Outer Space*, 17 Or. Rev. Int'l L. 183, 185 (2015) (suggesting that "the doctrine of appropriation, a modified version of the rule of capture, is a reasonable doctrine to incentivize the development of space. . .").

122. Examples of wars touched off or exacerbated by colonial conflict include the War of the Spanish Succession, the French and Indian War, and, to some extent, World War I. *See, e.g.,* HEW STRACHAN, THE FIRST WORLD WAR, VOLUME 1: TO ARMS 1–35 (2003) (discussing German *Weltpolitik* and the Moroccan crises as causes of World War I).

123. In the maritime context, the "flags of convenience" problem refers to the selection of a country of registry (or flag) based on the least burdensome tax and regulatory scheme. *See* Brian Baker, *Flags of Convenience and the Gulf Oil Spill: Problems and Proposed Solutions*, 34 HOUS. J. INT'L L. 687, 695 (2012) (noting the advantages of flags of convenience for owners of vessels as "(1) easy registration of maritime vessels, (2) lower taxes, (3) reduced operating expenses, and (4) freedom of control by the country of registry.") (quoting Richard J. Payne, *Flags of Convenience and Oil Pollution: A Threat to National Security*, 3 HOUS. J. INT'L L. 67, 69 (1980)). The consequences of the flags of convenience problem in maritime

easily prevent this problem by facilitating the creation of uniform standards for labor, safety, and liability, making relocation to under-regulated states a less attractive prospect. The drawbacks of a system governed by individual nations, in conjunction with the advantages of a global system illustrated above, point to the desirability of a revised framework governing asteroid mining that is international in character.

B. *A System with Minimal Regulatory Barriers to Entry*

Whatever approach is chosen to resolve the ambiguities in the OST ought not to be overly restrictive or create burdensome regulatory obstacles for private asteroid mining companies. Substantial regulation could discourage investment and hamper the development of an already capital-intensive and high-risk industry.[124] The ideal regulatory system for asteroid mining should maintain an international character for the reasons described in the previous section but should not impose cumbersome regulation on asteroid mining companies at this stage in their development. Rather, allowing norms to develop over time through the resolution of disputes between asteroid mining companies would likely result in the most efficient regulatory system and would be more attractive to companies and nations that might be tempted to disregard the treaty.

The development of whaling custom offers insight into the extent to which "property rights may arise anarchically out of social custom."[125] The analogy to asteroid mining is strong in that both are extractive, high-risk, and capital-intensive industries that take place in what is effectively *mare liberum* (free sea).[126] Herman Melville in *Moby-Dick* suggests the whaling industry was not governed by a "formal whaling code," but rather that the

---

law include substandard working conditions, safety concerns, and difficulty assigning tort liability to individual owners of vessels. *See* H. Edwin Anderson, III, *The Nationality of Ships and Flags of Convenience: Economics, Politics, and Alternatives*, 21 TUL. MAR. L.J. 139, 162–67 (1996). *See also* Matthew Schaefer, *The Contours of Permissionless Innovation in the Outer Space Domain*, 39 U. PA. J. INT'L L. 103, 175 (2017) (noting that flags of convenience could prove to be a problem for the space economy).

124. *See* Kamil Muzyka, *The Common Burden of "Spacemankind,"* SPACE REV. (July 10, 2017), http://www.thespacereview.com/article/3279/1 ("Forcing . . . small space prospecting companies into an unfavorable license and reaping huge royalties is not a best future for a developing new space industry.").

125. Robert C. Ellickson, *A Hypothesis of Wealth-Maximizing Norms: Evidence from the Whaling Industry*, 5 J.L. ECON. & ORG. 83, 83 (1989) [hereinafter Ellickson, *Hypothesis*]. For a more thorough discussion of this theory, see ROBERT C. ELLICKSON, ORDER WITHOUT LAW: HOW NEIGHBORS SETTLE DISPUTES (1991),

126. *See generally* HUGO GROTIUS, THE FREE SEA (David Armitage ed., Richard Hakluyt trans., Liberty Fund 2011) (1609) (arguing for freedom of navigation of the high seas as a global commons); *see also* Muzyka, *supra* note 124 (mentioning briefly whaling in connection with asteroid mining).

"fishermen have been their own legislators and lawyers in this matter."[127] Over time, the custom developed that "I. A Fast-Fish belongs to the party fast to it [and] II. A Loose-Fish is fair game for anybody who can soonest catch it."[128] While Melville concedes that "the commentaries of the whalemen themselves sometimes consist in hard words and harder knocks—the Coke-upon-Littleton of the fist,"[129] he also notes that this code is "universal, undisputed law applicable to all cases"[130] that prevents "vexatious and violent disputes [arising] between the fishermen."[131] By and large, whalers were able to govern themselves by crafting norms over time that suited their needs.

Robert Ellickson, in his *Hypothesis of Wealth-Maximizing Norms*, cited the development of whaling norms as supporting the idea that, "when people are situated in a close-knit group, they will tend to develop for the ordinary run of problems norms that are wealth-maximizing."[132] Ellickson defines wealth-maximizing norms as those that minimize the sum of transaction costs and deadweight losses that the members of a group objectively incur.[133] Those involved in the group activity are likely to develop rules in a utilitarian manner, preferring "bright-line rules that would eliminate arguments to fuzzy rules that would prolong disputes."[134] The few asteroid mining companies currently in existence are not only a close-knit group under Ellickson's definition,[135] but are best positioned to create rules that will give rise to greater clarity and reduce transaction costs due to their proximity to and soon-to-be-developed experience with the business of asteroid mining. Rules like these would incentivize asteroid mining through greater legal clarity and predictability, thus facilitating the delivery of asteroid mining's benefits to all mankind.

The UNCLOS ratification debate helps illustrate why a more substantial regulatory regime might prove counterproductive for the international community. One of the primary reasons cited by American opponents of ratification is that accession to the treaty would subject American mining companies "to the whims of an unelected and unaccountable bureaucracy and would force them to pay excessive fees to the International Seabed Au-

---

127. HERMAN MELVILLE, MOBY-DICK 395 (Harrison Hayford et al. eds., 1988) (1851).

128. *Id.* at 396.

129. *Id.*

130. *Id.* at 395.

131. *Id.*

132. Ellickson, *Hypothesis*, *supra* note 125, at 84.

133. *Id.* ("A norm is 'wealth-maximizing' when it operates to minimize the members' objective sum of (1) transaction costs, and (2) deadweight losses arising from failures to exploit potential gains from trade.").

134. *Id.* at 87.

135. *See id.* at 84 (noting that "informal social control" is a key element of a close-knit group).

thority for redistribution to developing countries."[136] While other commentators have dismissed these concerns as "pure nonsense," noting that these same companies favor accession to the treaty for the sake of having a clear legal claim to mined minerals,[137] it is easy to imagine that a similar scheme of bureaucratic redistribution in the context of asteroid mining might be disregarded by the United States. A decision by nations leading the way on asteroid mining to opt out of a treaty would for all practical purposes cripple future treaty efforts. A key advantage of the proposed regulatory framework described in this Note is a practical one: it would offer the attractive prospect of legal clarity without an international bureaucratic bogeyman, making it more likely that key national stakeholders like the United States would sign on.

CONCLUSION

Maintaining the international character of outer space while allowing private companies to develop their own governing norms under a slightly revised OST would preempt the outbreak of a new race by sovereign governments to colonize space; create greater certainty for those undertaking the enterprise of asteroid mining; and permit the development of an efficient system tailored to maximize returns on celestial investment. The asteroid mining industry has the potential to confer benefits on all mankind as a means of facilitating space travel, spurring the development of science and technology, mitigating the potential for a calamitous asteroid impact, and facilitating climate change mitigation efforts. As such, it is in the interest of all nations to revise the OST to allow greater certainty in this endeavor. While the "entire unimaginable infinity of creation"[138] is still out of reach based on our existing physics and engineering capabilities, asteroid mining is a critical step in beginning to harness celestial resources and more fully explore the intricacies of the universe around us.

---

136. Thedore R. Bromund et al., *7 Reasons U.S. Should Not Ratify UN Convention on the Law of the Sea*, HERITAGE FOUNDATION (June 4, 2018), https://www.heritage.org/global-politics/commentary/7-reasons-us-should-not-ratify-un-convention-the-law-the-sea.

137. Stewart M. Patrick, *(Almost) Everyone Agrees: The U.S. Should Ratify the Law of the Sea Treaty*, ATLANTIC (June 10, 2012), https://www.theatlantic.com/international/archive/2012/06/-almost-everyone-agrees-the-us-should-ratify-the-law-of-the-sea-treaty/258301/. The article also notes that Lockheed Martin, one of the companies interested in deep seabed mining, "could not assume investment risks until it was clear that it would have a clear legal title to its findings." *Id.*

138. ADAMS, *supra* note 1, at 70.