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Mining the Milky Way: How to Bring America's Extraterrestrial Excursions Back Into Compliance With International Obligations

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**MINING THE MILKY WAY: HOW TO BRING AMERICA'S
EXTRATERRESTRIAL EXCURSIONS BACK INTO
COMPLIANCE WITH INTERNATIONAL
OBLIGATIONS**

BRADEN ANDERSON*

ABSTRACT

In November of 2015, the 114th United States Congress enacted the Commercial Space Launch Competitiveness Act of 2015 (Space Act) and, in turn, thrust the door to outer space mining wide open for Americans. Unfortunately, while the Space Act provided a solution for corporations, it created a dilemma for the United States. As currently enacted, the Space Act directly conflicts with the world's foundational and most basic framework for international space law: The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (Outer Space Treaty).

To reassure other signatories and to ensure the United States complies with its international obligations under the Outer Space Treaty, Congress should establish a centralized regulatory authority to govern the activities of American entities in outer space and amend the Space Act to require bonding and permitting processes for entities wishing to engage in asteroid mining. This Article is the first to analyze how to modify existing legislation to impose sufficient regulation so the United States may once again comply with its international obligations under Article VI of the Outer Space Treaty. This Article will show that

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given the inherent risks of outer space mining, the intent and origins of the Outer Space Treaty, and the conflicting allowances contained in the Space Act, changes must be enacted to ensure that the tradition of treaty compliance and mineral-extraction regulation does not stop at our planet's troposphere.

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I. AMERICA, WE HAVE LIFTOFF! BUT SHOULD WE SHUT DOWN?

IN NOVEMBER OF 2015, the 114th United States Congress enacted the Commercial Space Launch Competitiveness Act of 2015 (Space Act)¹ and, in turn, thrust the door to outer space mining wide open for Americans.² Passage of the Space Act came in response to more than a decade's worth of American interest in exploitation of asteroid resources and commercialization of outer space.³ The Space Act gave a greenlight to multiple corporations who, despite having the resources and technology to begin asteroid mining operations, hesitated to begin due to uncertainty regarding ownership rights of any materials they extracted.⁴ By providing legal certainty regarding ownership rights,⁵ the Space Act became an integral solution to the economic stalemate in the commercialization of outer space.⁶

While the Space Act provided a solution to corporations, it created a dilemma for the United States. As currently enacted, the Space Act directly conflicts with the world's foundational and most basic framework for international space law: The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (Outer Space Treaty).⁷ Ratified by 111 countries and signed by 23 others around the globe on its date of signature,⁸ the Outer Space Treaty is a pervasive framework

¹ U.S. Commercial Space Launch Competitiveness Act, Pub. L. No. 114-90, 129 Stat. 704 (2015) (codified as amended at 51 U.S.C. §§ 51301–51303).

² *See id.*

³ *See, e.g.,* Dennis Wingo, *The Resources of the Moon and Beyond*, SPACE.COM (Feb. 23, 2005), <https://www.space.com/816-resources-moon.html> [<https://perma.cc/CRY9-JR3D>].

⁴ *See* Jennifer Hackett, *New Law Paves the Way for Asteroid Mining—but Will It Work?*, SCI. AM. (Dec. 4, 2015), <https://www.scientificamerican.com/article/new-law-paves-the-way-for-asteroid-mining-but-will-it-work/> [<https://perma.cc/9BEF-8X6P>].

⁵ *See* 51 U.S.C. § 51303.

⁶ *See* Hackett, *supra* note 4.

⁷ *See generally* Joshua E. Duke, *Conflict and Controversy in the Space Domain: Legalties, Lethalities, and Celestial Security*, WILD BLUE YONDER ONLINE J. (Sept. 29, 2020), <https://www.airuniversity.af.edu/Wild-Blue-Yonder/Article-Display/Article/2362296/conflict-and-controversy-in-the-space-domain-legalties-lethalities-and-celesti/> [<https://perma.cc/3G7J-JYD7>].

⁸ Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, *opened for signature* Jan. 27, 1967, 610 U.N.T.S. 205 [hereinafter Outer Space Treaty]; Jon

enacted to promulgate principles of global safety and equity.⁹ Given the Outer Space Treaty's intentions and objectives, which include a desire to prevent militarization of space, any breach of its provisions is worrisome to other signatories; further, failure of the United States to meet its obligations under the Outer Space Treaty could prompt other spacefaring nations to abandon their duties as well, threatening the delicate but cardinal security provided by this legal framework.¹⁰

To reassure other signatories and to ensure the United States complies with its international obligations under the Outer Space Treaty, Congress should establish a centralized regulatory authority to govern activities of American entities in outer space and amend the Space Act to require bonding and permitting processes for entities wishing to engage in asteroid mining. By passing the Space Act, which is unusually simplistic and lacks the specificity usually observed in similar legislation,¹¹ the United States breached two of the Outer Space Treaty's key provisions: the Non-Appropriation Article and the Oversight provision.¹² The former, which demands that no signatory appropriate the moon or any other celestial body "by claim of sovereignty, by means of use or occupation, or by any other means,"¹³ is said to be directly breached by Congress's allowance of asteroid mineral ownership rights in the Space Act.¹⁴ While asteroids were contemplated during Committee markup hearings, Congress found asteroids to be outside the scope of the intent of the Arti-

Kelvey, *55-Years-Ago, the World Wrote the Prime Directives for Outer Space*, INVERSE (Jan. 27, 2022, 9:00 AM), <https://www.inverse.com/science/what-is-the-outer-space-treaty> [<https://perma.cc/EKE7-YV3X>].

⁹ Outer Space Treaty, *supra* note 8, pmbl.

¹⁰ See *infra* Section I.B.2 and accompanying text (discussing opposition to and concerns regarding passage of the Space Act).

¹¹ See *The Space Resource Exploration and Utilization Act of 2015 Full Committee Markup: Hearing on H.R. 1508 Before the H. Comm. on Sci., Space & Tech.*, 114th Congress 1(2015) [hereinafter Johnson] (Statement of Eddie Bernice Johnson, Ranking Member), <https://science.house.gov/imo/media/doc/EBJ%20Open%20Asteroids.pdf> [<https://perma.cc/EB9F-KYGK>] (criticizing simplicity of the bill presented at markup).

¹² See Senjuti Mallick & Rajeswari Pillai Rajagopalan, *If Space is 'the Province of Mankind', Who Owns its Resources? An Examination of the Potential of Space Mining and Its Legal Implications*, 182 OBSERVER RSCH. FOUND. 1, 12 (2019).

¹³ Outer Space Treaty, *supra* note 8, art. II.

¹⁴ Brooks Hays, *New U.S. Space Mining Law May Violate International Treaty*, UPI (Nov. 27, 2015, 11:16 AM) https://www.upi.com/Science_News/2015/11/27/New-US-space-mining-law-may-violate-international-treaty/8751448634436/ [<https://perma.cc/7ZRG-WAQ4>].

cle II Appropriation provision.¹⁵ And while important, any remaining, perceived noncompliance with that provision is not within scope of this Article.

This Article is the first to analyze how to ensure the United States complies with its international obligations by amending the Space Act to include adequate regulatory provisions so as to satisfy Article VI (the oversight requirement) of the Outer Space Treaty. As you will see in Section II.A.2, Article VI states that non-governmental entities in outer space must be authorized and continuously supervised by the country from which they originate.¹⁶ Section II.B will explain that currently, the Space Act maintains no regulatory or authorization specifications that would align it with the obligations under the oversight requirement in the Outer Space Treaty.¹⁷ The lack of such provisions not only places the United States in breach of a paramount treaty establishing the framework for global safety, but it also enhances the already unique and immense risks inherent in conducting operations in outer space.¹⁸ Part III will discuss how these risks can be mitigated and the obligations can be met by the establishment of a centralized regulatory agency for American outer space activities, and by simple but significant amendments to the Space Act to include bonding and permitting process requirements modeled after existing natural resource legislation.¹⁹

These solutions are soundly based in traditional principles, applicable to adjustment in outer space. Every section of the energy industry has regulatory and compliance aspects aimed at balancing interests of safety, economic efficiency, and competition.²⁰ This Article will show that given the inherent risks of outer space mining, the intent and origins of the Outer Space

¹⁵ H.R. REP. NO. 114-153, at 8, 10 (2015).

¹⁶ See *infra* Section II.A.2 and accompanying text; Outer Space Treaty, *supra* note 8, art. VI.

¹⁷ See *infra* Section II.B and accompanying text; see generally 51 U.S.C. § 51302 (noting lack of regulatory or authorization requirements, other than FAA guidelines, for private entities).

¹⁸ See generally Duke, *supra* note 7.

¹⁹ See *infra* Part III and accompanying text (discussing how a regulatory agency authorized to implement and enforce bonding and permitting requirements may help the United States comply with duties imposed by the Outer Space Treaty).

²⁰ Lillian Giering & Vince Flickinger, *What We Can Learn from the Energy Industry About Safety in the New Workplace*, GENSLER (Apr. 28, 2020), <https://www.gensler.com/blog/what-we-can-learn-from-the-energy-industry-about-safety-in> [<https://perma.cc/EB34-6R5V>].

Treaty, and the conflicting allowances by the Space Act, the U.S. tradition of regulatory compliance must not stop at our planet's troposphere.

II. A GLANCE BACK BEFORE WE BLAST OFF

Foundationally, it is critical to garner a comprehensive understanding of the key considerations that have, from the beginning and throughout time, shaped today's social and political landscapes, attitudes, and proclivities regarding outer space. Section II.A will examine the intent and requirements underlying the planet's most prolific and historic space-related treaty, which forms modern space law's most basic framework: The Outer Space Treaty.²¹ Section II.B will discuss the Space Act and specifically, the rights it extends to Americans and the strong responses, both positive and negative, it evokes.²² With a better understanding of space-specific political climates and perspectives, Section II.C will discuss the future of outer space mining operations and techniques while detailing the history of natural resource extraction, its failures, and the applicability of lessons learned to future extraterrestrial mining projects.²³

A. A BIG DIPLOMATIC BANG: THE OUTER SPACE TREATY

Since the Outer Space Treaty serves as space law's most foundational basis, understanding its key provisions and impositions is paramount to understanding the future of outer space mining. Section II.A.1 will highlight the foremost considerations contemplated by the drafting nations of the treaty, one of which was the United States, as well as the concerns and expectations of those that signed it.²⁴ Following the discussion of these frames of reference, Section II.A.2 will detail the core duties, primarily the oversight and authorization requirement, imposed upon signatories by the Outer Space Treaty in Articles II, VI, and VII.²⁵

²¹ See *infra* Section II.A and accompanying text (summarizing the key provisions and considerations of the Outer Space Treaty).

²² See *infra* Section II.B and accompanying text (summarizing key provisions of and reactions to the Space Act).

²³ See *infra* Section II.C and accompanying text (summarizing historical considerations in terrestrial mining that may be applicable to mining in outer space).

²⁴ See *infra* Section II.A.1 and accompanying text (summarizing the origins, obligations, intent, and concerns associated with the Outer Space Treaty).

²⁵ See *infra* Section II.A.2 and accompanying text (summarizing a signatory's duty to supervise its spacefaring entities).

1. *Origins, Obligations, Intent, and Concerns*

The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (Outer Space Treaty), commonly referred to as the Outer Space Treaty, was entered into force on October 10, 1967,²⁶ and serves as the foundational basis of international space law.²⁷ In total, 111 countries, including all spacefaring nations around the globe,²⁸ signed and ratified the Outer Space Treaty.²⁹ The Outer Space Treaty came primarily as a response to the development of intercontinental ballistic missiles (ICBMs) and threats of militarization of space.³⁰ In the early 1950s, the introduction of ICBMs meant that for the first time in the history of mankind, nations could be targeted from outer space, a possibility that many militaries, if not most, either did not contemplate or were not prepared to defend against.³¹ Planetary safety suddenly became a worldwide concern, and with the Soviet Union's historic launch of the world's first artificial satellite, Sputnik, an arms race between the Soviet Union and the United States began and prompted immediate efforts to prevent militarization of outer space.³² While demilitarization was a prominent focus of the Outer Space Treaty, there are several other aims that can be recognized by the provisions of the adopted Treaty. Among them is a resounding focus to "prevent 'a new form of colonial competition' and the possible damage that self-seeking exploitation might cause."³³

In recognition of these concerns, the Outer Space Treaty includes several provisions aimed at planetary safety and international equity. To address the former, the Outer Space Treaty prohibits nuclear weapons or weapons of mass destruction from being "place[d] in orbit around the Earth . . . install[ed] . . . on celestial bodies, or station[ed] in outer space in any other man-

²⁶ Outer Space Treaty, *supra* note 8, addendum 2.

²⁷ *See id.* addendum 8.

²⁸ *Id.*

²⁹ *Id.*; Kelvey, *supra* note 8.

³⁰ *See* Outer Space Treaty, *supra* note 8, vi.

³¹ *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies*, U.S. DEP'T OF STATE: BUREAU OF ARMS CONTROL, VERIFICATION, AND COMPLIANCE, <https://2009-2017.state.gov/t/isn/5181.htm> [<https://perma.cc/K8LX-FBVH>].

³² *Id.*

³³ Jessica West, *Back to the Future: The Outer Space Treaty Turns 40*, 28 PLOUGHSHARES MONITOR (2007), https://ploughshares.ca/pl_publications/back-to-the-future-the-outer-space-treaty-turns-40/ [<https://perma.cc/5K72-HLW4>].

ner.”³⁴ Regarding the latter, the Outer Space Treaty makes it expressly clear that space is open and “free for exploration and use by all States”³⁵ and that no nation shall appropriate the moon or *any other celestial body* “by claim of sovereignty, by means of use or occupation, or by any other means.”³⁶ These commands and many others reflect the vigorous intent of all signatories to promote peace, international cooperation, and planetary safety when conducting explorations and dealing with matters in outer space.³⁷

In efforts to construct meaningful enforcement of equitable inclusion and safety, the Outer Space Treaty contains several provisions aimed towards liability and conduct regulation of entities operating in outer space.³⁸ When drafting the Outer Space Treaty, the depositary governments (the Russian Federation, the United Kingdom, and the United States)³⁹ carefully examined and negotiated liability for actions and events occurring in outer space.⁴⁰ Currently, any State⁴¹ Party that launches an object into outer space, or “from whose territory or facility an object is launched, is internationally liable” for any damage resulting to another State Party from that object or its parts.⁴² This means, if a private individual, regardless of formal government affiliation, launches a satellite into space from within the borders of the United States or its territories, and that satellite crashes to Earth causing damage to property or otherwise along the way, the United States, not the individual, is internationally liable for the damage caused.⁴³ This liability was imposed by the 1972 Convention on International Liability for Damage caused by Space Objects (Liability Convention) and is an obvious reflection of international desire to further expand the scope of already-ex-

³⁴ Outer Space Treaty, *supra* note 8, art. IV.

³⁵ *Id.* art. I.

³⁶ *Id.* art. II.

³⁷ See *The Outer Space Treaty at a Glance*, ARMS CONTROL ASS’N, <https://www.armscontrol.org/factsheets/outerspace> [https://perma.cc/A842-8W5Y] (Oct. 2020) (discussing peaceful intent behind the drafting of the Outer Space Treaty).

³⁸ Convention on the International Liability for Damage Caused by Space Objects pmbl., Mar. 29, 1972, 961 U.N.T.S. 187 [hereinafter Liability Convention].

³⁹ Outer Space Treaty, *supra* note 8, art. XXIV.2.

⁴⁰ See Liability Convention, *supra* note 38, pmbl.

⁴¹ See *States in International Law*, BRITANNICA, <https://www.britannica.com/topic/international-law/States-in-international-law> [https://perma.cc/NWE7-M6Y4] (defining the term “state” within the context of international law).

⁴² Outer Space Treaty, *supra* note 8, art. VII.

⁴³ See Liability Convention, *supra* note 38, pmbl, arts. II–III.

isting liability provisions incorporated by the Outer Space Treaty.⁴⁴ By putting national governments on the hook for the actions of those within their sovereign borders, this provision's inclusion and expansion specifically highlights the global community's determination to incentivize spacefaring nations to regulate their and their constituents' outer space activities.⁴⁵

2. *Article VI: The Oversight and Authorization Requirement*

With the intent and provisions of the Outer Space Treaty as described above in mind, it should come as no surprise that the Treaty also contains an oversight requirement.⁴⁶ If the liability provision was not incentivization enough to promote the regulation of outer space activities, Article VI of the Outer Space Treaty is a direct commandment.⁴⁷ Article VI expressly states: "The activities of non-governmental entities in outer space, including the Moon and other celestial bodies, shall require *authorization and continuing supervision* by the appropriate State Party to the Treaty."⁴⁸ Article VI thus establishes State responsibility for the oversight of outer space activities conducted by individuals, organizations, and businesses emanating therefrom.⁴⁹ Therefore, it is commonly, and logically, argued that any State permitting private, non-governmental entities to launch into space, is not only liable for any damage the entities may cause, but also has a duty imported upon it to formulate and promulgate methods of authorization and observation of their extraterrestrial operations.⁵⁰ What is not so commonly agreed, however, is to what extent is that authorization and oversight sufficient?⁵¹

⁴⁴ See *id.* pmbl, art. II (detailing the imposition of liability unto states from with damage-causing launches originate).

⁴⁵ See *id.*

⁴⁶ See Outer Space Treaty, *supra* note 8, art. VI; Michael J. Listner, Op-ed, *A Reality Check on Article VI and Private Space Activities*, SPACENEWS (June 6, 2017), <https://spacenews.com/a-reality-check-on-article-vi-and-private-space-activities/> [<https://perma.cc/A8EZ-TCRP>].

⁴⁷ Cf. Brian J. Egan, *The Next Fifty Years of the Outer Space Treaty*, U.S. DEP'T OF STATE (Dec. 7, 2016), <https://2009-2017.state.gov/s/1/releases/remarks/264963.htm> [<https://perma.cc/X77J-WG6R>] (acknowledging the burden imposed on states to regulate space activity but suggesting that current safeguards sufficiently address such concerns).

⁴⁸ Outer Space Treaty, *supra* note 8, art. VI (emphasis added).

⁴⁹ See *id.*; cf. Egan, *supra* note 47.

⁵⁰ See, e.g., Egan, *supra* note 47.

⁵¹ See generally *Reopening the American Frontier: Exploring How the Outer Space Treaty Will Impact American Commerce and Settlement in Space: Hearing Before the Subcomm. on Space, Sci. & Competitiveness of the S. Comm. on Com., Sci. & Transp.*, 115th Cong.

B. ECLIPSING THE ORIGINS: PASSING THE COMMERCIAL SPACE LAUNCH COMPETITIVENESS ACT OF 2015

With a comprehensive understanding of the motives and requirements of the Outer Space Treaty, it is time to examine the same for the Space Act. Section II.B.1 will explore the fervent push for passing the Act quickly as well as the economic and market uncertainty it aims to clear up.⁵² Contrastingly, Section II.B.2 will take an in-depth look at the reasons the Space Act was so vehemently opposed by some legislators, experts, private individuals, and other nations as well as the direct conflict with the Outer Space Treaty that it imposes.⁵³

1. *Reasons for Passing*

Although the Outer Space Treaty clearly establishes damages liability and imposes a duty upon nations to authorize and supervise non-government entities in space, the lack of privatized space industry endeavors means that these provisions were largely of no concern to the United States for many years after the Outer Space Treaty's enactment.⁵⁴ It was not until the 1980s when the first privately funded rocket was launched into space⁵⁵ and not until the early 2000s that multiple U.S. companies began to develop launch vehicles and spacecraft.⁵⁶

However, by 2011, American interest in outer-space-related profits reached an all-time peak and spurred passionate legislative efforts to create a legally clear path towards outer space commercialization.⁵⁷ In 2015, President Barack Obama signed

3–49 (2017) (debating degrees of efficacy and sufficiency of proposed regulatory efforts).

⁵² See *infra* Section II.B.1 and accompanying text (discussing reasons the Space Act was passed and the problems it sought to solve).

⁵³ See *infra* Section II.B.2 and accompanying text (discussing points of contention those who do not support the Space Act raise).

⁵⁴ See Feyisola Ruth Ishola, Oluwabusola Fadipe & Olaoluwa Colin Taiwo, *Legal Enforceability of International Space Laws: An Appraisal of 1967 Outer Space Treaty*, 9 NEW SPACE 33, 34 (2021).

⁵⁵ John C. Abell, *Sept. 9, 1982: 3-2-1 . . . Liftoff! The First Private Rocket Launch*, WIRED (Sept. 9, 2009, 12:00 AM), <https://www.wired.com/2009/09/dayintech0909privaterocket/> [https://perma.cc/K3QG-HS38].

⁵⁶ See Michael Coren, *Private Craft Soars into Space, History*, CNN: SCI. & SPACE (July 14, 2004, 4:14 AM), <http://www.cnn.com/2004/TECH/space/06/21/sub-orbital.test/> [https://perma.cc/87P4-KN3A].

⁵⁷ See Brian Kennedy, *5 Facts About Americans' Views on Space Exploration*, PEW RSCH. CTR. (July 14, 2015), <https://www.pewresearch.org/fact-tank/2015/07/14/5-facts-about-americans-views-on-space-exploration/> [https://perma.cc/8YCB-DW2G]; Brian Kennedy & Mark Strauss, *Many in U.S. Have Confidence in*

into law the U.S. Commercial Space Launch Competitiveness Act (Space Act),⁵⁸ and changed the landscape of U.S. space exploration. The Space Act's primary functions were to grant U.S. companies legal certainty regarding outer space mining and to foster the ability of the United States to compete with other nations in the development of space mining as a robust, global industry.⁵⁹ In doing so, the Space Act legally permits U.S. companies to engage in exploitation of space resources⁶⁰ and provides that upon extraction, outer space miners are granted ownership interests in the minerals they recover.⁶¹ The Space Act particularly defines "space resources" as "an abiotic resource in situ in outer space."⁶²

Those who supported the Space Act's quick trip through Congress lauded the legislation as a crucial step in ensuring the United States does not fall behind other countries' industry endeavors.⁶³ By the time the Space Act was passed, other countries had already taken steps towards promoting development of the space mining industry,⁶⁴ and for good reason. Asteroids are generally classified into three main categories depending on composition.⁶⁵ Some contain rare and valuable metals at

What Private Space Companies Will Accomplish, PEW RSCH. CTR. (June 22, 2018), <https://www.pewresearch.org/fact-tank/2018/06/22/many-in-u-s-have-confidence-in-what-private-space-companies-will-accomplish/> [<https://perma.cc/VN26-5SKV>].

⁵⁸ 25 November 2015 – *President Obama Signs the SPACE Act Into Law*, APES IN SPACE (Nov. 25, 2017), <https://apesinspace.co/blogs/space-history/25-november-2015-obama-space-act> [<https://perma.cc/DH75-LRBB>].

⁵⁹ U.S. Commercial Space Launch Competitiveness Act, Pub. L. No. 114-90, 129 Stat. 704 (2015) (codified as amended at 51 U.S.C. §§ 51301–51303).

⁶⁰ 51 U.S.C. § 51302.

⁶¹ Gbenga Oduntan, *Who Owns Space? US Asteroid-Mining Act Is Dangerous and Potentially Illegal*, CONVERSATION (Nov. 25, 2015, 6:34 AM), <https://theconversation.com/who-owns-space-us-asteroid-mining-act-is-dangerous-and-potentially-illegal-51073> [<https://perma.cc/948V-3DH3>]; 51 U.S.C. § 51303.

⁶² 51 U.S.C. § 51301(2)(A).

⁶³ See Jacob Aron, *US SPACE Act Extends Easy Ride for Commercial Space Ventures*, NEW SCIENTIST (May 22, 2015), <https://www.newscientist.com/article/dn27583-us-space-act-extends-easy-ride-for-commercial-space-ventures/> [<https://perma.cc/T3ND-6FKZ>].

⁶⁴ Debbie Siegelbaum, *The Companies Vying to Turn Asteroids into Filling Stations*, BBC NEWS (Sept. 26, 2014), <https://www.bbc.com/news/magazine-29334645> [<https://perma.cc/K325-KDUJ>].

⁶⁵ Richard J. Bartlett, *Different Types of Asteroids (C, S, and M) – The Definitive Guide*, ASTRONOMY SOURCE (Aug. 11, 2020), <https://astronomysource.com/different-types-of-asteroids/> [<https://perma.cc/SF42-YZLC>].

concentrations much higher than what is found on Earth.⁶⁶ For example, 17% of known asteroids are S-Type asteroids.⁶⁷ These commonly contain minerals such as nickel, iron, and magnesium silicate mixture.⁶⁸ One small, ten-meter S-Type asteroid could contain up to 650,000 kilograms of metal with 50 kilograms in the form of rare metals, such as platinum and gold.⁶⁹ The rarest of asteroids, M-Types, contain up to ten times the amount of metal that S-Types do, making them even more valuable.⁷⁰ Even the most common of asteroids, C-Types, which make up 75% of known asteroids, have abundances of water.⁷¹ While not immediately used for mining, access to water in space could be used for rocket-fuel production and aid greatly in efforts to further exploration beyond currently known asteroids.⁷²

2. Concerns About Act Passage

However, not all in Congress or elsewhere approved of the Space Act's quick passage.⁷³ During the Space Act's Committee markup hearing, at least one member of Congress scrutinized the pace at which the Space Act reached markup sessions and the lack of general understanding of the practical effects it could have on planetary safety, as well as international trust and relations.⁷⁴ Among the most discussed concerns were the Space Act's ambiguities surrounding major terms; safety issues; and,

⁶⁶ *Asteroid Mining Could Solve Rare Metal Shortage*, MANUFACTURING.NET (Jan. 31, 2020), <https://www.manufacturing.net/technology/blog/21113380/asteroid-mining-could-solve-rare-metal-shortage#:~:text=asteroids%20can%20be%20grouped%20broadly,what%20is%20found%20on%20Earth> [<https://perma.cc/5DUF-MJ82>].

⁶⁷ Bartlett, *supra* note 65.

⁶⁸ *Id.*

⁶⁹ Science Desk, *Can Asteroid Nereus Be Mined for Metals Worth Billions?*, INDIAN EXPRESS, <https://indianexpress.com/article/technology/science/asteroid-nereus-mined-metals-worth-billions-7674276/> [<https://perma.cc/J6KZ-JQ3V>] (Dec. 15, 2021, 5:26 PM).

⁷⁰ *Id.*

⁷¹ *C-Type Asteroids: Facts & Information*, NINE PLANETS (Mar. 5, 2020), <https://nineplanets.org/c-type-asteroids/> [<https://perma.cc/MVA2-JHUV>].

⁷² See Neel V. Patel, *Here's How We Could Mine the Moon for Rocket Fuel*, MIT TECH. REV. (May 19, 2020), <https://www.technologyreview.com/2020/05/19/1001857/how-moon-lunar-mining-water-ice-rocket-fuel/> [<https://perma.cc/NC5Q-GTG9>].

⁷³ See, e.g., *Group Letter: Opposition to the SPACE Act, a Bill to Immunize Private Space Companies*, N.Y.U.: CTR. FOR JUST. & DEM. (May 20, 2015), <https://centerjd.org/Group%20Letter%20In%20Opposition%20to%20the%20SPACE%20Act> [<https://perma.cc/FCW2-S975>].

⁷⁴ See Johnson, *supra* note 11.

most importantly, perceived contradictions of express and implied principles in the Outer Space Treaty.⁷⁵ The latter has been the focus of many discussions and several articles. For example, critics of the Space Act point out that legalizing exploitation of asteroid resources is synonymous to national appropriation by “other means” as expressly prohibited in Article II of the Treaty.⁷⁶ Those critics point out that the definition of “celestial body” commonly and widely includes asteroids and that the “loophole” created by Congress—ownership rights in minerals extracted rather than in the mass they are extracted from—is nothing more than an inaccurate and insulting splitting of hairs.⁷⁷ However, Congress has determined, and it is unchallenged for purposes of this Article, that even though the Space Act permits exploitation of asteroids, its loophole avoids appropriation and maintains a key consideration of the Outer Space Treaty, which was the preservation and equitable access to the *Moon* and other *planets* in space.⁷⁸ That being so, arguments relating to the Space Act’s violation of the appropriation clause in the Outer Space Treaty were rejected by Congress and are not the focus of this Article.

Another prominent concern articulated during markup was the unusual simplicity of the Space Act compared to other legislation at this stage, particularly the ambiguity of key terms and the overall lack of specificity.⁷⁹ The Space Act legalized reasonable exploration and utilization of extraterrestrial resources but failed to identify any structure or guidance for a determination of a standard of reasonableness consistent with existing international obligations, such as those imposed by the Outer Space Treaty.⁸⁰ Furthermore, the Space Act failed to set forth any guiding criteria that would qualify entities to participate in space

⁷⁵ See Eddie Bernice Johnson, Ranking Member, Floor Statement by Ranking Member Eddie Bernice Johnson on Senate Amendment to Space Act of 2015 (Nov. 16, 2015), <https://science.house.gov/news/press-releases/floor-statement-by-ranking-member-eddie-bernice-johnson-on-senate-amendment-to-space-act-of-2015-> [https://perma.cc/V52V-VRRY].

⁷⁶ Peter B. de Selding, *New U.S. Space Mining Law’s Treaty Compliance May Depend on Implementation*, SPACENEWS (Dec. 9, 2015), <https://spacenews.com/u-s-commercial-space-acts-treaty-compliance-may-depend-on-implementation/> [https://perma.cc/V826-6BAB].

⁷⁷ Mallick & Rajagopalan, *supra* note 12, at 11–13.

⁷⁸ *Id.* at 11.

⁷⁹ Johnson, *supra* note 11.

⁸⁰ See 51 U.S.C. §§ 51302–51303; Outer Space Treaty, *supra* note 8, art. VI.

mining, and instead legalized it for anyone capable of doing so.⁸¹

Outside congressional walls, media outlets and space industry experts express concern that the Space Act poses threats to physical safety on Earth.⁸² Many of these commentators point out that mining operations inherently carry dangerous risks.⁸³ Among these risks include reverse contamination, pollution, and even asteroid collisions with Earth.⁸⁴ Most asteroids are not sedentary, meaning that alteration of their orbital trajectories is possible.⁸⁵ Accordingly, if mining entities are not careful in their operations, they risk altering the trajectories of asteroids near Earth and other celestial bodies, potentially causing serious and irrecoverable collisions.⁸⁶ Critics comment that because of the lack of standards for authorization and regulation within the Space Act, entities lacking the technology, knowledge, and even judgment to safely execute precarious mining operations are

⁸¹ See generally 51 U.S.C. §§ 51301–51303 (noting absence of qualifying criteria or limitation on participation for entities looking to engage in asteroid mining).

⁸² See, e.g., Joshua Rapp Learn, *Asteroid Miners Could Use Earth's Atmosphere to Catch Space Rocks*, Sci. AAAS (Aug. 29, 2018), <https://www.science.org/content/article/asteroid-miners-could-use-earth-s-atmosphere-catch-space-rocks> [<https://perma.cc/57PS-V5XN>]; see generally Steven J. Ostro & Carl Sagan, *Cosmic Collisions and the Longevity of Non-Spacefaring Galactic Civilizations*, JET PROPULSION LAB'Y, CAL. INST. TECH., May 1998, at 1, 2, 5 <https://trs.jpl.nasa.gov/bitstream/handle/2014/19498/98-0908.pdf> [<https://perma.cc/6R5T-4H2V>] [hereinafter Ostro & Sagan, *Cosmic Collisions and the Longevity of Non-Spacefaring Galactic Civilizations*]; Steven Ostro & Carl Sagan, *Cosmic Collisions and Galactic Civilizations*, 39 ASTRONOMY & GEOPHYSICS: J. ROYAL ASTRONOMICAL SOC'Y, 22, 22–24 (1998), <https://web.archive.org/web/20160304193730/http://abob.libs.uga.edu/bobk/cc/cc080498.html> [<https://perma.cc/SZS3-V9BH>] [hereinafter Ostro & Sagan, *Cosmic Collisions and Galactic Civilizations*]; Carl Sagan & Steven J. Ostro, *Dangers of Asteroid Deflection*, 368 NATURE 501, 501 (1994), <https://www.nature.com/articles/368501a0> [<https://perma.cc/24EW-FPKX>] [hereinafter Sagan & Ostro, *Dangers of Asteroid Deflection*].

⁸³ Lysette Maurice N. Sandoval, *Asteroid Mining: Beneficial or Dangerous?*, Sci. TIMES (Aug. 6, 2019, 5:48 AM), <https://www.sciencetimes.com/articles/23554/20190806/asteroid-mining-beneficial-dangerous.htm> [<https://perma.cc/M4EN-7TDZ>].

⁸⁴ *Id.*

⁸⁵ See Nola Taylor Tillman, *NASA Tracking Huge Asteroid with Radar for Tuesday Encounter*, SPACE.COM (Nov. 7, 2011), <https://www.space.com/13533-huge-asteroid-2005-yu55-radar-tracking.html> [<https://perma.cc/T95S-5A4S>].

⁸⁶ Learn, *supra* note 82; see also Ostro & Sagan, *Cosmic Collisions and the Longevity of Non-Spacefaring Galactic Civilizations*, *supra* note 82; Ostro & Sagan, *Cosmic Collisions and Galactic Civilizations*, *supra* note 82; Ostro & Sagan, *Dangers of Asteroid Deflection*, *supra* note 82.

nevertheless free to try their hand at an unknown industry with potentially deadly consequences.⁸⁷

C. MINES TO METEORS: PAST AND FUTURE OF NATURAL RESOURCE EXTRACTION LAW

Concerns regarding the regulation of natural resource extraction are nothing new. Every energy sector presently existing involves some type of regulation, is subject to the oversight of some type of governing body, or is both regulated and subject to the oversight of a governing body.⁸⁸ One notable example is the Railroad Commission of Texas (RRC). For over 100 years, the RRC has regulated the oil and gas industry to prevent abuses of power by large companies and to protect public economic and environmental interests.⁸⁹ Ironically, the RRC no longer regulates the railroads⁹⁰ as its name still implies. Today, the RRC maintains “primary regulatory jurisdiction over the oil and natural gas industry, pipeline transporters, natural gas and hazardous liquid pipeline industry, natural gas utilities, . . . and coal and uranium surface mining operations.”⁹¹

As the primary regulatory authority for energy in Texas, the RRC serves to protect natural resources, the environment, and the safety of all Texans.⁹² The RRC, like many other regulatory authorities, coordinates with multiple agencies, including the United States Environmental Protection Agency, which commended the RRC on its “outstanding enforcement monitoring program” for disposal wells and for “exceed[ing] the minimum performance measure” in its testing and surveillance for Class II injection wells.⁹³ Like the RRC, other regulatory agencies within the energy industry play a vital role in promulgating and enforcing adequate measures to ensure safety and efficiency.

1. *Physical Human Safety*

The fatalistic history of times when resource extraction regulation was lacking within traditional resource sectors is proof of

⁸⁷ See Sandoval, *supra* note 83; Oduntan, *supra* note 61.

⁸⁸ See Giering & Flickinger, *supra* note 20.

⁸⁹ *History of the Railroad Commission of Texas*, R.R. COMM’N OF TEX., <https://www.rrc.texas.gov/about-us/rrc-history/> [https://perma.cc/PWP3-ZVXF].

⁹⁰ *Id.*

⁹¹ *About Us*, R.R. COMM’N OF TEX., <https://www.rrc.texas.gov/about-us/> [https://perma.cc/QMN9-T4SJ].

⁹² *Id.*

⁹³ R.R. COMM’N OF TEX., *supra* note 89.

its absolute necessity in contemporary and all future resource sectors. Far too often has the world been reminded of the dangers that unregulated energy industries and their associated by-products pose to human health. For example, the Courrières Mine Disaster is said to have been Europe's worst mining disaster.⁹⁴ In 1906, 1,060 miners and 30 other people were killed after a coal-dust explosion destroyed the mine.⁹⁵ While the cause of the initial ignition was never determined with absolute certainty, it is widely accepted that ignition resulted from workers carrying open-flamed lamps⁹⁶ as opposed to safer, but more expensive, Davy lamps, which enclosed the flame within a mesh screen, reducing the risk of ignition in flammable environments.⁹⁷

The Courrières Mine Disaster is second only to the Benxihu Coal Mine Fire, which also was caused by a preventable explosion.⁹⁸ In 1942 in what is now modern-day China, the Benxihu Coal Mine Fire killed more than 1,500 workers, earning it the title of worst coal-mining disaster in history.⁹⁹ Workers were subjected to harsh, unregulated working conditions and died of carbon monoxide poisoning after Japanese operators shut off the ventilation in order to starve the fire, and their workers, of oxygen.¹⁰⁰

Such catastrophes are not restricted to Eurasia. In the United States, the Farmington Mine Disaster of 1968 involved a devastating explosion that cost dozens of lives but fortunately led to the passage of critical mining regulatory legislation.¹⁰¹ Investiga-

⁹⁴ See *The World's Worst Coal Mining Disasters*, MINING TECH., <https://www.mining-technology.com/features/feature-world-worst-coal-mining-disasters-china/> [<https://perma.cc/SL6U-T8B9>] (Oct. 25, 2021, 1:29 PM); see also STEPHEN J. SPIGNESI, *CATASTROPHE!: THE 100 GREATEST DISASTERS OF ALL TIME* 168 (2002 1st ed.).

⁹⁵ MINING TECH., *supra* note 94.

⁹⁶ *Id.*

⁹⁷ *Brief History of the Miner's Flame Safety Lamp*, MINERSLAMPS, <https://web.archive.org/web/20030826065256/http://www.minerslamps.net/homepage/safetylamphistory.htm> [<https://perma.cc/7FD2-6H99>].

⁹⁸ *The Ten Worst Worldwide Mining Disasters*, EPIC DISASTERS, https://web.archive.org/web/20100418115719/http://www.epicdisasters.com/index.php/site/comments/the_ten_worst_worldwide_mining_disasters [<https://perma.cc/UCM2-D53V>].

⁹⁹ See *id.*; MINING TECH., *supra* note 94.

¹⁰⁰ MINING TECH., *supra* note 94.

¹⁰¹ Bonnie Stewart & Scott Finn, *Memo Suggests Cause of 1968 Mine Deaths*, NPR (Nov. 18, 2008, 6:01 PM), <https://www.npr.org/templates/story/story.php?storyId=97115205> [<https://perma.cc/44FZ-BKZ4>].

tions into the explosion revealed that significant contributing factors involved inadequate, and in some locations non-existent, ventilation and a disabled ventilation fan that was responsible for flushing explosive methane gas from the mine.¹⁰² This disaster, though tragic, was a critical step leading to the passage of the Federal Coal Mine Health and Safety Act of 1969 (CMHSA).¹⁰³ This Act was the first regulatory action of its kind, and it greatly increased safety standards in mining operations and granted mine workers specific health and safety rights, forever changing the landscape of the coal industry¹⁰⁴ for the better.

2. *Environmental Safety*

As well as causing physical harm and human casualties, the failure or lack of extraction regulation has an immensely broad and long-lasting negative impact on the environment and has led to several legislative reformation responses.¹⁰⁵ In 2014, the Mount Polley mine in British Columbia, Canada accumulated a large amount of water held in place by a dam in its tailings facility.¹⁰⁶ A tailings facility is usually comprised of one or more dammed pools used to store water, sand, silt, and ground-up rock used in the milling process.¹⁰⁷ When the dam leaked, the entire one-and-a-half square mile pool of waste spilled into the surrounding water supplies.¹⁰⁸ The surrounding water sources subsequently contained increased levels of selenium and arse-

¹⁰² Ken Ward Jr., *Lawsuit Alleges Cover-up After 1968 Farmington No. 9 Mine Disaster*, CHARLESTON GAZETTE-MAIL (Nov. 6, 2014), https://www.wvgazette.com/news/lawsuit-alleges-cover-up-after-farmington-no-mine-disaster/article_7c414ce5-d80a-5908-b23a-b39908d3dbf3.htm [https://perma.cc/B4WZ-A7X5].

¹⁰³ See Gerhard Peters & John T. Woolley, *Richard Nixon: Statement on Signing the Federal Coal Mine Health and Safety Act of 1969*, AM. PRESIDENCY PROJECT (Dec. 30, 1969), <https://www.presidency.ucsb.edu/ws?pid=2389> [https://perma.cc/4AJK-PQZE].

¹⁰⁴ See *id.*

¹⁰⁵ See *What are Environmental Regulations on Mining Activities?*, AM. GEOSCIENCES INST. (Nov. 16, 2021), <https://www.americangeosciences.org/critical-issues/faq/what-are-regulations-mining-activities> [https://perma.cc/H6K9-Q54K].

¹⁰⁶ *Mount Polley Mine Tailings Spill: Imperial Metals Could Face \$1M Fine*, CBC NEWS, <https://www.cbc.ca/news/canada/british-columbia/mount-polley-mine-tailings-spill-imperial-metals-could-face-1m-fine-1.2728832> [https://perma.cc/6NE6-ZLVK] (Aug. 6, 2014).

¹⁰⁷ *What Is a Tailings Storage Facility (TSF)?*, MINING ASS'N B.C., <https://www.mining.bc.ca/what-tailings-storage-facility-tsf> [https://perma.cc/V8TP-JFT8].

¹⁰⁸ Yvette Brend, *7 Years Later, 2 Engineers Face Discipline for Actions That Led to Mt. Polley Mine Disaster*, CBC NEWS, <https://www.cbc.ca/news/canada/british-co>

nic, and the surrounding areas experienced considerable physical damage.¹⁰⁹ Investigatory reports revealed the dam's breach was the result of the province's regulatory body's—the British Columbia Ministry of Energy, Mines & Petroleum Resources—failure to ensure the dam was constructed and *operated* according to approved plans.¹¹⁰

Likewise, as is the case in most tailing facility failures, “inadequate commitment to safe storage combined with poor management” also led to the disastrous Baia Mare Cyanide Spill in 2000.¹¹¹ There, a dam breach resulted in 100,000 cubic meters of cyanide-contaminated water spilling over precious farmland and into the Somes River.¹¹² The spill, which is referred to as Europe's worst environmental disaster since Chernobyl, caused cyanide levels in the Somes to rise to over 700 times permissible levels.¹¹³ It contaminated the drinking water of over 2.5 million Hungarians and killed 80% of all aquatic life in the Serbian portion of the Tisza River.¹¹⁴ This environmental tragedy prompted widespread calls for banning dangerous mining practices, such as the cyanide heap leaching used there, and awakened Europe's eyes to the necessity of impactful resource extraction regulation.¹¹⁵

Overall, the consequences of ineffective or absent regulation in natural resource extraction law have devastating, long-lasting, and far-reaching impacts. The disasters detailed above, caused by failed regulation and a lack of adequate oversight, not only caused mass human casualties and environmental destruction, but severely impacted the travel and tourism economies of the

lumbia/discipline-engineers-mount-polley-mine-waste-quesnel-lake-1.6137265 [https://perma.cc/LJE9-EE34] (Aug. 12, 2021).

¹⁰⁹ *Mount Polley Spill: Testing Finds Elevated Selenium in Fish*, CBC NEWS, <https://www.cbc.ca/news/canada/british-columbia/mount-polley-spill-testing-finds-elevated-selenium-in-fish-1.2744343> [https://perma.cc/G9HL-MM7J] (Sept. 9, 2014).

¹¹⁰ Jose Olivares, *U.N. Body Alarmed Over Mining Waste Disasters*, NPR (Dec. 2, 2017, 7:00 AM), <https://www.npr.org/sections/goatsandsoda/2017/12/02/565681233/u-n-body-alarmed-over-mining-waste-disasters> [https://perma.cc/H8B4-XNGT].

¹¹¹ *See id.*

¹¹² Emma Batha, *Death of a River*, BBC NEWS (Feb. 15, 2000), <http://news.bbc.co.uk/2/hi/europe/642880.stm> [https://perma.cc/H2D7-GRXQ].

¹¹³ *Id.*

¹¹⁴ *Id.*

¹¹⁵ *See id.*; Nick Thorpe, *Second Cyanide Spill Blights Romania*, BBC NEWS (Jan. 26, 2001), <http://news.bbc.co.uk/2/hi/europe/1137460.stm> [https://perma.cc/MG7X-FLYW].

regions where they happened.¹¹⁶ These failures are strong evidence in support of the obvious need for effective regulations in existing as well as new areas of natural resource extraction in order to prevent ruinous harm to humans, the environments they populate, and the economies they rely on.

III. OVERHAUL TO OVERSEE: U.S. ESTABLISHMENT OF A REGULATORY AUTHORITY TO IMPLEMENT AND ENFORCE OVERSIGHT PROVISIONS FOR ENTITIES IN OUTER SPACE TO COMPLY WITH EXISTING INTERNATIONAL OBLIGATIONS

Space is commonly referenced as the final frontier,¹¹⁷ and rightfully so. Just as early prospectors once rushed to the West in search of riches and notoriety,¹¹⁸ today's billionaires are already working to stake their claim and make their mark on extraterrestrial commercialization.¹¹⁹ Space offers valuable resources in quantities unattainable on Earth¹²⁰ and has driven wealthy investors and private entities to expend vast resources in pursuit of such resources. As noted above, the Space Act authorizes United States citizens—and corporations—to legally obtain and possess minerals mined or extracted from outer space asteroids.¹²¹

While many legislators, activists, and foreign bodies challenge the Space Act's legality pertaining to Article II of the Outer Space Treaty's "sovereignty provision,"¹²² this Article disregards the alleged conflict with Article II, as has the United States Con-

¹¹⁶ See generally Jaume Rosselló, Susanne Becken & Maria Santana-Gallego, *The Effects of Natural Disasters on International Tourism: A Global Analysis*, ELSEVIER (Feb. 1, 2020), <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7115519/> [<https://perma.cc/VL7S-Q55H>] (discussing why a country that is home to a disaster usually experiences a subsequent decline in tourism).

¹¹⁷ See Giancarlo Genta & Michael Rycroft, *Will Space Actually Be the Final Frontier of Humankind?*, 58 SCI. DIRECT 287, 293 (Dec. 13, 2005), <https://www.sciencedirect.com/science/article/pii/S0094576506000130> [<https://perma.cc/43WU-H2BC>].

¹¹⁸ *California Gold Rush*, HISTORY, <https://www.history.com/topics/westward-expansion/gold-rush-of-1849> [<https://perma.cc/2394-Z7YV>] (Apr. 16, 2021).

¹¹⁹ Swish Goswami, *Why the Billionaire Space Race Is a Good Thing*, FORBES (Sept. 14, 2021, 11:08 AM), <https://www.forbes.com/sites/forbestechcouncil/2021/09/14/why-the-billionaire-space-race-is-a-good-thing/?sh=753eb21f2899> [<https://perma.cc/WC8G-UUX8>].

¹²⁰ MANUFACTURING.NET, *supra* note 66.

¹²¹ See Goswami, *supra* note 119.

¹²² See Mallick & Rajagopalan, *supra* note 12, at 10–11; de Selding, *supra* note 76; Johnson, *supra* note 11; Johnson, *supra* note 75; N.Y.U.: CTR. FOR JUST. & DEM., *supra* note 73.

gress,¹²³ and instead focuses on fulfillment of and compliance with Article VI's oversight requirement. Article VI requires that, as a signatory to the Outer Space Treaty, the United States must authorize and continuously supervise the activities of its "non-governmental entities in outer space."¹²⁴ This presents a significant issue because Congress has formally authorized non-governmental mining activities in outer space,¹²⁵ but it has failed to establish any regulations for authorization or supervision of those activities, outside the launching and reentry requisites, as required by the Outer Space Treaty¹²⁶ and monitored by the FAA.¹²⁷ To comply with existing international obligations,¹²⁸ the United States ought to appoint a centralized regulatory authority to govern space mining operations and to adopt bonding and permitting regulatory amendments to the Space Act. Such measures would create a sufficient framework to bring the United States Space Act back into compliance with the Outer Space Treaty by effectively providing for authorization and continuous supervision of non-government entities in outer space.

A. POLICING FOR PARSECS: ESTABLISHING A CENTRALIZED SPACE REGULATORY AUTHORITY IN THE UNITED STATES

Regulatory provisions are only as effective as they are enforceable, and enforceability is nurtured by a strong, central point of authority.¹²⁹ Just as the Railroad Commission of Texas is needed to "regulate[] the exploration, production, and transportation of oil and natural gas in Texas,"¹³⁰ space mining operations also

¹²³ See generally Mallick & Rajagopalan, *supra* note 12, at 11 (discussing how the United States and Luxemburg have exploited a loophole to "author[ize] companies to claim exclusive ownership over extracted resources (but not the asteroid itself)").

¹²⁴ See Outer Space Treaty, *supra* note 8, art. VI.

¹²⁵ See 51 U.S.C. §§ 51301–51303.

¹²⁶ See generally *id.* § 51301 (noting absence of qualifying criteria or limitation on participation for entities looking to engage in asteroid mining).

¹²⁷ *Commercial Space Transportation*, FAA, https://www.faa.gov/regulations_policies/faa_regulations/commercial_space [https://perma.cc/9R9Y-9MUA] (May 18, 2021).

¹²⁸ *E.g.* Outer Space Treaty, *supra* note 8, art. VI.

¹²⁹ See Charles F. Connolly & Parvin Daphne Moyne, *Key Takeaways from FERC Enforcement's Energy Trading Compliance and Market Manipulation Law White Papers*, AKIN GUMP (Dec. 7, 2016), <https://www.akingump.com/en/experience/industries/energy/speaking-energy/key-takeaways-from-ferc-enforcement-s-energy-trading-compliance-1.html> [https://perma.cc/ZV3H-Z5PH].

¹³⁰ See *Railroad Commission of Texas Transportation Division Special Authority Orders: An Inventory of Railroad Commission Transportation Division Special Authority Or-*

need a regulatory authority to ensure safe standards, protect public interests, and prevent physical and environmental harm to not only the planet but also the galaxy. Presently, the Space Act fails to establish any such authority apart from launch and reentry requirements guided by the FAA.¹³¹ These launch and reentry requirements are no different than ones used for launches that will not involve asteroid mining, and do not provide the type of oversight imagined and advised by the Outer Space Treaty.¹³² Without a regulatory authority to enforce and promulgate operational, safety, and other applicable guidelines, private United States entities are left with nearly limitless bounds by which to conduct themselves in space mining operations without consideration of the impacts such conduct may have.¹³³ Such broad allowance is at odds with the language and intent behind the Outer Space Treaty and has proven worrisome to several of its signatories and their nationals.¹³⁴

Delegating regulatory authority to an appropriate agency is an obvious and important first step at the necessary imposition of effective regulations of space mining activity. Fortunately, the United States has already established a body that, with input from other panels and committees, might form the basis of such an agency: The Department of Commerce's Office of Space Commerce (Office of Space Commerce). The Department's primary objective is the "coordination of space-related issues, programs, and initiatives,"¹³⁵ and it is certainly poised to establish

ders at the Texas State Archives, 1894–1935, R.R. COMM'N OF TEX., https://tx.archives.org/tslac/finding_aids/20087.xml#:~:text=the%20Railroad%20Commission%20of%20Texas%20regulates%20the%20exploration%2C%20production%2C%20and,and%20natural%20gas%20in%20Texas.&text=IT%20oversees%20hazardous%20materials%20pipelines,gas%2C%20 [https://perma.cc/P6ZZ-Y8ZS].

¹³¹ See, FAA, *supra* note 127; see generally 51 U.S.C. §§ 51301–51303.

¹³² See Johnson, *supra* note 11; Johnson, *supra* note 75.

¹³³ See Nick Stockton, *Congress Says Yes to Space Mining, No to Rocket Regulations*, WIRED (Nov. 18, 2015, 10:00 AM), <https://www.wired.com/2015/11/congress-says-yes-to-space-mining-no-to-rocket-regulations/> [https://perma.cc/585U-3L7M].

¹³⁴ See Interview by David Greene with Eddie Bernice Johnson, Rep., Audrey Quinn, and Rick Tumlinson, NPR (Dec. 22, 2015 5:06 AM), <https://www.npr.org/2015/12/22/460656826/commercial-space-industry-would-benefit-from-space-act-critics-say> [https://perma.cc/8SZB-5N3D]; see also James Rathz, *Law Provides New Regulatory Framework for Space Commerce*, REGUL. REV. (Dec. 31, 2015), <https://www.theregreview.org/2015/12/31/rathz-space-commerce-regulation/> [https://perma.cc/9J39-3ZW9] (discussing expert opinions on other nations' actual and potential responses to passage of the Space Act).

¹³⁵ 51 U.S.C. §§ 50701–50703.

itself as the governing authority on outer space mining regulations. However, even if the Office of Space Commerce is not deemed to be the best option for depositing regulatory authority, the importance of appointing a regulatory enforcement agency remains immense,¹³⁶ and the United States should expend every effort to identify the best option for delegation.

B. SAVE OUR SOLAR SYSTEM: BONDING REQUIREMENTS FOR PRESERVATION AND SAFETY

Within traditional and even newly emerging energy industries, bonding requirements continuously prove to be highly effective tools used to safeguard against the threats of related activities,¹³⁷ and can be equally applicable to safeguarding against the unique and dynamic threats posed by mining in space. Bond efficacy is lauded by both sides of a mining operation (the mining company and the impacted residents, governments, and environmental agencies) since the bond process ensures, among other things, adequate land restoration and safety requirements without forcing mining companies to immediately expend large amounts of capital that they could otherwise use to develop the project.¹³⁸ But to effectively safeguard against the distinguishing threats of outer space asteroid mining, this Article will focus on three main bond provisions: facility removal estimates, financial assurance for facility removal, and liability insurance requirements.¹³⁹

1. Facility Removal and Surface Restoration Requirement

One of the most important elements of a traditional natural resource extraction bond is the requirement that companies en-

¹³⁶ See Ian Christensen, Ian Lange, George Sowers, Angel Abbud-Madrid & Morgan Bazilian, *New Policies Needed to Advance Space Mining*, 35 ISSUES SCI. & TECH., Winter 2019, <https://issues.org/new-policies-needed-to-advance-space-mining/> [<https://perma.cc/9Z2K-SSXU>].

¹³⁷ See *Supporting Sustainable Resource Extraction and Green Investment*, U.N. ENV'T PROGRAMME, <https://www.unep.org/explore-topics/green-economy/what-we-do/economic-and-fiscal-policy/fiscal-policy/policy-analysis-5> [<https://perma.cc/2ZRT-5AM9>].

¹³⁸ *Mining and the Vanishing Surety Bond Market*, FINDLAW, <https://corporate.findlaw.com/business-operations/mining-and-the-vanishing-surety-bond-market.html#:~:text=because%20surety%20bonds%20allow%20mining,to%20develop%20a%20mining%20project> [<https://perma.cc/96SH-A9YT>] (Nov. 30, 2017).

¹³⁹ See *infra* Sections III.B.1–3 (introducing and explaining proposed regulatory and authorization requirements modeled after existing legislation).

sure the safe and sufficient closure of commercial facilities.¹⁴⁰ Within the energy field generally, there is a codified minimal standard for clean-up procedures depending on the resource sector, operation, and extraction method.¹⁴¹ This historical pattern of minimal standard codification should not stop with the advent of asteroid mining. If anything, given the particular and far-reaching threats presented by space mining, including potential collisions with Earth and backwards-contamination,¹⁴² this provision is even more necessary.

While not every asteroid mined will be of the size that warrants establishing a facility on its surface,¹⁴³ the United States would be wise to codify minimal standards for facility closure and cleanup on those that will, but also for various other extraction methods used on smaller sized asteroids. Sloppy or no clean-up procedures are responsible for billions of dollars in damages and thousands of lives lost here on Earth.¹⁴⁴ Without a system in place to ensure prevention of similar instances in space, the effects would be far more devastating and would impact the entire globe.¹⁴⁵

All spacefaring nations on Earth are somewhat counter-dependent in space.¹⁴⁶ This is evident by the language of the Outer Space Treaty, which calls for equitable inclusion and in-

¹⁴⁰ James Boyd, *Financial Responsibility for Environmental Obligations: An Analysis of Environmental Bonding and Assurance Rules*, U. COLL. LONDON 1, 13, 29–30, <http://www.cserge.ucl.ac.uk/Boyd.pdf> [<https://perma.cc/7NNY-U5WA>].

¹⁴¹ See, e.g., 2 DAVID EBNER, LAW OF FEDERAL OIL AND GAS LEASES § 24.03, Lexis.

¹⁴² Ostro & Sagan, *Dangers of Asteroid Deflection*, *supra* note 82, at 501; Sandoval, *supra* note 83.

¹⁴³ Lionel Wilson, Klaus Keil & Stanley J. Love, *The Internal Structures and Densities of Asteroids*, 34 METEORITES & PLANETARY SCI. 479, 479–80 (Feb. 5, 1999), <https://onlinelibrary.wiley.com/doi/10.1111/j.1945-5100.1999.tb01355.x> [<https://perma.cc/V3YV-ED9V>].

¹⁴⁴ See, e.g., J.R. Owen, D. Kemp, É. Lèbre, K. Svobodova & G. Pérez Murillo, *Catastrophic Tailings Dam Failures and Disaster Risk Disclosure*, 42 INT'L J. DISASTER RISK REDUCTION 1, 1–3 (2020), <https://www.sciencedirect.com/science/article/pii/S2212420919306648> [<https://perma.cc/PY4U-ZEHY>]; MINING TECH., *supra* note 94.

¹⁴⁵ Cf. Sarah Scoles, *Dust from Asteroid Mining Spells Danger for Satellites*, NEW SCIENTIST (May 27, 2015), <https://www.newscientist.com/article/mg22630235-100-dust-from-asteroid-mining-spells-danger-for-satellites/> [<https://perma.cc/BYV9-D38W>] (discussing the need for containment protocols to avoid dust from asteroid mining operations harming satellites).

¹⁴⁶ CASSANDRA STEER, CTR. FOR ETHICS & THE RULE OF L., UNIV. OF PENN., WHY OUTER SPACE MATTERS FOR NATIONAL AND INTERNATIONAL SECURITY, 4 (2020), <https://www.law.upenn.edu/live/files/10053-why-outer-space-matters-for-national-and> [<https://perma.cc/BT4G-M86B>].

ternational cooperation in space exploration.¹⁴⁷ Therefore, it is critical that the United States, as the first nation to legally recognize ownership of extracted space minerals,¹⁴⁸ ensures it complies with these notions. Adopting codified minimal facility closure and cleanup standards is a quality step at protecting international cooperation and care.

The United States should adopt bonding requirement language similar to that adopted by budding wind and solar industries. Unlike the narrowly tailored and complexly limited application of existing oil and gas legislative regulations,¹⁴⁹ newer sectors such as wind and solar serve as uniquely beneficial examples to model asteroid mining regulation after. The wind and solar legislation, which the proposition below is modeled after, incorporates the need for codification of minimal facility closure standards while using sufficiently broad language that will apply to various methodologies and processes as they are developed in real time, and far into the future.¹⁵⁰ This is highly advantageous since not all hazards that asteroid mining processes will pose can be currently accounted for or predicted.¹⁵¹ After all, no asteroid mining project has commenced.¹⁵² The language in wind and solar legislation helps safeguard against a chilling reality—humans don't know what they don't know.¹⁵³ Therefore, the following language, modeled after existing law,¹⁵⁴ should be adopted to codify minimal standards for facility closure and site cleanup in all asteroid mining operations:

¹⁴⁷ Outer Space Treaty, *supra* note 9, arts. I, III.

¹⁴⁸ Alex Gilbert, *Mining in Space Is Coming*, MILKEN INST. REV. (Apr. 26, 2021), <https://www.milkenreview.org/articles/mining-in-space-is-coming> [https://perma.cc/EFR6-HVHA].

¹⁴⁹ See *Asteroid Mining Might Actually Be Better for the Environment*, MIT TECH. REV. (Oct. 19, 2018), <https://www.technologyreview.com/2018/10/19/139664/asteroid-mining-might-actually-be-better-for-the-environment/> [https://perma.cc/9FMW-UFXW] (discussing how space mining efforts vary drastically from those undertaken on and beneath Earth's surface).

¹⁵⁰ See *generally* TEX. UTIL. CODE ANN. § 301.0003 (West 2022) (noting that the language is strikingly less complex and more broadly applicable than traditional oil and gas restoration requirements).

¹⁵¹ See Brandon Spektor, *Space Mining Could Ruin Our Solar System If We Don't Establish Protected Places Now, Researchers Warn*, LIVE SCI. (May 14, 2019), <https://www.livescience.com/65472-scientists-propose-solar-system-national-park.html> [https://perma.cc/BL2U-B7NL].

¹⁵² See Gilbert, *supra* note 148.

¹⁵³ See Spektor, *supra* note 151; Ostro & Sagan, *Dangers of Asteroid Deflection*, *supra* note 82, at 501; Sandoval, *supra* note 83.

¹⁵⁴ See TEX. UTIL. CODE ANN. § 301.0003 (West 2022).

1. *To the extent possible:*
 - a. *Clear, clean, and remove from the asteroid and surrounding area:*
 - i. *All mining materials, devices, refiners, etc.*
 - b. *For all foundations and/or pad sites:*
 - i. *Clear, clean, and remove the foundation from the surface to an adequate depth below the surface of the grade of the land in which it is installed.*
 - ii. *Ensure that all holes, cavities, or significant impressions created in the surface by the removal are filled with matter of the same type or similar type as the predominant regolith found on the asteroid.*
 - iii. *As near as reasonably possible, return the surface and surrounding area to the same condition as before operations were commenced.*

This language is an important step in ensuring that outer space remains a global common for the use and enjoyment of all nations as vehemently prescribed by the Outer Space Treaty.¹⁵⁵ By enforcing facility removal and surface restoration provisions whenever applicable, the United States will once again comply with its international obligations in the Outer Space Treaty¹⁵⁶ and exemplify the Treaty's objective of equitable international access, enjoyment, and protection.¹⁵⁷ Even more important is the prediction that such action by the United States could likely serve as an example for how other spacefaring nations should model their own regulations should they choose to adopt legislation similar to the Space Act.¹⁵⁸ After all, the United States is not the only spacefaring nation looking to profit from space.¹⁵⁹

¹⁵⁵ See generally Outer Space Treaty, *supra* note 8, art. I.

¹⁵⁶ See generally de Selding, *supra* note 76 (discussing the need for careful implementation of new space law to ensure compliance with the 1967 Outer Space Treaty).

¹⁵⁷ Outer Space Treaty, *supra* note 8, arts. I–III.

¹⁵⁸ See Anne-Marie Slaughter & Emily Lawrence, *The US and China Must Cooperate in Space*, PROJECT SYNDICATE (Jan. 22, 2021), <https://www.project-syndicate.org/commentary/america-china-cooperation-on-commercial-space-activity-by-anne-marie-slaughter-and-emily-lawrence-2021-01> [<https://perma.cc/9P8T-MWUL>] (discussing the need for and lasting impacts of cooperation amongst the United States and China in space, which would set an example for other countries).

¹⁵⁹ See Mallick & Rajagopalan, *supra* note 12, at 4–5.

2. *Financial-Assurance Requirement*

As mentioned above, one of the benefits of a bonding process is assurance of adequate clean up and restoration benefits, while leaving the company to utilize capital in developing the project.¹⁶⁰ However, inherent in this process is the requirement that someone, or something, assures the proper amount on behalf of the entity engaging in the mining operation.¹⁶¹ Without adequate assurances of liquidity, the bond is useless at safeguarding against threats of injury and negative environmental impacts.¹⁶² Therefore, just as the Railroad Commission and wind and solar lessors generally require evidence of financial assurance,¹⁶³ so too should space-mining authorities. Logically then, the United States should adopt the following language, or similar language, which is modeled after current wind legislation¹⁶⁴:

2. *Entity shall obtain and deliver evidence of financial assurance that conforms to the requirements of this provision to secure performance of the entity's obligations to remove all facilities and equipment used on or around the asteroid and to repair the asteroid's surface and the surrounding area.*

3. *The amount of financial assurance must be at least equal to the estimated amount by which the cost of removing facilities and equipment and restoring the asteroid surface and surrounding area to as near as reasonably possible to the condition it was as of the date the operation begins.*

Immediately, the issue of estimating closure costs comes into play. While not inherently clear, the best option for choosing an estimator may very well come in the form of a third-party expert, as is done in wind and solar leases.¹⁶⁵ Leaving estimation to the company or individual engaging in asteroid mining might result in deflated figures.¹⁶⁶ Companies looking to make a profit from

¹⁶⁰ See U.N. ENV'T PROGRAMME, *supra* note 137; *Environmental Impact Bonds Pay for Performance*, YALE CTR. FOR BUS. & ENV'T. (Jan. 24, 2019), <https://cbey.yale.edu/our-stories/environmental-impact-bonds-pay-for-performance> [<https://perma.cc/8P8C-MV2Z>].

¹⁶¹ Boyd, *supra* note 140, at 1.

¹⁶² See *id.* at 1–2.

¹⁶³ *Summary of Requirements and Responsibilities*, R.R. COMM'N OF TEX., <https://www.rrc.texas.gov/oil-and-gas/requirements-and-responsibilities/> [<https://perma.cc/FAC7-A59G>]; TEX. UTIL. CODE ANN. § 301.0004 (West 2022).

¹⁶⁴ See TEX. UTIL. CODE ANN. § 301.0004(a)–(b) (West 2022).

¹⁶⁵ *Id.* § 301.0004(c).

¹⁶⁶ *Cf.* 5 *Reasons Not to Use the Restoration Company Recommended by Your Insurance Carrier*, ABBOTTS BLOG, <https://abbottsfireandflood.com/blog/5-reasons-not-to->

an exceptionally expensive mining operation may not be inclined to be 100% forthcoming with their cost analysis, and could be persuaded by their own ambitions and financial obligations to underrepresent costs of closure and restoration in order to maximize profit.¹⁶⁷

On the other hand, if estimation were left to the government, corporations might feel slighted by a high estimation prepared by committees or teams who could, as a result of their lack of personal economic interest, not be as knowledgeable or diligent in determining accurate and pertinent costs.¹⁶⁸ Such discord between a corporation and its sovereign might lead to adverse economic results.¹⁶⁹ If a corporation feels the government is biased or unfair in its estimation, it may decide to relocate its primary place of business to another country with more favorable estimations.¹⁷⁰ Such possibilities must not allow corporations to strong-arm governments into insufficiently low bond calculations, but in light of the Space Act's intent to promote space commercialization and American competitiveness within the industry,¹⁷¹ preventing bias from disrupting the balance between corporate economic interest and federal conservation must be a key contemplation when implementing procedures for determining costs.

Some might argue that considering the Space Act's goal to promote American competition in the space-mining industry, heavy bonding requirements might serve as deterrents to companies operating from within the United States and could lead

use-the-restoration-company-recommended-by-your-insurance-carrier/ [https://perma.cc/5W9C-T2EN] (explaining that companies may be inclined to cut corners in order to save money and increase profits).

¹⁶⁷ Cf. *id.*

¹⁶⁸ See generally *Public Divides Over Environmental Regulation and Energy Policy*, PEW RSCH. CTR. (May 16, 2017), <https://www.pewresearch.org/science/2017/05/16/public-divides-over-environmental-regulation-and-energy-policy/> [https://perma.cc/N8AL-JM9N] (discussing how different ideological groups in American politics give different priorities to energy cost savings versus environmental protection); Lee Rainie & Andrew Perrin, *Key Findings About Americans' Declining Trust in Government and Each Other*, PEW RSCH. CTR. (July 22, 2019), <https://www.pewresearch.org/fact-tank/2019/07/22/key-findings-about-americans-declining-trust-in-government-and-each-other/> [https://perma.cc/9YWA-VFSQ] (discussing how Americans increasingly perceive each other as more distrustful of the federal government).

¹⁶⁹ See Michael E. Porter, *The Competitive Advantage of Nations*, HARV. BUS. REV., Mar.–Apr. 1990, <https://hbr.org/1990/03/the-competitive-advantage-of-nations> [https://perma.cc/726X-Y9DW].

¹⁷⁰ See *id.*

¹⁷¹ 51 U.S.C. § 51302(a)(2)–(3).

to mining entities “shopping around” for more favorable jurisdictions.¹⁷² However, this argument ignores one crucial fact—all current spacefaring nations are signatories to the Outer Space Treaty and thus are bound by the same oversight requirements as the United States.¹⁷³ What is the current difference? Only the United States has breached international obligations under the Outer Space Treaty by passing formal legislation legalizing non-governmental entities’ extraction and possession of outer space resources, absent a system for authorization and supervision of those entities.¹⁷⁴ Therefore, a third-party expert to which both a corporation and government mutually agree to the qualifications of could prove to be an effective basis for closure and surface restoration cost estimations, and could provide a valuable service in the effort to realign United States space-mining allowances with the obligations imposed on it by the Outer Space Treaty.

Further, because operations often shift in scope or complexity after the commencement of a project,¹⁷⁵ the United States should include a provision similar to those found in other energy sectors, which require that entities engaged in mining operations periodically provide updated estimates of cost of removal and restoration for the duration of the project.¹⁷⁶ Noting the possibility that some projects may not extend over a significant period of time, this provision may not be applicable to every asteroid-mining operation.¹⁷⁷ However, it would be applicable to long-term, or large-scale, operations with ambiguous timelines or unspecified end dates. Accordingly, the duration of a project should at least be a factor in determining the requirement or frequency of updates.

¹⁷² See David Coen, Mattia Guidi & Nikoleta Yordanova, *The Logic of Regulatory Venue Shopping: A Firm’s Perspective*, SAGE J. (Mar. 30, 2020), <https://journals.sagepub.com/doi/full/10.1177/0952076718814900> [<https://perma.cc/8MA6-KQR7>].

¹⁷³ Outer Space Treaty, *supra* note 8.

¹⁷⁴ See Oduntan, *supra* note 61.

¹⁷⁵ See T.S. Kagogo & H. Steyn, *Effect of Scope Readiness on Capital Projects in Mining: A Namibian Case Study*, 30 S. AFR. J. INDUS. ENG’G (2019).

¹⁷⁶ See PWC, FINANCIAL REPORTING IN THE MINING INDUSTRY: INTERNATIONAL FINANCIAL REPORTING STANDARDS 93–96 (6th ed. 2012).

¹⁷⁷ See generally Michael Belfiore, *The Tech We’ll Need to Mine Asteroids*, POPULAR MECHS. (Aug. 16, 2012), <https://www.popularmechanics.com/space/a8038/the-tech-well-need-to-mine-asteroids-11644892/> [<https://perma.cc/YH63-4W2F>] (discussing the various methods of resource extraction and the degree of difficulty involved with each).

3. *Liability Insurance Requirement*

To protect workers engaged in outer space mining, as well as those who could be adversely affected by outer space mining operations, the United States should impose liability insurance requirements in addition to the facility-closure bonds and financial-assurance requirements described above. Prior to the Farmington Mine Disaster of 1968 and the passage of the CMHSA in 1969, there were limited, if any, remedies available to the workers harmed or the families of the deceased caused by the explosion.¹⁷⁸ Similar to the pre-Farmington era, the Space Act does not provide for the health and safety of outer space mining workers or provide a remedy for those killed, injured, or otherwise adversely affected by outer space mining operations.¹⁷⁹

However, this does not mean that no one is held accountable for outer space activity-based liability.¹⁸⁰ Under current international law, “a country that launches a space object (or from whose territory it is launched) is absolutely liable to pay compensation for damages *caused by that object* on the surface of the earth or to aircraft in flight.”¹⁸¹ Because the 1972 Convention on International Liability for Damage Caused by Space Objects (Liability Convention) imports this liability, the United States would be internationally liable for damages resulting from the modification of asteroid trajectory, failure of asteroid-mining equipment, and all other harmful events resulting from an entity or operation launched from within the United States.¹⁸² Depending on the size of the asteroid impacted, or the magnitude of the mining project, liability could rise to trillions if not

¹⁷⁸ Cf. *Report on the Farmington Disaster*, CHARLESTON GAZETTE-MAIL (Nov. 20, 2008), https://www.wygazette.com/news/special_reports/report-on-the-farmington-disaster/article_a37bff7d-66cb-5016-812d-1cf25f7d3b29.html (discussing how the victims of the Farmington disaster were not initially given a complete formal federal inquiry).

¹⁷⁹ See 51 U.S.C. §§ 51301–51303 (absence of liability coverage criteria for participation in mineral extraction).

¹⁸⁰ See Raul Magallanes, *If a Satellite Falls, Who is Responsible for Damages?*, VIA SATELLITE (Dec. 1, 2011), <https://www.satellitetoday.com/government-military/2011/12/01/if-a-satellite-falls-who-is-responsible-for-damages/> [<https://perma.cc/7YUF-X8MF>].

¹⁸¹ *Id.* (emphasis added).

¹⁸² See *id.*; Liability Convention, *supra* note 38, arts. II–IV.

quadrillions of dollars, for which the United States would be responsible for paying.¹⁸³

To avoid this immense financial liability, the United States should require that all entities engaging in outer space mining obtain sufficient liability insurance to cover the costs of potential injury and devastation. This way, in the event of suffering injury or damage, victims are justly compensated, and not from the pockets of American taxpayers who do not share in the profits of the operations responsible for the damage.¹⁸⁴ Consequently, the United States should adopt the language below or similar language into liability insurance requirements for outer space mining entities¹⁸⁵:

4. *After an application is approved, but before it is issued, the applicant shall file a certificate of insurance certifying that they have in force a public liability insurance policy.*
5. *The policy must cover all mining operations of the applicant within the permitted area and shall afford bodily injury protection, accidental private and public property damage protection, and accidental business property damage protection in an amount determined by the [governing authority] to compensate adequately any persons, nation, or entity damaged because of asteroid-mining or restoration operations.*
6. *The policy must be maintained in full force and effect during the term of the permit, including the length of all restoration operations.*

While determining a figure that is adequate to cover such costs, and therefore determining the figure sought for insurance, may prove difficult, it could be approached in the same way as previously suggested for estimating cost of facility removal and surface restoration: third-party expert determination.¹⁸⁶ Use of third-party experts would help to reduce bias of governments

¹⁸³ See Oduntan, *supra* note 61; Ostro & Sagan, *Cosmic Collisions and the Longevity of Non-Spacefaring Galactic Civilizations*, *supra* note 82; Sandoval, *supra* note 83; Magallanes, *supra* note 180.

¹⁸⁴ See generally GENEVA INT'L CTR. FOR HUMANITARIAN DEMING, A GUIDE TO LIABILITY AND INSURANCE IN MINE ACTION 71–74 (2011), <https://www.files.ethz.ch/isn/131799/Guide-Liability-Insurance-June2011.pdf> [<https://perma.cc/8HQ4-DJGS>].

¹⁸⁵ Modeled after 30 U.S.C. § 1257(f).

¹⁸⁶ See *infra* Section III.B.2 (discussing why using third-party estimators for cost coverage is beneficial to both sides).

and profit-seeking entities in the same way it would for bonding requirement estimation.¹⁸⁷

Additionally, this flexibly written process would provide a codified system that is easily adaptable to the experiences realized by completed endeavors. Codification of presently estimated numbers or percentages currently deemed adequate by various parties would not allow for easy adaptation if completion of actual mining operations revealed the figures to be inadequate or overly inflated.¹⁸⁸ Codifying a determination by a third-party expert allows the United States to establish sufficiently broad legislation that is equally protective as it is adaptable to real scenarios as this burgeoning industry unfolds.

C. SLOW THE SUPERNOVA: ENSURING SUSTAINABILITY THROUGH IMPOSITION OF PERMITTING REQUIREMENTS

Permitting processes and requirements within energy industries can serve as controlled barriers to entry, foster considerations for safety and efficacy, establish a record of accountability and contact, and ensure environmental protection and the avoidance of waste, among other benefits.¹⁸⁹ By vesting permitting power within an appointed regulatory authority, the United States can effectively maintain a sustainable rate of participation in asteroid mining. Current mining and even wind regulations and permitting processes already place restrictions on considerations such as well and turbine spacing and drilling placement to promote safety and sustainable participation.¹⁹⁰ Without regulatory limits upon which or how many entities may conduct

¹⁸⁷ See Boyd, *supra* note 140, at 1; ABBOTTS BLOG, *supra* note 166; PEW RSCH. CTR., *supra* note 168; Rainie & Perrin, *supra* note 168.

¹⁸⁸ See generally STATE FINANCIAL ASSURANCE REQUIREMENTS, INTERSTATE OIL & GAS COMPACT COMM'N (2016), https://iogcc.ok.gov/sites/g/files/gmc836/f/financial_assurances_final_web_0.pdf [<https://perma.cc/Z4PK-BP3N>] (illustrating codified requirements for financial assurance in oil and gas extraction methods without a method for adjustment other than legislative amendment).

¹⁸⁹ See, e.g., *How the UK Planning and Environmental Permitting Systems Work for Minerals*, INST. OF MATERIALS, MINS. & MINING (Mar. 5, 2021), <https://www.iom3.org/resource/how-the-uk-planning-and-environmental-permitting-systems-work-for-minerals.html> [<https://perma.cc/FQ8C-XCLK>]; Paul Boyce, *Barriers to Entry Definition*, BOYCE WIRE, <https://boycewire.com/barriers-to-entry-definition/> [<https://perma.cc/4MZF-PCQR>] (Feb. 3, 2021).

¹⁹⁰ PAUL DENHOLM, MAUREEN HAND, MADDALENA JACKSON & SEAN ONG, NAT'L RENEWABLE ENERGY LAB'Y, LAND-USE REQUIREMENTS OF MODERN WIND POWER PLANTS IN THE UNITED STATES 1-4 (Aug. 2009), <https://www.nrel.gov/docs/fy09osti/45834.pdf> [<https://perma.cc/BFV3-4VEH>]; 16 TEX. ADMIN. CODE § 3.37(a) (2022).

outer space mining operations in which zones and when, the United States runs the risk of having authorized a free-for-all that would mirror the California Gold Rush, but with deadlier results.¹⁹¹

Unless restrictions on the rate of participation in asteroid mining are imposed, depletion of resources, atmospheric disruption, environmental pollution and contamination, and violence in response to overcrowding and competing claims could ensue.¹⁹² A permitting process would be an effective strategy to prevent such threats. Space is regarded as a “global commons,”¹⁹³ similar to the ocean. While no one can colonize either, they may certainly reap the benefits of outer space minerals¹⁹⁴ just as they can the fish from the sea. But with the idea of a global commons comes the implied—and in the case of space, the treaty-based—duty to maintain peace and security.¹⁹⁵

Accordingly, the United States should implement a permitting process for companies seeking to engage in asteroid mining. Such a process should mirror existing standards to establish sufficient information about the entity, provide the issuing agency with sufficient knowledge about the proposed project, and allow for approval or denial to prevent safety and environmental concerns.¹⁹⁶

A permitting requirement is important not only for mineral sustainability but also economic sustainability.¹⁹⁷ Without an adequate permitting process to effectively limit participation, there is no safeguard against the economic instability of prices, which could result from a mass rush on asteroid mineral extraction by American entities.¹⁹⁸ The Space Act authorizes ownership of as-

¹⁹¹ Spektor, *supra* note 151; *see also* APES IN SPACE, *supra* note 58.

¹⁹² *See* APES IN SPACE, *supra* note 58.

¹⁹³ L.A. Fisk, *Space as a Global Commons*, U.N. OFF. FOR OUTER SPACE AFFS., https://www.unoosa.org/documents/pdf/hlf/1st_hlf_Dubai/Presentations/26.pdf [<https://perma.cc/33XV-WL35>].

¹⁹⁴ *Id.*

¹⁹⁵ Outer Space Treaty, *supra* note 8, arts. I, III.

¹⁹⁶ *Cf.* *Mineral Exploration, Licensing and Permitting*, DENTONS, <https://www.dentons.com/en/find-your-dentons-team/industry-sectors/mining/mining-operations/mineral-exploration-licensing-and-permitting> [<https://perma.cc/4C8J-ZXYB>] (discussing how Dentons helps navigate clients complex regulations and permitting processes in the mining space).

¹⁹⁷ INST. OF MATERIALS, MINS. & MINING, *supra* note 189; *see also* DENTONS, *supra* note 196.

¹⁹⁸ *See* ENV'T L. INST., WASH. & JEFFERSON COLL., GETTING THE BOOM WITHOUT THE BUST: GUIDING SOUTHWESTERN PENNSYLVANIA THROUGH SHALE GAS DEVELOP-

teroid mineral resources, but it erects zero barriers to entry.¹⁹⁹ As mentioned above, asteroids hold abundant quantities of rare Earth minerals, which pose enticing profits to those capable of extracting them.²⁰⁰ However, if the United States does not take steps to limit rates of participation, a mass rush to harvest space minerals could lead to a “boom and bust” cycle of space mineral prices, creating a highly unstable and unsustainable economic climate.²⁰¹

If the permitting process is to serve as a barrier to entry by allowing the governing authority to dictate which entities are allowed to mine and when, that authority will need sufficient information about the applying entity to make an informed decision. Like the proposed bonding requirements, a permit process that demands disclosure of scope, extraction methods to be employed, a reasonably expected duration, and location of the project will allow a governing authority to carefully evaluate the proposal under the totality of the circumstances in order to make a careful judgement on whether to permit an entity to proceed or not.²⁰² Such evaluation is in the best interest of global safety²⁰³ and may provide one method capable of satisfying the oversight and authorization requirement proscribed by the Outer Space Treaty. The following language, as modified from existing standards,²⁰⁴ should be employed:

7. *No entity shall conduct a mining operation unless it first obtains a mining permit issued by the governing authority.*

MENT 14–15 (2014), <https://www.eli.org/sites/default/files/eli-pubs/getting-boom-final-paper-exec-summary-2014-07-28.pdf> [<https://perma.cc/WTN7-6XLS>] (discussing how new technologies allow for faster extraction of resources).

¹⁹⁹ See generally 51 U.S.C. §§ 51301–51303 (noting lack of statutorily imposed barriers to entry).

²⁰⁰ Bartlett, *supra* note 65; MANUFACTURING.NET, *supra* note 66.

²⁰¹ See ENV'T L. INST., *supra* note 198, at 1, 14–15 (discussing history of boom and bust cycles in mineral resource extraction and proposing policies to avoid such a cycle in Pennsylvania's Marcellus Shale field).

²⁰² See generally Specktor, *supra* note 151 (detailing the importance of regulatory intervention to protect designated areas of space).

²⁰³ See generally Duke, *supra* note 7 (detailing the inherent risks of conflict in space and celestial security); STEER, *supra* note 146, at 2, 4–5 (discussing how each spacefaring nation is somewhat interdependent in space); Fisk, *supra* note 193 (noting that space is regarded as a “global commons” requiring unique cooperation and policing among spacefaring nations).

²⁰⁴ See TEX. NAT. RES. CODE ANN. § 131.131(a)–(b) (West 2022).

In the event this requirement is imposed subsequent to the initiation of mining projects in outer space, the following provision may be applicable:

8. *Any entity conducting an operation prior to the enactment of this amendment must immediately file a permit application and may continue to conduct that operation until the commission approves or denies the application.*

Allowing an operator under these circumstances to continue, rather than halting their project, is important and speaks towards notions of fairness.²⁰⁵ It would be quite prejudicial, and against the spirit of historical American law, to penalize an operator who has made a significant financial investment in the development of a project under what was, at the time, sufficient under existing law.²⁰⁶

While initiation and completion of actual outer space mining operations will reveal other pertinent information that would aid governing authorities if included in permit applications,²⁰⁷ the following set of information, which mirrors existing law,²⁰⁸ could aid the governing authority in its evaluations of safety and other applicable considerations until those operations commence:

9. *The name, address, ownership, and managing officers of the permit applicant and affiliated persons engaged in the mining operation.*
10. *Current or previous space or terrestrial mining permits held by the applicant, including revocations, suspensions, or bond forfeitures.*
11. *The type and method of mining operation, the engineering techniques, and the equipment reasonably expected to be used, including mining schedules, the nature and expected amount of overburden to be removed or displaced, the depth of excavations if any, a description of the affected asteroid(s) and surrounding area, the results of any test borings, test pits, core samplings that have been gathered from the permit area, or any other scoping or identify-*

²⁰⁵ See generally Jane Harris Aiken, *Ex Post Facto in the Civil Context: Unbridled Punishment*, 81 Ky. L.J. 323, 323–24 (1992) (discussing the inherent prejudice and inequity imposed by ex post facto punishment devices in the civil context).

²⁰⁶ See *id.* at 324 (stating that “[t]here is a strong argument to be made that the framers debated the issue and determined that all retroactive laws were suspect and that only upon a showing of necessity should a civil law be allowed to have retrospective effect.”).

²⁰⁷ See Gilbert, *supra* note 148.

²⁰⁸ See TEX. NAT. RES. CODE ANN. § 131.133(1), (4), (5) (West 2022).

ing tests, and the reasonably anticipated consequences of the mining operation.

The above information includes critical considerations that weigh heavily on the potential impact an operation could have on other parties.²⁰⁹ Significant is the consideration of past forfeited bonds or permits.²¹⁰ Due to the volatile nature of activities in space and the far-reaching consequences negligent actions may have,²¹¹ entities that have shown a history of non-compliance, both in space and here on Earth, should be harshly scrutinized upon application for further operations.²¹² Furthermore, to ensure compliance with this requirement, the United States might consider statutory penalties for failing to disclose such information, regardless of whether the permit is later approved or denied. Including such information allows an agency to closely monitor the histories of individuals and entities wishing to conduct outer space mining operations while statutory penalties provide an incentive for cooperation and punishment to deter similar behavior from others.²¹³

In keeping with the spirit of cooperation embodied in the Outer Space Treaty,²¹⁴ a unique provision of an effective permitting process could include the submission of the application to other agencies for comment. While the Office of Space Commerce may be suitable as the governing body authorized to issue permits, it is certainly not the only established body with valua-

²⁰⁹ See generally STEER, *supra* note 146, at 2 (discussing how each spacefaring nation is somewhat interdependent in space); Fisk, *supra* note 193 (noting that space is regarded as a “global commons” requiring unique cooperation and policing among spacefaring nations).

²¹⁰ See generally Sarah Vogelsong, *After Blackjewel Settlement, Virginia Has Coal Mining Permits No One Wants*, VA. MERCURY (Mar. 26, 2021, 12:01 AM), <https://www.virginiamercury.com/2021/03/26/after-blackjewel-settlement-virginia-has-coal-mining-permits-no-one-wants/> [https://perma.cc/L44U-QQYT] (discussing the negative impact of a company’s forfeited coal-mining permit on the local community and economy).

²¹¹ See Duke, *supra* note 7.

²¹² See generally Willie Dodson, *Gov. Jim Justice’s Straight Fork Surface Mine Again Facing Possible Permit Revocation*, APPALACHIAN VOICES, <https://appvoices.org/2022/01/19/straight-fork-surface-mine/> [https://perma.cc/NG49-D5L2] (Jan. 20, 2022) (asserting that companies with a history of noncompliance tend to continue not complying in subsequent endeavors).

²¹³ See Gary Banks, Chairman, Productivity Comm’n, Address to the Minerals Council of Australia’s *Annual Industry Seminar*, Old Parliament House: “Minimum Effective Regulation” and the Mining Industry, (June 3, 2003), <https://www.pc.gov.au/news-media/speeches/cs20030603/cs20030603.pdf> [https://perma.cc/MLP9-EF4H] (discussing the importance of incentives in regulation generally).

²¹⁴ See ARMS CONTROL ASS’N, *supra* note 37.

ble knowledge or experience in dealing with space-commercialization policy procedures.²¹⁵

The Aerospace Safety Advisory Panel; the Committee on Science and Technology of the House of Representatives; and the Senate Committee on Commerce, Science, and Transportation, as well as various other international organizations, are all bodies that may prove to offer valuable considerations in the granting of space mining permits. Responsibilities vested in these organizations range from reviewing “adequacy of proposed or existing safety standards”²¹⁶ to ensuring the United States remains competitive in space-related industry development.²¹⁷ Accordingly, each body offers unique and valuable perspectives regarding the regulation and control of space mining development.

Upon receipt and review of an application, the primary permitting agency may be inclined to submit the application to one or more of these bodies for comment, as is done in current mining and mineral extraction regulation in some jurisdictions.²¹⁸ Within a specified time period, the bodies could review the application and return it with any comments they care to make.²¹⁹ The comments of each agency could be incorporated into a record and furnished to the applicant.²²⁰

Such a process would ensure well-rounded and diverse safety considerations from multiple bodies armed with relevant knowledge.²²¹ Yet for efficiency purposes, great deference regarding the weight given to such comments should be vested in the permitting authority agency for final approval or denial.²²² For

²¹⁵ *Other U.S. Government Agencies Involved in Space Policy & Regulation*, GEO. L. LIBR., <https://guides.ll.georgetown.edu/c.php?g=1037047&p=7762102> [<https://perma.cc/4XLR-WYX3>] (Dec. 8, 2020, 11:22 AM).

²¹⁶ 42 U.S.C. § 2477.

²¹⁷ *Committee Information*, U.S. S. COMM. ON COM., SCI., & TRANSP., <https://www.commerce.senate.gov/about#:~:text=these%20issues%20range%20from%20communications,%2C%20product%20safety%2C%20and%20insurance> [<https://perma.cc/J5PJ-9QPY>].

²¹⁸ *See* TEX. NAT. RES. CODE ANN. § 131.139(a) (West 2019).

²¹⁹ *See id.* § 131.139(b).

²²⁰ *Id.* § 131.139(d).

²²¹ *See generally* GEO. L. LIBR., *supra* note 215 (discussing the various contributions that each agency offers to space regulation).

²²² *Cf.* Daniel P. Pellegrino, *Too Many Cooks in the Kitchen? Local Government Fragmentation and Economic Growth*, DUKE SPACE 4–6, 22 (Dec. 16, 2013), <https://dukespace.lib.duke.edu/dspace/handle/10161/8182> [<https://perma.cc/AS5Q-YNFU>] (discussing the dangers that municipal government fragmentation poses to productivity).

these reasons, the following language, modeled after existing legislation,²²³ may prove useful for incorporation regarding permit application procedures:

12. *The primary permitting agency immediately shall submit copies of the permit application to all applicable agencies and other agencies whose jurisdiction to the commission feels the particular space mining operation may affect.*
13. *Each of these agencies shall review the permit application and submit any comments the agency cares to make within [x] days of receipt of the application.*
14. *An agency's comments shall include an enumeration of permits or licenses required under the agency's jurisdiction.*
15. *The comments of each agency shall be made a part of the record, and a copy shall be furnished to the applicant.*

Contemplation of application approval inherently brings about contemplation of application denial. While not every reason warranting denial of a permit application is currently contemplatable, given the absence of actual experience in outer space mining,²²⁴ special consideration should be given to the area the applicant seeks a permit for. Just as the Railroad Commission denies permits for disposing of certain wastes in unsuitable areas,²²⁵ so too should the permitting authority deny applications if the area sought to be mined is deemed unsuitable for mining. Factors bearing on suitability should mirror existing law:²²⁶

16. *Location sought for mining operation will be deemed unsuitable and a permit for said area will be immediately declined if:*
 - a. *Operations will result in significant damage to important areas of archaeological or scientific value or to internationally important celestial systems;*
 - b. *Operations will affect renewable resource land resulting in substantial loss or reduction of long-range productivity of water supply;*

²²³ See TEX. NAT. RES. CODE ANN. § 131.139(a)–(d) (West 2022).

²²⁴ See Specktor, *supra* note 151.

²²⁵ See *Landfarming, Landtreatment, & Land Application Facilities*, R.R. COMM'N OF TEX., <https://www.rrc.texas.gov/oil-and-gas/applications-and-permits/environmental-permit-types/landfarming-landtreatment-and-land-application-facilities/> [https://perma.cc/FS4V-EE57].

²²⁶ See TEX. NAT. RES. CODE ANN. §§ 131.035–131.040 (West 2022).

- c. *Operations are located in an area that is geologically unstable and may reasonably be expected to endanger life or property;*
- d. *It is advised that the operation will likely cause significant pollution or contamination of Earth or other celestial bodies; or*
- e. *It is determined that the proposed mining operation will unreasonably endanger the health and safety of the public.*

The above considerations for suitability will force companies seeking to engage in mining operations to carefully examine and survey the areas they desire to mine, thus striking a beneficial balance between efficiency of production and degree of harm in operations.²²⁷

IV. CONCLUSION

Passage of the Space Act was a necessary step in paving the way for American competitiveness in the space-mining industry and space commercialization in general.²²⁸ The Space Act gave long-awaited legal certainty to American corporations looking to operate asteroid-mining projects and ended an economic stalemate caused by hesitation and concerns regarding legal ownership of extracted minerals.²²⁹

Unfortunately, while the Space Act was a solution to one problem, it created another with international effects. By passing the Space Act, the United States directly contradicted the most basic and foundational legal framework for international space law: The Outer Space Treaty.²³⁰

Due to its lack of specificity²³¹ and complete omission of regulatory or authorization requirements,²³² the Space Act is a dangerous greenlight for all entities with the resources and capabilities of asteroid mining²³³ to race to space. Such encouragement is directly opposite to the intent and express condition of Article VI of the Outer Space Treaty.²³⁴ Article VI, the “oversight requirement,” demands that governments authorize and continuously supervise activities of non-governmental entities in

²²⁷ See Specktor, *supra* note 151.

²²⁸ See Stockton, *supra* note 133.

²²⁹ See *id.*

²³⁰ See de Selding, *supra* note 76; Mallick & Rajagopalan, *supra* note 12, at 2–3, 6–7.

²³¹ See Johnson, *supra* note 11.

²³² See 51 U.S.C. §§ 51301–51303.

²³³ Cf. Goswami, *supra* note 119 (acknowledging the pending influx of entities wishing to engage in space mining and evaluating the beneficial economic impacts).

²³⁴ See Outer Space Treaty, *supra* note 8, art. VI.

space.²³⁵ The Space Act, which grants mineral ownership rights but fails to establish authorization or regulatory oversight provisions limiting participation and conduct,²³⁶ falls far from the sort of supervision and command imagined by the drafters of the Outer Space Treaty, one of which was the United States.²³⁷

While the United States must be mindful to balance notions of global safety and cooperation with its own economic efficiency and development, the Space Act currently strikes an inequitable distribution leaning too far towards profits with too little regard for protection. Consequently, steps must be taken to enforce meaningful regulation that fosters American economic growth within the space industry but also complies with existing international obligations.

The founding of a centralized regulatory authority to oversee non-governmental entities in space, implementation of bonding requirements, and establishment of a permitting process for asteroid-mining operations may suffice to comply with the oversight requirement of the Outer Space Treaty. While outer space mining varies in many ways from traditional terrestrial mining operations,²³⁸ the two share very similar concerns, but on far different scales.²³⁹

Given the knowledge we have of terrestrial mining, and the inherent complexity and risks associated with outer space mining, imposition of bonding and permitting requirements by a centralized regulatory authority is highly appropriate. Fortunately, the United States is poised to implement these changes without significant effort or delay.²⁴⁰ By appointing one, or a combination of, existing federal agencies with experience in space policy and commerce²⁴¹ and implementing bonding and permitting requirements modeled after existing legislation with appropriate adjustments,²⁴² the United States will take signifi-

²³⁵ *Id.* art. VII.

²³⁶ *See* 51 U.S.C. § 51302.

²³⁷ Outer Space Treaty, *supra* note 8, pmb., art. VI.

²³⁸ *See* Belfiore, *supra* note 177.

²³⁹ *See* Ostro & Sagan, *Cosmic Collisions and the Longevity of Non-Spacefaring Galactic Civilizations*, *supra* note 82; Ostro & Sagan *Cambridge Conference Correspondence*, *supra* note 82; Belfiore, *supra* note 177.

²⁴⁰ *See* 51 U.S.C. §§ 50701–50703.

²⁴¹ *See supra* Section III.A (discussing the proposed structure of a regulatory authority with input from applicable agencies).

²⁴² *See supra* Sections III.B.1–.3 (proposing applicable amendments modeled after existing legislation).

cant steps towards compliance with the Outer Space Treaty's oversight requirement.

Without establishing a regulatory authority or implementing bonding and permitting requirements, the United States will continually fail to meet its international obligations regarding conduct in space.²⁴³ As a drafter of the Outer Space Treaty, the United States sets a strong example for treaty compliance.²⁴⁴ If the United States ignores its obligations under the treaty, other space powers, such as Russia and China, may well choose to do the same.²⁴⁵ Given the unique characteristics of space and the United States' interdependence upon other signatories when operating above its troposphere, abandonment of the principles exemplified by the treaty could result in catastrophic threats to planetary safety and the destruction of the planet.²⁴⁶ Accordingly, it is imperative that the United States imposes the actions suggested above and meets its international duties assigned by the Outer Space Treaty.

²⁴³ See *supra* Section II.A.2 (laying out the requirements of the Outer Space Treaty).

²⁴⁴ See generally Slaughter & Lawrence, *supra* note 158 (discussing the need for cooperation amongst Earth's two most leading space powers, the United States and China, and how cooperation sets a norm for other countries to follow).

²⁴⁵ See generally *id.*

²⁴⁶ See generally *id.*

V. APPENDIX

SECTION 1: FACILITY REMOVAL AND RESTORATION REQUIREMENT²⁴⁷

1. *To the extent possible:*
 - a. *Clear, clean, and remove from the asteroid and surrounding area:*
 - i. *All mining materials, devices, refiners, etc.*
 - b. *For all foundations and/or pad sites:*
 - i. *Clear, clean, and remove the foundation from the surface to an adequate depth below the surface of the grade of the land in which it is installed.*
 - ii. *Ensure that all holes, cavities, or significant impressions created in the surface by the removal are filled with matter of the same type or similar type as the predominant regolith found on the asteroid.*
 - iii. *Return the surface and surrounding area to as near as reasonably possible to the same condition as before operations where commenced.*

SECTION 2: FINANCIAL-ASSURANCE REQUIREMENT²⁴⁸

2. *Entity shall obtain and deliver evidence of financial assurance that conforms to the requirements of this provision to secure performance of the entity's obligations to remove all facilities and equipment used on or around the asteroid and to repair the asteroid's surface and the surrounding area.*
3. *The amount of financial assurance must be at least equal to the estimated amount by which the cost of removing facilities and equipment and restoring the asteroid surface and surrounding area to as near as reasonably possible to the condition it was as of the date the operation begins.*

SECTION 3: LIABILITY INSURANCE REQUIREMENT²⁴⁹

4. *After an application is approved, but before it is issued, the applicant shall file a certificate of insurance certifying that they have in force a public liability insurance policy.*
5. *The policy must cover all mining operations of the applicant within the permitted area, and shall afford bodily injury protection, accidental private and public property damage protection, and accidental business*

²⁴⁷ Modeled after Required Agreement Provisions on Facility Removal codified at TEX. UTIL. CODE ANN. § 301.0003 (West 2022).

²⁴⁸ Modeled after Required Agreement Provisions on Financial Assurance codified at *id.* § 301.0004(a)–(b).

²⁴⁹ Modeled after Bond and Insurance Requirements for Surface Coal Mining and Reclamation Operations Under Regulatory Programs codified at 30 U.S.C. § 1257(f).

property damage protection in an amount determined by the [governing authority] to compensate adequately any persons, nation, or entity damaged because of asteroid mining or restoration operations.

6. *The policy must be maintained in full force and effect during the term of the permit, including the length of all restoration operations.*

SECTION 4: PERMITTING PROCESS AND REQUIREMENTS²⁵⁰

SUBSECTION 4.1: GENERAL PERMIT REQUIREMENT²⁵¹

7. *No entity shall conduct a mining operation unless it first obtains a mining permit issued by the governing authority.*
8. *Any entity conducting an operation prior to the enactment of this amendment must immediately file a permit application and may continue to conduct that operation until the commission approves or denies the application.*

SUBSECTION 4.2: REQUIRED DISCLOSURES²⁵²

9. *The name, address, ownership and managing officers of the permit applicant and affiliated persons engaged in the mining operation.*
10. *Current or previous space or terrestrial mining permits held by the applicant, including revocations, suspensions, or bond forfeitures.*
11. *The type and method of mining operation, the engineering techniques, and the equipment reasonably expected to be used, including mining schedules, the nature and expected amount of overburden to be removed or displaced, the depth of excavations if any, a description of the affected asteroid(s) and surrounding area, the results of any test borings, test pits, core samplings that have been gathered from the permit area, or any other scoping or identifying tests, and the reasonably anticipated consequences of the mining operation.*

SUBSECTION 4.3: PROCEDURAL PROVISIONS FOR AGENCY REVIEW²⁵³

12. *The primary permitting agency immediately shall submit copies of the permit application to all applicable agencies and other agencies whose jurisdiction to the commission feels the particular space mining operation may affect.*

²⁵⁰ Modeled after Chapter 131 Uranium Surface Mining and Reclamation Act codified at TEX. NAT. RES. CODE ANN. § 131 (West 2022).

²⁵¹ Modeled after Permit Required for Operation codified at *id.* § 131.131(a)–(b).

²⁵² Modeled after Required Information codified at *id.* § 131.133(1), (4), (5).

²⁵³ Modeled after Submission of Application to Agencies for Comment codified at *id.* § 131.139(a)–(d).

13. *Each of these agencies shall review the permit application and submit any comments the agency cares to make within [x] days of receipt of the application.*
14. *An agency's comments shall include an enumeration of permits or licenses required under the agency's jurisdiction.*
15. *The comments of each agency shall be made a part of the record, and a copy shall be furnished to the applicant.*

SUBSECTION 4.4: NON-EXHAUSTIVE LIST OF FACTORS SUPPORTING DETERMINIZATION THAT LOCATION SOUGHT IS UNSUITABLE²⁵⁴

16. *Location sought for mining operation will be deemed unsuitable and a permit for said area will be immediately declined if:*
 - a. *Operations will result in significant damage to important areas of archaeological or scientific value or to internationally important celestial systems;*
 - b. *Operations will affect renewable resource land resulting in substantial loss or reduction of long-range productivity of water supply;*
 - c. *Operations are located in an area that is geologically unstable and may reasonably be expected to endanger life or property;*
 - d. *It is advised that the operation will likely cause significant pollution or contamination of Earth or other celestial bodies; or*
 - e. *It is determined that the proposed mining operation will unreasonably endanger the health and safety of the public.*

²⁵⁴ Modeled after Unsuitability Designation codified at *id.* §§ 131.035–131.040.