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THE PHYSICS OF EXTRACTION AND THE LAW OF SOVEREIGNTY: RECONCILING SPACE MINING WITH THE OUTER SPACE

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ABSTRACT

As humanity expands its technological and industrial capabilities, the rapid depletion of Earth's natural resources presents a growing challenge. Space resource extraction offers a viable alternative to terrestrial resource dependence. This paper explores the fundamental physics governing space mining, focusing on energy constraints, material science in extreme environments, resource identification, and processing techniques. The role of the Tsiolkovsky rocket equation in fuel efficiency, challenges posed by microgravity on material handling, and the impact of radiation on mining equipment are examined. Case studies on lunar water ice extraction and asteroid mining highlight the intersection of scientific feasibility and geopolitical sovereignty. Legal frameworks such as the Artemis Accords and the Outer Space Treaty underscore the complexities of resource appropriation and governance. Addressing both technical and legal challenges, this study provides a comprehensive understanding of space mining's implications for sustainable human advancement.

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The commercialization of space has triggered legal and ethical dilemmas regarding resource exploitation and sovereignty. While the Outer Space Treaty (OST) establishes space as the common heritage of mankind, its limitations have allowed nations and private entities to push forward with space mining initiatives. The Moon Agreement (1979) failed to gain global acceptance, paving the way for unilateral policies like the U.S. Space Act (2015) and Artemis Accords (2020), legitimizing private resource extraction. This raises concerns over de facto ownership and monopolization by first-moving nations and corporations. Drawing from Earth's legal frameworks, particularly UNCLOS' seabed regulations, this paper explores the potential for a UN-led space resource regulatory body. It proposes a three-tier governance system balancing international oversight, national cooperation, and corporate accountability to ensure equitable and sustainable space exploration while preventing geopolitical conflicts and unchecked resource appropriation.

INTRODUCTION TO SPACE RESOURCE EXTRACTION

Planet Earth is home to billions of species of living organisms. Earth is the only known celestial body that harbours such a life. For millions of years, life has sprouted and evolved, utilizing every resource Earth has to offer and still sustain it. However, in the past few centuries, since humans have entered the age of an industrial revolution and technological advancement, the utilization of Earth's resources has accelerated. At the current exponential rate of exploitation, human society is entering an era of limited resource availability. Every day, the things we call resources—mineral reserves, forest areas, fossil fuels, fresh water bodies, the ocean, and atmospheric gases—are being consumed, in raw or processed forms, in massive amounts, meeting the needs and greed of an advancing human society. This nearly exhausts most of the resource reserves. The demand for energy is higher than what the world may have used decades ago. The proposed solution was to master recycling and reuse techniques and reduce dependency on fossil fuels, thus reducing the burden on sources. However, the fundamental law of thermodynamics prevents us from repeating this unlimited number of times. To remedy this, the vast span of space beyond Earth, which stores nearly unlimited quantities of minerals and other raw materials, is our only hope to put an end to the stress generated on earth-based resources.

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Space exploration, which began as a theoretical endeavour, is a remedial resource limitation. Such space resources are not merely supplementary to the endangering resources on Earth; they also have the potential to aid our journey further into this vast span of space. This is also a step towards the evolution of humanity into a type I civilization, which begins when our capability of space resource extraction reaches the scale of our solar system. This extraction process is generally referred to as harvesting materials from celestial bodies, such as asteroids, the Moon, or any planet, to support both space exploration and economic development. This encompasses approaches such as in situ resource utilization (ISRU), where resources are processed directly in space, as well as terrestrial-focused mining of space-derived materials.

Beyond curiosity, humanity's aim for space resource extraction is two-fold. Primarily, it is seen as a crucial battery for sustainable and prolonged space exploration, thus facilitating on-site fuel production and enriching life support systems on go- and space-based constructions by reducing dependency on Earth-based supplies. At the same level, our access to valuable resources such as rare earth metals, hydrocarbon fuels, and other strategic materials such as lithium will offer a significant boost in economy and technology for both nations and private enterprises alike1. Importantly, while most discussions on space resource extraction come under the jargon of engineering and technology, the physics that underpin these procedures directly carry over to the ongoing debates over space law and sovereignty. Without a thorough comprehension of the technical feasibility and efficiency of both extraction and transportation methods renders any legal interpretations and policies regarding resource appropriation in outer space inadequate. This inevitable communication between science and law is central to understanding how nations and corporations can redefine sovereignty in terms of space resource exploitation.

CORE PHYSICS PRINCIPLES AND CHALLENGES

Understanding the physics behind space resource extraction is critical not only for its technical feasibility but also for shaping the legal and economic frameworks that govern its practice. This section outlines the fundamental physical principles and challenges inherent to extraction and utilization of resources in space.

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A. Energy and Gravity Constraints

Space missions are directly affected by the constraints imposed by gravitational forces and payload mass. Information about the shape, mass, and matter distribution is critical in launching, landing, and orbiting around celestial bodies. For example, during launch, the constraints placed by the Tsiolkovsky rocket equation directly affect fuel efficiency and place restrictions on payload-carrying capacity1. The equation defines the relationship between payload mass and fuel used. There is an exponential increase in fuel usage with increasing mass; hence, optimal utilization of fuel is of utmost priority in any space mission. The positioning of landers in orbits is also a fuel-consuming procedure. The orbit manoeuvring system uses thrusters that burn fuel (a combination of Mono-methylhydrazine and Dinitrogen tetra-oxide) to orient a spacecraft into precise orbits around celestial bodies. Moreover, low-gravity environments encountered on bodies such as moons or asteroids introduce unique challenges. For example, the behaviour of regolith (loose surface material) in low gravity complicates material handling and extraction processes since reduced gravitational force can cause dust and particles to disperse more easily than on Earth2. These challenges necessitate innovative engineering solutions to optimize both energy expenditure and mechanical handling of materials in space.

B. Material Science in Extreme Environments

The extreme conditions of space environments pose a threat to equipment used for extraction that is rarely encountered on Earth. Extreme temperature fluctuations—such as drastic shifts between day and night or significant thermal gradients on asteroids—necessitate durability and reliability of extraction and processing systems2. In addition, high levels of radiation exposure from space can degrade materials and electronic components much faster over time, complicating both extraction processes and long-term operation of machinery. Developing materials and systems that can withstand these conditions is a challenging research and development task.

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C. Resource Identification and Extraction Mechanics

Remote sensing techniques can play a pivotal role in this regard. State-of-the-art spectral analysis technology is a viable option for detecting specific compounds in mineral deposits. Radar systems are employed to locate water ice deposits—particularly on the Moon and in dark regions of asteroids2. Once promising resource deposits are identified, actual extraction processes typically rely on advanced robotic systems. Programmable mining systems—which include precision drills to bioengineered microbes capable of biomining—are being developed to perform these tasks with minimal human intervention. The design and control of these robotic systems must be able to withstand unique challenges posed by the space environment—including microgravity and harsh surface conditions.

D. Processing and Utilization

Following extraction processes, the next challenge is converting raw materials into usable forms. A good example is electrolysis of ice water—which can be a source of oxygen for life support—and hydrogen as a fuel source1. Metallurgical processes also need to be redefined to extract metals from regolith—a heterogeneous material that closely resembles Earth ores2. Processing will significantly depend on both space- and ground-based stations; however, there is a need to meet initial costs associated with energy-intensive processes.

CASE ANALYSES CONNECTING PHYSICS WITH SOVEREIGNTY

The technological challenges involved in the exploitation of

space resources are closely intertwined with issues of sovereignty and jurisdiction over outer space. In this section, we present two paradigmatic examples—extracting lunar water ice and asteroid mining—and demonstrate how physical constraints and breakthroughs influence legal and political discussion.

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A. **Lunar Water Ice Extraction**

Physics:

Recent studies have investigated techniques of low-energy extraction to create water ice from the permanently shadowed craters on the Moon. Such regions, with their extremely low temperatures and restricted solar radiation

exposure, are a scenario where specific strategies such as thermal processing and sublimation-driven extraction can be efficiently employed.

The physics behind these techniques—ranging from the topic of heat transfer in cryogenic conditions to the phase behaviour of water—is crucial in determining the feasibility and economic feasibility of tapping lunar resources.

Sovereignty Approach:

The strategic value of lunar water ice is highlighted by its ability to supply in-situ life support and propellant resources, especially around the lunar poles.

This value has created geopolitical interests as countries and

private players compete for control over such high-value assets. The Artemis Accords, for example, provide modalities for cooperation and sharing of

resources in lunar space, but the legal status of claims and rights is unclear. This is compounded by the Principle of Non-Appropriation in international space law, which makes unilateral claims impossible in spite of the strategic value of the resources.

B. **Asteroid Mining**

Physics:

Asteroid mining is typified by a unique set of challenges that are being influenced by microgravity conditions and the intricacies of orbital mechanics. In the microgravity environment on asteroids, the handling of materials requires the application of

customized technologies that can effectively operate in the lack of significant gravitational forces. Additionally, the orbital dynamics involved in the transport of mined resources from the asteroids to Earth or other destinations demand careful navigation and energy-saving propulsion techniques. These physical constraints have a direct impact

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on the structure and operation of robotic mining systems, making them crucial to the overall feasibility of asteroid mining activities.

Sovereignty Approach:

Asteroid mining is in a legally ambiguous state by dint of the "non-appropriation" principle enshrined in the Outer Space Treaty, excluding national appropriation of outer space and celestial bodies. This exclusion creates uncertainty regarding private property rights to extra-terrestrial lands, since asteroids do not have clearly defined territorial boundaries, unlike the Moon. The uncertainty that pervades international space law allows different interpretations,

which can allow countries or groups to claim resources discovered on asteroids.

This uncertain legal landscape creates difficulties in equitable distribution of resources ana and provides the platform for current discourses on sovereignty in space use of resources.

INTRODUCTION: PROMISE AND PERIL OF THE NEW SPACE ERA.

For centuries, humanity has looked to the night sky in awe, inspired by the vastness of space and the mysteries it holds. From the first moon landing to the ambitious plans of colonizing Mars, space has long been a symbol of boundless possibilities. It is a realm untouched by national borders, where exploration transcends politics, uniting humankind in its pursuit of knowledge and discovery. However, as the new era of space exploration unfolds, the race is no longer just about scientific curiosity—it is about resources, power, and control.

The 21st century has witnessed an unprecedented rise In space commercialization, with nations and private corporations alike setting their sights on lunar mining, asteroid extraction, and space resource utilization. While the Outer Space Treaty declares that space is the common heritage of mankind, it lacks clear and binding regulations on resource exploitation. The Moon Agreement of 1979 attempted to address this, but its failure left a legal vacuum. In contrast, recent

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frameworks like the Artemis Accords (2020) and U.S. Space Act (2015) have begun shaping a new space economy—one that could redefine sovereignty and ownership beyond Earth.

A pressing question emerges: Will space become the next frontier of monopolization, much like deep-sea mining, where powerful corporations and wealthy nations dominate resources meant for all? While the International Seabed Authority (ISA) regulates deep-sea mining under the United Nations Convention on the Law of the Sea (UNCLOS), space currently lacks such a robust regulatory body. Without global cooperation, the unchecked appropriation of extra-terrestrial resources may result in inequality, geopolitical tensions, and environmental consequences.

With private companies like SpaceX, Blue Origin, and iSpace leading space ventures, national governments are losing control over policymaking. The legal ambiguity surrounding space mining could leave developing nations at a disadvantage while allowing spacefaring countries to stake their claims unchecked. To prevent such an outcome, a new legal framework is essential—one that ensures fair, sustainable, and peaceful utilization of space resources.

LEGAL FOUNDATION: THE ILLUSION OF NON APPROPRIATION IN THE AGE OF SPACE CAPITALISM

1. The Outer Space Treaty: Why No sovereignty fails in practice.

The untrodden bounds of outer space await to present many opportunities for the fast progressing and developing Nations and private entities to mark their presence in the outer space. However, the Conventions that are in active role place ambiguity on the topic of “appropriation of resources extracted from the Celestial bodies and the Moon. The Conventions mentioned include – the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, actively known as the Outer Space Treaty. The Outer Space Treaty was initially signed by the three depository governments – the Soviet Union, the United Kingdom and the United States of America) in the year 1967 which

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entered into force in October 1967. The major provisional framework of Outer Space Treaty on International Space Law are as follows:

- The exploration and use of outer space shall be carried out for the benefit and in the interests of all countries and shall be the province of all mankind.
- Outer space shall be free for exploration and use by all States.
- Outer space is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means.
- State shall not place nuclear weapons or other weapons of mass destruction in orbit of on celestial bodies or station them in outer space in any other manner.
- The Moon and other Celestial bodies shall be used exclusively for peaceful purposes.
- Astronauts shall be regarded as the envoys of mankind.
- States shall be responsible for national space activities whether carried out by government or non-governmental entities.
- States shall be liable for damage caused by their space objects; and
- States shall avoid harmful contamination of space and celestial bodies.

2. The Moon Agreement Debacle

Ideally, the international community considers maintaining these fundamental principles are necessary for sustaining the form of law. If the treaty did not exist and the Nations interpreted the concept of first – come, first – serve basis method, this would then lead to extremely unequal appropriation of resources to only the developed nations. Neither the developing Nations nor the underdeveloped nations may possess the capability and by the time they do, the stronger Nations might grab an unequal portion of the space territory and resources. This will breach the primary objective and purpose of the Space conventions, i.e., the peaceful use of the Outer Space by all States.

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Henceforth, the most fundamental principle governing the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (popularly known as the Outer Space Treaty), and the Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (popularly known as the Moon Agreement) is the Principal of Non – Appropriation. The Principal of Non – Appropriation is mentioned in the Article 2 of the Outer Space Treaty which is indeed the Grundnorm of International Space Law. Article 2 of the Outer Space Treaty states that Outer Space, including the Moon and other Celestial Bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means. The objective of this principle is to guarantee peaceful means of exploration by all States and to prevent any private disputes regarding proprietary right over the outer space of the Lunar surface. All States shall have access to the Space for exploration in a non – discriminatory basis. However, the non – appropriation principle in context of private entities, though creates certain restrictions but there do exist loopholes that can be used by such private entities that seek proprietary rights over celestial bodies or the Moon, or seek to gain monetary benefits by space mining as well as moon mining. On the contrast to the non – appropriation principle, the private entities may use such grey areas in the treaty to sidestep violation of the Treaty or any provision of international law or municipal law.

In case of the Moon Agreement, the Article 11(2) of the Agreement states that the Moon is not subject to national appropriation by any claim of sovereignty, by means of use or occupation, or by any other means. Moreover Article 11 (3) of the Moon Agreement provides more clarity to the above-mentioned provision, stating that Neither the surface nor the subsurface of the Moon, not any part thereof or natural resources in place, shall become property of any State, international intergovernmental or non – governmental entity or of any natural person. The placement of personnel, space vehicles, equipment, facilities, stations and installations on or below the surface of the Moon, including structures connected with its surface or subsurface, shall not create a right of ownership over the surface or the subsurface of the Moon or any areas thereof. This prohibits national appropriation as well as other means of proprietorship.

Nonetheless, out of 193 countries that are members of the United Nations, the Moon Agreement 1979 was signed by only 11 countries and ratified by only 14 countries as of the year 2025. This

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demonstrates that countries that have not signed the Moon Agreement still have pathways to explore lunar resources and engage in mining activities. Additionally, countries that have signed but not ratified the agreement retain a loophole that could allow them to extract resources or circumvent non-appropriation provisions.

3. US Space Act 2015: A Legislation of Space Gold Rush

Commercial Space Launch Competitiveness Act, also referred to as Spurring Private Aerospace Competitiveness and Entrepreneurship (SPACE) Act of 2015.

The US Space Act 2015 is a legislation introduced by the Government of the United States of America. This legislation explicitly allows the citizens of USA as well as governmental and non – governmental organisations to exploit space resources – including water and mineral resources for commercial purposes. However, this act does not provide right to commercial exploration of extra-terrestrial life, but this act is contrasting with the Moon Agreement of 1979.

ARTEMIS ACCORDS: A US LED FRAMEWORK FOR SPACE EXPLOITATION?

Artemis Accords 2020 – Principles for Cooperation in the Civil Exploration and Use of the Moon, Mars, Comets, and Asteroids for Peaceful Purposes.

The Artemis Accords, co- led by the Department of State – United States of America and the National Aeronautics and Space Administration (NASA) are a set of non – binding principles that is designed to be adapted by signatories for guided civil exploration and Use of the Moon, Mars, Comets, and Asteroids. The role of these principles is to be establish a common set of guidelines regarding beneficial practices of exploration of the Outer Space while ensuring the maintenance of a safe and predictable outer space environment. The Artemis Accords were launched in the year 2020 October conjoining with Australia, Canada, Italy, Japan, Luxembourg, the United Arab Emirates, the United Kingdom and the United States. According to the data of January 2025, this multilateral policy framework has 53 signatories.

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DE FACTO SOVEREIGNTY: HOW PHYSICS AND CAPITAL DICTATE LUNAR LAND GRABS

One of the most significant advantages of certain lunar regions, particularly near the Moon's poles, is their near-continuous exposure to sunlight. Due to the Moon's axial tilt, some areas—such as the rims of Peary Crater in the north and Shackleton Crater in the south—receive sunlight for extended periods, sometimes almost continuously during lunar summers. This is an essential factor for future mining stations because it provides a stable source of solar energy, which could help in power mining equipment and life-support systems without the need for nuclear or battery-based alternatives.

The ability to generate continuous solar power Is a critical logistical advantage, making these locations highly desirable for long-term human and robotic presence. Unlike equatorial regions, where the lunar night lasts for about 14 Earth days, these sunlit areas allow for uninterrupted energy harvesting, reducing dependency on stored power. Such conditions make them the most practical locations for permanent lunar bases and mining operations. According to NASA research, these areas have been identified as prime targets for future missions due to their energy sustainability.

Apart from their solar power potential, these polar regions also have another crucial advantage—proximity to water ice deposits. The permanently shadowed regions (PSRs) within craters near the poles have been found to contain significant amounts of water ice, trapped in the extremely cold conditions that prevent it from sublimating into space. Water is an invaluable resource in space exploration, as it can be used not only for human consumption but also for producing oxygen and hydrogen, essential components of rocket fuel.

By having access to both continuous solar energy and water resources, mining stations in these regions could operate in a relatively self-sustaining manner. This is especially important considering the high cost of transporting resources from Earth. If a lunar base could generate its own water, oxygen, and fuel, it would dramatically reduce the expenses associated with deep-space missions. The discovery of lunar water has been supported by NASA's Lunar

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Reconnaissance Orbiter (LRO) and India's Chandrayaan-1 mission, both of which detected significant ice deposits. Detailed research on lunar water ice can be explored in NASA's Water on the Moon and a more technical analysis is available in the Planetary Science Journal.

The legal status of lunar resources is a subject of ongoing debate. The Outer Space Treaty (OST) of 1967, which serves as the foundational legal document for space activities, explicitly prohibits national sovereignty claims over celestial bodies, including the Moon. However, it does not provide clear regulations regarding private or corporate ownership of resources extracted from these bodies. This creates a grey area where companies that establish long-term mining operations could effectively claim de facto ownership over specific locations.

While the treaty states that space shall be free for exploration and use by all nations, the lack of an enforcement mechanism means that whoever reaches valuable locations first may gain exclusive practical control over them. This could lead to monopolization, where a handful of spacefaring nations or private entities dominate access to critical lunar resources. In response to this issue, NASA introduced the Artemis Accords, an international agreement outlining principles for responsible space exploration, including resource utilization. However, the accords have not yet been universally accepted, and concerns remain about how lunar mining rights will be regulated in the absence of a unified legal framework.

A well-established principle in economics, known as first-mover advantage, suggests that the first entity to enter and establish operations in a market often gains long-term dominance. This concept is particularly relevant in the context of lunar mining, where early settlers will have the opportunity to secure the most resource-rich and strategically significant locations. On Earth, industries such as oil drilling, deep-sea mining, and land colonization have historically demonstrated that early claimants often retain control, even in legally ambiguous situations.

If no clear international regulations are enforced, private companies or nations that establish permanent operations on the Moon might end up controlling crucial areas, potentially creating an unregulated "land grab" situation. This could lead to conflicts over access, much like disputes over territorial waters and Arctic resources on Earth. The question then arises: should first-movers be granted priority rights, or should a more equitable system be implemented? These

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concerns are currently being debated by space policy experts, legal scholars, and economic analysts.

COMPARATIVE ANALYSIS: SPACE LAW v. EARTH'S RESOURCE GOVERNANCE

1. Parallel's between deep- sea mining regulations and space mining regulations

The United Nations Convention on the Law of the Sea (UNCLOS) is far most the biggest convention consisting of 320 articles and 9 annexes addressing various topics such as territorial seas, exclusive economic zones, deep seabed resource management. Based on the Law of the Sea, the sea water can be classified into five categories namely – internal water, territorial sea or Maritime belt, contiguous zone, Exclusive economic zones, high seas and patrimonial sea. Based on the established categories, in case of contiguous zone the citizens has rights for exploration of natural resources, subject to exceptions, whereas, in case of the Exclusive economic zones the coastal state has the right for exploitation of natural resources. The sea water that extends beyond 200 nautical mile – the High Seas is considered as "common heritage" of the mankind. No State shall strive to claim authority or sovereignty over the High Seas.

Several nations have approached the United Nations' International Seabed Authority (ISA) seeking authorization for deep-sea mining of minerals, corals, and other critical ocean resources. However, after failing to reach a consensus on deep-sea mining regulations in July 2023, the ISA has until 2025 to finalize the rules, regulations, guidelines, and principles governing such activities. The 30th session of the ISA Assembly and Council is scheduled to take place in March 2025.

Although the ISA was given two years to develop a regulatory framework, deep-sea mining remains a highly debated and complex issue. Despite extensive research, knowledge about deep-sea ecosystems is still limited, and numerous scientific uncertainties persist. Stakeholders, scientists, and environmental experts express concerns that extracting critical ocean resources could have severe ecological consequences, potentially disrupting marine life and disturbing the planet's delicate equilibrium.

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Nonetheless, even with the establishment and ratification of the new ISA code, nations will continue to conduct deep-sea mining within their Exclusive Economic Zones (EEZs), which are considered their sovereign territories. As per the United Nations Convention on the Law of the Sea (UNCLOS), coastal states have the right to explore and exploit mineral resources within their EEZs, extending up to 200 nautical miles from their coastlines. This raises further concerns regarding environmental impacts, regulatory inconsistencies, and the need for sustainable management of deep-sea resources beyond ISA's jurisdiction.

Scientists and astronomers dedicate their lives to researching space and the universe, yet they readily acknowledge that outer space remains nearly impossible to fully comprehend. Every new discovery reinforces the notion that the universe extends beyond human imagination, with countless mysteries yet to be uncovered. As outer space exploration and space mining continue to advance, there is an urgent need to establish a regulatory framework, similar to the International Seabed Authority's (ISA) role in governing deep-sea mining.

A key aspect of the ISA's forthcoming regulatory code is its opportunity to proactively address the potential ecological impacts of deep-sea mining. These include direct harm to marine life, long-term disruption of species and ecosystems, potential consequences for fishing industries and the food web, and even emerging risks that could contribute to climate change. By collaborating with stakeholders, marine experts, and scientific researchers, the ISA has the chance to adopt a precautionary approach—prioritizing environmental and social considerations before permitting large-scale resource extraction.

Rather than extracting resources first and mitigating the consequences later, this is a critical moment to step back and evaluate the long-term implications of deep-sea mining. The regulations developed must be firmly rooted in scientific evidence, ensuring that no irreversible harm is inflicted on humanity, marine ecosystems, or the planet's climate balance.

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THE POWER STRUGGLE: WHO CONTROLS THE FINAL FRONTIER

1. Corporate Sovereignty: How SpaceX and Blue Origin are Rewriting Space Law

For decades, space exploration was primarily managed by government-funded agencies. However, in recent years, there has been a significant rise in private space companies aiming to revolutionize space exploration, introduce space tourism, and utilize space for mineral and resource extraction. The concept of space exploration has evolved considerably, shifting from state-controlled missions to a rapidly expanding commercial sector.

Prominent private entities have emerged as key players in this transformation. SpaceX, founded by tech entrepreneur Elon Musk, has become a dominant force in the commercial space industry, pioneering reusable rocket technology. Similarly, in the early 2000s, Jeff Bezos founded Blue Origin, positioning it as a leader in the development of reusable rockets and space systems technology. British entrepreneur Sir Richard Branson has taken space exploration to another level by establishing Virgin Galactic, a space tourism venture offering passengers a unique experience of Earth's curvature and reduced gravity.

Initially, private space initiatives were met with scepticism, but the success of companies like SpaceX has significantly altered perceptions. However, excessive commercialization poses challenges. According to the Global Risks Report 2022, space is becoming increasingly crowded due to the growing number of commercial space activities. While the United Nations' Outer Space Treaty of 1967 establishes outer space and the Moon as the common heritage of all humankind, loopholes in international law allow private entities to exploit space resources. The Moon Agreement of 1979, which sought to prevent resource appropriation, has largely failed due to a lack of ratification by major space-faring nations.

Given these challenges, there is a pressing need for an international regulatory body to oversee the launching and servicing of satellites, enforce space law principles, and regulate the sustainable use of outer space resources to prevent monopolization and environmental degradation.

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TOWARDS A MULTILEVEL GOVERNANCE MODEL: REFORMING SPACE RESOURCE REGULATIONS

The current legal framework governing space exploration, while established under United Nations conventions, remains insufficiently binding, leaving loopholes and gray areas in the law. One of the primary agreements, the Moon Agreement of 1979, was intended to regulate the exploitation of lunar resources but has largely failed due to a lack of ratification by major spacefaring nations.

In response to the growing need for space governance, leading nations have introduced their own legal frameworks. The Artemis Accords, initiated by NASA in 2020, outline principles for sustainable lunar exploration and have attracted numerous signatories. Despite their emphasis on peaceful and cooperative space activities, the Accords have faced criticism for potentially favouring the interests of the United States and its partners, raising concerns about equitable participation.

Similarly, the China-Russia Pact of 2021 represents a collaborative effort between these two nations to establish a lunar research station. This alliance underscores a shift towards bilateral and multilateral agreements outside the existing UN frameworks, potentially complicating the international legal landscape and posing challenges for developing countries seeking to engage in space exploration.

The rise of private space entities further complicates the scenario, increasing the risk of monopolization by early entrants in the space industry. The Global Risks Report 2022 highlights concerns about the growing congestion in space due to increased commercialization, emphasizing the need for comprehensive governance to prevent the monopolization and unsustainable exploitation of space resources.

Given these developments, there is an urgent need to establish an internationally accepted regulatory body tasked with overseeing space exploration activities. Such an entity would aim to prevent the excessive exploitation of space resources, ensure equitable access for all nations, and uphold safety standards to protect humanity, the environment, and the outer space ecosystem.

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This approach would promote a balanced and sustainable framework for the continued exploration and utilization of space.

A UN-led space regulatory body can be proposed to maintain peace among nations and ensure the peaceful resolution of conflicts related to space activities. Such a body would play a crucial role in preventing the exploration and exploitation of outer space in ways that could disrupt the equilibrium of nature and space, particularly in areas like space mining and resource extraction.

The establishment of this regulatory body must include the formulation of a comprehensive code of conduct, ensuring that space companies from every nation adhere to standardized principles for responsible space activities. Just as the International Seabed Authority (ISA) is set to introduce new regulations following two years of scientific research, it would be far more effective to analyse risk factors before permitting large-scale space activities rather than addressing hazards only after they occur.

Additionally, rather than relying solely on unilateral policies, nations can develop cooperative agreements with private space entities, fostering a balanced approach to space governance. Such agreements would promote international collaboration, ensuring that space exploration remains a shared and sustainable endeavour rather than a race for resource monopolization.

CONCLUSION: TOWARDS EQUITABLE GOVERNANCE IN THE NEW SPACE ERA

To conclude, this article has primarily examined the legal aspects surrounding the increasing interest in space resource exploitation by nations and private entities. The Outer Space Treaty, established under United Nations conventions, declares outer space as the common heritage of mankind, prohibiting any nation from claiming sovereignty over celestial bodies. However, while designed for Cold War diplomacy, this treaty has become outdated in the context of modern commercial space activities. Notably, it does not explicitly ban private companies from extracting space resources.

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The Moon Agreement (1979), which sought to regulate resource appropriation, failed due to minimal ratification. In contrast, the Artemis Accords (2020) and the U.S. Space Act (2015) have effectively legalized space mining under U.S. norms, raising concerns about the future of resource ownership in space. Certain lunar regions receive continuous sunlight, making them ideal locations for mining stations. This raises a fundamental question: if a company or nation constructs permanent infrastructure in space, does this amount to economic sovereignty?

A comparative analysis with the United Nations Convention on the Law of the Sea (UNCLOS) and the International Seabed Authority (ISA) highlights a precedent for regulating deep-sea mining. While the deep sea is also designated as a "common heritage of mankind," in practice, corporate entities exert significant control over its resources. This raises concerns over whether space mining will follow the same path, leading to monopolization by powerful nations and corporations.

The growing power struggle between national governments and private space entities further complicates the legal landscape. Companies like SpaceX, Blue Origin, and iSpace are increasingly bypassing government-led regulations, positioning themselves as major stakeholders in space resource exploitation. The ideal corporate strategy appears to involve both resource extraction and appropriation, which could place developing nations at a severe legal and economic disadvantage. While the UN supports the common heritage principle, the reality is that wealthier nations are already dominating space resources.

Given these challenges, a new legal framework is urgently needed. The current system lacks binding regulations on space mining, increasing the risk of resource monopolization by early space powers. A three-tier governance system can be proposed:

1. International Oversight: A UN-led space regulatory body should be established to oversee space resource utilization and prevent conflicts.

2. National & Regional Cooperation: Countries should prioritize multilateral agreements over unilateral policies, ensuring fair participation for all nations.

3. Corporate Regulation: Space companies must be subject to a strict code of conduct, similar to regulations governing deep-sea mining, to prevent reckless exploitation.

Such a structured legal framework would ensure that space exploration and resource utilization remain equitable, sustainable, and peaceful, safeguarding the interests of all nations and future generations.

REFERENCES

1. *In-Situ Resource Utilization (ISRU). Wikipedia. Retrieved from: https://en.wikipedia.org/wiki/In_situ_resource_utilization*

2. Overview of In-Situ Resource Utilization (ISRU). NASA. Retrieved from: https://www.nasa.gov/overview-in-situ-resource-utilization/

3. Mining the Moon: Why Extracting Lunar Resources Could Be Lucrative. Business Insider. Retrieved from: https://www.businessinsider.com/mining-moon-minerals-lucrative-bad-news-science-research-astronomists-2025-2

4. Commercial Space Resource Utilization: Congress Research Service Report. CRS Reports. Retrieved from: https://crsreports.congress.gov/product/details?prodcode=R48144

5. Abigail D Pershing, Interpreting the Outer Space Treaty's Non-Appropriation Principle: Customary International Law from 1967 to Today, (Mar. 15, 2019), https://openyls.law.yale.edu/bitstream/handle/20.500.13051/6733/Pershing.pdf?sequence=2.

6. The Outer Space Treaty, (Nov. 10, 2022), https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introouterspacetreaty.html.

7. Circumventing the Non-Appropriation Principle of International Space Law, (May 11, 2022), https://www.berkeleyjournalofinternationallaw.com/post/circumventing-the-non-appropriation-principle-of-international-space-law.

8. Agreement governing the activities of states on the moon and other celestial bodies, 1979, (July 11, 1984), https://whatconvention.org/en/ratifications/ .

9. Moon Agreement, (Mar. 21, 2025), https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/intromoon-agreement.html?

10. https://www.congress.gov/bill/114th-congress/house-bill/2262

11. Artemis Accords, NASA https://www.nasa.gov/artemis-accords/.

12. De Facto Regimes in International Law, Utrecht Journal of International and European Law https://utrechtjournal.org/articles/10.5334/

13. De Facto Regimes in International Law, Utrecht Journal of International and European Law https://utrechtjournal.org/articles/ .

14. Maggie Mckee, Sunny spot picked out for future lunar base, New Scientist (Apr. 13, 2005), https://www.newscientist.com/article/dn7263-sunny-spot-picked-out-for-future-lunar-base/.

15. Mike Wall, No Digging Required: Space Mining on the Moon and Beyond May Be Solar Powered, Space (Sept. 4, 2019), https://www.space.com/moon-asteroid-space-mining-with-concentrated-sunlight.html.

16. UNCLOS: United Nations Convention on the Law of the Sea, https://www.unclos.org/.

ISSN (O): 2584-2196

13. What We Know About Deep-sea Mining — And What We Don't, World Resources Institute (Feb. 23, 2024), https://www.wri.org/insights/deep-sea-mining-explained.

17. About ISA, International Seabed Authority (Mar. 17, 2022), https://www.isa.org.jm/about-isa/.

18. Luna Spacey, Private Space Companies: Best in 2025, My Space Museum (Jan. 3, 2024), https://myspacemuseum.com/private-space-companies.

19. As private satellites increase in number, what are the risks of the commercialization of space?, World Economic Forum (Jan. 12, 2022), https://www.weforum.org/stories/2022/01/what-are-risks-commercial-exploitation-space/.

20. Loura Hall, Lunar Polar Propellant Mining Outpost (LPMO): A Breakthrough for Lunar Exploration & Industry, NASA (Apr. 7, 2020), https://www.nasa.gov/general/lunar-polar-propellant-mining-outpost-lpmo-a-breakthrough-for-lunar-exploration-industry/.

21. NASA TechPort, https://techport.nasa.gov/view/106023.

22. One Small Step For Man, One Giant Leap For Exploitation: A Note on the Legitimacy of Lunar Mining, CENTRE FOR RESEARCH IN INTERNATIONAL LAW (Feb. 24, 2022), https://nliu-cril.weebly.com/blog/one-small-step-for-man-one-giant-leap-for-exploitation-a-note-on-the-legitimacy-of-lunar-mining.

23. Economics of the Stars : The Future of Asteroid Mining and the Global Economy, https://www.google.com/amp/s/hir.harvard.edu/economics-of-the-stars/amp/