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OFFWORLD: RESOURCES OUT OF THIS WORLD

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Abstract (100 words maximum)

Despite major uncertainties and extreme costs of failure, space mining is evolving as a highly attractive industry for private companies, investors, and governments alike. This case study presents the position of OffWorld, a developer of autonomous swarm robotic mining systems for resource exploitation, extraction, and utilisation in the extreme environments of space. Although the space mining market offers a plethora of promising opportunities, this paper raises ethical concerns and highlights the implications these can have on OffWorld's strategy going forward, especially in the identification of customers. The topic is analysed using a stakeholder theory of management and business ethics theories.

Keywords: Space Economics, Space Mining, Space Ethics, Resources, Business Ethics, Business Strategy, Market Entry, Environment, Entrepreneurship

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OffWorld: Resources out of this World

“The first trillionaire in the world will be the person who mines asteroids” (Salon 2015). These are the words of Neil DeGrasse Tyson, an American astrophysicist, author, and science communicator. It comes as no surprise that such promise has motivated numerous skilled scientists, large companies, and prominent entrepreneurs to enter the space mining industry. However, trailblazing a new industry is not that easy. Especially when this industry is emerging in space. As available information is highly restricted and uncertainty higher than for any industry on planet Earth, the cost of failure grows significantly larger. Regardless of the risks involved, the phenomenon has spiked substantial interest. More and more space mining companies are being founded at a fast rate, each trying to approach the unprecedented missions in their own way. Like in the gold rush in the 1800s, space mining companies seem to happily take large risks and invest all the money they can get their hands on to find and extract valuable resources. Herein, all realistically accessible planets, moons, and asteroids are targeted to collect a whole spectrum of natural resources (Cosmos 2023).

In the summer of 2023, Jim Keravala and his executive team sat together and reflected on the past seven years since founding OffWorld. They had developed a game-changing technology in possibly the most exciting industry of their time. A technology that has the potential to contribute to humans leaving planet Earth and exploring space through enabling space mining – a vision that has constantly guided Jim for the past decades. The company had met its initial operational goals. They signed their first commercial contracts, setting them up with financial legitimacy for the next steps, and had just opened a new office in Luxembourg, extending their presence to four continents. While the feeling of achievement and pride was gratifying, they also developed a feeling of responsibility over their technology. At this moment, the group of space experts realised that the next steps of OffWorld would be decisive for their product’s development, the company’s image, and the evolution of a whole new industry.

Into the Unknown: A Founding Story

Like so many other kids in the 1970s, Jim had always dreamed about going to space growing up. Back then, it was science fiction heroes fighting over planets. He was fascinated by the potential of exploring the seemingly infinite space environment and the idea of human life being possible in space. Jim envisioned a practically indefinite realm of possibilities and a life without wars over territory and struggle for scarce resources. Coming out of university, Jim gained first experiences in the field, working in international committees and councils. While space was gaining public attention on a large scale, he quickly realised that governments and public agencies were not acting fast enough. He was convinced that access to space was an urgent matter and that the race to new celestial bodies and the contingent possibilities would be won in the early days of the field. Thus, it seemed logical to him that private companies would be the trailblazers of the industry. Eventually, Jim decided to work as a launch manager for Surrey Satellite Technology, a developer of microsatellite technologies in London. He enjoyed the work the company did, his role, and the impact they had. In his six years at the company, his team managed over a dozen launch programs. However, one major issue in the industry remained to bug Jim. An issue, which was not tackled enough in his current position and the general field: The underlying problem of space missions being limited by repellent, energy, and power. A spacecraft built on Earth can only go so far with materials and fuel equipped before launch. Jim envisioned solutions that would utilise resources available in space to advance the magnitude of possibilities. Jim decided that he had to act himself[1]. (See Appendix 1.1.)

With more of a basic direction than a concrete idea in mind, Jim knew he needed to assemble a team of specialists to make his vision become reality. After months of search, numerous personal conversations, and countless planning sessions, in 2016, a group of scientists and space experts was put together, comprising Jim, Dr Alicia Kavelaars, Dr James

[1] Founding Story based on Interview Podcast by Pyle 2020

Murray, Dr Norbert Frischauf, Erika Ilves, Joshua Izenberg, and Mark Nall. Together, they observed the booming space environment and discussed possibilities to participate in the futuristic endeavour.

Should they try to claim resources from a specific asteroid, competing for large amounts of funding and the first spot with dozens of other companies? Or should they try to specialize in the collection of expensive metals and sell them as quickly as possible to achieve unimaginable wealth? But why should they be the ones to make it in a field full of highly educated and specialized gold diggers? Maybe, they thought, the way to succeed is not to rush towards extra-terrestrial spheres themselves but to develop the means to these ends. A famous saying, which arose after the Californian Gold Rush between 1848 and 1855, states "During a gold rush, sell shovels" (Upstate Business Journal 2022). Following the same line of thinking, Jim and his team came up with a plan to bridge the infrastructure capability gap in space by developing technology that could not only explore and collect resources and materials but also directly process them to provide important substances in space directly.

What is Space Mining?

Space mining, also referred to as extra-terrestrial mining or asteroid mining, describes the concept of extracting valuable resources and materials from celestial bodies such as the Moon, asteroids, and other planets. The idea emerged from the imperative to address resource scarcity on Earth, offering a strategic solution to resource procurement while simultaneously laying the groundwork for future space exploration. Employing cutting-edge technology, including robotic spacecraft, space mining involves the identification, capture, and processing of resources directly in space. This transformative approach not only mitigates the limitations imposed by terrestrial resource constraints but also marks a paradigm shift in the approach to sustaining human activity beyond Earth. Building spacecrafts on Earth and then launching them into orbit is incredibly inefficient, especially since there is an excessive supply of iron and titanium in space. Water, too, can be extracted from asteroids for life support and rocket propellant. Foreseeable targets for space mining include the Moon (Helium-3, gold, platinum group metals, rare Earth metals, water), Near-Earth asteroids (water, iron, nickel), the asteroid belt (almost everything), and Jupiter (Helium-3) (BBC Science Focus 2018). Space mining is expected to become reality in the next decade and believed to be a crucial step towards enabling sustainable space colonization and advancing our understanding of the orbit (Cosmos 2023).

Launching the Future: OffWorld's Technological Breakthrough

OffWorld aims to become a trailblazer in space mining technology and position itself in a rising market from early on. As for many uprising industries, underlying technology is a key differentiator and thus a decisive force that determines the success or demise of companies in the market. This is especially true for the space sector, as technologies are often unheard of, and the cost of failure is extraordinarily high (Bloomberg 2023). Jim and his colleagues develop and produce proprietary technology for swarm robotic mining systems. In simple terms, OffWorld sells multiple kinds of smart robots that fulfil all types of mining operations in extreme environments, such as asteroid surfaces. Moreover, these robots can navigate the challenges posed by low-gravity environments, demonstrating their versatility in building and maintaining structures. On top of that, they are designed to operate autonomously with the ability to learn and act independently. Key features of OffWorld's robots are extreme terrain autonomous navigation, built-in behaviours, unique machine-learning abilities, as well as highly resilient, dust-tight, and waterproof armour. The swarm competencies comprise a range of robots, constituting a wide spectrum of potential mining needs. As of 2023, OffWorld's product portfolio comprised five kinds of robots with various abilities: Surveyors (map and survey), Excavators (selective material extraction), Collectors (collection of materials), Haulers (transportation), and Dozers (clearance of paths and routes). Swarms of robots can be arranged according to any specific mining project's needs. Additionally, individual robots can be customized in terms of height, tools, and materials. Depending on the project, customers will further be able to customize behaviour through advanced user interfaces. (See Appendix 1.2.)

The robotics are designed for a mixture of use cases across applications related to space exploration, construction, and resource utilization. Though also functional in earthly environments, they are primarily designed for extra-terrestrial and extreme environments. The technology can be applied to celestial construction, for example for developing infrastructure on the Moon and Mars, and the establishment of self-repairing cities. Moreover, they can be utilised for In-Situ Resource Utilization (ISRU), the practice of using celestial resources to sustain human missions in space. OffWorld's robots can help process and employ raw materials to generate oxygen, water, and other basic supplies. Additionally, the robots can assist in space debris removal. Herein, they can contribute towards the safety of space missions and the preservation of the extra-terrestrial environment. Finally, they can be used to support planetary exploration projects by assisting with data collection, sample retrieval, and even maintenance.

OffWorld in 2023

OffWorld was founded in Pasadena (United States) in 2016 by a consortium of scientists and experienced professionals in the space field. The project emerged as a visionary space mining technology company aiming to revolutionize extra-terrestrial resource exploration and extraction. Within this field, OffWorld does not operate space missions itself. They develop, build, and market mining robots for other companies' or institutions' space missions. Since its inception, OffWorld has made remarkable strides, expanding its presence across the globe. Currently, the company boasts four strategically located offices, each in a distinct part of the world. Situated in Pasadena, Johannesburg (South Africa), Perth (Australia), and Luxembourg (Luxembourg), OffWorld employs over 100 individuals (Silicon Luxembourg 2023). The journey has already been marked by significant milestones. In 2021, the company celebrated the successful deployment of its first autonomous robot in an underground environment, showcasing the technological prowess that underscores its operations. In 2022, OffWorld achieved a remarkable distinction by becoming the first company to secure a development mining contract on more than one celestial body, solidifying its position as a space industry trailblazer. Looking ahead, OffWorld is poised for another transformative chapter. As of December 2023, the company is actively engaged in raising Series A funding (Silicon Luxembourg 2023). These funds will be instrumental in accelerating the company's go-to-market strategy, ultimately kicking off the sale of its products by 2024. In doing so, OffWorld continues to be a driving force in reshaping the future of space exploration and resource utilization, one technological leap at a time.

Jim and his team have established a visionary and forward-thinking business model that revolves around the creation of autonomous swarm robotic mining systems. To tap into the large pool of potential in celestial resources and materials, the founders came up with a multifaceted approach. First and foremost, the heart of its business model lies in the development of space mining technology, particularly in the realm of resource extraction, aiming to become the global technological leader in the field. To achieve this, OffWorld is actively engaged in planetary and technological research, focusing on functionality across widespread habitats and ground compositions as well as artificial intelligence. The cutting-edge robotics are tailored for space missions, offering their customizable solutions on a project-based basis, making it possible to build on commercial revenues and finance the production in the long-run. On top of that, OffWorld aims to create a self-enforcing infrastructure of robotics. As the robotic systems can be collectively controlled and interact with each other, they can eventually be used for complex infrastructure within certain environments. For example, if humans were to go to Mars, OffWorld's robots could act as a planet-wide supply system for water or other resources, becoming indispensable to the space mission. Finally, the company aims to build a strong network of partnerships by collaborating with space agencies, private companies, and research institutions to deploy their robotic technology.

The Promiseland: Opportunities in Space

But is space a viable option in the first place? Should Jim not explore possibilities in the automation of earthly mining? Next to being of personal interest and more exciting, the business reason is compelling, too: Space holds a multiple in the potential for financial and social return.

As space is multiple times bigger than planet Earth, so is the volume of certain resources (Keck Institute for Space Studies 2012). While the conditions on planets and asteroids are not the same as on Earth, many well-searched near-Earth-asteroids (NEA) offer a wide spectrum of useful resources, including metals (such as iron, nickel, and cobalt), stones, rare Earth elements, precious minerals (such as gold and platinum), and even water. And all of those in large quantities. One much-discussed asteroid alone, named 16 Psyche, is estimated to contain more than $700 quintillion worth of gold according to the current gold price (The Print 2019). Moreover, it is approximated that mining the ten most cost-effective NEAs can produce a value in the range of $1.5 trillion (Asterank 2023). Investors are convinced of the potential of space mining as well. In a research report from 2017, leading investment bank Goldman Sachs stated that they view investments in asteroid mining projects as a highly realistic target and added that single asteroids the size of an American football field contain north of $50 billion worth of platinum (Business Insider 2017; CNBC 2017). (See Appendices 1.3, 1.4, 1.5, and 1.6.)

The benefits of mining in space extend further than purely financial motivations. As earthly resources near the limit of exhaustion and become more troublesome to attain, outsourcing mining operations to space and away from terrestrial grounds unlocks environmental relief. Contemporary mining methods come with immense water footprints, large-scale pollution from leakages and mining tailings, and greenhouse gas emissions (Earth.Org 2022). Scaling down or eventually stopping harmful earthly mining practices would lead to less pollution and soil depletion as well as a decrease in chemical contamination within natural habitats (The Week 2015). Additionally, human involvement in dangerous mining methods could be alleviated. According to the International Labour Organisation, mining accounts for roughly eight per cent of fatal work accidents worldwide (BBC 2010). In 2022 alone, ten countries reported major mining disasters, spreading across four continents (Mining Technology 2023). Child labour, too, is a major issue within the mining industry. In the Republic of the Congo, for example, the biggest supplier of rare metal cobalt, children as young as seven years old were found in hazardous and unregulated mines, constantly breathing in fatal cobalt dust (The Guardian 2021). Space mining makes a credible case to correct these issues.

Finally, space mining plays a pivotal role in making space research and the eventual human expansion into space more feasible. By harnessing the vast resources of celestial bodies, space mining offers a potentially self-sustaining and cost-effective source of raw materials and propellants (Heise 2018). This reduces the need for Earth-based resupply missions and minimizes the logistical challenges and costs associated with long-duration space missions. Additionally, the prospect of extracting water from regolith for life support systems and fuel production paves the way for extended human presence in space. As space mining technology advances, it not only supports the sustainability of extra-terrestrial habitats but also fuels innovation and research, driving the development of new technologies and scientific discoveries that are integral to humanity's long-term presence beyond our planet.

Space Chronicles: History of Space Mining

Collecting natural resources and materials in space was on humanity’s agenda far before technology even made it possible to go to space. In 1903, the Russian and Soviet rocket scientist Konstantin Tsiolkovskii included the exploitation of asteroids in his plan for space travel (Tsiolkovskii 1903). A few decades later, humans’ affinity to gather objects from space started with the very first successful space mission Apollo 11 in 1969, bringing back moon rocks. In 2005, dust was collected from an asteroid for the first time during the Japanese Hayabusa mission. While these missions were conducted for research purposes, they proved the possibility of extracting materials from celestial bodies and paved the way for things to come. The history of space mining is a tale of great innovation and ambition, yet one marked by the failure of early pioneers. While the idea of acquiring scarce and hard-to-attain resources from space dates back to the mid-twentieth century, mostly through overly enthusiastic scientists, the first serious attempts were conducted in the 1970s and 1980s by the National Aeronautics and Space Administration (NASA). Due to immense technical difficulties and unexpectedly high costs, however, these initial efforts remained purely hypothetical.

With advancements in technology and spurring interest across private ventures, space mining became a prevalent idea again in the 21st century. Prominent early movers, such as the highly funded Planetary Resources and close follower Deep Space Industries, gained a lot of attention and made large contributions to the field. They set a technological basis for mining in the form of satellites and identified a plethora of suitable asteroids (The Space Review 2013). Despite a more auspicious outlook than ever before, both companies ran out of money before ever launching any mission into space, again due to financial challenges from piling costs (MIT Technology Review 2019). Both ended up being strategically acquired. (See Appendix 1.7.)

To date, there have not been any fully successful space mining missions. Nonetheless, belief and enthusiasm are rising steadily as development and material costs are falling, funding and investment are rising, and more and more players enter the market (Rich et al. 2020). The first ever mission is expected to be realised in 2024, most likely by California-based Astroforge (Forbes 2023). With that, space and asteroid mining are evolving from a mere hypothesis to a reachable reality with legitimate consequences. (See Appendix 1.8.)

A Cosmos of Vagueness: The Legal Environment

Space is a legally complicated area. Historically, most ownership claims over territories have been decided through the execution of power and war, with diplomatic negotiations, treaties, and other forms of agreements as a means to define borders. Due to the relatively recent possibility of even leaving Earth, space has not been a concern of historic law-making and neither was claimed by any ancient empires or nation-states. Governance and ownership concerns have only recently become a matter of interest. As outer space spans beyond the borders of any nation, a common perception is that international law is the most logical basis for space law (Milken Institute 2021). In 1967, the United Nations (UN) developed the so-called Outer Space Treaty, which declares that no individual nation may claim ownership of any kind of celestial body (United Nations 1967; see Appendix 1.9). The idea was that space should be free for all exploration and could be searched by all members unrestrictedly. In 1979 followed the second major planned agreement by the UN, the Moon Treaty, suggesting that exploiting resources on the Moon is only allowed by international regimes and that no celestial body may be owned by private organisations (United Nations 1979). However, not all member states were convinced by the proposed treaties. The potential source of resources, wealth, and power is one that was difficult to disregard. Influential countries that did not ratify the treaties include the United States, Russia, and China, leaving them in a kind of undefined grey zone within international law. On top of that, the treaties themselves are ambiguous and outdated (Heise 2018). For example, the Outer Space Treaty prohibits “national appropriation” of celestial bodies (United Nations 1967). However, the term “appropriation” is not clearly defined, leaving it open to interpretation whether mining small amounts of resources can be considered as “appropriation” or if only exclusive claims over full territories are. In 2015, the United States launched its own space mining law, the Commercial Space Launch Competitiveness Act. The act grants rights to private companies in the United States to explore and mine celestial bodies, given they get official approval (Mining Technology 2019). The European frontrunner in space law is Luxembourg. In 2016, they enacted the Space Resources Initiatives, building on the foundation of the US law and granting substantial rights to private companies. This was followed up in 2017, with the launch of an additional mining law, further promoting the initiatives of private companies and governmental bodies. While these legal efforts pave the way for space mining, the international sphere remains characterized by ambiguity and vagueness when it comes to ownership and governance laws.

Another Dimension: Ethical Challenges

Despite undoubtedly exciting and potentially world-changing possibilities, asteroid mining still poses many question marks and concerns (Schwartz and Milligan 2016). The impact of space mining looks to be colossal across a wide range of layers. Whole economies, political systems, and global society can be expected to be affected in both the short- and long-term (Yarlagadda 2022). Government agencies, policy groups, and commercial companies involved in the space mining industry ought to account for more than purely financial and technological difficulties. Ethical considerations, too, are a major concern.

The first ethical question that needs addressing is “Who owns space?”. As outlined, there is no commonly accepted legal framework for space mining and ownership of celestial resources, yet the implications of this questions are profound. The notions of who can and will go to space as well as who owns what in space are unclear and raise worries of conflict (Zeisl 2019). As with any desirable territory in history, one can anticipate competition, and in the worst-case scenario war, over the territory in question. When the British encountered economically desirable land in India, it led to colonialization between the 17th and 19th centuries. In the same manner, in the late 19th century, big European powers, including France, Germany, and Britain, fought over the ownership of newly discovered African territory in the Scramble for Africa. With modern and quickly developing technology, space travel will eventually be feasible in a spectrum of countries. Thus, the contest for access to celestial bodies and resources might become disputed and the risk of terrestrial conflict rises sharply. Additionally, the settlement ownership matters impact the direction and extent of scientific exploration and thus use to the global community, as different players come with different incentives (Munro 2022). For example, if ownership rights are given to whoever reaches any given asteroid first, implying a rule of first-mover advantage, private companies may benefit from high funding and fast processes but merely utilise said asteroid for commercial purposes (Toosi 2019). The ethical conundrum that emerges from such legal inconclusiveness is the issue of how to govern and supervise space and how to deal with misconduct. If control over resources falls into false hands, the effects on space and Earth could be disastrous. Without overarching authorities or legal framework, there is currently no legally and ethically sound answer to this question.

A second ethical concern lies in the question of “How much should be mined?”. Though space appears to be endless when looking from Earth, resources in space, especially attainable and useable ones, are finite. Astrophysicists Martin Elvis and Tony Milligan (2019) argue that the exhaustion of space resources is already calculable due to the current rush into the industry. According to them, the risk of “super-exploitation” could limit the potential that the space economy offers and, if approached without care, could compromise the needs of future generations. Historically, new, and potentially highly lucrative fields oftentimes attract an overflow of governments, businesses, and investors, with most players simply following the trends due to fear of missing out or heavy reliance on the judgements of others (Scharfstein and Stein 1990). A large-scale surge of space missions would lead to an overflow of resources and materials and eventually a depletion thereof. Hence, Elvis and Milligan suggest that a majority of space resources should be shielded from exploitation to secure the well-being of future human life. According to them, only one-eighth of space resources should be permissible for mining. Thus, a key emphasis must be put on managing the extent of mining to protect the environment and preserve attainable resources.

The third dimension of ethical concerns is of geoeconomic nature: “What will be the negative consequences on Earth, and who is in charge of dealing with them?”. Firstly, and linking back to the previous section, most bubbles end in bursts, leading to major economic downturns. This is especially true for natural resources, as oversupply and false expectations cause prices to crash and investments to break down, as was the case with the Silver Bubble in 1980 (The Washington Post 1980). Secondly, an additional supply of rare resources and materials could cause the global economy to be shaken up. Many emerging economies, notably, tend to rely on natural resources. South Africa offers an illustrative example of the possible effect of unregulated space mining. The third-biggest African economy (Statista 2023) is the world's largest producer of platinum, a valuable metal that is used for converters, electronics, and medical devices amongst others, supplying a share of more than 70 per cent of annual platinum production (World Platinum Investment Council 2019). In absolute terms, this amounts to roughly $4 billion worth of platinum mined yearly at current market prices (Statista 2023). According to research by Goldman Sachs, single NEAs may contain over $50 billion worth of platinum, making miners immediately gain outstanding control over the worldwide market platinum (Business Insider 2017). Imaginable uncontrolled inflows would not only crush the global platinum price but the entire South African economy. The same scenarios could unfold for the Democratic Republic of Congo (Cobalt), Mongolia (Coal), Bolivia (Lithium), Papua New Guinea (Gold), Chile (Copper), Brazil (Iron Ore), and Kazakhstan (Uranium), amongst others. These examples highlight the vulnerability of the global economy, especially emerging countries, to external resources and material retrieval. Prominent legal philosopher Daniel Pilchman (2016) underlines these issues by stating that asteroid mining is likely to increase inequalities on Earth. The subsequent question of who is responsible for managing such unprecedented levels of resource invasion and ensuring the economic health of impacted countries is a great concern, too. It seems unlikely that a single overarching institution will be accepted by all relevant states and players in the foreseeable future, as countries like China and Russia already oppose international space law. Leaving decisions to local or regional regulatory bodies bears risks of oversupply and competition wars. Private companies must account for ethical considerations in their operations and planning, at least for now.

OffWorld's Role in Space: Identifying Appropriate Customers

Over the past seven years, Jim has put together a team of over 100 talented industry experts, expanded to four continents, and developed a highly promising technological base for swarm robotics. OffWorld is in a favourable position to become a leading technology supplier for space mining missions. As early movers, they hold price-making power and look to become a staple in the sphere, given that they play their cards right. However, entering the space mining industry does not solely require financial considerations. Providing space mining projects with necessary tools has a plethora of ethical implications, many of which are unprecedented and remain a source of uncertainty. Governments and private institutions that go to space alike can gain great power, be it politically, economically, or socially. Control over resources, access to research and knowledge, authority over extra-terrestrial bodies, and being the first in line to eventually move to space are all decisive factors for the allocation of wealth and power in the foreseeable future.

The stakes are high. Not every company or institution that desires abundant resources should go to space. Not every asteroid should be mined as soon as possible. Due to the lack of regulatory governance and missing ability to control, a share of responsibility falls to private players active in the space industry. Private companies engaged in space mining must strike a delicate balance between economic interests and ethical considerations. They bear the responsibility of ensuring that their activities are conducted in an environmentally sustainable and socially responsible manner, considering the potential impact on celestial bodies, space debris management, the preservation of the extra-terrestrial environment, political and legal risks, and economic consequences on Earth and in space. In the case of Jim and his team, one fundamental consideration is the choice of who to sell to. OffWorld supplies the means to other actors' ends. Their products take an enabling role by giving governments, agencies, private companies, and research institutions the ability to conduct space missions, enabling them to find, extract, and process celestial resources. In that sense, the company grants its customers the power to mine a broad of resources in space for a plethora of use cases. Certainly, OffWorld customers themselves are accountable for their actions, yet the founding team's sales decisions have strong implications for the outlook of the space mining industry. (See Appendix 1.10.)

Beyond the immediate ethical considerations, the potential consequences of placing space mining technology in the wrong hands extend far beyond the realms of merely wasted opportunities. Space mining has the potential to reshape economic landscapes on a global scale. If not managed responsibly, this transformative technology could exacerbate existing socioeconomic disparities. Moreover, the geopolitical implications of unregulated space mining may give rise to conflicts over resource ownership, creating a breeding ground for global crises. Therefore, the moral obligation to consider the ethical ramifications of customers' actions becomes imperative. Though debatable, it may be argued that Jim and his team are morally obliged to consider the plans and actions of their customers in their sales decisions. A similar argument is often raised in the arms industry. Engelbrecht and Hanighen (1934) famously labelled organizations that sell weapons to countries at war as "Merchants of Death". Of course, the arms industry bears more obvious and directly harmful implications than space mining robots. Yet, placing space mining technology in the wrong hands may lead to wasted opportunities, rising inequalities, and even global crises.

Jim and his team ought to ask some fundamental questions moving forward. What is their role in addressing these ethical questions? Should OffWorld take ethics into account in a highly competitive market, or leave decision-making to customers and governing bodies? Especially in these early stages? In case they do want to be selective with their customers, who are the appropriate ones? Is it right to partner with governments and space agencies and trust in their ability to judge and rule? Or should they refer to their own judgement to fuel exploration and innovation at a high pace? But what factors can they use to determine which customers are suitable to act on the ethical challenges? And who can be the moral judge of these questions?

Teaching Note - OffWorld: Resources out of this World

Case Summary

This case study presents the story of Jim Keravala and his company OffWorld.

Jim has always been enthusiastic about space. After studying and working in the field for several years, he decided to establish his very own space company, tackling the issue of resource availability. Together with an array of selected industry experts, Jim put together the idea behind OffWorld. The company specializes in cutting-edge swarm robotic mining systems, designed to extract resources from celestial bodies such as the Moon and asteroids. The journey unfolds as OffWorld achieves remarkable milestones, securing commercial contracts and earning the distinction of being the first to hold a development mining contract on multiple celestial bodies. Their reflection on their journey so far, however, introduces a critical juncture. The ethical landscape of space mining emerges as a complex challenge, with OffWorld facing dilemmas that demand careful navigation.

Three specific ethical challenges are highlighted and ought to be considered by OffWorld when entering the field of space mining: “Who owns space?”; “How much should be mined?”; and “What will be the negative consequences on Earth and who is in charge of dealing with them?”. Jim’s brainchild, while revolutionary, is not excepted from such profound ethical considerations. The company grapples with the moral implications of its technology, questioning the responsibility of providing advanced capabilities to customers with potentially divergent intentions. The dilemma extends to environmental sustainability, resource management, and the prevention of space debris, amplifying the need for a conscientious approach. The absence of a universally accepted regulatory framework in space law further complicates matters. OffWorld finds itself in uncharted territory, contending with legal ambiguities and diverse international perspectives on the ownership and governance of celestial resources. In a world where space exploration intersects with economic interests and ethical imperatives, OffWorld stands as a pivotal player. The company's decisions will not only shape its trajectory but also influence global economies, environmental practices, and the ethical direction of space exploration.

Jim and his team are confronted with different options to strike a balance between economic viability and responsible business, as OffWorld pioneers a path that could redefine access to resources in the cosmos. They must decide what role they want to play on this journey and what their priorities truly are.

Learning Objectives

This case study was designed with the goal of constituting an in-class discussion on approaching an unknown industry. Students are expected to understand the opportunities and challenges that arise with the creation of emerging industries. More specifically, this case study aims to make students accustomed to the following contents:

- Familiarise the concept of business in space and grasp the potentials and risks therein.
- Explore characteristics and peculiarities of space economics.
- Identify available strategic approaches for OffWorld in their endeavour within the space industry.
- Analyse the complex ethical dimensions of doing business in space.

In this way, this case is designed to help students develop critical thinking skills by evaluating the complexities and challenges of the space mining industry, particularly in terms of ethical decision-making and sustainability as well as to develop the ability to make informed decisions in a business context, considering all ethical, legal, and competitive factors. This case is suitable for courses related to strategy, entrepreneurship, sustainability, business ethics, and corporate social responsibility.

Questions for Discussion

1. The Business of Space: OffWorld is active in an up-and-coming space sector, making the company's situation and outlook much more complex to understand and analyse.
    a. What makes the space industry different from other traditional industries? List potential advantages and disadvantages.

b. What kind of institutions do you think are best suited to be in charge of deciding who gets to mine in space and in what quantities?

2. OffWorld's Strategy and Market Positioning: To become a relevant player in the space industry while also maintaining sustainable business operations, OffWorld must define a targeted strategy and establish its role in the market from the start.
   a. Many predecessors of OffWorld have failed to set footing in the asteroid mining industry. What is OffWorld's role in the space mining industry, and how does it differ from other space mining companies? What features of OffWorld's business model could set the company apart and make it successful in the long run?
   b. Who are the relevant stakeholders OffWorld ought to consider in their decision-making process?
3. Business Ethics in Space: Due to the distinctive nature of doing business in space and the severe influence that the industry can have on the current state of the world as well as the future of human life, OffWorld faces difficult ethical questions looking forward.
   a. From an ethical perspective: What moral responsibilities do companies like OffWorld have when providing enabling technologies for space mining? How might the lack of clear legal frameworks for space mining impact the industry's ethical decision-making? What potential technological advancements or changes in the legal and ethical landscape could impact the industry?
   b. Should OffWorld be selective in choosing its customers, and if so, what criteria should they consider?

Teaching Plan

Please note that the exact composition of the class should depend on the focus of the course it is taught in. Courses focusing on topics of Entrepreneurship or Business Strategy could emphasize option III.i. and spend 40 minutes on this section while disregarding III.ij. Courses focusing on topics of Business Ethics and Corporate Social Responsibility could emphasize option III.ii. and spend 40 minutes on this section while disregarding III.i. If both areas seem relevant to the contents of the course, the professor should attribute 20 minutes to each topic A regular class of 90 minutes is proposed to be divided as follows:

I. Brief introduction to the space mining sector and OffWorld. *(10 min)*

II. Discussion of The Business of Space: Defining characteristics, opportunities, and risks and conferring what players are best suited to guide the legal framework. *(15 min)*

III.

i. Analysis of OffWorld's Strategy and Market Positioning: Key differentiators and identification of most relevant stakeholders. *(40 min / 20 min / 0 min)*

ii. Discussion of Business Ethics in Space: Moral responsibilities and the customer question. *(40 min / 20 min / 0min)*

IV. Interactive class debate on OffWorld's challenge: What could OffWorld do to secure a solid long-term position in the space sector? Are they on the right path? What should be their role in this upcoming industry? *(10 min)*

V. Final remarks by the professor. *(5 min)*

Case Analysis

This section proposes insights to be included in the in-class discussion of the case study.

1a) The in-class discussion of the case can be commenced by collaboratively brainstorming and collecting specific characteristics of the space mining industry, categorized into advantages and disadvantages for companies in the market. Arguments can include but are not limited to:

<u>Advantages:</u>

- Industry Momentum: The whole space industry is currently gaining back attention and trust, leading to high funding and government backing.
- Large Economic Potential: Successful space mining ventures have the potential to generate significant economic returns by tapping into untouched celestial resources and establishing new markets and demands.
- Reduced Environmental and Social Impact on Earth: By obtaining resources from space, the environmental and social impact on Earth, associated with traditional mining activities, can be significantly reduced, contributing to sustainability efforts.
- Space Infrastructure Development: Successful space mining operations could lead to the establishment of infrastructure and eventually human life in space, supporting future exploration, colonization, and industrialization beyond Earth.
- Global Collaboration: As access to resources and exploration of new environments is of global interest, the industry could foster nations and private companies worldwide to collaborate to regulate and develop this space mining.

Disadvantages:

- High Initial Costs and High Cost of Failure: The space mining industry involves high capital costs, especially before even starting space missions, including the development, launch, and maintenance of specialized mining equipment and infrastructure.
- Complex Technological Challenges: Space mining poses significant technical challenges, including the development of efficient extraction methods and dealing with the specific conditions of space.
- Legal and Regulatory Uncertainty: The legal framework for space mining is still evolving, leading to uncertainties regarding property rights, ownership of extracted resources, and international regulations.
- Dependency on Market Demand: The success of space mining is contingent on the demand for extra-terrestrial resources, and fluctuations in market demand can impact the profitability and sustainability of space mining ventures.
- Ethical Concerns: The ethical implications of space mining, including the responsible use of resources and equitable distribution of benefits, are subjects of ongoing debate.

1b) Students are expected to extract the different possibilities in modes of governance in the space industry, on regards such as amounts to be mined, resource allocations, and mining timelines. Mentioned options should particularly include national governments, international institutions and agencies, private companies themselves, and hybrid models. In a next step, respective pros and cons should be highlighted. Exemplary arguments include:

i. National governments possess the authority to regulate and control activities within their borders, ensuring national interests are prioritized. This may lead to a centralized approach with clear regulations, but it could also hinder innovation and competition.
ii. International institutions and agencies offer a collaborative and standardized approach, promoting shared resources and expertise. However, coordination challenges and the potential for conflicting interests among member states could arise.
iii. Free market dynamics enable private companies to drive innovation and efficiency in space exploration. The profit motive may accelerate technological advancements, but concerns over unequal resource distribution, environmental impact, and the potential for monopolies must be considered.
iv. Hybrid models, combining elements of both government and private sector involvement, aim to balance regulatory control and innovation. Striking the right

balance is crucial to leveraging the strengths of each approach while mitigating their respective weaknesses.

Finally, and if not mentioned beforehand, the instructor should ask which option seems most likely to be realized. This question encourages students to apply critical thinking skills and consider current trends, technological advancements, and geopolitical factors influencing the evolving landscape of space governance. It prompts students to analyse the practical feasibility and potential challenges associated with each option, fostering a deeper understanding of the complex decision-making processes in the space industry.

2a) Students are asked to brainstorm some differentiators that make OffWorld competitive and likely to persist in a fast-evolving and risky industry. The answers should especially reflect on the information that earlier promising projects failed due to not being able to cover the costs in the long term. Potential answers could highlight:

- Niche specialization: OffWorld has carved out a niche specialization within the space mining ecosystem. This focused approach enhances efficiency, reduces risks, and allows OffWorld to establish itself as a go-to player in its specialized market segment.
- Business model based on pre-order contracts: The utilization of a business model centred around pre-order contracts sets OffWorld apart from its predecessors. By securing commitments from customers before initiating mining operations, the company mitigates financial risks associated with cost overruns or market uncertainties.
- Production on project- and contract-basis: OffWorld adopts a flexible production model that aligns with specific projects and contracts. This tailored approach allows the company to adapt to varying demands and market conditions. By avoiding large-scale, rigid operations, OffWorld remains nimble and responsive, essential qualities in an industry marked by unpredictability.
- Global approach: OffWorld embraces a global perspective in its operations. By considering the international landscape, regulatory environments, and diverse markets, the company is better equipped to navigate the complexities of the space mining industry.
- Focus on team: OffWorld recognizes the significance of its team in driving success. By assembling a multidisciplinary and experienced workforce, the company ensures that it has the talent and expertise necessary to tackle the challenges unique to space mining.

2b) The classical stakeholder theory approach to strategic management, which was popularised by Robert E. Freeman (1984), proposes that a company should not only consider its direct shareholders but should aim to create value for all its stakeholders. Freeman originally stated that this approach was more ethical and just, as a firm has moral obligations to all stakeholders involved and not only those who profit from its stock. As such exercise may be impossible, especially for larger companies, additions to the approach followed. According to Mitchell et al. (1997), the influence and thus relevance of certain stakeholders to the management of a company depends on the respective power, legitimacy, and urgency of their claims.

The goal of this section is for students to understand OffWorld's situation and to gain a detailed understanding of the company's stakeholders and their respective claims. Relevant stakeholders can include but are not limited to:

i. The founding team
ii. Employees
iii. Customers
iv. The global community
v. The environment / environmental advocacy groups, NGOs, etc.
vi. International space community

For each point, students should especially analyse each claim in terms of its urgency, power, and legitimacy, as proposed by Mitchell et al. This is done to evaluate the importance of each stakeholder to the company as well as the priority their claims should have to Jim and his colleagues. Exemplary points are listed in Appendix 2.1.

3a) Arguing from an ethical perspective, Jim and his executive team ought to consider the potential harm their product could do, as the consequences of their decision can be expected to influence a wide range of their stakeholders as well as the future of planet Earth (Carroll et al. 2007; Porter and Kramer 2011). Many moral arguments can be brought forward in the case of space mining. Pilchman (2015), for example, displays possible views of space mining being morally incompatible with human flourishing, violating moral standards, and increasing economic inequality. While the general image of space mining is not that negative and the novel technology holds a wide range of positive potential, too, companies like OffWorld can be held accountable for managing negative externalities. Just like any company operating on Earth, the actions taken by Jim and his team will reflect on them in both positive and negative turnouts.

A wide range of theories from the field of ethics and morality can be brought forward to support such an argument. If students do not have any prior knowledge of ethics, the following three theories from the field of ethics are suggested to be briefly introduced, as they appear most suitable to the topic of resource exploration and mining in space:

- Utilitarianism: The central idea of utilitarianism is that it is ethical to maximize overall well-being, or, stated differently, to produce the greatest happiness for the greatest number of people (Mill 1861). In the context of space mining, utilitarian ethics would involve evaluating the consequences of resource allocation and mining activities to determine their overall impact on human well-being (Baum 2016). Utilitarianism may support space mining if it can be demonstrated that the benefits to a wide range of humanity, such as improved living conditions, outweigh any potential negative consequences.
- Environmental ethics: Environmental ethics emphasize the intrinsic value of the environment and aspects of it (Taylor 1986). Such theories consider the ethical implications of human actions on the natural world. As outlined in the case study, mining in space raises environmental concerns, and an environmental ethics perspective would advocate for sustainable practices that minimize harm to celestial bodies and ecosystems. Ethical considerations may involve assessing the impact on extra-terrestrial environments and the preservation of celestial bodies for scientific exploration.
- Rights-based ethics: Rights-based ethical theories, like deontology, focus on the inherent rights and dignity of individuals or entities. In the case of space mining, this could involve considering the rights of future generations or even the celestial bodies themselves. Rights-based ethics may, for example, caution against space mining activities that violate the abilities and rights of future generations to access and benefit from celestial bodies.

A suggested in-class discussion focuses on the utilitarian view, as it is among the most prominently applied ethical theories and one that is easily comprehensible. Taking a utilitarian perspective, the following crucial aspects of space mining should be examined:

- Environmental consequences on Earth, with possible consequences including decreased soil depletion, decreased pollution, influence on air and water quality, and balance of ecological systems after introduction of potentially new materials (Mane and Krishna 2022).
- Environmental consequences in space, with possible consequences including resource depletion, impact of space debris, disruption to celestial bodies, and preservation of space environment (Xu 2020).
- Political-economic consequences, with possible consequences including resource allocation, impact on resources-reliant countries (especially developing countries), geopolitical tensions, and legal aspects (Affatato et al. 2023; Baum 2016).

It is also worth mentioning that all these aspects can be viewed in both short- and long-term. A utilitarian perspective emphasizes the importance of considering the duration and sustainability of the consequences associated with space mining. Short-term gains, such as economic profit, might be weighed against potential long-term costs, such as irreversible environmental damage. This temporal dimension adds a layer of complexity to the utilitarian analysis, requiring a thorough examination of the time frames over which the consequences unfold and their lasting impact on overall well-being.

Based on these theoretical considerations, the students are expected to form an ethical view of space mining. Opinions can differ widely. One plausible view is presented by Affatato et al., who state the belief that space mining can be ethical if it is done with care and an awareness of both positive and negative consequences. A possible solution proposed by Affatato et al. is a strictly limited approach to space mining, meaning that it can be ethical given mining is regulated to avoid the destruction of environments, does not interfere with existing or future forms of life, and does not cause tensions between or within participating nations.

3b) This section aims to draw out the personal opinions of students, backed up by all previously discussed points. There are no right or wrong answers, yet a solid reasoning and foundation to the argument are expected.

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Appendices

PART 1: Case Study

Appendix 1.1: Jim Keravala's Resume

Education

1988 – 1991: Aerospace Engineering at City University of London

1991 – 1991: Space Systems at RWTH Aachen

1992 – 1996: Physics and Mathematics at University of London

1997 – 1997: Space Studies at International Space University

1998 – 2000: Spacecraft Engineering and Satellite Communications at University of Surrey

2019 – 2019: Scaling Ventures at Harvard University

2019 – 2019: Artificial Intelligence Strategy at Massachusetts Institute of Technology

Honours

Member at International Institute of Space Law (IISL)

Fellow at British Interplanetary Society

Senior Member at AIAA

Academician at International Academy of Astronautics

Career Highlights

1991 – 1997: Director at Commercial Space Technologies Ltd

1999 – 2000: Founding Delegate at Space Generation Advisory Council

1998 – 2003: Launch Manager at Surrey Satellite Technology Ltd

2010 – 2012: Founder at Stellarbrain

2012 – 2014: Board Member at Pacific International Space Center for Exploration Systems

2013 – 2015: CEO at Transplanetary

2016 – 2018: Board Member at National Space Society

2016 – current: Co-Founder, CEO, Chief Architect & Chairman of the Board at OffWorld Inc.

Appendix 1.2: Selection of OffWorld's Planned Product Portfolio

Figure 1: Source: Mining Digital

Appendix 1.3: Distribution of Asteroids in Earth's Solar System

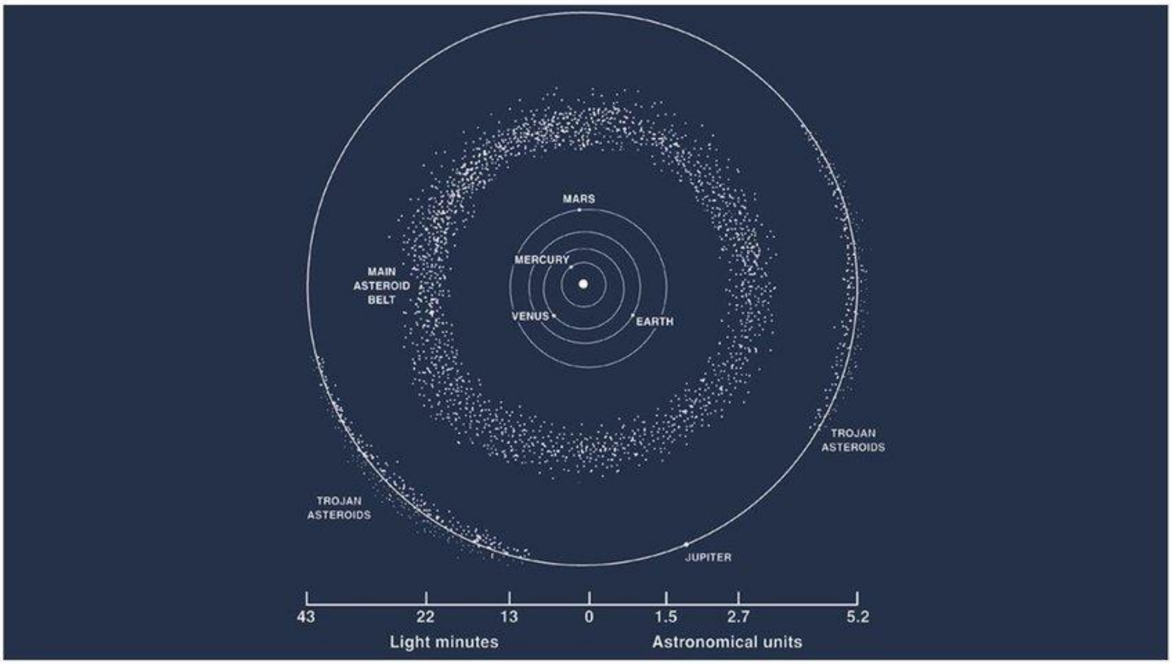

Figure 2: Source: NASA

Appendix 1.4: Comparison of Earthly Reserves and Reserves on Psyche

Location	REE (thousand metric tonnes)	Iron (million metric tonnes)
Brazil	22.000	12.000
India	6.900	5.200
Russia	18.000	14.000
South Africa	8.600	770
United States	1.400	760
Vietnam	22.000	0
Terrestrial Reserves	127.830	73.130
Psyche	27.200.000.000	27.200.000.000.000

Figure 3: Comparison of Earthly Reserves in Rare Earth Elements (REE) and Iron with Reserves on Single Asteroid Psyche; Source: Oxford Analytica

Appendix 1.5: Estimated Value of Most Valuable NEAs

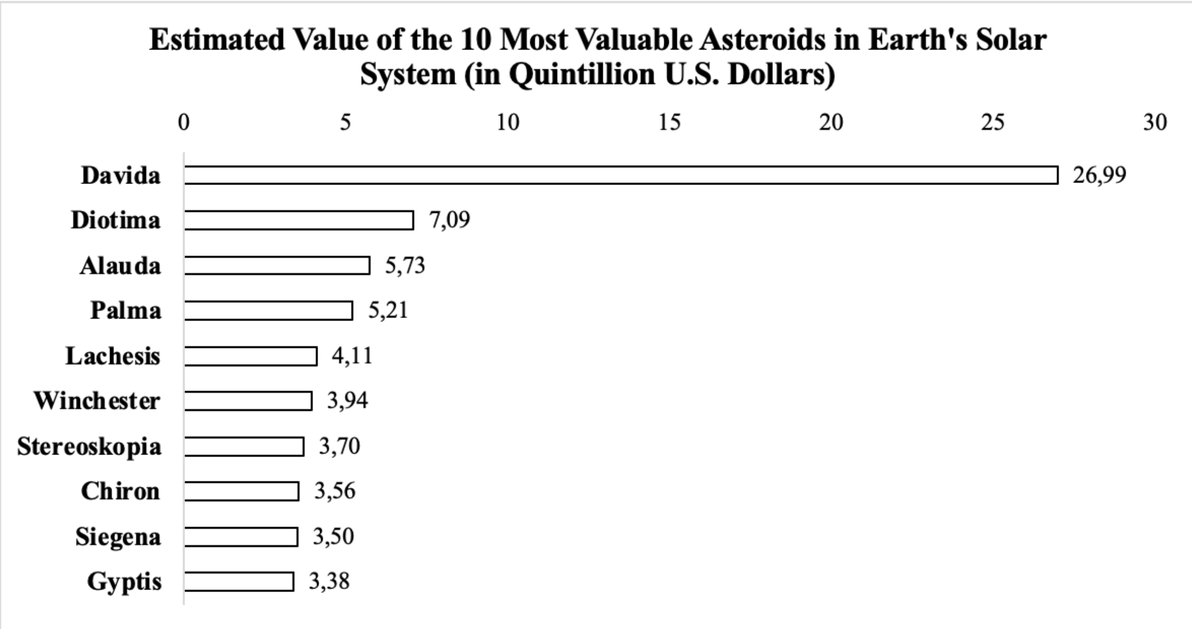

Figure 4: Source: Statista

Appendix 1.6: Comparison of Average Abundance of Minerals in Metallic Asteroids and on Earth

Mineral	Asteroids Average Abundance in g/mt	Earth's Crust Average Abundance in g/mt
Iron (Fe)	893	41
Cobalt (Co)	6	20
Nickel (Ni)	93	80
Ruthenium (Ru)	22	<1
Rhodium (Rh)	4	<1
Palladium (Pd)	17	<1
Osmium (Os)	15	<1
Iridium (Ir)	14	<1
Platinum (Pt)	29	1
Gold (Au)	1	1

Figure 5: Source: Dahl et al.

Appendix 1.7: News Excerpts of Planetary Resources' Rise and Failure

<u>Rise:</u>

AIRCRAFT

Grand plans for asteroid mining unveiled by Planetary Resources

By Brian Dodson
April 25, 2012

"I'm Chris Lewicki, and I'm an asteroid miner!" These were the opening words spoken by the President and Chief Engineer of Planetary Resources Inc., as the asteroid mining company emerged from three years of silent running to outline its plans to begin mining Near-Earth Asteroids (NEAs) within the decade.

Figure 6: Source: New Atlas

<u>Failure:</u>

Asteroid Mining Company Planetary Resources Acquired by Blockchain Firm

News By Jeff Foust published November 02, 2018

WASHINGTON — Planetary Resources Inc., once a high-flying company backed by billionaires with aspirations to mine asteroids, only to later suffer funding problems, has been acquired by a blockchain company, the firms announced Oct. 31.

Figure 7: Source: Space.com

Appendix 1.8: Space Mining Timeline

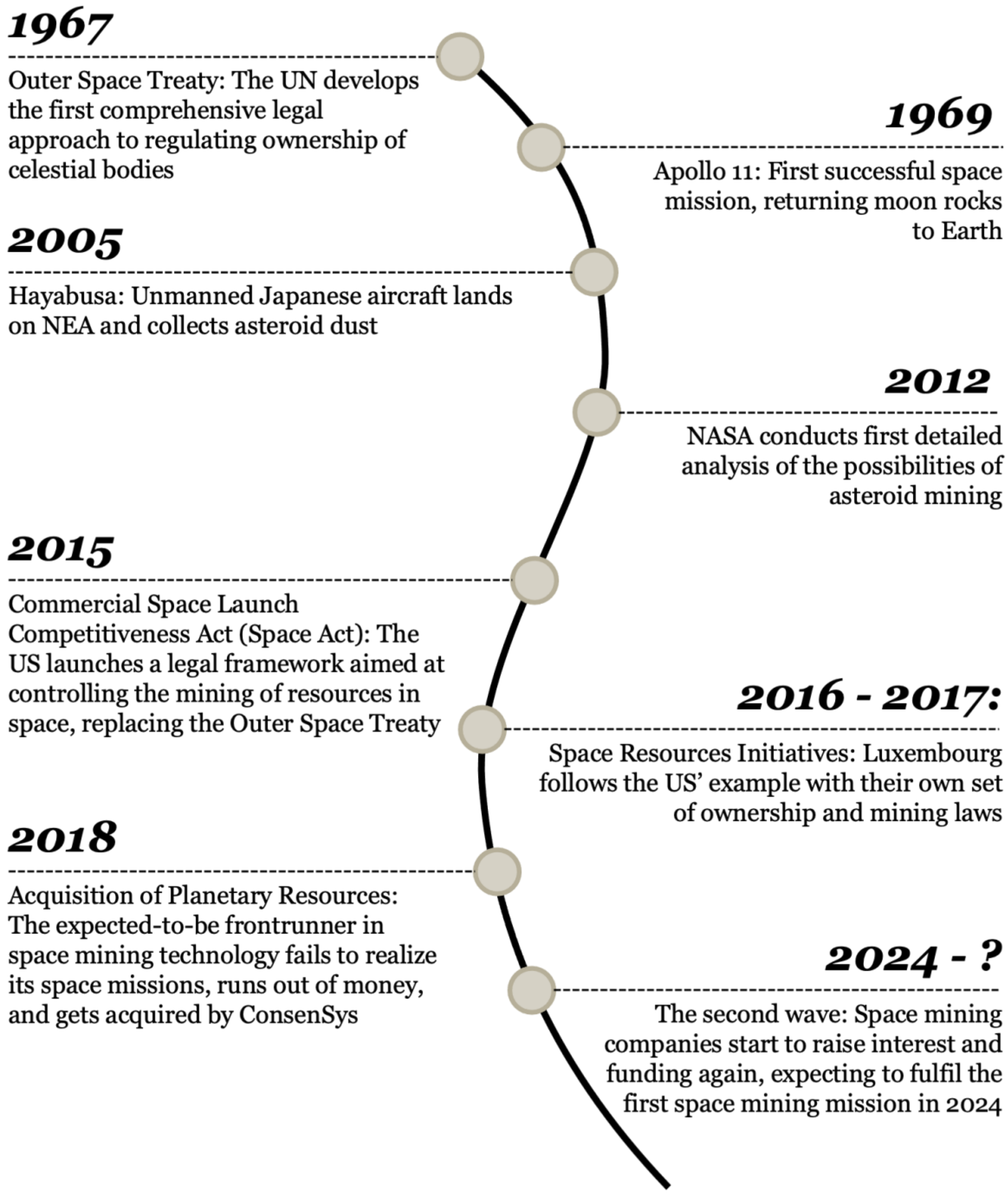

Figure 8: Sources: Mining Technology, Harvard International Review, MIT Technology Review

Appendix 1.9: First Article of Outer Space Treaty from 1967

Article I

The exploration and use of outer space, including the Moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind.

Outer space, including the Moon and other celestial bodies, shall be free for exploration and use by all States without discrimination of any kind, on a basis of equality and in accordance with international law, and there shall be free access to all areas of celestial bodies.

There shall be freedom of scientific investigation in outer space, including the Moon and other celestial bodies, and States shall facilitate and encourage international co-operation in such investigation.

Figure 9: Source: United Nations

Appendix 1.10: Selection of Potential Customers

Space Agencies	National space agencies such as NASA (United States), ESA (European Space Agency), Roscosmos (Russia), and others may be interested in OffWorld's robotic technology for space exploration missions.
Private Space Companies	Private space exploration companies, like SpaceX, Blue Origin, or other emerging space start-ups, may require advanced robotic systems for their missions, including tasks such as surface exploration, habitat construction, or resource extraction.
Research Institutions	Research institutions and universities conducting experiments or studies in extreme environments, such as space or other challenging terrains, may find OffWorld's robots useful for their research purposes.
Mining Companies	Companies involved in resource extraction, both on Earth and potentially on celestial bodies like the Moon or asteroids, could be interested in OffWorld's robotic technology for mining and extracting valuable resources.
Government Agencies	Government agencies involved in defence or disaster response may explore the use of OffWorld's robotic systems for tasks in extreme environments on Earth.
Space Habitat Developers	Organizations working on the development of space habitats, whether for research or potential colonization efforts, may seek robotic solutions for construction, maintenance, and other tasks.

Appendix 1.11: OffWorld Company Logo

Figure 10: Company Logo

Appendix 1.12: Simulated Image of OffWorld's Robots in Action

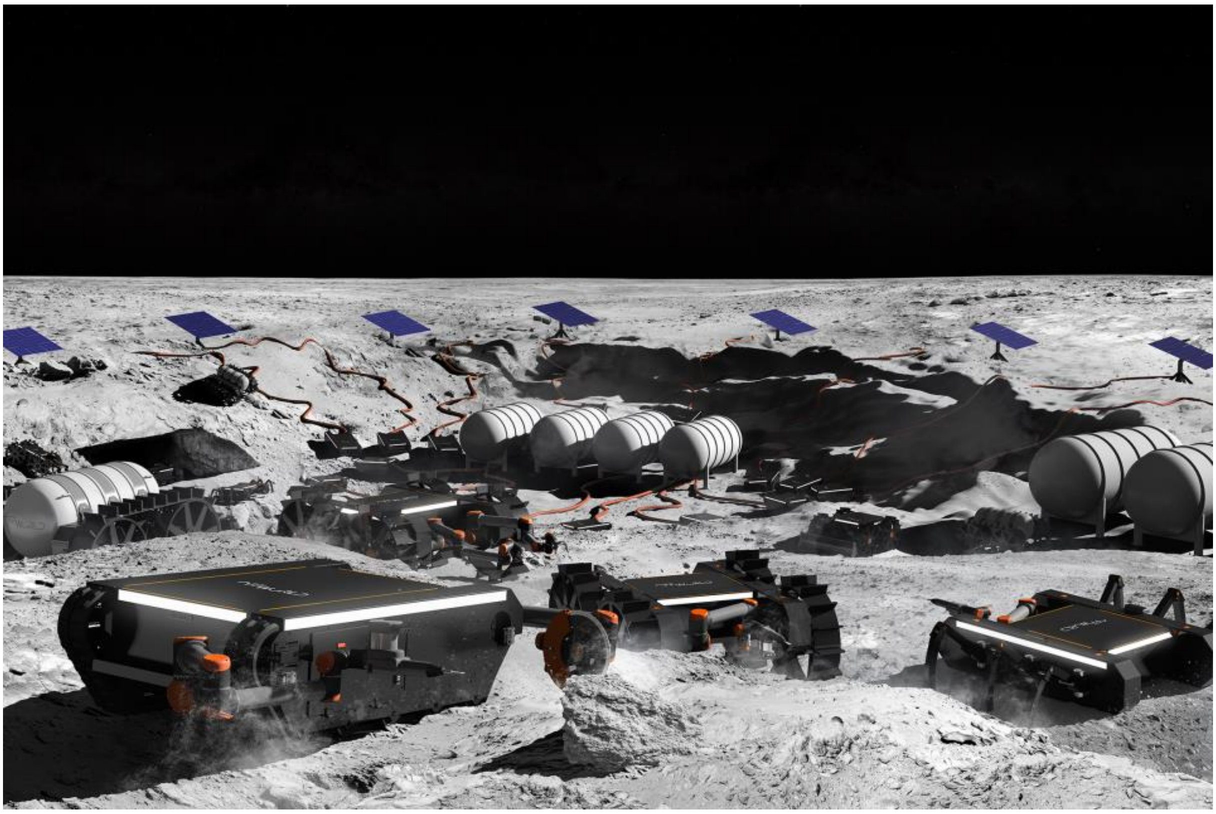

Figure 11: Source: Luxembourg Space Agency

Appendix 1.13: Photograph of Prototype Space Mining Robots

Figure 12: Source: Luxembourg Space Agency

Appendix 1.14: Simulated Image of 16 Psyche

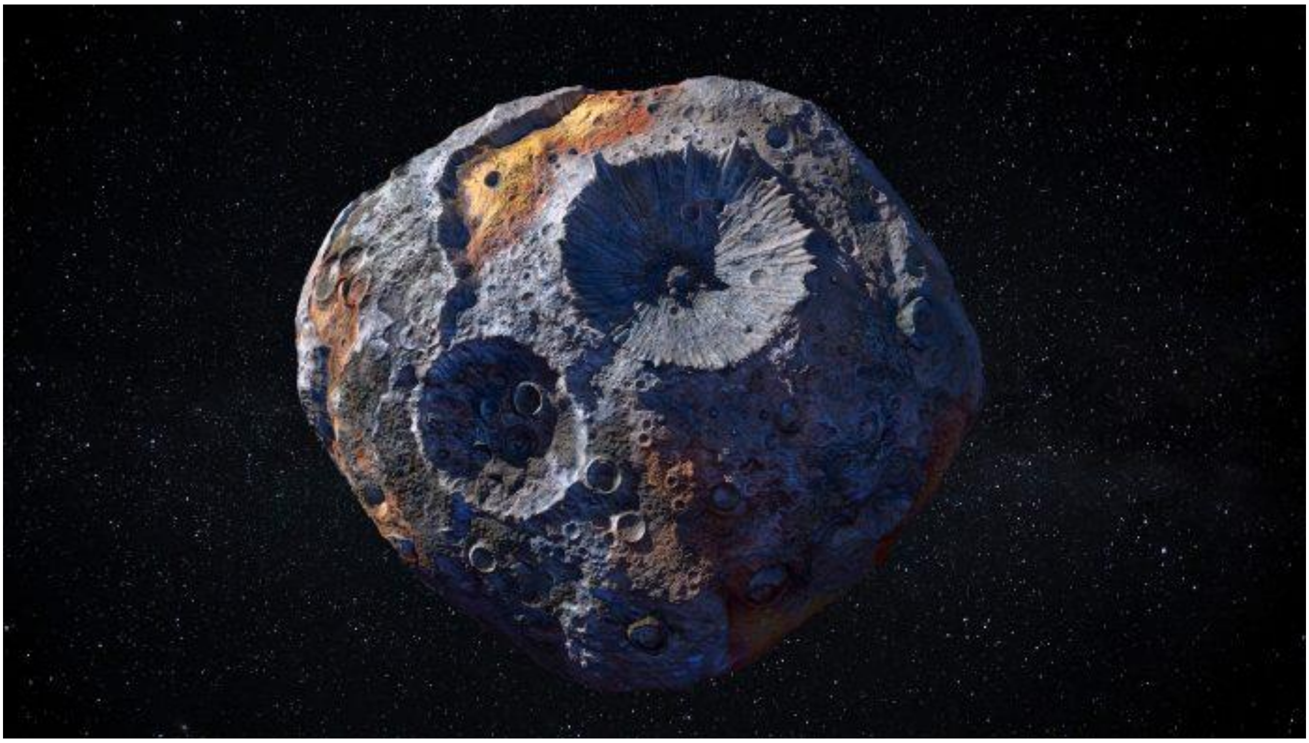

Figure 13: Source: Innovation News Network

Appendix 1.15: Competitive Landscape of OffWorld

OffWorld's Competition: Who Wants to Go to Space?

Asteroid mining has attracted a wide spectrum of actors wanting to engage in space missions for resource exploration and extraction. Governmental space agencies like NASA in the United States and the European Space Agency (ESA) in Europe view asteroid mining as a pivotal aspect of their broader space exploration efforts and a pivotal step to gain competitiveness in an economy on the rise. Space research institutions and other scientific organizations, such as The Planetary Society, the Search for Extraterrestrial Intelligence (SETI), and several universities, are equally interested, utilizing mining missions to deepen our understanding of celestial bodies and the solar system's history. Finally, private companies are pioneering the development of advanced technology for asteroid mining and aim to turn ambitious visions into profit (The Economist 2018; Houser 2017).

Due to the novelty and risky nature of the emerging space technology industry, the competitive environment of OffWorld is still embattled and erratic. While being a technological pioneer in its niche, the founding team is faced with competition from space agencies, states, and private companies. Established institutions such as NASA have proprietary robotic mission development programs, such as the Robotic Alliance Project (NASA 2023). Moreover, and perhaps even more threatening, a selection of highly funded private players is exploring the field, including Elon Musk's SpaceX, Jeff Bezos' Blue Origin, and American-based Astrobotic Technology. While not merely specialised in OffWorld's niche, such companies are moving quickly and aim to dominate the whole sector. The competitive pressure from upcoming entrepreneurs and start-ups is also ever-present in the promising industry, naturally attracting investors and top talent.

PART 2: Teaching Note

Appendix 2.1: Applied Stakeholder Theory of Management to Selected Stakeholders

	Founding Team	*Employees*
Main Claims	Achievement and preservation of original mission and vision, sustained growth.	Job security and equitable treatment, participation in building something with added value and success.
Urgency	Medium urgency, depending on the current challenges & opportunities faced by the company.	Medium urgency, with concerns about job security, fair wages, and workplace conditions.
Legitimacy	Legitimate claim as the founding team has a vested interest in the success and sustainability of OffWorld Inc.	Legitimate claim as employees contribute to the company's success and have rights for fair treatment.
Power	High power, especially if the founding team still holds significant ownership and decision-making influence.	Medium power, particularly if employees are organized or have collective bargaining power.

	Customers	*Global Community*
Main Claims	Reliable and efficient celestial mining solutions, fair pricing and transparent business practices, continuous innovation and improvement in technology and services.	Equitable and responsible distribution of celestial resources, minimization of environmental impact, adherence to sustainable practices, contribution to global scientific knowledge and progress.
Urgency	Medium to high urgency as customers are concerned about the efficiency and reliability of celestial mining solutions.	Medium urgency as the global community may be concerned about equitable resource distribution and environmental impacts.
Legitimacy	Legitimate claim as customers play a crucial role in the success of OffWorld Inc.	Legitimate claim as OffWorld's operations could have implications for the broader global community.
Power	Medium to high power, depending on the availability of alternatives and the importance of OffWorld's solutions to customers.	Medium power, as the global community can exert influence through public opinion, activism, and potential regulatory pressure.

	Environment / Environmental Advocacy Groups, NGOs, etc.	*International Space Community*
Main Claims	Mitigation of potential environmental harm caused by celestial mining including responsible management of amounts mined, adoption of environmentally friendly technologies and practices, compliance with or exceeding environmental regulations.	Responsible and collaborative use of celestial resources, adherence to international agreements and norms governing space activities, contribution to the peaceful and cooperative development of space.
Urgency	High urgency, as potential downsides can be high and are not fully known.	High urgency, as potential downsides can be high and are not fully known.
Legitimacy	Legitimate claim as the protection of the environment is a fundamental matter of success and the future of human life.	Legitimacy depends on the future of law-making.
Power	Medium to high power, as they can influence public opinion, advocate for environmental regulations, and potentially take legal action.	Medium power as of currently, as cooperation and agreements within the international space community are essential, but direct enforcement may be challenging.