Federico Bonarota[1] – Lucia Adele Savatteri[2]

The Role of Private Sector in Space Settlements

INTRODUCTION

In 1969, with the Apollo 11 mission, the first humans took the first step on the Moon. Starting perhaps with Méliès and his film "Le Voyage dans la Lune" and continuing through Kubrick's "2001: A Space Odyssey" and all the episodes of "Star Trek" and beyond, cinematography has captured one of humanity's greatest dreams in images: the exploration of the universe.

In today's landscape, the new goal is not only to return to the Moon but also to establish settlements and explore various other potentially habitable places. However, humanity is undergoing a paradigm shift where, in a sector that was overly expensive and reliant on seemingly unattainable technologies in the past, not only public institutions but also private companies are now emerging as major players. This shift is due to the fact that government projects have to contend with cyclical budget fluctuations, changes in political leadership and, consequently, shifts in priorities within a country. In contrast, private companies are in many ways more efficient and, paradoxically, more forward-looking in their objectives.

While the private sector has been involved in the space industry in the past, albeit in a more technical and less prominent capacity, the perspective has changed significantly over the last decade. It is important to remember that this paradigm shift has not yet reached a global level. It is a heterogeneous movement that is witnessing the emergence of private companies, especially

[1] Luiss Business School; ORCID: https://orcid.org/0009-0006-5929-0761; e-mail: federico.bonarota93@gmail.com

[2] Link Campus University; ORCID: https://orcid.org/0009-0009-9138-257X; e-mail: lucia.savatteri12@gmail.com

DOI: https://doi.org/10.36250/01209_10

in the United States and, to a certain extent, in some European countries. In other politically divergent countries, the public sector remains the only way to pursue space programs.

> "...transfer of certain roles in space from the government to industry. In some cases, this was intentional and proactive on the part of governments to facilitate formation of a commercial space economy. Intentional because this is the only means to continue the growth of value creation in space in a way that is proportional to the needs of society and does not involve ballooning government budgets" (McElroy 2023: 1–12).

As McElroy points out, these private companies, with their disruptive technologies, are not only aligning themselves with space agencies but are also displacing them in the new areas they are approaching. From security to tourism, from the revenue sectors to sustainable management, this chapter aims to provide an overview of the importance that private companies have in the global mission to establish space settlements.

A "new generation of space programs is currently being observed" (Paravano et al. 2023), in which not only has there been a shift in socio-political and economic dynamics but also a new wave of regulations and public funding to support the development of the space sector, including in the private domain.

It is indeed true that private entities are highly incentivised to invest in the space settlements market, due to the possibility of a high profit gain in the long term. The immense potential and importance that a settlement could provide are significant motivating factors. These settlements would represent vast resources under the control of private enterprises, which could then leverage them to support and establish their own outposts, forging entirely novel business domains that are currently beyond our imagination. Additionally, there is concern about utilising settlement resources to support and create a parallel market that could potentially contribute to sustaining the world in various ways. Although this might appear somewhat utopian from certain perspectives, it is the present and the future that are embracing us, and to which we must adapt.

Regarding the settlement of celestial bodies, there are private companies that are showing more significant interest in the subject and are pragmatically taking steps in this direction. Among these, SpaceX, Blue Origin and ispace are the ones we will delve into. With the Starship project, SpaceX is developing the most powerful launch system ever designed, capable of carrying payloads to much greater distances and at a lower marginal cost per launch. Due to its payload compartment size, the vehicle will enable the transportation of substantial payloads as well as a large number of individuals. While there were issues with the initial launch, progress is now being made for subsequent ones. Such technology has the potential to revolutionise the way we perceive space travel, enabling longer and more enduring expeditions to celestial bodies.

Staying within the United States, another significant player in the field is Blue Origin, the space company led by Jeff Bezos, which has been actively pursuing the possibility of finding and establishing a presence on other celestial bodies for several years. Bezos envisions the future of humanity residing in extraterrestrial settlements, with Earth becoming a vacation destination. An interesting recent project in this regard is undoubtedly Blue Moon, which NASA has selected for crewed missions shuttling between the orbital station and the lunar surface. It will debut with the Artemis V mission in 2029, with an investment exceeding 7 billion dollars.

Another noteworthy player making strides in this field is undoubtedly ispace, a Japanese lunar exploration company. Their self-defined company vision is to become the bridge between Earth and the Moon, advancing missions aimed at mapping the lunar surface to locate essential water resources for human sustenance. By splitting water molecules, it will be possible to produce hydrogen-based fuel, addressing the challenge of energy production. Unfortunately, their Mission 1, Hakuto-R, launched in December 2022, ended in failure. However, this setback will certainly not deter the company from continuing its pursuit. Certainly, numerous other entities, including Virgin Galactic, Boeing, Axiom and Voyager will soon be engaging in the emerging paradigm of the settlement economy.

However, providing a private entity with the opportunity to establish itself on the Moon or other celestial bodies could have significant implications, both politically and economically. Certainly, a regime solely dictated by capital, which these actors would likely bring, might lead to the creation of the parallel market we mentioned earlier, with "virtually unlimited resources" (Pearson 2019) primarily for affluent individuals, exponentially exacerbating the existing inequalities on Earth. It may seem like a scenario from science fiction, but in some way, it is not, and it is essential to pay attention to this point before it becomes irreversible. While outer space, in many respects, could be our salvation, it is crucial to take precautions from now on to prevent excessive competition between the public and private sectors, or as it will be more appropriate to say in the coming years, between the public and the new public, leading to self-destruction.

THE ROLE OF THE PRIVATE SECTOR IN SPACE DIPLOMACY

Space Diplomacy lacks a single and univocal definition, as each school of international relations contributes its own theory to the discourse. To simplify this complex subject, we can characterise Space Diplomacy as a subset of International Relations (IR) where soft power, particularly economic and scientific influence (Davis Cross – Pekkanen 2023) is predominantly wielded to manipulate counterparts and advance specific agendas or secure agreements. Within this framework, the State is just one among several actors, including International Organisations, the global environmental movement, the corporate sector and expert groups (O'Neill 2022).

Historically, countries employed Space Diplomacy as a tool either to mitigate threats in space or to foster cooperation towards shared objectives. However, the landscape is shifting with the remarkable growth of private entities, exemplified by SpaceX and Blue Origin. These private entities are increasingly engaging in political actions, irrespective of the consent of the countries in which they operate. A notable turning point occurred in February

2022 with the intervention of Elon Musk, the owner of SpaceX, and the pivotal role played by his Starlink internet service during the Russia–Ukraine conflict.

To illustrate this transformative shift, an examination of events in Ukraine and the role played by private entities is crucial. Ukraine, anticipating Russia's impending attack (Graham-Yooll 2022), had initiated discussions with SpaceX regarding the utilisation of Starlink even before the outbreak of the war.

Post-invasion, a tweet from Vice Prime Minister Mykhailo Fedorov conveyed an unconventional request for the prompt deployment of Starlink in Ukraine (Mykhaylo Fedorovov 2022). Thanks to a prior agreement, the system was nearly ready for deployment. In just 48 hours, Starlink provided its signal antennas to Ukraine (Howell 2022), enabling internet connectivity and military communication. The turning point was the utilisation of the private service on the battlefield through the use of remotely controlled drones and missiles (Davenport–Menn 2023).

In 2022, Ukraine further requested Elon Musk to extend signal coverage, including the Crimean Peninsula, where the main fleet of Russia's Black Sea force was based, to lead a sortie. Musk declined, citing concerns about a potential Russian nuclear counterattack (Copp 2023). This refusal prompted, in September 2023, the U.S. Secretary of the Air Force, Frank Kendall, to suggest that future contracts explicitly address the potential military applications of procured services or products (Kendall 2023).

Consequently, it is plausible to expect the direct involvement of the private sector in conflicts between countries in the near future. This speculation extends to a more remote future: space settlements. From this point, we can envisage new scenarios that would significantly impact space diplomacy and redefine our understanding of it. The role of private entities is anticipated to evolve, ushering in a new era in current international relations. Certainly, it is essential to assume that, in the future, when settlements are established, Outer Space Law will undergo modifications to accommodate and ensure successful development moving from a paradigm where the Celestial Bodies, and so the resources, are a common good for all mankind to a paradigm where the resources can

be extracted and used. Based on this premise, we can delineate three distinct scenarios in which the private sector plays a role.

The first scenario, with limited feasibility, envisions private entities under the control or contractual obligations of the government, reminiscent of the old space era. Abundant resources and raw materials drive settlements to thrive under strict state supervision. The state regulates and oversees costs and profits derived from extraction through rigorous contracts with severe penalties. Despite being regulated instruments, private entities ensure gains, addressing research and development costs incurred by the state. In this outline, international relations remain relatively unchanged, with actors retaining similar power dynamics. However, the private sector has lost autonomy and capacity, impeding rapid development observed in recent years. The primary risk is the potential emergence of a State-planned Space Economy, akin to historical instances in the Soviet Union (Hanson 2003: 13–48).

The second scenario, with moderate plausibility, depicts a hypothesis where private entities attain significant autonomy, no longer tethered to any specific country. They establish independent settlements, reminiscent of the concept of Merchant Republics (Lindemann 2014), engaging in trade with Earth and others for mutual benefit. These settlements thrive through innovation, financial prosperity and resource abundance. Each private actor establishes their own settlement, fostering state-like entities or leagues for collaborative efforts, such as defence, and creating free trade areas for goods and services exchange. In this hypothesis, private entities wield comparable or even greater power than major space powers, capable of initiating wars for resources or forming new organisations. They operate freely, bypassing the consent of other international actors. This disrupts international relations, as states struggle to uphold the Rule of Law. The principal risk is the potential emergence of a *Far West* scenario, where the strongest entities dominate.

The third scenario, with the highest likelihood under current conditions, envisions a collaboration between the public and private sectors, manifesting

as an enhanced form of Public–Private Partnership (OECD 2012).[3] This partnership fosters private ideas and productivity to meet client needs, managing settlements through joint cooperation. The collaborative approach ensures prosperity and peaceful space utilisation, with settlements under the control of both parties, yielding benefits and drawbacks. In this outline, public and private entities maintain distinct competencies, avoiding attempts to control one another. Human needs are met, and international relations evolve, granting a preeminent role to private entities. These entities operate independently or under a country's "umbrella". However, the primary risk is Extreme Capitalism[4] (Rahman 2021) where private entities and politicians intertwine their interests in wealth and money, leading to societal division between the affluent and the impoverished.

Upon a brief analysis of these scenarios, a notable emergence is the transformed role of Space Diplomacy within International Relations. Once a peripheral concern, it becomes a central or one of the central elements due to space exploration and settling, marking a shift from Geo-politics to Space-politics with the ascent of new players and novel ideas.

PRIVATE ENTITIES AND SPACE SETTLEMENTS

Considering that "the value chain of the space economy refers to the various activities and processes involved in the creation and provision of products and services related to space" (OECD 2022), the question to be asked is whether, in a space settlement, one can still speak of the space economy in a narrow sense or whether there will be a new lunar economy, Mars economy, and so on. It is

[3] The OECD defines public–private partnerships (PPPs) as "long term agreements between the government and a private partner whereby the private partner delivers and funds public services using a capital asset, sharing the associated risks".

[4] Extreme capitalism is a condition in which large companies and rich people raise too much money and leave too little for the rest of society. As a result, the public does not have enough money to increase consumption. Demand is not increasing and the market is not growing.

certainly premature to discuss at least the Mars Economy. As long as the stakeholders, the normative framework and the perspective remain Earth-centric, speaking of the Martian economy and in some way of a Lunar Economy seems to be distant from the public opinion ideas. Certainly, there is already discussion of the lunar economy, as the Moon is a source of helium-3 reserves and rare earth elements, both essential for potential nuclear fusion and, consequently, energy sustenance, and for the technological industry.

As can be well understood, in the space settlement, there will be needs for the production of services and products related not only to space in a strict sense but also to the territory at hand, which will prove to be extremely valuable in many aspects. Thus, along with a new concept of upstream and downstream, where data collected by satellites orbiting directly around the Moon and other relevant celestial bodies will be transmitted directly to the settlement without passing through Earth, a parallel market will be created, stemming from extractions and the utilisation of all available materials. Subsequently, a range of products and services related to the subsistence of the people working on these celestial bodies will also emerge. For a private entity, therefore, investing in the new economies that are emerging and will continue to develop represents a unique opportunity.

According to the Euroconsult report for 2023, it is anticipated that market expansion will continue to stimulate global investments. Over the next decade, lunar exploration is forecasted to achieve a significant 10-year compound annual growth rate (CAGR) of 5%, ultimately reaching an estimated value of nearly $17 billion by the year 2032 (Euroconsult 2023a).

As can be observed, there are numerous economic opportunities. However, when it comes to Mars, there is much more at stake. Elon Musk himself, referring to the red planet, characterises it not just as a source of resources to extract, but as the ultimate hope for humanity, thereby rejecting the famous phrase by Branson: "There is no planet B."

Ensuring the design of the space settlement's economy aligns with users' actual needs is crucial, offering an improved balance between costs, benefits and trade-offs compared to alternative approaches. Only through this approach

can a private company attract the essential investments in financial, technical, policy, organisational and human resources to overcome the diverse engineering, legal and other challenges hindering its progress.

Considering this perspective, let us delineate some of the potential revenue sectors for a private entity in a settlement.

Mining: Partially addressed earlier, mining appears to be the primary revenue source that settlements could offer. In the future, there might be settlements solely dedicated to this purpose, as the phenomenon demonstrates immense potential. Depending on the celestial body, extractable resources and the actual profit potential would vary.

One of the most lucrative celestial bodies, for instance, is asteroids, rich in nickel silicates, iron, magnesium, carbon and more. There is ongoing discussion not only about using them as extraction sources but also about the possibility of establishing new settlements on these celestial bodies (Allison 2018). Astrophysicist Neil deGrasse Tyson even states: "The first trillionaire there will ever be is the person who exploits the natural resources on asteroids" (Kramer 2015).

In general, mining is not limited to precious minerals but also includes the extraction of icy water, as envisioned by companies like ispace, for nuclear energy production, and sustenance. It is also crucial to consider the significance of water in the production of hydrogen and oxygen used as propellants for launchers. Additionally, an Italian initiative involving OHB Italia and Politecnico di Milano aims to utilise the lunar regolith to extract water. It would be a great opportunity for new privates that want to approach the sector.

Shriya Yarlagadda, the Editor-in-Chief of the Harvard International Review, posits that space mining could provide a solution to challenges associated with terrestrial mining, such as child labour and other unjust practices by private companies (Yarlagadda 2022). However, unconditional possession of a vast quantity of space resources by a few private entities could potentially lead to the collapse of entire economies, posing negative repercussions. The key lies in balancing these two sides of the same coin, ensuring that this phenomenon has predominantly positive effects.

Energy: Moreover, settlements will undoubtedly require robust energy sustenance, presenting ample opportunities for private enterprises to contribute through innovative and sustainable ideas. In this context, the recent presentation of the Solaris project is noteworthy, a venture developed by ESA and led by Arthur D. Little and Thales Alenia Space Italy. This initiative involves Space-Based Solar Power, capable of consistently providing power on a 24/7 basis. This reliability addresses the need for stability in the electricity grid, particularly as the proportion of intermittent renewables grows, thereby decreasing reliance on extensive storage solutions. Undoubtedly, a project of this nature has the potential to catalyse a plethora of new initiatives and ideas, paving the way for significant private sector involvement.

Another significant project is MAPLE (Microwave Array for Power-transfer Low-orbit Experiment), a project being developed by the California Institute of Technology (Caltech) to address the challenges of space-based solar power generation. Recently, MAPLE achieved a significant milestone by successfully conducting its inaugural test of wireless microwave power transfer in space, thereby paving the way for innovative solutions in orbital solar energy production. This initiative, which is part of Caltech's Space Solar Power Project, aims to confront global energy challenges by harnessing solar power in space. The successful demonstration of MAPLE represents a promising advancement toward sustainable and efficient space-based energy solutions.

Another project, Alba, is dedicated to studying 32 different types of solar cells to identify those best suited for operation in space. This constitutes a crucial step in ensuring the efficiency and longevity of solar panels utilised in future space solar energy projects. Meanwhile, the Dolce project, which stands for Deployable on-Orbit ultraLight Composite Experiment, will test the technologies developed for packaging and deploying future solar power production and transmission stations.

Cloud services and data centre: These sectors could be of significant interest to private entities seeking investment opportunities.

In this regard, it is noteworthy that the company Lonestar has looked far ahead, considering the Moon a potential data storage location. Their motto:

"Saving Earth's data one byte at a time" reflects their vision, and with this, they have raised $5 million for lunar data centres.

Cybersecurity: Space settlements will introduce a "new approach to cybersecurity in space" (Vasquez 2023). The development of critical infrastructure in celestial bodies distant from Earth is inevitable, necessitating secure connections between these new celestial entities and the Homeland. In this regard, the private sector could have significant opportunities by providing crucial services. Simultaneously, in many aspects, these private companies are subject to the necessity of availing themselves of new cybersecurity services, therefore, both from the demand and supply perspectives, it will be a rapidly expanding sector. Given the vast scope of this topic, we will confine our examination to its foundational aspects in this context.

Space Traffic Management: Space Traffic Management (STM) refers to the coordination and regulation of space activities to ensure the safe and sustainable use of outer space. It involves monitoring and controlling spacecraft, satellites and other objects in orbit to prevent collisions and minimise space debris. STM initiatives aim to develop international guidelines and regulations to address the growing congestion and potential hazards in space, fostering cooperation among spacefaring nations and commercial entities for the peaceful and responsible exploration and use of space.

SPACE TOURISM

Among the diverse lucrative activities that the private sector could undertake in space settlements, one that is transitioning from aspiration to reality today and capturing the imagination of the public is space tourism. Envision exploring the liquid methane sea of Titan, one of Saturn's Moons, where temperatures hover around a warm minus 179 degrees Celsius. Alternatively, consider submerging into the sea beneath the frozen surface of Europa, Jupiter's icy moon, with temperatures slightly colder at minus 225 degrees Celsius. For those seeking relaxation and a touch of history, there is the option to stay at the new Moon

Grand Hotel and visit the historic site of Apollo 11 in the Sea of Tranquillity, where the first humans set foot on the Moon (NASA 2024a; NASA 2024b).

While these possibilities might appear as mere commercial suggestions from sci-fi films or novels, they are transforming into reality through the commercialisation of human space flight, allowing individuals to become passengers on space journeys and return to Earth. Thanks to the efforts of the private sector, particularly companies like SpaceX, Blue Origin, Virgin Galactic and Boeing, experiencing space travel and microgravity is now achievable through payment. It has to be said that currently going into space is like climbing Mt. Everest, launching yourself with a parachute or diving deep in the ocean: an extreme sport with a lot of side effects for the body. So, the body and mind have to be trained to get to space.

However, this is merely the initial stage, as more ambitious projects are in the planning and development stages. Projects such as the Axiom Space Station, set to be the first-ever commercial station replacing the International Space Station (ISS), and Voyager Station are on the horizon. Additionally, companies like Bigelow, that went bankrupt in 2020 (Wattles 2022) and is known for bringing the first bingo machine to space, had or are contemplating the creation of space or lunar resorts to cater to clients. Of course, each of those companies risks a lot of money and not always is their bet a winning one. Major players in the tourism sector are already in the process of developing the initial projects for their space resorts in collaboration with other space companies. For instance, the renowned hotel chain Hilton is partnering with NanoRacks (Waldek 2022), a company owned by Voyager Space – the same company behind the future Voyager space station – to explore the development of shared spaces, rooms and restaurants for prospective clients.

The project envisions constructing a circular structure of 200 metres in length to replicate the gravity of Mars. This structure is designed to accommodate up to 280 guests and 112 crew members, featuring various facilities such as a restaurant, gymnasium, bar, entertainment centre and relaxation spots (Chiedu 2023). Those involved in the construction of these space resorts are aiming for an inauguration in 2027, aligning with financial projections from

UBS estimating that the space tourism industry will be valued at 3 billion dollars by 2030 (Kamin 2022).

Regarding settlements on celestial bodies, the first proposal is the concept of a Moon village, situated on our satellite, which is the nearest celestial body to Earth. According to the European Space Agency (ESA), a distinctive aspect of this proposal is its inclusivity: "The Moon Village is open to any and all interested parties and nations. There are no stipulations as to the form their participation might take: robotic and astronaut activities are equally sought after. You might see not only scientific and technological activities but also activities based on exploiting resources or even tourism" (Woerner 2016).

Therefore, the trajectory for future settlements is expected to align with this pattern, progressively evolving to include new and expanded facilities or activities similar to those already present on Earth.

SECURITY AND SAFETY POLICIES OF FUTURE SPACE SETTLEMENTS

In the realm of space activities, security and safety entail distinct definitions: the first one defines the risk that can be referred to technical issues not directly linked to human activities such as flight safety, security, on the other hand, refers to ill or malevolent human behaviour or activities. This discussion refrains from delving into military aspects and national threats but centres on the private sector's role in ensuring the security of colonies.

As settlements and space settlements expand to the scale of cities in terms of infrastructure and population, a new imperative surfaces: public security that, in this case, overlaps with public safety. In the face of potential emergencies, companies, citizens and workers necessitate a dependable system. It is paramount to acknowledge that human lives are at stake, underscoring the indispensability of establishing a form of policing. Once again, the private sector assumes a crucial role by offering the prospect of furnishing a private police force as a measure to control and counter criminal behaviours (Elkins 2022).

Private entities are already able to ensure and will be able to ensure physical and infrastructural security through prevention and response plans, ranging from workplace violence to natural disasters. Concerning the last ones, they can support only with the State's permission. A similar collaborative trend is anticipated for settlements, where private entities may independently investigate minor crimes. There is also the prospect that in settlements, this type of "service" could serve as a substitute for national police. In such a scenario, it would fall under their jurisdiction, potentially encompassing personal injuries. The maintenance of jurisdiction by states could be facilitated through international agreements and the establishment of local courts or extradition mechanisms to Earth (Stanton Hardenstein 2016).

Continuing in the same vein of consideration regarding the presence of human settlers, another significant concern that surfaces is safety. Presently, safety in outer space is delineated as the "result of measures precluding inherent malfunction and mitigating the risks of accidental damage that would be caused by or undergone by a space object, including its component parts" (Cesari 2023).

Consequently, workers in space settlements will necessitate novel models and policies to ensure their safety throughout both working hours and leisure time. As of today, in the United States, where the private sector takes the lead, there is no overarching policy applicable to both the public and private sectors, as the Federal Aviation Administration (FAA 2022) and Congress have yet to formulate such a policy. The U.S. Congress implemented a regulatory moratorium on commercial human spaceflight in 2004. This has been subsequently extended multiple times, now persisting through 2023 (Marge 2023). What underscores the urgency is that, presently, commercial spaceflight crew and participants engage in spaceflight operations under the principle of informed consent. Hence, it is imperative for the private sector to actively collaborate with authorities in delineating policies to safeguard not only the ongoing human spaceflight endeavours but also the prospective development of the entire industry.

RISKS AND OPPORTUNITIES: SPACE SUSTAINABILITY AND THE PRIVATE SECTOR

Concluding the exposition, it is fitting to emphasise the principle that should underpin all activities within the emerging space economy, whether conducted by private entities or public institutions: sustainability.

> "Space sustainability is the ability to sustain space activities indefinitely into the future in a manner that achieves the objectives of equitable access to the benefits of the exploration and use of outer space for peaceful purposes, in order to meet the needs of the present generations while preserving the outer space environment for future generations" (UN COPUOS 2019).

This is the definition of space sustainability provided by UN COPUOS in 2019 and will serve as our foundation in the future. Recognising the potential significance of settlements on celestial bodies for all of humanity, and acknowledging that space resources, such as raw materials, are inherently limited due to the restricted availability of habitable celestial bodies, a necessity arises for a concentrated effort on resource preservation. In response to this requirement, specific attention must be devoted to the conservation of these finite resources. This can be accomplished through the establishment of sustainable cycles for resource extraction and utilisation in space.

At the intergovernmental level, it is imperative to establish guidelines, not only for public entities but even more so for private organisations engaging in space activities. This is necessary to prevent excessive liberalism, in that specific context. Specifically, this could manifest as an unrestricted and disproportionate utilisation of space resources and a lack of measures concerning debris disposal, which could lead to greater harm than benefit.

In terms of space environmental sustainability, planet Earth is confronting the issue of inactive satellites. Indeed, there are over 36,500 space debris objects larger than 10 cm, 1,000,000 space debris objects between 1 and 10 cm and 130,000,000 smaller ones in low Earth orbit (LEO). Both public initiatives

and private companies are already taking measures to address the problem. Private companies, such as European entities like D-Orbit and Clear Space, as well as the Japanese company Astroscale, are launching missions aimed at "clearing the path for the future of space exploration" (Clearspace [s. a.]) and establishing a new sustainable approach to space travel.

The key point in this discussion is that instead of addressing this issue *ex post,* as in this case, it would be more beneficial in future endeavours, including the settling of new celestial bodies, to proactively prevent the problem from arising in the first place. However, being sustainable will not merely be an obligation for private entities; it will also yield substantial benefits. This pertains not only to "minimising the costs of resupplying resources" (Santomartino et al. 2023), but also to the image and longevity of planned missions. When considering the establishment of a presence on the Moon, Mars, or any other celestial body, the ultimate objective is to remain indefinitely and achieve self-sufficiency. A sustainable approach is the sole means of accomplishing this goal, and it is important to always remember that.

CONCLUSIONS

Currently, the private sector is rapidly gaining prominence, emerging as a major player in the space industry. The generated revenue amounted to 460 billion dollars in 2022, with an estimated growth projection to reach a trillion dollars by 2040 (Euroconsult 2022). This economic expansion is poised to instigate a transformative shift in various facets of our lives, influencing not only current politics and international relations, but also necessitating a re-evaluation of international regulations.

A parallel transformation will be observed in safety and security, with private companies assuming a new role. These entities are set to leverage space resources, utilising not only the raw materials from celestial bodies, but also technological advancements to position servers and systems in outer space. This burgeoning space sector will offer private citizens the opportunity to access space

at an affordable price, providing a firsthand experience of life beyond planet Earth. Innovative investment mechanisms will be devised to facilitate services analogous to those available on Earth. In all likelihood, within the next decade, human presence on the Moon will be a reality, marking just the inception of an extraordinary journey.

REFERENCES

Allied Universal [s. a.]: *Public–Private Security Partnerships Are Essential to Public Safety.* Online: www.aus.com/security-resources/manufacturing-security-best-practices-5-critical-considerations

Allison, P. R. (2018): How We Could Survive on an Asteroid. *BBC,* 13 June 2018. Online: www.bbc.com/future/article/20180612-will-we-ever-colonise-an-asteroid

Cesari, L. (2023): What's in a Word? Notions of 'Security' and 'Safety' in the Space Context. *UNIDIR,* 12 May 2023 Online: https://unidir.org/whats-in-a-word-notions-of-security-and-safety-in-the-space-context/

Chiedu, J. (2023): The World's First Space Hotel Is Opening Soon & Here's What to Know About It. *The Travel,* 2 January 2023. Online: www.thetravel.com/what-to-know-about-the-first-space-hotel-in-the-world/

Clearspace [s. a.]: *Clearing the Way for the Future of Space Exploration.* Online: https://clearspace.today/

Copp, T. (2023): Elon Musk's Refusal to Have Starlink Support Ukraine Attack in Crimea Raises Questions for Pentagon. *AP News,* 12 September 2023. Online: https://apnews.com/article/spacex-ukraine-starlink-russia-air-force-fde93d9a69d7dbd1326022 ecfdbc53c2

Elkins, F. C. (2022): Police and Private Security Partnerships: Collaborating to Meet Growing Challenges. *Dispatch,* 15(2). Online: https://cops.usdoj.gov/html/dispatch/02-2022/police_private_partnerships.html

Davis Cross, M. K. – Pekkanen, S. M. (2023): Introduction. Space Diplomacy: The Final Frontier of Theory and Practice. *The Hague Journal of Diplomacy*, 18(2–3), 193–217. Online: https://doi.org/10.1163/1871191x-bja10152

Davenport, C. – Menn, J. (2023): Musk Refused to Allow Ukraine's Military to Use Starlink to Attack Russian Fleet. *The Washington Post,* 11 September 2023. Online: www.washingtonpost.com/technology/2023/09/07/ukraine-starlink-musk-biography/

Durante, F. (2021): Un'idea tutta italiana per la produzione d'acqua dalla regolite lunare. *Astrospace,* 7 May 2021. Online: www.astrospace.it/2021/05/07/unidea-tutta-italiana-per-la-produzione-dacqua-dalla-regolite-lunare/

ESA (2001): *Green Propellant for Space Propulsion.* European Space Agency. Online: www.esa.int/Applications/Observing_the_Earth/Green_Propellant_for_Space_Propulsion

ESA (2023): *ESA Developing Space-Based Solar Power Plant Plans.* European Space Agency. Online: www.esa.int/Enabling_Support/Space_Engineering_Technology/SOLARIS/ESA_developing_Space-Based_Solar_Power_plant_plans

ESA (2023): *Space Debris by the Numbers.* European Space Agency. Online: www.esa.int/Space_Safety/Space_Debris/Space_debris_by_the_numbers

Euroconsult (2022): *Value of Space Economy Reaches $464 Billion in 2022 Despite New Unforeseen Investment Concerns.* Online: www.euroconsult-ec.com/press-release/value-of-space-economy-reaches-424-billion-in-2022-despite-new-unforeseen-investment-concerns-2/

Euroconsult (2023a): *Space Economy Report.* Online: https://digital-platform.euroconsult-ec.com/product/space-economy-report/

Euroconsult (2023b): *Lunar Ambitions Boost Space Exploration Funding as Investment Set to Reach $33 Billion by 2032.* Online: www.euroconsult-ec.com/press-release/lunar-ambitions-boost-space-exploration-funding-as-investment-set-to-reach-33-billion-by-2032/

European Commission [s. a.]: *Space Traffic Management, Safeguarding Space Operations.* Online: https://defence-industry-space.ec.europa.eu/eu-space-policy/space-traffic-management_en

FAA (2022): *Providing the Safest, Most Efficient Aerospace System in the World.* Federal Aviation Administration. Online: www.faa.gov/space/additional_information/faq#commercial6

Graham-Yooll, A. (2022): Ukraine's Foreign Minister Calls for the Inclusion of Kyiv and Other Allies in Possible Talks with Russia. *CNN,* 21 February 2022. Online: https://edition.cnn.com/europe/live-news/ukraine-russia-news-02-21-22/index.html

Hanson, P. (2003): *An Economic History of the USSR 1945–1991.* London: Routledge.

Herridge, L. (2019): *50 Years Ago: Apollo Astronauts Land, Take First Steps on Moon*. Online: www.nasa.gov/centers-and-facilities/kennedy/50-years-ago-apollo-astronauts-land-take-first-steps-on-moon/

Howell, E. (2022): How SpaceX Got Starlink Up and Running in Ukraine: Report. *Space,* 10 March 2022. Online: www.space.com/how-spacex-got-starlink-running-ukraine

Kamin, D. (2022): The Future of Space Tourism Is Now. Well, Not Quite. *The New York Times,* 7 May 2022. Online: www.nytimes.com/2022/05/07/travel/space-travel-tourism.html

Kendall, F. (2023): *Speech Tour, Space and Cyber Conference Sessions.* Online: www.airandspaceforces.com/watch-read-secretary-kendall-great-power-competition/#:~:text=Department%20of%20the%20Air%20Force,11%2C%202023

Kramer, K. (2015): Neil deGrasse Tyson Says Space Ventures Will Spawn First Trillionaire. *NBC News,* 3 May 2015. Online: www.nbcnews.com/science/space/neil-degrasse-tyson-says-space-ventures-will-spawn-first-trillionaire-n352271

Lindemann, M. (2014): Introduction. A Tale of Three Cities. In *The Merchant Republics. Amsterdam, Antwerp, and Hamburg, 1648–1790.* Cambridge: Cambridge University Press. 1–17. Online: https://doi.org/10.1017/CBO9781139696852.001

McElroy, M. W. Jr. (2023): *The Space Industry of the Future.* London: Routledge.

Marge, M. (2023): Health Research Is Needed Now before Sending Civilians to Space. *Scientific American,* 22 March 2023. Online: www.scientificamerican.com/article/health-research-is-needed-now-before-sending-civilians-to-space/#:~:text=NASA%27s%20reports%20on%20astronauts%20before,muscle%20atrophy%20and%20bone%20loss

Mykhaylo Fedorov [@MykhailoFedorov] (2022):@elonmusk, while you try to colonize Mars. *Twitter,* 26 February 2022. Online: https://x.com/FedorovMykhailo/status/1497543633293266944

Nalla, M. K. – Gurinskaya, A. (2020): Private Police and Security Governance: Mapping Emerging Trends and Future Directions. *Journal of Contemporary Criminal Justice,* 36(1), 101–109. Online: https://doi.org/10.1177/1043986219890208

NASA (2024a): *Europa Overview.* National Aeronautics and Space Administration. Online: https://science.nasa.gov/jupiter/moons/europa/

NASA (2024b): *Titan Overview.* National Aeronautics and Space Administration. Online: https://science.nasa.gov/saturn/moons/titan/

OECD (2012): *OECD Principles for Public Governance of Public–Private Partnerships.* Organisation for Economic Co-operation and Development. Online: www.oecd.org/gov/budgeting/oecd-principles-for-public-governance-of-public-privatepartnerships.htm

OECD (2022): *OECD Handbook on Measuring the Space Economy.* Paris: OECD Publishing. Online: www.oecd.org/publications/oecd-handbook-on-measuring-the-space-economy-2nd-edition-8bfef437-en.htm

O'Neill, K. (2012): *The Environment and International Relations.* Cambridge: Cambridge University Press. Online: https://doi.org/10.1017/CBO9780511805974

Paravano, A. – Locatelli, G. – Trucco, P. (2023): Evolution of Space Programs Governance. In Müller, R. – Sankaran, S. – Drouin, N. (eds.): *Research Handbook on the Governance of Projects.* Cheltenham: Edgar Elgar Publishing. 411–428. Online: https://doi.org/10.4337/9781802208078.00043

Pearson, J. (2019): American Capitalism Is Suffocating the Endless Possibilities of Space. *Vice,* 10 May 2019. Online: www.vice.com/en/article/59qmva/jeff-bezos-space-capitalism-outer-space-treaty

Rahman, A. A. (2021): *Extreme Capitalism and the Diminishing Growth.* Online: http://dx.doi.org/10.2139/ssrn.3901652

Santomartino, R. – Averesch, N. J. H. – Bhuiyan, M. – Cockell, C. S. – Colangelo, J. – Gumulya, Y. – Lehner, B. – Lopez-Ayala, I. – McMahon, S. – Mohanty, A. – Santa Maria, S. R. – Urbaniak, C. – Volger, R. – Yang, J. – Zea, L. (2023): Toward Sustainable Space Exploration: A Roadmap for Harnessing the Power of Microorganisms. *Nature Communications,* 14. Online: https://doi.org/10.1038/s41467-023-37070-2

Stanton Hardenstein, T. (2016): In Space, No One Can Hear You Contest Jurisdiction: Establishing Criminal Jurisdiction of the Outer Space Colonies Tomorrow. *Journal of Air Law and Commerce,* 81(2), 251–288. Online: https://scholar.smu.edu/jalc/vol81/iss2/4

UN COPUOS (2019): *Guidelines for the Long-term Sustainability of Space Activities.* UN Committee on the Peaceful Uses of Outer Space. Online: www.unoosa.org/res/oosadoc/data/documents/2018/aac_1052018crp/aac_1052018crp_20_0_html/AC105_2018_CRP20E.pdf

Vasquez, C. (2023): *Growing Reliance on Satellites Requires New Approach to Cybersecurity in Space, Expert Says.* Online: https://cyberscoop.com/space-cybersecurity-critical-infrastructure/

Waldek, S. (2022): Hilton Is Building Astronaut Hotel Rooms in Space. *Travel and Leisure,* 20 September 2022. Online: www.travelandleisure.com/hilton-voyager-space-starlab-hotel-rooms-6741170

Wattles, J. (2022): The International Space Station Could Fall from the Sky in 2031. What Happens Next? *CNN,* 4 February 2024. Online: https://edition.cnn.com/2022/02/04/tech/international-space-station-commercial-business-scn/index.html

Woerner, J. (2016): *Moon Village.* ESA, European Space Agency. Online: www.esa.int/About_Us/Ministerial_Council_2016/Moon_Village

Yarlagadda, S. (2022): Economics of the Stars: The Future of Asteroid Mining and the Global Economy. *Harvard International Review,* 8 April 2022. Online: https://hir.harvard.edu/economics-of-the-stars/