

Space Mining in Practice

An International Space Law Perspective on Upcoming Challenges

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1. Introduction

On January 19, Japan became – with the Smart Lander for Investigating Moon (SLIM) – the fifth country to land on the Moon, after the Soviet Union, the US and, more recently, China and India.¹ Remarkably, the SLIM landed as intended within 100m of its targeted location. Such unprecedented precision in landing, made possible by the use of new navigation technologies, will be key to touchdown on rugged terrains, like on the lunar south pole.² That terrain, like many others on celestial

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¹ The Slim was quickly shut down after landing by the Japanese Aerospace Exploration Agency (JAXA) due to a power supply problem. It resumed its mission on January 28. See eg Kelly Ng, 'Japan: Moon Lander Slim comes back to life and resumes mission' on *BBC News* (January 28, 2024) available at <https://www.bbc.com/news/world-asia-68125589> (last visited 15 February 2024).

² See JAXA, 'In Search of Origins – Smart Lander for Investigating Moon (SLIM)' available at <https://global.jaxa.jp/projects/sas/slim/> (last visited 15 February 2024).

bodies,³ contains resources that are crucial for human activities in outer space and also on Earth, notably in relation to energy transition.⁴ Iced water in particular,⁵ from which hydrogen, oxygen and water can be produced, will be of the utmost importance to ‘feed’ astronauts and their spacecrafts alike.⁶

The commercial exploration and exploitation of those space resources⁷ has become the object of a fierce competition between nations and between corporations.⁸ Like during the Cold War, this competition has a geopolitical dimension and appears to be a matter of national pride and prestige. But more than ever in the past, this competition is driven by economic and financial prospects. The profit that according to Asterank the exploitation of the 10 most cost-effective asteroids would produce is really telling in this regard: US\$ 1.5 trillion.⁹ To make this exploration and exploitation possible in the future, investments are necessary in the present to continue technological development. Like in other economic sectors, but to an even greater extent given the high-stakes and massive size of the investments that are necessary in space mining,¹⁰ investors and companies ask for legal security and certainty. This contributes to explaining why a number of countries, starting with the US in 2015,¹¹

³ The phrase ‘celestial body’ used in this *ESIL Reflection* refers notably to planets, natural satellites and asteroids.

⁴ See e.g. Maxwell Fleming, Ian Lange, Sayeh Shojaeinia and Martin Stuermer, ‘Mining in Space Could Spur Sustainable Growth’ (2023) 120 *Proceedings of the National Academy of Sciences* available at <https://www.pnas.org/doi/10.1073/pnas.2221345120> (last visited 15 February 2024).

⁵ For an account of water discovery on the Moon, see National Aeronautics Space Administration (NASA), ‘Water & Ices’ available at <https://moon.nasa.gov/inside-and-out/composition/water-and-ices/> (last visited 15 February 2024).

⁶ On the use of water in outer space, see e.g. Philip Metzger, ‘13 Things To Do with Space Water’ (May 28, 2013) available at <https://www.philipmetzger.com/things-to-do-with-space-water/> (last visited 15 February 2024).

⁷ ‘Space resource’ can be defined as ‘an extractable and/or recoverable abiotic resource in situ in outer space’, see the 2019 Building Blocks for the Development of an International Framework on Space Resources Activities (Building Blocks) available at <https://www.universiteitleiden.nl/binaries/content/assets/rechtsgeleerdheid/instituut-voor-publiekrecht/lucht--en-ruimterecht/space-resources/bb-thissrwwg--cover.pdf> (last visited 15 February 2024).

⁸ See e.g. Boutik Biswas, ‘Chandrayan-3: The Race to Unravel the Mysteries of Moon’s South Pole’ on *BBC News* (August 23, 2023) available at <https://www.bbc.com/news/world-asia-india-66518303> (last visited 15 February 2024).

⁹ See Asterank, ‘Scientific and Economic Database of over 600.000 Asteroids’ available at <https://www.asterank.com/> (last visited 15 February 2024), quoted in Shriya Yarlagadda, ‘Economics of the Stars: The Future of Asteroid Mining and the Global Economy’ in *Harvard International Review* (April 8, 2022) available at <https://hir.harvard.edu/economics-of-the-stars/> (last visited 15 February 2024).

¹⁰ The phrase ‘space mining’ is used in this *ESIL Reflection* as referring to the commercial exploration and exploitation of space resources.

¹¹ See Section 402, US Commercial Space Launch Competitiveness Act, 129 STAT. 704, Public Law 114-90 – November 25, 2015 available at <https://www.congress.gov/114/plaws/publ90/PLAW-114publ90.pdf> (last visited 15 February 2024).

have already adopted legislation legalizing the commercial exploration and exploitation of space resources.

Yet, whether space mining is legal under international law remains highly controversial among states and experts alike. In particular, it is debated whether the commercial exploration and exploitation of space resources is compatible with the 'non-appropriation' principle set out in Article II of the 'Outer Space Treaty'.¹² This debate results notably from the formulation of Article II, which leaves unanswered the question of whether that principle applies only to the surface of celestial bodies or also to their subsurface, including their component parts. This is to be contrasted to the 'Moon Agreement', which is much clearer on the matter.¹³ Its Article 11.3 provides indeed that: "Neither the surface nor the subsurface of the moon, nor any part thereof or natural resources in place, shall become property of any State, international intergovernmental or non-governmental organization, national organization or non-governmental entity or of any natural person". Whatever the clarity of the Moon Agreement, or maybe because of it, it has gained little support from states, of which, to date, only 17 have become a party to it.¹⁴

Irrespective of those legal uncertainties and controversies under international space law, the fact is that domestic legislation legalizing space mining will certainly remain and proliferate. In this context, and whatever one's own view on the principle, it is important to pay attention to the modalities of the commercial exploration and exploitation of space resources and to the legal questions that arise therefrom. Thinking ahead is all the more necessary as those activities have no doubt a significant potential to cause tensions, disputes and conflicts, both in space and on earth.

Let's contemplate the following situation to illustrate this. Two competing companies, A and B, nationals of two spacefaring nations, have both prepared a mission to explore the same area on the Moon and exploit the resources it contains. Company A makes its mission public first, but company B is the first one to touch down on our natural satellite and to actually start its mission. It is joined a few months later by company A's team. Many questions arise from such a basic case study. For instance, can either company claim to have any priority right to explore and exploit the resources? If so, who

¹² 'Outer space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means' (Article II), Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (Outer Space Treaty) (adopted 27 January 1967, entered into force 10 October 1967) 610 UNTS 205.

¹³ Agreement governing the Activities of States on the Moon and Other Celestial Bodies (Moon Agreement) (adopted 18 December 1979, entered into force 11 July 1984) 1363 UNTS 22.

¹⁴ This is to be contrasted with 114, which is the number of states parties to the Outer Space Treaty.

should grant that right and how should it be granted? Also, does such a priority right include the right to limit access to the area explored? If there is no priority right, the practical questions that arise are also manifold. How can both companies explore/exploit that same area at the same time? In particular, how then to mitigate the risk of incidents and accidents, for instance damage caused to machines by the dust generated by either team? To conclude this non-exhaustive list of questions, how to ease the tensions and settle the disputes that are likely to emerge between the two competing teams, whether or not either of them enjoys a priority right?

International space law and in particular the Outer Space Treaty provide elements to answer some of these questions. Among them, the above-mentioned non-appropriation principle helps, as do notably the principles of 'freedom of exploration and use'¹⁵, 'due regard'¹⁶ and 'non-harmful interference'.¹⁷ However, they do not provide clear-cut answers to a number of these questions, and for some of them, they provide no answer at all.

This ESIL Reflection tackles this normative uncertainty and intends to raise awareness thereon as it appears highly problematic from a societal, a political and a business perspective. More specifically, the Reflection focuses on two issues that are likely to be the most crucial ones from those perspectives: 1) priority rights, and 2) safety zones. Each is addressed in turn from the standpoint of international space law. Due attention is also paid to the Building Blocks for the Development of an International Framework on Space Resource Activities (Building Blocks), which is an authoritative non-binding document on the matter prepared by the Hague International Space Resources Governance Working Group (Hague Working Group).¹⁸

¹⁵ See i.e. Article I.2, Outer Space Treaty, fn 12.

¹⁶ See i.e. Article IX, Outer Space Treaty, fn 12.

¹⁷ *ibid.*

¹⁸ The Hague International Space Resources Governance Working Group (Hague Working Group) was made of various stakeholders representing states, international organizations, the industry, NGOs, and academia. For information about that Group and the methodology it adopted, see <https://www.universiteitleiden.nl/en/law/institute-of-public-law/institute-of-air-space-law/the-hague-space-resources-governance-working-group> (last visited 15 February 2024). For the text of the Building Blocks, see fn 7. For their commentaries, see Olavo O Bittencourt Neto ao (eds), *Building Blocks for the Development of an International Framework for the Governance of Space Resource Activities – a Commentary* (2020 Eleven International Publishing) available in Open Access at <https://www.boomportaal.nl/boek/9789462361218> (last visited 15 February 2024).

2. Priority rights

Put simply, priority rights reflect a ‘first come, first served’ approach to the utilization of space resources.¹⁹ They have notably been supported by the Hague Working Group in Building Block 7, which reads as follows:

The international framework should enable the attribution of priority rights to an operator to search and/or recover space resources for a maximum period of time and a maximum area upon registration in an international registry, and provide for the international recognition of such priority rights. The attribution, duration and the area of the priority right should be determined on the basis of the specific circumstances of a proposed space resource activity.²⁰

In support of the recognition of those priority rights, the Hague Working Group stressed the importance of protecting the opportunities for a return on the investments made by a company in locating and developing its mining operation. It also insisted on the need to avoid harmful interferences between competing companies.²¹

Such rights beg a number of legal and practical questions, pertaining for instance to their allocation. How would they be granted and by whom? Inspiration to answer those questions could certainly be found in existing mechanisms, such as the regime contemplated in the Moon Agreement,²² the system of the International Telecommunication Union applicable to the geostationary orbit,²³ or the system for deep seabed resources established on the basis of the UN Convention on the Law of the Sea.²⁴ But, first and foremost, it is the very compatibility of priority rights with international space law that requires an examination.

¹⁹ Interestingly, an early version of the US Commercial Space Launch Competitiveness Act (fn 11) referred implicitly in Section 202 to that principle in relation to a civil action brought by a US plaintiff who was first in time to conduct an ‘asteroid resources utilization activity’ and who allegedly suffered a harmful interference to its operation due to an entity subject to US jurisdiction, available at <https://www.congress.gov/bill/114th-congress/house-bill/2262/text/eh> (last visited 15 February 2024).

²⁰ Building Blocks, fn 7.

²¹ See Olavo O Bittencourt Neto ao, fn 18, 46.

²² See Article 11, Moon Agreement, fn 13.

²³ This system is based on the Constitution/Convention of the International Telecommunication Union (ITU), including the ITU Radio Regulations (adopted 22 December 1992, entered into force 1 July 1994) UNTS 1825, 1826. For an account of the system applicable to geostationary orbits, see ‘ITU Radio Regulatory Framework for Space Services’ available at https://www.itu.int/en/ITU-R/space/snl/Documents/ITU-Space_reg.pdf (last visited 15 February 2024).

²⁴ See notably Article 153, United Nations Convention on the Law of the Sea (adopted 10 December 1982, entered into force 1 November 1994) 1833 UNTS 397.

In a way, priority rights can be seen as being akin to those international obligations, such as the above-mentioned due regard and non-harmful interference principles, which aim to ensure the safety of space activities.²⁵ Indeed, if a company gets a priority right to search and recover space resources over an area, this will not only avoid any competition between two (or more) companies, but this will also avoid them being in the same place, at the same time, preventing thereby harm from occurring. Indeed, mainly scientific missions would then still have an interest in accessing the area for research purposes.

On the other hand, the legal relation between priority rights and other international space law principles appears more complex. Obviously, this holds true in particular for what regards the non-appropriation principle.²⁶ Depending on whether one understands that principle as applying or not to the subsurface of celestial bodies and to their component parts, the recognition of any priority right to recover space resources can be seen, at least indirectly, as being incompatible with that principle. Indeed, having such a priority right only makes sense, both legally and practically, if companies benefitting from that right enjoy an ownership over the resources, which, again, is debated under international law.²⁷ Whatever one's own opinion on the matter, it is worth noting in this regard the 'internal' coherence of the Building Blocks that also put forward 'resources rights', i.e. rights allowing the acquisition of space resources through domestic legislation or bilateral/multilateral agreements.²⁸

Another instance of complexity raised by space mining as it relates to international space law principles pertains to the most preeminent of those principles, i.e. the freedom to explore and use outer space. It is notably enshrined in Article I of the Outer Space Treaty according to which: "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

²⁵ See fn 16 and 17.

²⁶ See fn 12.

²⁷ See Introduction.

²⁸ See Building Block 8, fn 7. In this regard, Building Block 8.3 specifies that the utilization of space resources should be carried out in accordance with the principle of non-appropriation under Article II of the Outer Space Treaty, acknowledging thereby implicitly that such an utilization is – as a matter of principle – compatible with that principle. Likewise, the 2020 Artemis Accords provide, under Section 10, that 'the extraction of space resources does not inherently constitute national appropriation under Article II of the Outer Space Treaty, and that contracts and other legal instruments relating to space resources should be consistent with that Treaty.', Artemis Accords – Principles for Cooperation in the Civil Exploration and Use of the Moon, Mars, Comets, and Asteroids for Peaceful Purposes available at <https://www.nasa.gov/wp-content/uploads/2022/11/Artemis-Accords-signed-13Oct2020.pdf?emrc=653a00> (last visited 15 February 2024).

there shall be free access to all areas of celestial bodies”.²⁹ Obviously, granting a priority right to search and recover comes as a limit to the freedom to explore and use. This may be the reason why the Hague Working Group, mindful of this difficulty, specified in the text of Building Block 7 that the priority rights granted should have a maximum period of time and a maximum area, taking into account the specifics of each mission.³⁰ Such an approach introduces a proportionality element, aiming to strike a balance between the economic and financial interests of pioneers and the freedom that all other entities enjoy under international space law. Yet, the question of whether such limits can be put on the freedom of exploration and use remains open.

3. Safety zones

Similar questions arise as regards safety zones,³¹ a concept that has also been endorsed by the Hague Working Group. Building Block 11, paras 3 and 4, provide indeed:

Taking into account the principle of non-appropriation under Article II OST, the international framework should permit States and international organizations responsible for space resource activities to establish a safety zone, or other area-based safety measure, around an area identified for a space resource activity as necessary to assure safety and to avoid any harmful interference with that space resource activity. Such safety measure shall not impede the free access, in accordance with international law, to any area of outer space of personnel, vehicles and equipment of another operator. In accordance with the area-based safety measure, a State or international organization may restrict access for a limited period of time, provided that timely public notice has been given setting out the reasons for such restriction. The international framework should provide that appropriate international consultations are undertaken in case of possible overlap of safety zones or conflicts with the freedom of access recognized by international law.³²

Most famously, safety zones constitute a key element of the Artemis Accords, a non-binding instrument initiated by the National Aeronautics and Space Administration (NASA) in coordination with

²⁹ See fn 12.

³⁰ See fn 20.

³¹ It is worth noting that the establishment of protective zones in outer space, like in other ‘areas’ such as the air and sea, is not a new concern in international law, see e.g. Lucas Mallowan ao, ‘Reinventing Treaty Compliant “Safety Zones” in the Context of Space Sustainability’ (2012) 8 *Journal of Space Safety Engineering* 155.

³² See fn 7.

the US Department of State, and concluded with 34 states to date.³³ Its Section 11 ('Deconfliction of Space Activities') provides notably:

In order to implement their obligations under the Outer Space Treaty, the Signatories intend to provide notification of their activities and commit to coordinating with any relevant actor to avoid harmful interference. The area wherein this notification and coordination will be implemented to avoid harmful interference is referred to as a 'safety zone'. A safety zone should be the area in which nominal operations of a relevant activity or an anomalous event could reasonably cause harmful interference.

As it appears, safety zones aim primarily at avoiding the harmful interference between space missions that could result from collisions, explosions, or from the dust generated by landing and surface operations.³⁴ As such, and even more closely than priority rights, they are akin to the above-mentioned due regard and non-harmful interference principles.³⁵ On the other hand, some of the potential features of safety zones call into question their compatibility with other international space law principles.³⁶

Non-appropriation comes first to mind among them, not as regards the subsurface of celestial bodies this time, but as regards their surface. The question arises in particular of whether safety zones can be seen as embodying a claim of sovereignty. There is a crucial temporal dimension inherent in the answer to this question. As long as a safety zone is (reasonably) temporary, it is fair to say that it does not amount to such a claim and therefore that it is not in breach of the non-appropriation principle. In that regard, it is worth noting that both the Artemis Accords and the Building Blocks insist on the temporary nature of the safety zones they promote.³⁷

Another concern that such zones create pertains to the freedom of exploration and use.³⁸ Could a company operating in such a zone forbid access to others, be they another company or a scientific mission? Here again, both instruments stress that safety zones must not impede free access to the

³³ See fn 28.

³⁴ On some of those risks, see Michelle Hanlon, 'The Legal Imperative to Mitigate the Plume Effect: an Aggravation and Frustration that Imperils our History and our Future' (2019) 43 *Journal of Space Law* 309.

³⁵ See fn 16 and 17.

³⁶ It has been noted in the literature that ensuring that safety zones are consistent with international law is more about how they are implemented in practice as opposed to general theory, see Alexander Q Gilbert, 'Implementing Safety Zones for Lunar Activities under the Artemis Accords' (2023) 10 *Journal of Space Safety Engineering* 103, 106.

³⁷ See Building Block 11.3 (fn 32) and Section 11.7.c, Artemis Accords (fn 28).

³⁸ See fn 29.

areas. Yet, each in their own way, they acknowledge that the access to such areas may not be completely free as long as the safety zone exists. The Artemis Accords provide that the Signatories commit to respecting reasonable safety zones to avoid harmful interference with operations under the Accords, including by providing prior notification to and coordinating with each other before conducting operations in a safety zone established as pursuant to them.³⁹ One step further, the Building Blocks foresee the possibility that a State may restrict access – for a limited period of time – provided that timely public notice is given that sets out the reasons for such a restriction.⁴⁰ Even though such a restriction shall then be reasonable, it is debatable whether the freedom of exploration and use can be limited in this way.

Irrespective of the legal dimension of that discussion, it is important here again to take into account the facts, whether we like them or not. There will very likely be situations in the future where a company is exploiting an area and where it comes to limit its access for safety or other reasons. It appears to be the inevitable consequence of having mining operations on celestial bodies. No doubt then, tensions, disputes and potentially conflicts will arise in such situations between those companies limiting access and other entities, notably their competitors. To deal with those situations and many others in outer space, it is crucial to have dispute prevention and settlement mechanisms put in place to avoid an escalation.⁴¹ Outer space is already an extremely hazardous environment for human activities; it is best – to say the least – to avoid adding a human touch to this natural reality.

4. Conclusion

For what regards space resources or other current challenges, like space debris,⁴² international space law appears not to be fit for purpose. Such a deficiency is mainly due to the mismatch between the time when space law treaties were adopted in the 1960s and '70s and current times. New outer space activities are becoming possible due to technological innovations and new actors have come to play a preeminent role therein. To avoid that outer space becomes a new 'Wild West', a normative framework pertaining to conducts, responsibility, and dispute settlement must be developed to set clear rules for all stakeholders, notably all those people who will be on a mission up there.

³⁹ Section 11.10, fn 28.

⁴⁰ Building Blocks 11.3, fn 32.

⁴¹ In this regard, it is noteworthy that Building Block 11.4 provides that appropriate international consultations should be undertaken in case of conflicts involving the freedom of access or in case of possible overlap of safety zones, see fn 32.

⁴² See Yannick Radi, 'Clearing up the Space Junk: On the Flaws and Potential of International Space Law to Tackle the Space Debris Problem' (2023) 12 *ESIL Reflections* 1.

This appears all the more necessary when one takes seriously the fact that this new West is further away than any area ever explored by human beings. Even though they will be in contact with Earth (if no technical problem occurs), this means that – physically and psychologically – they will be on their own to apply decisions made below or to take decisions themselves. In such a *huis clos*, there is a high risk for uncontrolled and unpredicted drama. It is therefore crucial and even vital to avoid such risks by adopting an anticipative approach to the regulation of space mining.⁴³

What's more, for any such regulation to actually prove efficient, it must be endorsed by a large number of states, including – competing – spacefaring nations. Such a need is well illustrated by the priority rights and safety zones discussed in this ESIL Reflection. What is the practical value of priority rights agreed on only on a bilateral or at best on a plurilateral basis, if important spacefaring nations and their companies are left out of that agreement? Likewise, if safety zones create obligations only for two or some states to the exclusion of important spacefaring nations and their companies, what to think of the safety it confers? And what about the risk of overlapping safety zones? As it appears, short of a multilateral consensus, the future of space mining will consist of tensions, disputes, and conflicts. Unfortunately, multilateralism is in crisis and the years to come will certainly remain characterized by the lack of appetite among states for multilateral initiatives.

In that geopolitical context, companies and the space industry at large may be the best hope we have. Obviously, tensions and conflicts are harmful to their business. More generally, they need legal stability and certainty to increase their chances of getting a return on the massive investments they need to make to develop a space mining industry. As they did in asking (some) states to adopt national legislation legalizing the commercial exploitation of space resources, it would then make sense for them to put pressure on states to adopt a tailor-made multilateral legal framework. This is as much in their interest as it is in the interest of humankind.

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⁴³ Rossana Deplano notes in this regard that the Artemis Accords and the Hague Building Blocks introduce a significant innovation in international space law by replacing the anticipatory approach to the regulation of outer space activities with the staged principles of adaptive governance, Rossana Deplano, 'The Artemis Accords: Evolution or Revolution in International Space Law?' (2021) *International and Comparative Law Quarterly* 799, 814-816.