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Legal and political aspects of space mining

Abstract

In recent years, there has been a great interest of states and international corporations in the problem of obtaining raw materials from celestial bodies. Space mining is a future branch of industry that does not exist yet, related to the extraction of natural resources from celestial bodies. Although we currently bring from space at most samples of material for research, serious companies have been established that deal with the development of technologies related to the extraction of raw materials. Today, space mining is treated as an inevitable and important element of the future world economy. Moreover, it is already a source of conflicts. Space mining is of interest mainly to those countries which have not been endowed by nature with deposits of rare raw materials sufficient to meet the needs and ambitions, and private entities encouraged by the scale of potential profits. The flagship example of the first type is the United States, for which the ultimate goal of the space programme is the expansion of humanity throughout the solar system; it also counts on quick and big profits. For years, the Americans have been concerned about maintaining freedom of action, e.g. by remaining outside the regime of the Moon Treaty; they even introduced in their domestic legislation preliminary regulations regarding extraterrestrial extraction and ownership of raw materials.. In April this year, President Trump issued a decree affirming the right to commercial extraction of raw materials from space bodies, rejecting the concept of space as a “global community” that

had been the international norm until then. Some researchers say that recent US policy actions are part of a coordinated effort to redirect international space cooperation to short-term commercial interests that could lead to a "race to the bottom", sabotaging the efforts to ensure secure access to space activities. The only way out of this situation is an international agreement, which will amend space laws (international and national) towards their modernization and harmonisation.

Key words: space mining, international law, national law, research missions

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Introduction

Many countries in the world, including the United States, Russian Federation, China, Japan, India, Canada, United Arab Emirates and certain Member States of the European Union have expressed their interest in acquiring raw materials from outer space and suggest that they have suitable means to do it. Moreover, still back in 2017, four large corporations: Planetary Resources, Deep Space Industries, Shackleton Energy and Moon Express formulated their space mining programmes. Those companies actually are still at the phase of developing technology, and starting extraction is still a remote business proposition. So far, they rely on other projects, for example those related to monitoring various types of LEO (Low Earth Orbit) wireless communication signals.

Therefore, the commencement of practical mining operations requires a lot of expensive research and resolution of a number of fundamental issues, inter alia of a legal and technological nature[1].

1. Exploration of outer space vs international and national space laws

Given the growing involvement of governments and private capital as well as technological development there is a need to explain many issues, for instance difference in the interpretations of such term connected with outer space as "use" and "exploration".[2] In the existing space law, the treaties and common law the principle of non-appropriation and freedom

[1] Jakhu, Pelton (2019): 379–380.

[2] Nyman-Metcalf (1999): 192–194.

to use outer space are well established. The analysis of these principles reveals, however, that in certain circumstances they may be mutually contradictory. A possible conflict between use and appropriation is a challenge for future space law.

Current space law does not provide any definition of the word "use". Several indications are provided in the 1979 Moon Treaty, but it was adopted by very few states. Certain principles are laid down in the 1967 Outer Space Treaty; the major indication is that the use of outer space resources, including celestial bodies, is permitted, though applies exclusively to resource sampling.[3] Given the absence of international regulations, certain states regulate the issues associated with the operation of private entities in the outer space in their internal legislation.[4] This gave rise to the idea of global cooperation of governments and private entities.[5] A good example are the provisions regulating the operation of the International Space Station (ISS).[6] However, there is still a lack of sufficient legal solutions regulating for instance the operation of satellites.[7] Even in the case of space tourism there is a need for numerous procedures associated in particular with transport: spaceship equipment, types of routes, insurance of the crew and passengers, emergency procedures, space port infrastructure, etc.

Commercialization of outer space activities involves also to many legal problems, e.g. in connection with third-party liability. Some people believe that the issue of this type of liability should be left for the market to

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3 Bőckstiegel (1995) 1–6.
4 Skaar (2004): 5.
5 Filho (2000) 22–23.
6 Farand (2003): 83–88.
7 Leister, Frazier (2000): 164–167.

resolve.[8] Space transport and telecommunication services may require separate and specific international regulations. Other authors believe that a space flight may use the fourth and third freedom traffic rights (jointly) established by the Chicago Convention in 1944 and still used in civil aviation. Transport of a satellite to Earth may be compared to cabotage (the satellite is recognized as a quasi-territory of a state).[9]

However, not all lawyers are advocates of excessive liberalisation of operations in outer space. They believe that the "international regulator" should take in account the difference of opinion and requirements of states, hence transport rights and expansion of space operations cannot be the same for all states.[10] Some authors point out the need to create a new branch of space law concerning commercial activity in outer space.[11]

So far, however, issues of jurisdiction are a serious problem for private entities. The concept of responsibility for activities that are out of compliance with international law, including the activities of private entities, as well as state liability for damage caused by space objects, including by private operators, becomes a fundamental problem of international space law. Therefore, states are forced to undertake internal measures, to monitor and supervise the activities of private entrepreneurs. Therefore, interaction of international and national legislation is a must.

States controlling private enterprises should, therefore, have in place legislative mechanisms necessary to set up a regime for licencing and monitoring as well as a system

8 Quizhi (1990): 333–342.
9 Ravillon (1998): 61–62.
10 Wassenbergh (1998): 201–229.
11 Salin (2001): 179–195.

of sanctions. It seems that it should be left to international law to define the parameters and the extent to which such control of private enterprises should take place. States should be able to decide as to the categories private entities may operate in.[12]

2. Raw materials found on celestial bodies

Space mining is a future branch of industry that does not exist yet, related to the extraction of natural resources from celestial bodies. Although we currently bring from space at most samples of material for research, serious companies have been established that deal with the development of technologies related to the extraction of raw materials. Today, space mining is treated as an inevitable and important element of the future world economy. Moreover, it is already a source of conflicts.

The internal structure of Earth is such that the majority of the planet's natural resources is trapped too deeply to be available for mining. The crust, that is the layer from which extraction is possible, contains relatively small deposits of minerals. At the same time, some of them are particularly valuable for power generation, heavy industry, jewellery and other areas of the economy. The state that have such deposits in their territories profit – not only financially but also politically – from extracting and selling raw materials. The best example of this mechanism is the activity of OPEC states, although oil is not the sole strategic raw material. Also states that have other raw materials, such as e.g. natural gas, cobalt, tungsten, platinum group metals or rare earth elements acquire considerable from their sale. If their extraction is for

[12] von Dunk (2019) 470–471.

various reasons particularly intensive, it may inescapably lead to the depletion of those deposits. This means not only an end to the inflow of cash and political influence of the extracting states, but also a pressure on customers to find alternative sources of their supply. In extreme cases this may involve development of new technologies, such as e.g. producing petrol from hard coal by Germany during World War II.

The concept of space mining offers the simplest solution to those dilemmas: a new, external source of raw materials that are rare on Earth. The operations of their extraction will be theoretically available to anyone who is the first to develop the technology and make the undertaking profitable.

Over the past decades our perception of the Solar System has been significantly changed. Ever more precise instruments allow for continuous cataloguing of new objects: not only the moons of distant outer planets or the ring of debris called the Kuiper belt, but also planetoids, comets and meteoroids close to Earth (i.e. NEOs – Near Earth Objects); it turns out that there is a lot of them in the immediate neighbourhood of Earth.

We also improve our knowledge about NEOs composition and structure. Spaceships with robots have been sent to some of them. There are even online services, such as *Asterank*, which offer information on the likely value of a given object based on the estimates of its mineral deposits. Nothing is more appealing to imagination as a vision of acquiring raw material independence and unimaginable wealth which is available almost within hand's reach. Those minerals may be divided into several major categories: scarce raw materials potentially transported to Earth (iridium, osmium, palladium, platinum, rhenium, ruthenium, tungsten, etc.), raw materials to be used for the development of space infrastructure

(*inter alia* titanium, iron, cobalt, manganese, molybdenum, nickel), substances indispensable for life support systems (water and oxygen), as well as those for the production of rocket fuel, such as hydrogen, oxygen or ammonium. This list is obviously not exhaustive and is only meant to illustrate the scale of possibilities and diversity of space mining.

Given the prospect of colonisation of other celestial bodies declared by both state agencies and commercial entities the possibility of acquiring raw materials from outer space would be invaluable. It is simply not profitable to overcome terrestrial gravity well each time with deliveries growing ever bigger alongside the increasing needs and expansion of colonies, even if the costs of flights decline, which is intensively worked on by the largest corporations in this sector. Therefore, the development of space mining seems to be a historic necessity.[13]

3. Plans to mine raw materials in near and more distant future

Most frequently the media inform about the plans to mine rare materials that are scarce on Earth, e.g. platinum or rare earth elements. In reality, much more rational seem to be the ideas of getting water from regolith, that is superficial layers of celestial bodies. Outside of our planet water can be found in the form of ice practically on each celestial body in the solar system except Venus; development of such water resources will help expand our capabilities to explore outer space. It is water on which all activities in outer space can be based since the viewpoint of space missions it is most important as the source of drinking water and oxygen.

[13] Stutt (2020).

It is fuel that is the greatest impediment to our exploratory capabilities: in order to overcome gravity and get away from Earth enormous amounts of fuel are needed; hence the view that it is water which may be the basis for the entire chain of deliveries and orbital infrastructure. United Launch Alliance, an American rocket manufacturer, which in this business may be additionally supported by NASA, claims that 2450 tonnes of moon water can yield about 450 tonnes of fuel. In this way the construction of orbital infrastructure will be initiated, which will later allow to put in motion more complicated operations. However, extraction of other space resource from asteroids is a distant perspective, extending even to the next century.

As calculated by the Colorado School of Mines, implementation of such integrated mining and processing process on the Moon should cost about US$ 4 billion. On the other hand, it is capable (within the timeframe of 10 years) bring about some US$2.5 billion in profit from the sale of fuel. Moreover, other sources of income may be deliveries of drinking water for manned stations on the Moon, generation of energy or cheaper tourist flights.

As regards financing for space mining, the majority of the funds is in the United States, which is followed suit by China, which frequently keeps its detailed plans secret, however. Both states are planning to build at least a temporary base on the Moon – and one of them is likely to do so in the forthcoming 10 to 15 years.[14]

Also a Polish engineer, Adam Jan Zwierzyniecki, is an optimist and estimates that on asteroid Hebe there is enough iron to cover mankind's needs for a least one million years, and

[14] Florencka (2020).

gold for over 700 thou. years. For the time being, however, the main stress has been placed on developing the Moon. NASA plans for landing people on the Moon under its ARTEMIS program in 2024. Americans have such ambitious plans among other things because of China, which plan to create by 2050 a special Earth-Moon economic zone that is to generate an income of US$10 billion annually.

When Starship constructed by SpaceX is ready, the way to the Moon and Mars will be opened for private companies. That planet is even more interesting as regards mining as there are many craters left by asteroids. As we know, most of rare earth elements on Earth originate from asteroids.

Enormous progress has been made recently as regards space technology. In 2011, the cost of launching a space shuttle amounted to US$ 450 million, and on the average over 30 years – US$1.5 billion. And a shuttle is able to carry only 23 tons of cargo into space. The theoretical cost of the Falcon Heavy rocket, which takes much more cargo, amounts to slightly over US$90 million. Technological problems will be sooner or later overcome; political and organisational barriers may prove to be more difficult.[15]

At the conference of the International Astronautical Congress (IAC) organised in 2019 in Washington results of a very interesting analysis of space mining were presented to the effect that space mining is likely not to bring about any benefits for the forthcoming decades. However, if space raw materials (e.g. precious metals) could be acquired at a cheaper cost, their prices on the world market would collapse. At the same conference, a presentation was shown at a space sector economics session, which focused on delivering water as a raw

[15] Britoa, Deeb (2020).

material for the production of fuel, oxygen and potable water for manned missions on the Moon. It turned out that until 2050 actually the only clients will be space agencies, which may not be sufficient to create even a germ of space mining.

However, the new generation of rockets may offer the greatest competition for space mining. It is very likely that in the next decade new powerful launchers will be brought into service, such as SpaceX's Starship or Blue Origin's New Glenn. Apart from that, SpaceX's Falcon Heavy rocket is already in service. It may be assumed that those rockets will transport supplies towards the Moon and planetoids. It turns out that the cost of delivering water from Earth with those rockets will be comparable or even lower. This means that regular missions from Earth with the use of such rockets will be simply cheaper and more attractive than longer and more complicated flights to planetoids in order to acquire raw materials. Anyway, so far there is no technology for extracting metals from metallic planetoids. So far it is possible to "collect" metallic gases from the surface of planetoids – the problem is that in a large measure these would be blocks of iron-and-nickel matter whose value would be too low to make even a smallest unmanned mission profitable. It seems that after the initial enthusiasm as regards space mining, currently the sentiments are much "cooler". It is however possible that alongside technological progress new options for the extraction and use of raw materials from planetoids will surface.[16]

[16] Kanawka (2019).

4. A political game for extra-terrestrial resources

Still back in the 1980s, the United States announced a programme of commercialisation of space technologies, which included *inter alia* postulates to ensure convenient conditions for the development of private companies, continuation of exploration and discoveries, containment of risks and limitations imposed by space technologies. Many American researchers are even of the opinion the US companies involved in space operations should be allowed to circumvent certain regulations until they themselves create relevant rules concerning space operations.[17] A lot of interest is also aroused by commercial exploration of celestial bodies, including the Moon; even a new concept of "Moon economy" has been coined. In 2015, the United States passed the draft of the Commercial Space Launch Competiveness Act. The bill obliges the President, who acts through appropriate federal agencies, to facilitate commercial exploration and extraction of space resources by US cotizens.

Luxembourg, which is not a space superpower, adopted similar legislation. The Luxembourg government is very active; it organises symposia and conferences, which attract experts and businessmen. It also cooperates with other states and international organisations (e.g. United Nations Office for Outer Space Affairs - UNOOSA) with respect to various space initiatives and projects. It has also created favourable economic conditions for space sector companies and useful legal framework for them. The Space Resources Innovation Centre has been established. Moreover, a legislative act opening the market for external companies involved in outer space

[17] Dula (1984) 12–18.

research has been elaborated (the Law of 2017 on the Exploration and Use of Space Resources). Art. 1 of the law provides that: "space resources may be subject to ownership." Exploration is permitted.

> Authorisation is granted to an operator for a mission to explore and use space resources commercially upon a written application addressed to ministers[18],[19].

At the symposium on this issue organised by the Luxembourg Space Agency (13–14 November 2019) – the Hague international working group for space resources management adopted the "Building Blocks for the Development of an International Framework on Space Resource Activities." The working group had been appointed to promote international cooperation and dialogue with many interested parties in order to determine the method of commercial exploitation of space resources.

Space mining is of interest mainly to those countries which have not been endowed by nature with deposits of rare raw materials sufficient to meet the needs and ambitions, and private entities encouraged by the scale of potential profits. The flagship example of the first type is the United States, for which the ultimate goal of the space program is the expansion of humanity throughout the solar system; it also counts on quick and big profits. The Americans have been for years concerned with retaining freedom of operation, among other things by remaining outside of the Moon Treaty regime. In 2015, they even adopted in internal legislation preliminary

[18] The Law of 2017 on the Exploration and Use of Space Resources, Art. 3.

[19] Johnson (2020): 12.

regulations concerning extra-terrestrial mining and ownership of raw materials.

There are also those who are dissatisfied – those who face considerable losses as a result of fast development of space mining. Regular deliveries of various raw materials from outer space will totally change the market, which at present is a profitable source of their income. Another group which politically restrains the development of asteroid mining includes those entities which would like to secure their part in this business, but for various reasons cannot do it – for example they cannot afford to carry out their own programme. It is in the interest of those groups to delay this type of undertaking as much as possible or enforce creation of international law regime that would be favourable for them.

How such attempts end is best illustrated by the history of international space law. Despite high-flown propaganda as to peaceful utilisation of outer space, its content was in practice determined by two superpowers, the them monopolists as regards orbital flights (USA and USSR) – while satellites are today legally used for military or actually warfare purposes. The same happened as regard the geostationary orbit. Poorer equatorial states claimed their rights to it – not to use it in practice, but to be able to sell orbital slots. The only permanent remnant left behind after this attempt is the phrase frequently used by the United Nations Office for Outer Space Affairs: "taking into account the interests of the developing countries", and the defunct provision of the Constitution of Columbia, which is still claiming the right to the exclusive use if the fragment of the GEO located above its territory. When money and strategic interests are at play – and it is undoubtedly the case as regards space mining – usually this race ends with the victory of stronger and wealthier entities.

Politics is but one of the problems. Another – and for the time perhaps the most important one – is money. Insofar as space mining constitutes a potential gold mine, the current available technology, primarily rocket technology, is imperfect and expensive to operate. It is unknown which of the technological solutions that are considered will be most profitable as concerns transporting raw materials to Earth. Also the start-up of the operation has to be paid for. If commercialisation of the rocket sector actually leads soon to the lowering of the costs of space flights, mining infrastructure needs to be designed right now. Against all appearance, there is a pressure of time. The greatest profits are derived from a breakthrough technology in the period immediately following its implementation, before it is copied by the competition.[20]

Aaron Boley and Michael Byers from University of British Columbia invoke the US Space Act of 2015, which grants US citizens and companies the right to won and sell space resource in accordance with US law. In April this year, President Trump issued a decree affirming the right to commercial extraction of raw materials from space bodies, rejecting the concept of space as a "global community" that had been the international norm until then. These researchers state that recent US policy actions are part of a coordinated effort to redirect international space cooperation to short-term commercial interests that could lead to a "race to the bottom", sabotaging the efforts to ensure secure access to space activities.

Recently Nasa announce that each state wishing to become a partner in the forthcoming American missions aimed to establish permanent human presence on the Moon

[20] Stróż (2017).

(Artemis Program) will have to sign a bilateral agreement with the US. Those agreements will reinforce the idea that commercial space mining will be governed by nationalrather than international law, and that the companies will be able to get protection for their operations by not allowing competitors to operate in a given area. In this way the United States will be able to utilise its dominating position to enforce its interpretation of international law and commercial goals of outer space development. Such policy of Moon exploitation, which practically gives private companies total freedom in many areas of mining activities, may lead to e.g. destruction deposits which may contain invaluable scientific information. It may also lead to creating dangerous quantities of moon dust, which could seriously damage spacecrafts, increase the amount of cosmic waste, or – in the worst case – form meteorites which could threaten satellites or even hit Earth.[21]

Some people are afraid that other space powers will try to create their own regulation and interest groups, which may lead to armed conflicts. Such intentions are attributed by the US to China. B. Mulvaney, an American, representative of the China Aerospace Studies University, is however of the opinion that for the time being China does intend to trigger off a war but focuses on scientific and experimental objectives, including working out the principles for extracting raw materials from celestial bodies, mainly the Moon.[22]

It seems that China's latest actions correspond with that thesis. For instance, China invited other countries to cooperate in its moon missions. Such invitation was also issued to India (long-time adversary of China) – until 2036 it would

21 Gent (2020).
22 Mulvaney (2020).

co-implement the Chinese plan of lunar exploration. Another Chinese initiative is invitation of individual states to use its navigation system "Beidou". Simonetta di Pippo, Director of the United Nations Office for Outer Space Affairs (UNOOSA) signed with China representatives an appeal addressed to the UN Member States to file applications for participation in the operations of a future Chinese space station. This Chinese initiative has been call a peaceful Marshall Plan by the Southern African Customs Union.

Looking for raw materials in outer space, China signed a memorandum of understanding with Luxembourg and established a unit for outer space research there, mostly because of the liberal local regulations. In exchange, the Bank of China concluded a contract with Luxembourg for the sale of Chinese bonds (worth US$ 500 million) allocated for the construction of a space station.[23]

In March 2019, the Canadian government published a long awaited "national space strategy" focused on artificial intelligence, deep-sea robot systems, Earth observation and cooperation with the European Space Agency. However, the central element of the 22-page strategy was the recently announced commitment in a NASA project called the Lunar Orbital Platform Gateway providing for a 24-year financial contribution and development of a new generation of the Canadarm robot. Canada was the first country to formally commit in the Gateway Project (the Canadian government is to expend 2 billion Canadian dollars for this and other space programmes). Moreover, It was noted in the "space strategy" that the government would allocate 125 million Canadian dollars, which would help the country to remain the world leader in space

[23] Goswami (2019).

robotics utilising artificial intelligence. Apart from that, in that document 150 million Canadian dollars were guaranteed to paid out over 5 years to small and medium-sized companies involved in lunar exploration.[24]

The Indian Space Research Organisation (ISRO) can boast of the unmanned Chandarayaan-1 lunar probe launched in 2008 and the Mars Orbiter Mission probe, which in 2014 reached a Mars orbit. Thus, India is the first country to have successfully place it spaceship on a Mars orbit at first attempt.[25] At present, there are 58 Indian satellites on orbit, which places India 6th in the world in this respect. The Indian space economy is valuated at US$7 billion, which accounts for around 2% of the global space economy.[26] The Indian government adopted a decision on assistance of the state space sector to private companies and their close cooperation with ISRO. This was recognised as a significant step in Indian politics towards entering the elite group of space powers.

On the other hand Japan not only considerably increases its defence spending, but also considers joining the American lunar programme planning *inter alia* to build a structure on the Moon.

Conclusion

Space mining still remain a hypothetical branch of global economy. Nevertheless, the growth of Earth's population and depletion of local raw materials justifies looking for a solution of these issues in the outer space. At the same time, space mining may contribute to development of traditional mining

[24] Pugliese (2019).
[25] Alberti (2018): 9–40.
[26] Patkowska (2019).

techniques thanks to utilisation of new space technologies on Earth.

The existing international space law regime not only fails to provide economic incentives for space investors, but also arouses uncertainties as regards ownership rights to extracted resources. The possibility of appropriating a part of outer space and thus exercising certain forms of ownership there may result in international tensions and lead to conflicts between the entities involved. On the other hand, should the ban on appropriation of outer space be lifted, states and private entities would start a competition aimed at acquiring an ownership title to potentially most valuable parts of celestial bodies. Because of the absence of any regulatory mechanism or authority, the richest states and the largest global corporations would be beneficiaries of this process. As a result of recent adoption by the US and Luxembourg of internal laws concerning admissibility of conducting extraction operation on the Moon and other celestial bodies the subject of space mining ceased to be purely theoretical and has become a real challenge for the international community. Hence, future development of space mining requires adjustment of national laws to the requirements of international space law, which in turn requires reasonable changes. Neglecting this may lead to conflicts between states as regards access to raw materials from celestial bodies. Moreover, an international agreement may protect the world market against the threat caused by the rapid growth of supply of scarce minerals and uncontrolled decline of prices.

So far, however, the activities of the Legal Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space have failed to bring about any results. Notwithstanding the above, one may hope that in the near future

certain states (among other the USA) in their own interest will agree for elaboration and adoption of new international law regulating space mining operations. An example may be a number of existing international agreement, including the Antarctic Treaty and geostationary orbit agreements, and those which pending, e.g. on sea bottom.

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