REGULATION OF SAFETY OF SPACE MINING AND ITS IMPLICATIONS FOR SPACE SAFETY(*)

Ram S. Jakhu[(1)] and Joseph N. Pelton[(2)]

[(1)] Associate Professor, Institute of Air and Space Law, McGill University, Montreal, Canada.
[(2)] Executive Board, IAASS & former Dean International Space University.

1. INTRODUCTION

The practical uses of satellites has grown over the past half century. Such use was demonstrated with the deployment of telecommunications satellites, which now include broadcasting satellites, mobile communications satellites, search and rescue, and data relay satellites. Shortly after the first communications satellites were deployed and proved to be commercially viable other applications quickly followed. Next came, remote sensing satellites, weather satellites, and then navigation and timing satellites. Nor has this chain of space development come close to ending.

We may soon have operational systems for robotic repair and refueling of satellites, solar power satellites, as well as increasingly sophisticated satellites for various types of defense and security operations. But something entirely new is also now on the horizon for space applications and instead of operation in Earth orbits these systems may seek to operate in deep space. The next major commercial space application may redefine the future of space activities to include major off world activities. This new activity would constitute a serious attempt to reclaim natural resources from space, or quite simply, to engage in space mining. Some of those engaged in this activity also envision processing of materials in space and even space manufacturing. Such deep space operations may not only involve a new range of deep space technologies, smart robotics, autonomous operations, independently operated power supplies and space systems, but also completely new challenges in terms of space safety systems as well as new types of standards and approaches to space safety for deep space operations, where immediate Earth-based response systems may simply not be available.

There are at least four "space mining" companies that are seeking to implement space mining explorations and develop the deep space tools needed to undertake such future operations. This suggests that space mining is no longer an issue for the longer-term future, but a real for today's regulators. Deep Space Industries (DSI), Moon Express, Planetary Resources Inc., and Shackleton Energy Corporation - each with a different set of strategic plans - are primarily focused on developing the key technologies and developing target locations for their future operations. Yet each of these entities - all with a U.S. base of operations - also recognize that there are regulatory issues and safety standards questions that also must be addressed. This is why they actively supported new U.S. legislation that has sought to define the process whereby space mining might be undertaken and the development of a new U.S. law that would define how space mining might be conducted. This initiative at the national regulatory level to create new national law to cover future space-based mining operations as well as possible space-based processing and manufacturing have now started to come forward as one possible means to cope with the "regulatory gap" that has now started to become apparent. However, national space mining operations must also be conducted in accordance with the provisions of the currently applicable UN space treaties.

2. ADEQUACY OF INTERNATIONAL TREATIES ON SPACE FOR NEEDS RELATED TO SPACE MINING?

In addition to the regulatory system created by the Outer Space Treaty,[1] four other associated international treaties,[2] provide good governance foundation, but would also prove inadequate, to providing for an effective international safety regulatory environment and "rules of the road" that are fully responsive to the needs related to space mining operations. Particularly from the perspective of responsibility for safety in space mining, there are two issues that need to be addressed. Firstly, who is entitled to exploit space resources and secondly what and by whom space safety standards and procedures should be adopted and implemented?

Under international space law, all States are free to explore and use outer space, including the moon and other

(*) For a detailed discussion on this subject, see Ram S. Jakhu and Joseph N. Pelton, *Space Mining and its Regulation* (2016) New York, Springer Press.

celestial bodies, without discrimination of any kind, on a basis of equality and in accordance with international law.[3] Such freedom covers exploitation of space resources but does not extend to non-governmental entities (private corporations), which must carry out their space activities only pursuant to "authorization and continuing supervision" by their respective States. Therefore, States decide who, within their jurisdictions, should be allowed to carry out space mining operations and under what terms and conditions. Some of the standard conditions that are generally imposed are the requirements for compliance by the licensees with: (a) the international obligations of the respective States and their national security or foreign policy interests and (b) the safety standards as determined by the concerned States. Safety standards are imposed to protect public health and safety, and safety of property, or to implement international obligations. Moreover, imposition of safety standards is generally accompanied with the requirement of procurement of liability insurance to cover claims against government property damage and third party death, bodily injury, or property damage. Internationally, it is the launching State[4] that is liable for damage caused by space object of its private licensees, irrespective of the fact that the damage occurred in air space or in outer space, on the moon and other celestial bodies, including asteroids.[5]

States may undertake space mining operations on their own, allow their private companies to carry out such activities or participate in the space mining operations of international organization(s). However, in latter case the responsibility for adoption of and compliance with safety standards would be borne both by the international organization(s) and by the States participating in such organization(s).[6] Similarly, if two or more States jointly undertake space mining activities,[7] each State will be expected to adopt and impose space mining safety standards and procedures. Moreover, in order to avoid accidents, damage to property, death of and injury to humans, Earth and space environment damage, it would be imperative to adopt and implement complementary national and international space mining safety standards and procedures. Currently, there are no international safety standards and procedures for space mining.

3. THE U.S. SPACE RESOURCE EXPLORATION AND UTILIZATION ACT OF 2015 (SREU).

On 25th November 2015, the U.S. President Barack Obama signed the "Space Resource Exploration and Utilization Act of 2015" which is Title IV of the U.S. Commercial Space Launch Competitiveness Act (Space Act of 2015).[8] The Space Act of 2015 contains four formal parts designed to: (i) promote commercial space transportation and provide increased indemnification for space flight participants; (ii) deal with commercial remote sensing statutory particularly the updating of licensing of private remote sensing space systems; (iii) cover issues such as reporting requirements to Congress, the creation of a new Office of Space Commerce, and guidance to four key Departments of the US Government in the Space Arena namely Dept. of Defense, Dept. of Transportation, NASA, and the Department of Commerce; and (iv) address the legislative issues related to space mining (i.e. SREU Act).

The overall broad purpose of the new legislation is essentially to promote new space commercial transportation systems as well as "promote the right of United States citizens to engage in commercial exploration for and commercial recovery of space resources free from harmful interference, in accordance with the international obligations of the United States and subject to authorization and continuing supervision by the Federal Government."[9]

This national legislation, which is the first of its kind in the world, expresses the right of the U.S. government to "entitle an American company to possess, own, transport, use, and sell the space resources obtained through its commercial undertakings".[10] This legislative initiative has attracted unprecedented appreciation, primarily from the American private space sector, but has also aroused concerns[11] about the potential violation of the U.S. international obligations as well as possible safety risks such operations might pose.

It should be noted that the above-mentioned right of the private companies shall be granted only "in accordance with applicable law, including the international obligations of the United States."[12] This implies that there should be national law in the U.S. under which licenses for space mining can be issued. At present, no such law exists, though it has recently been reported that Rep. Jim Bridenstine (R-OK), is drafting a legislation "regarding property rights to resources mined from asteroids by U.S. companies."[13] Secondly, there is no clear official statement on the U.S. international obligations with respect to space mining. Thus one cannot determine precisely whether or not the SREU Act is in violation of the international obligations of the U.S. Such proclamation may be spelled out in a Report which the U.S. President is required and expected to submit to the U.S. Congress within 180 days of the adoption of the SREU Act; i.e. from 25 November 2015.[14] Though the U.S. is obliged to interpret and comply with its treaty obligations in good faith,[15] merely having a national law which is inconsistent with such obligation is not a violation of its international obligations. According to Ian Brownlie, "a breach

[of an international obligation] arises only when the State concerned fails to observe its obligations on a specific occasion."[16] Therefore, if and when properly licensed U.S. private companies are engaged in space mining, which is determined to be contrary to the provisions of applicable international treaties, only then the U.S. would be considered in breach of its international obligations.

Article II of the Outer Space Treaty declares that "Outer space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means." This prohibition is considered to be strict and comprehensive covering appropriation by States, public and private companies and individuals. It is well known that the U.S. has been of the opinion that in accordance with this Article no State or individual or private company can validly claim sovereignty over or ownership of outer space and any celestial body, including asteroids. However, with respect to the ownership of natural resources of celestial bodies, there has been two different views internationally. The U.S. appears to be of the opinion that the legal status of natural resources of celestial bodies is different from that of their surfaces, thus natural resources can be appropriated. This is reflected, at least impliedly, by the provisions of the newly adopted SREU Act of 2015. On the other hand, several States and legal scholars have been expressing that Article II prohibits both the surfaces and the natural resources of all celestial bodies, including the moon and asteroids. The latter opinion appears to be more logical when one reads the provisions of the Outer Space Treaty by using established rules of treaty interpretations.[17] In this regard, Lyall and Larsen express more respective and well-established view:

> It is argued that the terms of Art. II of the [Outer Space Treat] prohibit only claims by states, therefore leaving open the possibility of a claim by an individual, and that such a claim creates a title which can then be passed on to a purchaser. We disagree. A valid right of property to immoveable estate can exist only with a legal system established by a state and in relation to property over which the state has sovereignty. Since state claims to sovereignty in space cannot exist, neither can title to immoveable property on celestial bodies in space.[18]

Moreover, the intention of the Outer Space Treaty is undoubtedly to expand the benefits of all forms of space exploration and utilization. Therefore, when Article II is interpreted in the light of other provisions of the Treaty, it becomes clear that prohibition of appropriation is necessary to allow the conduct of "exploration and use of outer space, including the moon and other celestial bodies……. for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development."[19] The Treaty establishes 'balance of interests' of all States. At the time of ratifying the Outer Space Treaty, the U.S. did not deny the requirement of sharing of space benefits, though it reserved the right to how to share these benefits.[20] Briefly, inclusive interests of States should prevail over the exclusive interests of some States and their respective private companies.

However, it can be said that currently there exists some ambiguity on the question of ownership of the resources extracted during space mining. The future of smooth and controversy-free conduct of space mining operations will depend upon a satisfactory answer to this question: What are potentially positive global benefits space mining that might be derived and equitably shared through future regulation?

One option to address the issue of uniform international regulatory system for space mining could be that all States should ratify by the Moon Agreement, which provides for phased development of global governance system as exploration and exploitation progress, allows expressly some appropriation of extracted natural resources, attempts to prevent celestial bodies from becoming an area of international conflict, expands the provisions for exploration and exploitation of celestial bodies exclusively for peaceful purposes, establishes the rule for help during emergency for humanitarian purposes, envisions equitable sharing of benefits derived from space natural resources, etc. The second option may be, though not exclusive of the first option, to create an international public-private consortium modelled on the original INTELSAT. For this purpose, the U.S. may adopt a national law, similar to the COMSAT Act of 1963, inviting other States to join such organisation. The U.S. private companies possessing significant financial and technological resources would be able to play dominant role in the development of the required technologies, organizational structure and business operations, safety standards and procedures, and to reap substantial benefits from space mining. It is believed that this approach will help eliminating, or at least minimizing international political tensions that are arising due to the adoption of the SREU Act of 2015, which is perceived to be a unilateral attempt to appropriate the celestial bodies.

The SREU Act of 2015 introduces an important distinction between 'asteroid resource' and 'space resource'. While the term 'asteroid resource' means a space resource found on or within a single asteroid, the term 'space resource' on the other hand means an abiotic resource in situ in outer space, including water and minerals.[21]

Their status is not fully spelled out in the Act. It should be noted that under the international space treaties there is no clear definition of "celestial bodies" and the Moon is undoubtedly a celestial body. The question is whether asteroids are celestial bodies, and if yes, what size, weight and nature of asteroids or meteorite will be used to determine their legal status. Tons of "star dust" falls to Earth every week and there are billions of asteroids, bolides, meteorites, micrometeorites. No one knows at what level something becomes a "celestial body". In other words, the definitions used in the SREU Act of 2015 need to be assessed with their compatibility with those in the international space treaties, particularly the Outer Space Treaty.

Irrespective of the fact that billions (or even trillions) of dollars can be earned in profits and the right of States and their private companies to own space natural resources can be guaranteed, the success of space mining operations will heavily depend upon the formulation, adoption and implementation of safety standards and procedures for initiating and pursuing such operations. For this purpose, the most important questions need to be addressed include: What would the major safety risks in space mining, who and how should safety standards and procedures be formulated and implemented? What would be the legal consequences for non-compliance with such standards and procedures?

4. TECHNICAL CHALLENGES TO SPACE MINING AND SAFETY STANDARDS

The essential elements for space mining operations include robotic systems that can carry out the mining operations, a sustaining power source that can allow the robotic systems to operate, the sensing ability to locate valuable ores, water or minerals on the Moon or asteroids for possible recovery, transportation systems to and from the sites for the mining operations and to extract and process space resources without damaging the space and earth environment. The first stage to launching a credible effort to engage in space mining is to design, build and deploy surveyor probes that can go out at very low cost to identify likely sources for space mining and to create low cost transportation systems to support this effort. It is possible that in the future 3D printing systems equipped with the right "smart" software, robotic capabilities and raw materials could implement the infrastructure for an entirely functional space colony or other sophisticated tasks. For the nearer term space mining activities, advanced survey and prospecting, low cost commercial transportation systems, robotic mining systems, and self-sustaining power systems represent the true core technologies.

Clearly space mining to be successful must not only take on a wide range of technical challenges and find new solutions but along the way work with safety experts and standards organizations (both national and international) to ensure that both automated systems and human crewed transportation systems and habitats are provided at the highest level of safety. There are, unfortunately many different types of systems, each with their own unique technical, operational and safety challenges and safety. Some of these systems include:

(a) Continuity and sustainability of remote electrical power systems,
(b) Low cost and reliable deep space transportation systems,
(c) Reliable and precision low thrust maneuverability jets,
(d) Remote robotically-controlled drilling and excavation equipment that can be operated with reliably in deep space,
(e) Informational technologies, networking, and telecommunications systems that are "smart", efficient, and constantly sustainable, and
(f) Virtually all of these systems will also require a high degree of artificial intelligence, particularly if these systems are to operate remotely without human astronauts and at sufficiently great distances that tele-robotic systems are infeasible.

What is urgently needed is to adopt safety standards and procedures for extracting, processing, storing and using space natural resources on the celestial bodies, including asteroids, for orderly, safe and sustainable development of such resources. The nature of the technical challenges significantly increase if there are astronauts and remote human technical experts involved in the space mining operations. The additional requirements would include such features and life support systems for not only oxygen and water supply, but the even greater challenge of food and other expendables that humans expect in the course of their daily lives. The ability to create off world growing of nourishment and material processing to create sophisticated products such as television sets, furniture, and other items for a remote habitat is clearly some years away. Thus it is likely that the first decades of space mining and material processing would be based on automated systems. In time, however, there could develop capabilities for remote space colonies that can sustain human life.

5. CONCLUSIONS

With well-funded projects and full determination private companies can be expected to develop necessary technologies and infrastructures required for space mining.

However, the success of their operations will depend upon appropriate and timely determination of solutions to the following issues:

(a) What are potentially positive global benefits space mining that might be derived and equitably shared through future regulation?

(b) What would the major safety risks in space mining, who and how should safety standards and procedures be formulated and implemented?

(c) What would be the legal consequences for non-compliance with such standards and procedures?

The adoption of national laws, like the U.S. SREU Act of 2015, are the first important steps for initiating governance system as they provide national regulatory basis for licensing process and continuous supervision of, and for imposition of safety standards and procedures upon, the space mining activities of private companies. However, the challenge will be to implement these laws in such a way that would not breach international obligations of the concerned States. Since space mining operations will be taking place in international environment of outer space or on celestial bodies (including asteroids), it would seem logical that safety standards and procedures be international and comprehensive in nature and scope so that all interests of countries (space faring and non-space faring) remain protected. It would also be prudent for these standards and procedures to use common metrics and interfaces so that rescue or repair operations could be more easily achieved. This is perhaps an areas where the IAASS could play a constructive future role.

6. REFERENCES

1. *The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies*, 27 January 1967, 610 UNTS 205, 18 UST 2410, TIAS No 6347, 6 ILM 386 (entered into force on 10 October 1967) [*Outer Space Treaty*] (as of 4 April 2016, there are 104 ratifications and 25 signatures).

2. The *Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space* [*Rescue and Return Agreement*], adopted by the General Assembly in its resolution 2345 (XXII), opened for signature on 22 April 1968, entered into force on 3 December 1968, there are 94 ratifications, 24 signatures, and 2 acceptance of rights and obligations (as of 4 April 2016); the *Convention on International Liability for Damage Caused by Space Objects*, 29 March 1972, 961 UNTS 187, 24 UST 2389, 10 ILM 965 (1971) (entered into force 1 September 1972) [*Liability Convention*] (as of 4 April 2016, there are 92 ratifications, 21 signatures, and 3 acceptances of rights and obligations); the *Convention on Registration of Objects Launched into Outer Space* [*Registration Convention*], adopted by the General Assembly in its resolution 3235 (XXIX), opened for signature on 14 January 1975, entered into force on 15 September 1976, there are 62 ratifications, 4 signatures, and 3 acceptances of rights and obligations (as of 4 April 2016); the *Agreement governing the Activities of States on the Moon and Other Celestial Bodies*, 5 December 1979, 1363 UNTS 3 (entered into force 11 July 1984) [*Moon Agreement*] (as of 4 April 2016, there are 16 ratifications and 4 signatures).

3. Outer Space Treaty, article I, para 2.

4. I.e. the State that launches or procures the launching of an object into outer space, including the moon and other celestial bodies, and each State from whose territory or facility an object is launched. The State whose private company launches or procures a launch will be considered a launching State.

5. Outer Space Treaty, article VII; Liability Convention articles II and III.

6. Outer Space Treaty, article VI.

7. It is recently reported that the "Luxembourg Government will work with Deep Space Industries [from the U.S.]..… to develop the technology needed to mine asteroids and build a supply chain of valuable resources in space." See "Prospector-X™: An International Mission to Test Technologies for Asteroid Mining," online Deep Space Industries at: https://deepspaceindustries.com/prospector-x-an-international-mission-to-test-technologies-for-asteroid-mining/

8. 51 USC § 513 (2015).

9. 51 USC § 51302 (3).

10. 51 USC § 51303.

11. Marcia S. Smith, "Bridenstine Drafting Legislation to Implement CSLCA Asteroid Mining Provision," 7 May 2016, Spacepolicyonline at: http://www.spacepolicyonline.com/news/bridenstine-drafting-legislation-to-implement-cslca-asteroid-mining-provision

12. 51 USC § 51303.

13. Marcia S. Smith, "Bridenstine Drafting Legislation to Implement CSLCA Asteroid Mining Provision," 7 May 2016, Spacepolicyonline at: http://www.spacepolicyonline.com/news/bridenstine-drafting-legislation-to-implement-cslca-asteroid-mining-provision

14. 51 USC § 51302 (b) stipulates that: "Not later than 180 days after the date of enactment of this section, the President shall submit to Congress a report on commercial exploration for and commercial recovery of space resources by United States citizens that specifies (1) the authorities necessary to meet the international obligations of the United States, including authorization and continuing supervision by the Federal Government; and (2) recommendations for the allocation of responsibilities among Federal agencies for the activities described in paragraph (1)."

15. V*ienna Convention on the Law of Treaties*, 23 May 1969, 1155 UNTS 31, articles 26 and 31.

16. Ian Brownlie, *Principles of Public International Law*, Oxford: Oxford University Press, (2003), p. 35.

17. *Vienna Convention on the Law of Treaties*, 23 May 1969, 1155 UNTS 31, articles 31 and 32.

18. Francis Lyall and Paul B. Larsen, *Space Law: A Treatise*, (2009) at 184-185.

19. Outer Space treaty, article I, para 1.

20. When expressing its advise and consent to ratification of the Outer Space Treaty by the U.S, the U.S. Senate attached some understandings of the provisions of the Treaty, one of which related to Article I, which provided that: "It is the understanding of the Committee on Foreign Relations that nothing in article I, paragraph 1 of the treaty diminishes or alters the right of the United States to determine how it shares the benefits and results of its space activities." U.S., Senate Committee On Foreign Relations, 90th Cong, 1st Session, *Treaty on Outer Space* (S Exec Rep No 8) (18 April 1967), p.4.

21. 51 USC § 51301.