

Space Debris Remediation on the Surface of Moon and Its Orbits

Alexander Solntsev and Irina Chernykh***

Abstract

In the XXI century, numerous States announced their plans to participate in the lunar race. The USA adopted the Artemis Program, China made public its Chinese Lunar Exploration Program with the participation of Russia and building together the International Lunar Research Station. All these programs are expected to include not only exploration purposes, but active use and utilization of the Moon and its orbits. However, the increase in lunar activities, as well as any activities, are suggested the creation of different physical debris (e.g., building materials, machinery, vehicles, general rubbish) plus chemical contaminants. Today problems with debris on the surface of the Earth and with space debris in the near-space have already been challenges for the whole of humanity. Therefore, the purpose of this paper will be to analyze different legal acts and mechanisms which can be used for the remediation of space debris on and around the Moon.

1. Introduction

In recent years, there has been an increase in different lunar activities: some States decided to organize some special lunar missions to Selena, some adopted national programs. E.g. the USA announced the mission 'Artemis' in 2017, which aiming at exploration, utilization, and exploitation of the Moon and lunar surface to receive new knowledge and economic benefit, as well as to inspire new generations. Chinese lunar program has been made public in 2004 and includes 4 phases covering orbital missions, soft-landing on the Moon and deploying lunar rovers, a lunar sample-return mission, and development of an autonomous lunar research station near the Moon's south pole. Russian draft concept of the lunar program was suggested in 2014-2015 and adopted in 2018 and has exploration purposes. China made public its Chinese Lunar Exploration Program with the participation of Russia and building together the International Lunar Research Station. India has

* Department of International Law, Peoples' Friendship University of Russia named after Patrice Lumumba (RUDN University).

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Chandrayaan programme, within this program on August 23, 2023, the Chandrayaan-3 spacecraft landed on the lunar surface.

All these programs are expected to include not only exploration purposes, but active use and utilization of the Moon and its orbits.

On October 1, 2023, under the UN Space Object Register, 1 space object in the Moon L2 Lagrange point (China), and 57 space objects have been on the lunar surface since 1959. However, the increase in lunar activities, as well as any activities, are suggested the creation of different physical debris and waste (e.g., building materials, machinery, vehicles, general rubbish) plus chemical contaminants.

Today problems with debris on the surface of the Earth and with space debris in the near-space have already been challenges for the whole of humanity. The lunar environment consists of but is not limited to the lunar surface and subsurface, including mountains and craters, rocks and boulders, regolith, dust, minerals, gasses, water, ice, boundary exosphere, and surrounding lunar orbits. Therefore, before we begin to increase the anthropogenic activity on the Moon and conduct active lunar activities, strict rules for sustainable lunar activities should be developed. These rules should cover both the attitude with space debris and the handling of all types of wastes on the surface of the Moon. Special rules should apply to environmental standards when mining minerals on the Moon.

2. Main Part

2.1. Definition of Space Debris in International Law and International Space Law

In the process of lunar activity, waste will be formed. Moreover, it should be noted that there are different types of waste.

States shall promote the effective control of all sources of pollution of the lunar environment, and pledge themselves especially to take all practicable steps to prevent the pollution of the Moon by the waste and other matter that is liable to create hazards to human health.

There is no general term ‘waste’ in international law,¹ as no universal convention about waste. In relation to various international legal regimes, different terms are applied: ‘hazardous waste’,² several law of the sea

1 See e.g.: N. Jones and G. van Calster, ‘Waste Regulation’, in: E. Lees, J. Viñuales (Eds), *The Oxford Handbook of Comparative Environmental Law*, OUP, 2019, pp. 607–625; A. Gillespie, *Waste Policy: International Regulation, Comparative and Contextual Perspectives*, Edward Elgar, Cheltenham, 2015, 230 p.

2 Bamako Convention on the Ban of the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes within Africa (adopted 30 January 1991); Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (adopted 22 March 1989).

conventions use the term “waste” towards all sources of pollution of the marine environment,³ International Atomic Energy Agency documents talk about ‘radioactive waste’.⁴

During lunar activity there will be space debris, radioactive materials, hazardous waste and waste generated in the process of economic activity. Moreover, the immediate plans for lunar activity include an increase in anthropogenic load: mining and construction of lunar bases. With such high economic activity, in order to preserve the lunar environment, interstate regulation of the activities of legal entities and individuals on the Moon is certainly required. It is necessary to decide, from the point of view of the possibility of disposal and danger to humans, which substances can or cannot be transported to the Moon.

International law identifies four global commons, namely the High Seas and Area (seabed beyond the national continental shelf), the Atmosphere, the Antarctica, and the outer space. International acts adopted to regulate activities in *Antarctica* and at the *Area*⁵ can be cited as best practice in our case. In these internationalized areas, separate international legal regimes have been developed, which include both mandatory norms of international treaties and a list of soft law.

2.2. Objective Obstacles to the Implementation of Lunar Sustainability

It should be noted that the international legal regime for the preservation of tangible and intangible world heritage objects on the Moon is currently being discussed. It seems that such an international legal regime for the preservation of cultural property on the Moon will further contribute to the protection of the lunar environment. On the one hand, this is positive, since there will be more places on the Moon that are protected from pollution since the object itself and a certain area around it are supposed to be protected. On the other hand, there are more and more such cultural objects every year. Objects, being essentially space debris, acquire a protective status, remaining under the protection of national and international law.

Another problem is the increased burial of ashes on the Moon. In 1998, the first human burial site appeared on the Moon. The grave at the south pole of our satellite was a metal urn containing the ashes of planetary scientist

3 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention) (adopted 29 December 1972).

4 IAEA Code of Practice on the Transboundary Movement of Radioactive Waste (1990).

5 Under the 1982 United Nations Law of the Sea Treaty, this is defined as being the ocean floor and its subsoil beyond the limits of national jurisdiction. Thus, it constitutes that area beneath the oceans that does not come within any of the coastal zones. The resources within such an area are the common heritage of mankind. Under the Treaty an organization nominated the International Seabed Authority will control deep seabed mining in the area.

Eugene Shoemaker. Now there are more and more capsules with ashes,⁶ missions to the Moon are proposed by both Elysium Space and Celestis as part of a mission by Astrobotic Technology of Pittsburgh. Moreover, in 2014, Celestis launched Celestis Pets, a pet memorial spaceflight service for animal cremated remains.⁷ What legal status will capsule with ashes have on the Moon?

The third problem is caused by the lack of strict requirements for registration of space objects. In the absence of normal statistics, it is difficult to say how much space debris is actually on the surface of the Moon.

All three of these problems are serious challenges to the establishment of an international legal regime for lunar stability.

2.3. International Legal Basis

Vigorous lunar activity puts in perspective the issues of space debris remediation. The Outer Space Treaties do not regulate this problem directly. However, some important provisions of such treaties can be highlighted.

The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies of 1967 (hereinafter – the Outer Space Treaty) stipulates in Art. 1 para. 1 that “the exploration and use of outer space, including the Moon and other celestial bodies, shall be carried out *for the benefit and in the interests of all countries*.” It proclaims equal opportunities for all States and underline the common benefit principle.⁸ To perform space activities for the benefit and in the interests of all countries, it is worth to interpret this phrase, taking into account other articles of the Outer Space Treaty.

Art. III of the Outer Space Treaty enshrines that space activities should be carried on “*in accordance with international law* (1), including the Charter of the United Nations, *in the interest of maintaining international peace and security*... (2)”. Therefore Art. III gives an opportunity to go beyond its provisions and in some issues to apply provisions of other branches of international law, including international environmental law and international sea law. Wording “in accordance with international law” of Art. III is a link between international space law and other elements of the system of international law also, considering “the interest of *maintaining international peace and security*” it is appropriately to single out environmental security along with other types of international security as the

6 H. Pettit, the Sun, NASA sending human remains to the moon in summer 2021, <https://nypost.com/2020/11/18/nasa-sending-human-remains-to-the-moon-summer-2021/> (accessed 01.08.2023).

7 Commemorate Your Pet on a Celestis Memorial Spaceflight, <https://www.celestis.com/blog/celestis-pets/> (accessed 01.08.2023).

8 S. Hobe, Article I, in: S. Hobe, B. Schmidt-Tedd, K-U Schrogl (Eds.), Cologne Commentary on Space Law Volume I, BWV Berliner Wissenschafts-Verlag, 2009, para. 10. Para 50.

concept of international security includes many types: military, political, human, food, information and other types of security.

So, in the context of prevention and mitigation of the new space debris and remediation of the current space debris on the lunar surface and Moon orbits it is important to think about environmental safety and sustainability of lunar activities.

The next article of the Outer Space Treaty dealing with lunar activities and remediation of space debris is Art. VI, which stipulates

Responsibility of States for national activities in outer space, including the Moon and other celestial bodies, whether such activities are carried on by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty.

States should authorize and supervise national space activities and look after how space entities fulfil their obligations under national space law and policy. It is mentioned that today States strive to implement at the national level principles and recommendations adopted by the UN COPUOS on different aspects of specific space applications taking into account a problem of space debris.

Art. VII is being interested in the context of liability for potential damage by space debris to functional space objects in lunar orbits or lunar surface. It states that:

Each State Party to the Treaty that launches or procures the launching of an object *into outer space, including the Moon* and other celestial bodies, and each State Party from whose territory or facility an object is launched, *is internationally liable for damage* to another State Party to the Treaty or to its natural or juridical persons *by such object or its component parts* on the Earth, in air space or *in outer space, including the Moon* and other celestial bodies.

Convention on International Liability for Damage Caused by Space Objects of 1972 (hereinafter – Liability Convention) expands the provision enshrined in Art. VI of the Outer Space Treaty. In Art. III of the Liability Convention is said that

In the event of damage being caused elsewhere than on the surface of the Earth to a space object of one launching State or to persons or property on board such a space object by a space object of another launching State, the latter shall be liable only if the damage is due to its fault or the fault of persons for whom it is responsible.

Art. IX of the Outer Space Treaty is of the most interest articles both to prevent space debris and to remediate it.

It singles out principles for the exploration and use of the Moon, which can be applied for tackling lunar space debris. It includes the principle of cooperation and mutual assistance, due regard principle (“*with due regard to the corresponding interests of all other States Parties to the Treaty*”), as well as provision about avoidance of harmful contamination of the Moon (“States Parties to the Treaty *shall pursue studies of outer space, including the Moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination*”).

In the question of lunar space debris remediation, the provisions of the Convention on Registration of Objects Launched into Outer Space of 1975 (hereinafter – the Registration Convention) will be applied to determine responsible State of register for a space object, which is not functional (space debris). This provision should be applied in view of Art. VIII of the Outer Space Treaty stipulating jurisdiction and control over such object if a State Party to the Treaty registered it in the national registry.

The Agreement Governing the Activities of States on the Moon and Other Celestial Bodies of 1979 (hereinafter – the Moon Agreement) in spite the fact that few States accessed to it has interesting provisions too:

Art. 4 of the Moon Agreement underlines the principle that:

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

At the same time, it singles out that “*due regard shall be paid to the interests of present and future generations*”.

Art. 7 stipulates provisions dedicated to the the disruption of the existing balance of lunar environment. Issues of space debris are not underlined but wording “through the introduction of extra-environmental matter *or otherwise*” gives an opportunity to broader interpretation, suggesting that the disruption of the existing balance of its environment could be due to pollution of the Moon, because of lack remediations rules on its surface and orbits.

Except of international treaties, some non-binding documents prepared by the UN COPUOS or by some international non-governmental organizations and intergovernmental agreements also contain rules aiming at the resolving space debris problem. These documents are more detailed in comparison with provisions of the Outer Space Treaty, which is silent about remediation of space debris as well as space debris problem in general.

The Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space of 2007 deals with appropriate debris mitigation

measures as “a prudent and necessary step towards preserving the outer space environment for future generations” (Background). The document consists of two parts: measures that curtail the generation of potentially harmful space debris in the near term and those that limit their generation over the longer term. From the point of remediation view the second type of measures is interesting considering that “concerns end-of-life procedures that remove decommissioned spacecraft and launch vehicle orbital stages from regions populated by operational spacecraft.” The document suggests 7 non-binding principles, each of them could be applied to the disposal phase of a space object from lunar orbits. At the same time the document does not single out lunar orbits as a potentially polluted place of outer space. It underlines a problem of growing population of space debris as it is.

The Guidelines for the Long-term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space of 2019 has several guidelines aiming in general at some actions to mitigate and remediate future space debris. These guidelines are: Guideline B.3 “Promote the collection, sharing and dissemination of space debris monitoring information”, Guideline B.6 “Share operational space weather data and forecasts”, Guideline B.7 “Develop space weather models and tools and collect established practices on the mitigation of space weather effects”, Guideline B.8 “Design and operation of space objects regardless of their physical and operational characteristics”, Guideline C.4 “Raise awareness of space activities”, and Guideline D.2 “Investigate and consider new measures to manage the space debris population in the long term”.

The mentioned documents can be realized only at the national level through their implementation.

Recommended Framework and Key Elements for Peaceful and Sustainable Lunar Activities drafted by the GEGSLA (MVA) contains Chapter 6 “Safe Operations and Lunar Environmental Protection”. Moreover, this document is interesting from the point of terminology view. It contains a definition of the lunar environment, and environmental sustainability.

Part “Debris Mitigation & Environmental Sustainability” of Chapter 6 has detailed recommendations on the whole aspects of space debris problematic:

Defining environmental sustainability this part suggests direct actions which lunar stakeholders (not States) may fulfill:

- to design space systems in such a way as to minimize the release of space debris as much as possible;
- to limit the probability of accidental collision in orbit of /to or on the Moon;
- to use interoperability principles in constructing lunar infrastructure;

- to avoid the intentional destruction of space objects and assets and other harmful activities which may generate unreasonable and unnecessary space debris during normal operations within lunar orbits or on the lunar surface;
- to minimize the risk of post-mission breakups, including those resulting from stored energy in their lunar activities;
- to adopt appropriate measures, where necessary, and follow due regard and other principles under international law to prevent environmental harm to the Moon and to lunar orbits;
- Also, States and lunar stakeholders on the basis of up-to-date scientific research in line with any relevant COSPAR requirements prior to authorizing and/or conducting lunar activities, may:
 - conduct and present an analysis of the environmental impact to determine any environmental harm of the lunar activities;
 - plan for remediation or mitigation as appropriate, and provide proper notification of those activities;
 - request consultations with all interested stakeholders if the lunar activities may cause potentially harmful contamination to the Moon and lunar orbits.

Finally, this part enshrines recommendation to monitor lunar activities: “States and international organizations should monitor any harmful impacts to the Moon and lunar orbits resulting from lunar activities for which they are responsible to the greatest extent feasible and practicable.”

And “if a harmful impact resulting from a lunar activity is discovered or is reasonably expected to occur, the responsible States or lunar stakeholders should implement appropriate measures to respond to such harmful impact and consider whether the lunar activity should be adjusted or terminated.”

It should be noted that these recommendations were based on the extensive legal framework, including on provisions of the Outer Space Treaty and of the Moon Agreement, which have been reformulated in the manner of direct recommendation as a guide for action in a particular situation for the lunar stakeholders.

2020 Artemis Accords has section 12 dedicated to orbital debris. It reads as follows:

1. The Signatories commit to plan for *the mitigation of orbital debris*, including the safe, timely, and efficient *passivation* and *disposal of spacecraft at the end of their missions*, when appropriate, as part of their mission planning process. In the case of cooperative missions, such plans should explicitly include which Signatory has the primary responsibility for the end-of-mission planning and implementation.

2. The Signatories commit to limit, to the extent practicable, the generation of new, long-lived harmful debris released through normal operations, *break-up in operational or post-mission phases, and accidents and conjunctions*, by taking appropriate measures such as the selection of safe flight profiles and operational configurations *as well as post-mission disposal of space structures*.

This section separately pays attention to the different levels of mitigation that includes *passivation and disposal*.

2020 Artemis Accords and 2022 Recommended Framework and Key Elements for Peaceful and Sustainable Lunar Activities drafted by the GEGSLA (MVA) should be taken into account as they have been specially developed for the future lunar missions.

2.4. EIA within Lunar Activities

When designing lunar projects, it is important to take this into account and plan activities under the principle of environmental impact assessment (EIA). The Protocol on Environmental Protection to the Antarctic Treaty was signed 4 October 1991. Annex III to the Environment Protocol requires that:

The amount of wastes produced or disposed of in the Antarctic Treaty area shall be reduced as far as practicable so as to minimize impacts on the Antarctic environment and to minimize interference with the natural values of Antarctica, with the scientific research and with other uses of Antarctica which are consistent with the Antarctic Treaty (Art. 1.2).

The Annex identifies types of waste which have to be removed and establishes rules for the storage and disposal of waste. Some products like PCBs cannot be introduced into Antarctica at all. The Annex also provides for waste management planning and the removal of wastes of past activities. In 2013 the Antarctic Treaty Consultative Meeting adopted the *Clean-up Manual to assist* (latest version 2019) with addressing their obligations under Article 1(5) of Annex III to the Protocol.

If mining is prohibited in Antarctica until 2048 and, accordingly, there are no documents regulating compliance with environmental standards for mining, then active activity has been underway in the deep seabed area for a long time. So International Seabed Authority (hereinafter – ISA) adopted:

- Recommendations for the guidance of contractors for the assessment of the possible environmental impacts arising from exploration for marine minerals in the Area 2020;⁹

⁹ ISA Document ISBA/25/LTC/6/Rev.1 https://www.isa.org.jm/wp-content/uploads/2022/06/26ltc-6-rev1-en_0.pdf (accessed 01.08.2023).

- Draft regulations on exploitation of mineral resources in the Area 2019.¹⁰

These documents also regulated such problems as development of environmental standards; environmental management system; preparation of the environmental impact statement and the environmental management and monitoring plan, pollution control and management of waste, establishment of an Environmental Compensation Fund.

The International Seabed Authority has developed detailed and substantive provisions, regulations and recommendations related to the assessment of possible environmental impacts arising from exploration for marine minerals in the Area, which define the sort of activities that require environmental impact assessments (hereinafter – EIA), the form and content of such EIAs when required, as well as guidance on baseline studies, monitoring and reporting. The Recommendation 2020 addresses impacts on marine biodiversity on the seabed and in the water column above it. Draft regulations for the exploitation of mineral resources in the Area, including detailed and sophisticated provisions relating to EIAs. These regulations will be supplemented by a set of environmental standards and guidelines. It seems that these issues are extremely important to take into account when extracting mineral resources on the Moon, and this must be taken into account when developing the appropriate regulatory framework.

Environmental harm is an adverse effect, both present and future, on the lunar environment that is not trivial or negligible in nature, extent or context that hinders the use of the Moon for scientific and/or commercial purposes or for safe human habitation. Serious environmental harm is actual or potentially adverse effect that are irreversible, of high impact or widespread, or causes actual or potentially adverse effect to the environment of an area of high conservation value, scientific interest, or otherwise is of special significance. In the process of economic lunar activity, waste will be formed. Moreover, it should be noted that there are different types of waste. When designing lunar projects, it is important to take this into account and plan activities under the principle of EIA. To do it is necessary to develop universal Guidelines under the COPUOS's umbrella and discussion with the following bodies that have experience in the regulation of international territories: UNEP, Committee for Environmental Protection of the Antarctic Treaty System (2016 Revised Guidelines for Environmental Impact Assessment in Antarctica, 2019 Revised Clean-up Manual), International Seabed Authority (Recommendations for the guidance of contractors for the assessment of the possible environmental impacts arising from exploration for marine minerals in the Area, Draft regulations on exploitation of mineral resources in the Area).

10 ISA Doc. ISBA/25/C/WP.1 https://www.isa.org.jm/wp-content/uploads/2022/06/isba_25_c_wp1-e_0.pdf (accessed 01.08.2023).

3. Conclusions

After analyzing different legal acts and mechanisms which can be used for the remediation of space debris on and around the Moon, we could make the following conclusions and suggestions.

In order to curtail the generation of space debris on the lunar surface and in lunar orbits, it is recommended that space systems constructed for lunar activities to be designed to minimize the release of space debris to the greatest extent possible; stakeholders should limit the probability of accidental collision in orbit of /to or on the Moon. During normal operations within lunar orbits or on the lunar surface, stakeholders should avoid the intentional destruction of space objects and assets and other harmful activities which may generate unreasonable and unnecessary space debris. Stakeholders should minimize the risk of post-mission breakups, including those resulting from stored energy in their lunar activities.

It is necessary to maintain the conduct of space activities on and around the Moon indefinitely into the future in a manner that realizes the objectives of equitable access to and the benefits from 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. States shall prevent environmental harm to the Moon and to lunar orbits and use EIA to determine any environmental harm of the lunar activities. If a harmful impact resulting from a lunar activity is discovered or is reasonably expected to occur, the responsible States or lunar stakeholders should implement appropriate measures to respond to such harmful impact and consider whether the lunar activity should be adjusted or terminated.

Guidelines for activities on the Moon should be developed based on the principle of environmental sustainability. The *Guidelines* should detail the procedure for environmental impact assessment (EIA) and provide for the creation of an insurance fund to cover emergency situations.

To do it is necessary to develop it under the COPUOS's umbrella and discussion with the following bodies that have experience in the regulation of international territories: UNEP, Committee for Environmental Protection of the Antarctic Treaty System (2016 Revised Guidelines for Environmental Impact Assessment in Antarctica, 2019 Revised Clean-up Manual), International Seabed Authority (Recommendations for the guidance of contractors for the assessment of the possible environmental impacts arising from exploration for marine minerals in the Area, Draft regulations on exploitation of mineral resources in the Area).

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