LUNAR MISSIONS BY NEWER SPACE ACTORS IN THE NEXT FIVE YEARS: AN EVALUATION OF LEGAL ISSUES

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ABSTRACT

At present, we are witnessing a renewed interest in probing the Moon by the space powers and private entities. With this renewed interest, it is relevant to evaluate the legality of carrying out space activities in and around the Moon, including human settlement and mining, the legality of which are debatable. These operations will, in any case, require huge financial commitments, resources and technological expertise which only a few governments and even fewer private entities possess. However, there are several other lunar activities possible which may be exercised by governments of non-space power States and small to medium sized private space actors in near future, possibly within the next five years. This article examines the legal issues surrounding these possible smaller scale lunar activities including: (a) deploying satellites in lunar orbit; (b) providing cargo supplies to stations and installations on the Moon. Examination of the legal issues will involve learning lessons from space activities around the Earth's orbit and understanding the physical differences between the Moon and the Earth.

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I. INTRODUCTION

Human interest and endeavor in exploring the Moon are as old as the beginning of the space age. Whereas the first satellite around the Earth's orbit, the Sputnik, was launched in 1957, the first successful spacecraft to flyby the vicinity of the Moon was Luna 1 in 1959.[1] Soon thereafter, we witnessed humans landing on Moon with the Apollo 11 mission on July 20, 1969.[2] During the 1960s and 1970s, we saw a hiatus, especially with the end of the Cold War and a shift of budgetary preference from space exploration to other arenas in the United States (US). Now more 50 years since humans last walked on the Moon, there has been renewed interest in the exploration of the Moon. In December 2017, the President of the US called on the National Aeronautics and Space Administration (NASA) to lead a human return to the Moon and beyond with commercial and international partners.[3] The US Artemis Program plans to send humans again to the Moon by 2024.[4] The Artemis Accords, an agreement on principles for cooperation in space activities, has been signed by the US and more than 20 other countries.[5] China and Russia are working on an International Lunar Research Station mission and invite international partners to return to Moon via uncrewed and crewed missions.[6] United Arab Emirates (UAE), a new entrant in the space arena, which is rapidly expanding its space exploration potential, successfully deployed spacecraft around Mars orbit in 2021 and plans to transport a rover to the

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[1] NASA Space Science Data Coordinated Archive, NASA, https://nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=1959-012A.

[2] *Apollo 11, Mission Overview*, NASA https://www.nasa.gov/mission_pages/apollo/apollo-11.html.

[3] US Space Policy Directive-1, Reinvigorating America's Human Space Exploration Program, 82 Fed. Reg. 59501 (Dec. 11, 2017).

[4] NASA, Artemis Plan - NASA's Lunar Exploration Program Overview, NASA (Sept. 2020), https://www.nasa.gov/sites/default/files/atoms/files/artemis_plan-20200921.pdf [hereinafter Artemis Plan].

[5] The Artemis Accords: Principles for Cooperation in the Civil Exploration and Use of the Moon, Mars, Comets, and Asteroids, NASA, https://www.nasa.gov/specials/artemis-accords/img/Artemis-Accords-signed-13Oct2020.pdf (last visited Oct. 15, 2022) [hereinafter Artemis Accords].

[6] Andrew Jones, *China, Russia Reveal Roadmap for International Moon Base*, SPACENEWS (June 16, 2021), https://spacenews.com/china-russia-reveal-roadmap-for-international-moon-base/.

Moon in 2023 as payload on Japanese company, iSpace, mission.[7] The renewed interest of States to send crewed and uncrewed missions to explore the Moon, opens up avenues for the space industry in general.

With renewed interest in Moon exploration and exploitation, it is pertinent to examine the legality of and legal issues surrounding lunar space activities. This renewed interest in lunar activities is mostly motivated by ambitious plans of long-term exploration of the solar system beginning with the return of humans to the Moon, human settlement on the Moon and Mars,[8] mining the Moon's resources[9] and building a lunar economy.[10] However, whereas the permissibility of some of these large-scale operations under international law is in question,[11] renewed interest in Moon will also involve less controversial operations which will be lucrative to the private space industry and the scientific community. These operations include the deployment of satellites in lunar orbit and

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[7] Lisa Barrington and Alexander Cornwell, *UAE Partners With Japan's ispace to Send Rover to the Moon in 2022*, REUTERS (Apr. 14, 2021) https://www.reuters.com/world/middle-east/uae-partners-with-japans-ispace-send-rover-moon-2022-2021-04-14/#:~:text=DUBAI%2C%20April%2014%20(Reuters),business%20to%20diversify%20its%20economy.

[8] NASA, *NASA's Plan for Sustained Lunar Exploration and Development*, NASA https://www.nasa.gov/sites/default/files/atoms/files/a_sustained_lunar_presence_nspc_report4220final.pdf. *See* Michael Sheetz, *Elon Musk Wants SpaceX to Reach Mars so Humanity is not a "Single-planet Species,"* CNBC (Apr. 23, 2021), https://www.cnbc.com/2021/04/23/elon-musk-aiming-for-mars-so-humanity-is-not-a-single-planet-species.html.

[9] NASA, *supra* note 8. *See* Christian Davenport, *A Dollar Can't Buy You a Cup of Coffee but That's What NASA Intends to Pay for Some Moon Rocks*, THE SEATTLE TIMES (Dec. 3, 2020), https://www.seattletimes.com/nation-world/a-dollar-cant-buy-you-a-cup-of-coffee-but-thats-what-nasa-intends-to-pay-for-some-moon-rocks/#:~:text=A%20dollar%20may%20not%20buy,agency%20for%20a%20small%20fee.

[10] Brian Dunbar, *Moon to Mars*, NASA (July 8, 2021), https://www.nasa.gov/topics/moon-to-mars/overview.

[11] The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, Jan. 27, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205 [hereinafter Outer Space Treaty], which has been ratified by 110 State parties, clearly stipulates that the outer space "is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means." *Id.* at art. II. As under the Outer Space the State assumes responsibility for space activities by its non-governmental entities, appropriation by private entity would also amount to national appropriation and thereby, prohibited by the Outer Space Treaty. *Id.* at art. VI.

providing cargo supplies to stations and installations on the Moon.[12] This article examines the legal issues surrounding the operations which are less capital intensive and can be carried out by governments of non-space power States and small to medium sized private space actors. While examining these issues, one must remember the lessons learned from space exploration to date, particularly space activities in Earth's orbit while understanding that the physical characteristics of the Moon and the lunar orbit are different from that of the Earth.

II. DEPLOYING SATELLITES IN LUNAR ORBIT

Deploying satellites in the outer space void has been the State practice since 1957 with the launch of Sputnik 1. As Judge Manfred Lachs stated:

> [t]he first instruments that men sent into outer space traversed the air space of States and circled above them in outer space, yet the launching States sought no permission, nor did the other States protest. This is how the freedom of movement into outer space, and in it, came to be established and recognized as law within a remarkably short period of time.[13]

The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies provides as follows: "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 there shall be free access to all areas of celestial bodies."[14] This principle was also earlier articulated in General Assembly Resolution 1721

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[12] NASA, *Lunar Reconnaissance Orbiter*, NASA https://lunar.gsfc.nasa.gov/; *See also*, NASA, *About Gateway Deep Space Logistics*, NASA https://www.nasa.gov/content/about-gateway-deep-space-logistics.

[13] *North Sea Continental Shelf Cases (Federal Republic of Germany v. Denmark and Federal Republic of Germany v. The Netherlands)*, Dissenting Opinion of Judge Lachs [1969] ICJ Rep 3 at 230, https://www.icj-cij.org/public/files/case-related/52/052-19690220-JUD-01-10-EN.pdf; *See also*, Bin Cheng, *United Nations Resolutions on Outer Space: "Instant" International Customary Law?* (1965) 5 INDIAN J. INT'L L 23.

[14] Outer Space Treaty, *supra* note 11, art. I (2).

(XVI), 1961[15] and the Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space, 1963.[16] Thus, the concept of the freedom of exploration and use of outer space is both treaty law as well as customary law since the beginning of the space age.[17] This suggests that the deployment of satellites in the lunar orbit is permitted under international space law. There are already a few active satellites around the Moon at this moment – such as the US's Lunar Reconnaissance Orbiter.[18] However, deploying satellites in lunar orbit brings up a number of unexplored legal issues. Such issues include sustainability of lunar orbits, allotment and assignment of radiofrequency for satellites around Moon, the legality of deploying military satellites around the Moon, the requirement for registration of satellites around the Moon and liability for damage caused by satellites around the Moon.

A. Sustainability of Lunar Orbits

The Outer Space Treaty provides that

> [i]n the exploration and use of outer space, including the Moon and other celestial bodies, States Parties to the Treaty shall be guided by the principle of co-operation and mutual assistance and shall conduct all their activities in outer space, including the Moon and other celestial bodies, with due regard to the corresponding interests of all other States Parties to the Treaty.[19]

The Outer Space Treaty further states that State Parties shall ensure while carrying out outer space exploration that harmful

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[15] International Co-Operation in the Peaceful Uses of Outer Space, G.A. Res 1721B (XVI) (Dec. 20, 1961).

[16] Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space, G.A. Res 1962 (XVIII) (Dec. 13, 1963).

[17] Ram S Jakhu & Steven Freeland, *The Relationship between the Outer Space Treaty and Customary International Law* (2016) 59 PROC INT'L INST SPACE L 183 at 189-190; Eugene Pepint, *Legal Problems Created by the Sputnik* (1957) 4 MCGILL L. J. 66 at 66-67.

[18] *In Depth: Lunar Reconnaissance Orbiter*, NASA (July 11, 2019) https://solarsystem.nasa.gov/missions/lro/in-depth/#:~:text=NASA's%20Lunar%20Reconnaissance%20Orbiter%20(LRO,continues%20to%20orbit%20the%20Moon.

[19] Outer Space Treaty, *supra* note 11, art. IX.

contamination of outer space is avoided.[20] Hence, while deploying satellites in lunar orbit, the operator has the responsibility to protect both the Moon and the lunar orbit.

Unlike the Earth's orbit which is at the risk of being over-populated due to space debris and an increasing number of satellites, lunar orbit remains relatively unexplored. To deal with long-term sustainability of the Earth's orbit, several guidelines have been adopted including Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space[21] and Guidelines for the Long-term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space.[22] The primary lesson of space sustainability that humans have learned from the experience of artificial satellites around the Earth is that the historical disregard for the space environment that has been witnessed in Earth's orbits should be avoided as we gradually deploy more and more satellites in lunar orbit. Moreover, it must be understood that lunar orbits are not as stable as that of the Earth's and there are always chances of satellites crashing on the Moon.[23] Whereas some orbits, known as frozen orbits, are relatively stable, there remains a likelihood of instability,[24] and without an atmosphere similar to Earth's, the chances of a satellite burning on reentry and thereby never reaching the surface are nil.

Currently, frozen orbits are a scarce resource, as only the frozen orbits are useful for satellites around Moon due to their stability. This is similar to the situation wherein Geosynchronous orbit (GEO) is the most desirable for communication satellites. Even

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[20] *Id*.

[21] *See generally,* Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space, G.A. Res 62/217 (Dec. 22, 2007) [hereinafter COPOUS Debris Mitigation Guidelines].

[22] *See generally*, Comm. on the Peaceful Uses of Outer Space, Rep. of the Comm. on Its Sixty-Second Session, Annex II, U.N. Doc A/74/20 (2019)[hereinafter LTS Guidelines].

[23] Robert W. Buchheim, *USA Air Force - Project Rand- Research Memorandum*, July 14, 1956, 11-13, https://www.rand.org/content/dam/rand/pubs/research_memoranda/2008/RM1941.pdf; For example, on Mar. 4, 2022, a leftover piece of SpaceX's Falcon 9 rocket has been circling the Earth on a very wide orbit and is predicted to accidentally slam into the far side of the Moon. Loren Grush, *A SpaceX Rocket Slamming into the Moon is Reminder to Clean up our Deep Space Junk*, THE VERGE (Jan. 27, 2022), https://www.theverge.com/2022/1/27/22904427/spacex-falcon-9-rocket-second-stage-moon-collision-deep-space-junk.

[24] *See generally*, Buchheim, *supra* note 23.

now, GEO is regarded as a scarce resource.[25] The character of GEO means that a satellite is orbiting at the same speed as the Earth's rotation, making it essentially stationary over one spot on Earth. This means that ground station receivers do not have to rotate, but can be pointed permanently at the position in GEO where the satellite is located.[26]

Like GEO, frozen orbits are scarce resources. Treaty obligations require that in deploying satellites in lunar orbit, one should take into account the "due regard to the corresponding interests" of others.[27] Measures should be taken to reduce the instances of first comers gaining access to limited spots in frozen orbits, leaving only a few or none for newcomers. One way to achieve this objective of not cluttering the frozen orbits is to use a shared telecommunications and navigations service which will make each individual mission lighter, freeing up space for future missions.[28] Further, some spots in frozen orbits should be reserved for newcomers, so that they can be allotted on an equitable basis.[29]

The Moon's Hill sphere is at 66,000 km, which means at this point gravity of other celestial bodies are more dominant than the Moon, so a satellite cannot orbit the Moon beyond 66,000 km with

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[25] Constitution of the International Telecommunication Union (ITU), art. 44, (hereinafter ITU Constitution) https://www.itu.int/en/council/Documents/basic-texts/Constitution-E.pdf.

[26] Louis de Gouyon Matignon, *Is the Orbital Environment a Natural Resource?*, SPACE LEGAL NEWS (Oct. 9, 2019), https://www.spacelegalissues.com/is-the-orbital-environment-a-natural-resource/.

[27] Outer Space Treaty, *supra* note 11, art. IX.

[28] European Space Agency, *ESA advances its plan for satellites around the Moon*, ESA (May 20, 2021), https://www.esa.int/About_Us/Corporate_news/ESA_advances_its_plan_for_satellites_around_the_Moon.

[29] By analogy, ITU Constitution, art. 44 and Radio Regulations, Appendices 30/30A/30B provides that there should be equitable access to radio frequencies, in addition to a first come first serve basis. Constitution of the Int'l Telecomm. Union [ITU] art. 44, available at https://www.itu.int/council/pd/constitution.html [hereinafter ITU Constitution], Int'l Telecomm. Union [ITU] Radio Regulations 2016, available at https://www.itu.int/publR-REG-RR [hereinafter Radio Regulations]. Equitable access means each ITU Member State gets a pre-determined allocation of part of the spectrum/orbit resources protected from harmful interference for current and future use. Jian Wang, *Introduction to BSS & FSS Plans*, ITU World Radiocommunication Seminar 2018, (Dec. 3, 2018) https://www.itu.int/en/ITU-R/space/plans/Documents/Seminar/WRS18_Space_Workshop/0_BSS-FSS%20Plans%20_Introduction.pdf.

stability.[30] Hence, orbital space for placing satellites in lunar orbit is tighter and constrained. Limited resources call for careful calculations and regulation of the use of the resources.

Whereas most existing long-term sustainability and debris mitigation guidelines are Earth-centric, they should apply to operators of satellites in lunar orbit *mutatis mutandis*.[31] However, despite best efforts, some of these guidelines may not be suitable for the satellites in lunar orbit. This is because due to the complex gravitational field of the Moon, satellites may not stay stable for long periods.[32] This may mean that the satellites around the Moon can be in orbit for limited periods only. This increases the chances of creating more space junk, typically on the Moon's surface.[33] Also, repositioning of satellites will require more fuel (which is expensive) and in some cases, another space mission. Soft laws such as Long-Term Sustainability Guidelines[34] and COPUOS Space Debris Guidelines[35] may not be as relevant for governing satellites around the Moon, since maximum junk will be collected on the Moon's surface and not in the lunar orbit. Hence, to the extent the existing soft laws on space sustainability are not sufficient to deal with missions to Moon and lunar orbit, new guidelines should be framed.[36]

B. Allotment and Assignment of Radio Frequency

The Constitution of the International Telecommunication Union provides that that International Telecommunication Union (ITU) shall

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[30] David A. Rothery, *Moons: A Very Short Introduction,* 15 (OXFORD UNI. PRESS, 2015) https://planet4589.org/space/gcat/web/worlds/index.html

[31] *See* Artemis Accords, *supra* note 5, §12 (indicating that signatories commit to plan for the mitigation of orbital debris, though it does not specify lunar orbit, the document itself contemplates lunar activities in general).

[32] *See* NASA, *Bizarre Lunar Orbits,* (Nov.6, 2006), https://science.nasa.gov/science-news/science-at-nasa/2006/06nov_loworbit.

[33] Already, we have seen unintentional crashes which have left items on the Moon. Kameron Virk, *Tardigrades: "Water Bears" Stuck on the Moon After Crash*, BBC (Aug. 7, 2019), https://www.bbc.com/news/newsbeat-49265125; *See also*, Karl Hille, *Vikram Lander Found*, NASA (Dec. 2, 2019), https://www.nasa.gov/image-feature/goddard/2019/vikram-lander-found.

[34] LTS Guidelines, *supra* note 22.

[35] COPUOS Debris Mitigation Guidelines, *supra* note 21.

[36] Moon Dialogs which is a partnership between various stakeholders for governance and coordination mechanisms for the lunar surface is a commendable effort. MOON DIALOGS, https://www.moondialogs.org/ (last visited October 15, 2022).

> effect allocation of bands of the radio-frequency spectrum, the allotment of radio frequencies and the registration of radio-frequency assignments and, for space services, of any associated orbital position in the geostationary-satellite orbit or of any associated characteristics of satellites in other orbits, in order to avoid harmful interference between radio stations of different countries.[37]

There is no restriction that ITU shall have jurisdiction only over Earth's orbit. The Radio Regulations expressly allocate radiofrequency for communication from Earth to deep space and space research in deep space in general.[38] It may be noted that "[s]pace research systems intended to operate in deep space may also use the space research service (deep space) allocations, with the same status as those allocations, when the spacecraft is near the Earth, such as during launch, early orbit, flying by the Earth and returning to the Earth."[39]

The electromagnetic spectrum is heavily used on Earth, and much of its potential value for passive scientific research has already been seriously affected. However, the far side of the Moon remains an accessible place where radio observations of the Universe are possible without interference over the whole radio spectrum from the Earth.[40] It is necessary to allocate frequencies for active use by deep-space probes, lunar satellites, scientific instrument packages and research stations on the lunar surface in such a way that interference with such passive observations is avoided. This area, called the Shielded Zone of the Moon (SZM), is the part of the Moon's surface that is always protected from interfering signals generated on and near the Earth because the Moon always presents nearly the same side towards the Earth. As noted, the SZM can be very useful for scientific missions.[41]

C. Military Satellites Around the Moon

The Outer Space Treaty provides that

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[37] ITU Constitution, *supra* note 29, art. 1(2)(a).

[38] *See generally*, Radio Regulations, *supra* note 29.

[39] Radio Regulations, *supra* note 29, art. 4.24.

[40] Protection of Frequencies for Radio Astronomical Measurements in the Shielded Zone of the Moon, Recommendation ITU-R RA.479-5.

[41] *Id*.

> [t]he Moon and other celestial bodies shall be used by all States Parties to the Treaty exclusively for peaceful purposes. The establishment of military bases, installations and fortifications, the testing of any type of weapons and the conduct of military maneuvers on celestial bodies shall be forbidden. The use of military personnel for scientific research or any other peaceful purposes shall not be prohibited. The use of any equipment or facility necessary for peaceful exploration of the Moon and other celestial bodies shall also not be prohibited.[42]

Though Outer Space Treaty uses the word "peaceful" at various places, it does not define the term. This has led to long debates on whether the term "peaceful" means either: non-military uses, thus prohibiting any military use altogether; or "non-aggressive" which would mean that only aggressive military behavior is prohibited, thereby permitting non-aggressive military uses.[43] It may be noted that the Artemis Accords also do not define peaceful purposes but do provide that exploration of the Moon shall be exclusively for peaceful purposes.[44]

Even if we accept the meaning of non-military use for the term "exclusively for peaceful purposes," it must be remembered that the Outer Space Treaty itself carves out certain exceptions and allows certain military uses.[45] For example, it has come to be accepted that remote sensing satellites which have dual use as reconnaissance satellites will be allowed if such space objects are "necessary for peaceful exploration of the Moon and other celestial bodies."[46]

D. Registration and Cataloging Satellites in Lunar Orbit

The Registration Convention provides that launching States should register space objects launched into Earth's orbit "or beyond."[47] Therefore, the Registration Convention also deals with space objects launched in lunar orbit, and all State parties to Registration Convention are legally bound to register such space

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[42] Outer Space Treaty, *supra* note 11, art. IV.

[43] Kai-Uwe Schrogl & Julia Neumann, *Article IV*, in STEPHAN HOBE ET AL., COLOGNE COMMENTARY ON SPACE LAW 70, 82 (2009).

[44] Artemis Accords, supra note 5.

[45] Outer Space Treaty, *supra* note 11, art. IV.

[46] *Id*.

[47] Convention on Registration of Objects Launched into Outer Space art. II, Jan. 14, 1975, 28 U.S.T. 695, 1023 U.N.T.S. 15 [hereinafter Registration Convention].

objects. In addition, non-State parties to the Registration Convention should furnish information on the registration of their space objects to the United Nations in accordance with General Assembly resolution 1721B (XVI).[48] International intergovernmental organizations conducting space activities that have not yet declared their acceptance of the rights and obligations under the Registration Convention should do so in accordance with Article VII of the Registration Convention.[49]

Article XI of the Outer Space Treaty is also relevant in this aspect. It provides as follows:

> In order to promote international co-operation in the peaceful exploration and use of outer space, States Parties to the Treaty conducting activities in outer space, including the Moon and other celestial bodies, agree to inform the Secretary-General of the United Nations as well as the public and the international scientific community, to the greatest extent feasible and practicable, of the nature, conduct, locations and results of such activities....[50]

However, historically State practice does not generally provide information on space objects located beyond Earth orbit.[51] There is a need to "ensure a minimum degree of coordination among upcoming lunar activities."[52] Registration Convention requirements of a national registry and furnishing registration information to the United Nations should be followed by State parties to the Registration Convention.[53] For non-State Parties, registration information should still be furnished under General Assembly resolution 1721B (XVI) and Article XI of the Outer Space Treaty.[54]

In addition to the registration of space objects in lunar orbit or on the Moon, a catalog of space objects on the Moon should be

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[48] *Supra* note 15. *See* Recommendations on Enhancing the Practice of States and International Intergovernmental Organizations in Registering Space Objects, G.A. Res 62/101, (Dec. 17, 2007).

[49] *Id*.

[50] Outer Space Treaty, *supra* note 11, art. XI

[51] Registration Mechanisms for the Moon, A Moon Dialogs Salon Report, 1https://static1.squarespace.com/static/5d36544d1438f10001b32ebd/t/5fd407cdf-fab5d3c56c1e9ba/1607731150768/MD+Registration+Report.pdf.

[52] *Id.* at 6.

[53] *See generally*, Registration Convention, *supra* note 47.

[54] Outer Space Treaty, *supra* note 11, art. XI

maintained. As Jonathan McDowell, an astrophysicist at the Harvard-Smithsonian Center for Astrophysics noted during a webinar on the topic:

> the difference between a registry and a catalog is that a registry is something where an object's owner provides information under some regulations, whereas a catalog looks at what people truly know about that object. The Registration Convention aims to deliver complete, accurate, and timely information. Still, he argued, these goals are not currently achieved because registering States often provide data with gaps and even incorrect information. Catalogs like McDowell's offer external validation, and are critical for assessing what is in the registration documents, as well as being useful for other applications.[55]

A USA-based non-profit organization, For All Moonkind, also voluntarily maintains a catalog for missions to Moon and attempts to include all missions on the Moon and in lunar orbit.[56]

Another way of cataloging space objects on the Moon and in lunar orbit is through Space Situational Awareness[57] (SSA). SSA is broadly defined as characterizing the space environment and its impact on activities in space.[58] It is the key factor behind protecting the space environment from possible collisions. Though SSA around the Moon is not as well developed as SSA of Earth's orbits, efforts are being made to improve the ability to track Moon's orbits.[59] The US Air Force Research Laboratory (AFRL) is designing a pathfinder satellite to find and track objects in the vast area of cislunar space, as well as those in lunar orbit.[60] Ground based sensors and

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[55] Registration Mechanisms for the Moon, *supra* note 51, at 3.

[56] FOR ALL MOONKIND, https://moonregistry.forallmoonkind.org/about-us/ (last visited Oct. 15, 2022).

[57] C. Frueh, K. et al., *Cislunar Space Traffic Management: Surveillance through Earth-Moon Resonance Orbits*, Proc. 8th ESA/ESOC European Conference on Space Debris (virtual) (Apr. 20, 2021), https://engineering.purdue.edu/people/kathleen.howell.1/Publications/Conferences/2021_ESA_FruHowDeMBhaGup.pdf.

[58] Brian Weeden, *Space Situational Awareness: Examining Key Issues and the Changing Landscape*, Testimony before the House Subcommittee on Space and Aeronautics (Feb. 11, 2020) 12.

[59] Theresa Hitchens, *AFRL Satellite To Track Up To The Moon; Space Force-NASA Tout Cooperation*, *BreakingDefense* (Sept. 21, 2020), https://breakingdefense.com/2020/09/afrl-satellite-to-track-up-to-the-moon-space-force-nasa-tout-cooperation/.

[60] *Id*.

telescopes are useful in observing lunar orbits. Before deploying satellites in lunar orbit, one should subscribe to an SSA service provider, which is at the moment mostly provided by the governments of certain countries only. Subscribing to such SSA service would be acting in "due regard to corresponding interests" of others.[61]

E. Liability for Satellites Crashing on Re-entry

The Liability Convention provides that,

> [i]n the event of damage 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 said damage is due to its fault or the fault of persons for whom it is responsible.[62]

Therefore, as per Liability Convention, liability will be according to fault in case of crashes of satellites on or around the Moon.[63] This provision is important in Moon context as due to the instability of lunar orbits there are higher chances of a crash on the lunar surface than on Earth.[64]

In addition to specific provisions in the Liability Convention, there is a more general provision dealing with liability for damage in outer space in the Outer Space Treaty. Article VI of the Outer Space Treaty provides as follows:

> 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

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[61] Outer Space Treaty, *supra* note 11, art. IX.

[62] Convention on International Liability for Damage Caused by Space Objects, art III, Mar. 29, 1972, 24 U.S.T. 2389, 961 U.N.T.S. 187 [hereinafter Liability Convention]

[63] *Id*.

[64] Kenneth Chang, *Study of Moon's Atmosphere Ends with Planned Crash*, N.Y. TIMES (Apr. 18, 2014), https://www.nytimes.com/2014/04/19/science/space/nasa-lunar-explorer.html ("The lunar atmosphere [is] just one-quadrillionth the density of Earth's"); *Bizarre Lunar Orbits*, *supra* note 32.

> on the Earth, in air or in outer space, including the Moon and other celestial bodies.[65]

It may be noted however, the Liability Convention provides for absolute liability for damage caused on Earth's surface or aircraft in flight.[66] The question that arises is whether a similar regime is necessary on the Moon. Such a regime may better protect scientific and industrial installations, as well as historic sites on the Moon. However, one must remember that the crashing of satellites on the Moon's surface is more likely than crashes on Earth due to the absence of lunar atmosphere and limited amounts of stable orbits. In any case, the complex gravitational field of the Moon and eccentric orbit of the Moon needs detailed gravitational calculations to find stable orbital positions.[67] These calculations can be created by experts and corroboration of the results of experts by other experts to eliminate chances of mistakes. Liability should arise for miscalculation, especially for private entities. Capacity-building for such calculations should be done by United Nations Office for Outer Space Affairs (UNOOSA) or through other international organizations as many States may not have the necessary knowledge and infrastructure to make these calculations. One way of dealing with the problem in the immediate future, and perhaps even later, is through insurance. At the moment, not all national laws of States require the space operators to buy third party insurance policies.[68] If every entity which deploys satellites on Moon is obligated to obtain insurance, the regime of liability will be easier to manage.

Recently, in 2020, the US passed the law "One Small Step to Protect Human Heritage in Space Act."[69] Pursuant to the act,

> "[i]t is the sense of the Congress that . . . as commercial enterprises and more countries acquire the ability to land on the Moon, it is necessary to encourage the development of best

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[65] Outer Space Treaty, *supra* note 11, art. VI

[66] Liability Convention, *supra* note 62, art. II.

[67] NASA, *A New Paradigm for Lunar Orbits,* (Nov. 30, 2006), https://science.nasa.gov/science-news/science-at-nasa/2006/30nov_highorbit.

[68] For more details on third party insurance, *see* Philippe Montpert, *Considerations on Space Liability Insurance,* Willis Inspace (Vienna, Mar. 22, 2010), https://www.unoosa.org/pdf/pres/lsc2010/symp04.pdf.

[69] One Small Step to Protect Human Heritage in Space Act., Pub. L. No. 116-275 Dec. 31, 2020.

> practices to respect the principle of due regard and to limit harmful interference to the Apollo landing site artifacts in acknowledgment of the human effort and innovation they represent, as well as their archaeological, anthropological, historical, scientific, and engineering significance and value.[70]

The question is if such heritage sites are damaged by a satellite due to no fault of the satellite operator, how will the heritage sites be protected?

A related issue is that such crash may cause distress, in which case the Rescue and Return Agreement will be applicable.[71] The Artemis Accords too provides that the signatories commit to taking all reasonable efforts to render necessary assistance to personnel in outer space who are in distress, and acknowledge their obligations under the Rescue and Return Agreement.[72]

II. PROVIDING CARGO SUPPLIES TO THE MOON

Another activity that will support larger missions to Moon is providing cargo transport of supplies to the Moon. We have examples of cargo being supplied to the International Space Station by SpaceX on a commercial basis.[73] In fact, SpaceX's Dragon was devised to send humans and cargo to outer space and has sent 28 visits to the International Space Station.[74] The example of Dragon spacecraft demonstrates that when there is a base in outer space including celestial bodies, there is a market for resupply.[75] Where crewed spacecrafts, such as the new Dragon, will need advanced technology, it will be easier for small to mid-sized space actors to engage in uncrewed missions to send supplies to Moon.

A. What Can Be Carried to the Moon?

The first question that arises is what kind of supplies can be carried to Moon as resupply. The Outer Space Treaty provides that

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[70] *Id*. § 2(b)(1)

[71] Agreement on the Rescue of Astronauts, the Return of Astronauts and Return of Objects Launched into Outer Space, Apr. 22, 1968, 19 U.S.T. 7570, 672 U.N.T.S. 119.

[72] Artemis Accords, *supra* note 5, § 6.

[73] SpaceX Dragon, https://www.spacex.com/vehicles/dragon/.

[74] *Id*.

[75] *Id*.

the Moon shall be used exclusively for peaceful purposes.[76] Hence, unless the States agree to a different interpretation, private industry should err on the side of caution. As stated above, a military facility or equipment necessary for peaceful exploration of the Moon and other celestial bodies is not prohibited.[77] Hence, resupply of such dual-use equipment or even military equipment, that are planned to be used for peaceful purposes, are allowed to be transported to Moon. However, if weapons are planned to be transported to the Moon, it is not allowed under Outer Space Treaty.[78]

One question that arises is if supplies transported to Moon are subsequently used for creating weapons, what will be the consequences for the transporter? Presumably, so long the original purpose of the supplies was not for military purposes, the transporter will have no liability. The issue becomes more difficult to ascertain if the transporter is grossly negligent while assessing the supplies transported.

The Outer Space Treaty provides that "all stations, installations, equipment and space vehicles on the Moon and other celestial bodies shall be open to representatives of other States Parties to the Treaty on a basis of reciprocity."[79] Travaux preparatoires indicates that open access stations is intended to be the general rule and exceptions to this rule may be made based on reciprocity.[80] Thus, all facilities "shall be open" to all unless there is an exception made by State parties.[81] The right of a State to refuse another State to access its facilities arises only towards a State that does not comply with its obligations to allow visits to its facilities.[82] It may be noted the facilities that have open access includes space vehicles.[83] Therefore, a transporter has the right to obtain details of the supplies transported. In fact, the transporter should request such information to avoid liability.

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[76] Outer Space Treaty, *supra* note 11, prmbl.

[77] Outer Space Treaty, *supra* note 11, art. IV

[78] *Id*.

[79] Outer Space Treaty, *supra* note 11, art. XII

[80] Lesley Jane Smith, *Article XII* in STEPHAN HOBE ET AL., COLOGNE COMMENTARY ON SPACE LAW 207, 210 (2009).

[81] *See generally, id*.

[82] *Id*. at 211.

[83] *See generally id*.

B. Can Transported Supplies Include Radioactive Material?

The Outer Space Treaty clearly prohibits installing nuclear weapons or any other weapons of mass destruction in celestial bodies.[84] Therefore, the transportation of nuclear weapons is clearly prohibited. It may be kept in mind that under Nuclear Proliferation Treaty, States are obligated to prevent the spread of nuclear weapons from activities related to nuclear energy.[85]

When nuclear power sources and related materials are transported to the Moon, the transporter should carry out a thorough safety assessment, including probabilistic risk analysis, with particular emphasis on reducing accidental exposure of the public to harmful radiation or radioactive material.[86] The design and use of space objects with nuclear power sources on board a spacecraft shall ensure with a high degree of confidence that the hazards in foreseeable operational or accidental circumstances are kept below acceptable levels.[87] The State of the transporter, as a launching State, shall be internationally liable for damage caused by the radioactive material on board a spacecraft.[88] The compensation that the transporter State shall be liable to pay for damage caused shall be according to the Liability Convention.[89] This compensation shall include reimbursement of the duly substantiated expenses for search, recovery and clean-up operations, including expenses for assistance received from third parties.[90]

C. Export Control Laws and Supplies Transported to the Moon

Even though the Artemis Accords are not accepted by all States, they provide an interesting perspective on interoperability.[91] It provides that the signatories shall develop

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[84] Outer Space Treaty, *supra* note 11, art. IV

[85] The Treaty on the Non-Proliferation of Nuclear Weapons, July 1, 1968, 729 U.N.T.S. 161.

[86] Principles Relevant to the Use of Nuclear Power Sources in Outer Space, G.A. Res. 47/68 (Dec. 14, 1992), pmbl. ¶ 4 and princ. 4.

[87] *Id*. at princ. 3(1)(a)

[88] *Id*. at princ. 9(1)

[89] *See generally,* Liability Convention, *supra* note 62.

[90] Principles Relevant to the Use of Nuclear Power Sources in Outer Space, *supra* note 86, at princ. 9(3).

[91] *See generally,* Artemis Accords, *supra* note 5.

> interoperable and common exploration infrastructure and standards, including but not limited to fuel storage and delivery systems, landing structures, communications systems, and power systems, will enhance space-based exploration, scientific discovery, and commercial utilization. The Signatories commit to use reasonable efforts to utilize current interoperability standards for space-based infrastructure, to establish such standards when current standards do not exist or are inadequate, and to follow such standards."[92]

If common facilities and standards are developed, then supplies can be shared between various entities carrying out activities on the Moon. This sharing of facilities and infrastructure is in consonance with the Outer Space Treaty which provides that "[t]he 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, irrespective of their degree of economic or scientific development."[93]

In case of interoperability, the export control laws of States involved will be applicable. Export control laws of States pose restrictions on transfer of technology and knowledge related to space sector. In the US, for example, export is defined as including not only physically sending or taking an article beyond the borders of the US but also transferring control or ownership (including, presumably, on-orbit transfer) and, notably, disclosing technical data to foreign persons (in the United States or elsewhere, including oral or visual disclosure).[94] In Europe, national and international regulations that are in force now include the Missile Technology Control Regime and the Wassenaar Agreement, both intended to provide higher transparency in the transfer of arms and dual-use technology.[95] Space technology is, in most cases, considered a dual-use technology with information about space products considered core

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[92] Artemis Accords, *supra* note 5, § 5.

[93] Outer Space Treaty, *supra* note 11, art. I.

[94] USA International Traffic in Arms Regulations, 22 CFR § 120.50.

[95] *See* Cristian Bank, *Consequences of the French Space Law on Space Operations (FSOA) on CNES's Mission as a Contracting Space Agency in*, CONTRACTING FOR SPACE: CONTRACT PRACTICE IN THE EUROPEAN SPACE SECTOR 133, 137 (Ingo Baumann & Lesley Jane Smith, eds., 2011).

technology knowhow, and hence, export control laws apply.[96] As a general matter, States are not comfortable allowing unrestricted transfer of space technology and goods.[97] For interoperability to work, a waiver under export control laws of relevant States will be required. This waiver may be limited and for the particular purpose of using certain facilities in Moon.

D. Product Liability May Arise Due to Harsh Temperature on the Moon

Long days and long nights with no atmosphere lead to extremely hot days and extremely cold nights on the Moon. For example, the Chinese Lunar Rover of Chang'e 4 mission hibernates at night but found the temperatures on the lunar far side, where it is operating, to be colder than expected.[98] In the Chang'e 3 mission, the lander and rover hibernated during the harsh cold nights in Moon, but the lander's main color camera didn't survive the first night.[99] While delivering cargo supplies to the Moon, manufacturers have to ensure that goods are not destroyed due to extreme weather on the Moon. If the goods are destroyed, the manufacturer of the cargo may incur liability. The customer has the right to require repair and/or rework, or at least an investigation followed by a correction, if similar equipment have been ordered by the customer/operator. The result of such a defect is that all similar equipment that might still be on-ground must be reworked and repaired or replaced as well, usually at no cost to the customer. This obligation is usually for the defined lifetime of the spacecraft.[100] Further, the operator receiving the cargo may consider property insurance to protect the cargo. However, this may not be a viable option since premiums for property insurance are high in the space industry.

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[96] *See* Patrick Goergen, *Space Technologies' Compliance with Export Control Regimes*, (Aug. 2019), https://crossborders.lu/wp-content/uploads/2019/08/20190818-working-paper-space-vfin.pdf.

[97] *Id*.

[98] Roland Jackson, *Chinese Rover Finds Lunar Nights "Colder Than Expected*," PHYS ORG (Jan. 31, 2019), https://phys.org/news/2019-01-chinese-rover-lunar-nights-colder.html.

[99] Emily Poore, *Sleep of Death For China's Lunar Rover?*, SKY TELESCOPE, (Jan. 29, 2014), https://skyandtelescope.org/astronomy-news/sleep-of-death-for-chinas-lunar-rover/.

[100] Ines Scharlach, *Performance and Warranty Articles in Space Industry Contracts*, *in* BAUMANN & SMITH *supra* note 95, at 260.

E. Lunar Dust Ejecta Caused by Moon Missions and Sustainability of Lunar Activities

Phil Metzger, a planetary physicist at the University of Central Florida and dust dynamics expert, states that the dust ejecta caused "by rocket exhaust can interfere with actors' activities and should be mitigated."[101]

> The vacuum environment [on the Moon] allows rocket exhaust to spread out faster and very widely . . .. This exhaust picks up dust particles, ejecting them in a thin sheet several degrees above the local horizon at a high velocity. The best data available on this phenomenon comes from studying video footage from lunar module landings, which depict objects ejected at high velocities from the lunar landers.[102]

Simulations of lunar modules have led Dr. Metzger to predict that "a 200 ton lunar lander will blow 1,000 tons of ejecta."[103] The larger the vehicle, the faster and father the ejecta will go.

In 2011, the US NASA issued Recommendations to Space-Faring Entities: How to Protect and Preserve the Historic and Scientific Value of U.S. Government Lunar Artifacts[104] This document suggests that safety requires that a 2.0 km exclusion radius be applied to the descent/approach path of a lunar landing vehicle.[105] While these are only recommendations and guidelines, recent US law makes them "a condition or requirement to contracts, grants, agreements, partnerships or other arrangements pertaining to lunar activities carried out by, for, or in partnership with [NASA]."[106] However, the 2 km limit is arbitrary and not based on science and 2 km distance reduces but does not eliminate chances of damage

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[101] The Implications of Dust for Resource Contention and Lunar Policy, A Moon Dialogs Salon Report, 1 (May 7, 2020), https://drive.google.com/file/d/1IwEotyYTDMR3wEF3g3BTR94_n1sS5oUO/view.

[102] *Id.* at 2.

[103] *Id.* This prediction may not be entirely correct according to Phil Metzger himself.

[104] *NASA's Recommendations to Space-Faring Entities: How to Protect and Preserve the Historic and Scientific Value of U.S. Government Lunar Artifacts*, NASA (July 20, 2011), https://www.nasa.gov/sites/default/files/617743main_NASA-USG_LUNAR_HISTORIC_SITES_RevA-508.pdf.

[105] *Id.* at § A2-1

[106] One Small Step to Protect Human Heritage in Space Act, *supra* note 69, §3(b)(1).

due to the dust.[107] Whereas NASA's Guidelines act as a model, science and engineering are not yet able to define a safe landing distance.[108] Multilaterally agreed guidelines need to be formulated to address ejecta issues; while doing so, one must remember that some areas of the Moon are more important based on science and economy and some missions may be more sensitive than others.

IV. CONCLUSION

In this article, the near future missions to Moon by mid-size and small space entities has been discussed. I have identified and focused on two such probable future missions: (a) deploying of satellites in lunar orbit and (b) transporting goods and supplies to Moon to assist bigger missions.

Whereas the author finds that existing space treaties, principles and guidelines assure that lunar activities do not take place in a legal vacuum, existing laws need to be amended or updated. While considering these laws, one must keep in mind the special physical characteristics of the Moon which is largely different from the Earth. However, humanity should keep in mind the lessons we have learnt from our space activities so far and should not continue to make historical mistakes such as disregarding the outer space environment, carrying out space activities without insurance and not registering all space objects. Hence, the Moon and lunar orbits should be utilized in a more planned manner and collaboration and cooperation should be encouraged wherever possible. The Outer Space Treaty, Liability Convention, Registration Convention and Rescue and Return Agreement which provides basic principles of operating in outer space including the Moon should be respected, especially by the State parties.

Liability for deploying and operating satellites in lunar orbit is heightened and complicated due to the complex gravitational field and eccentric orbit of the Moon. Such space missions require complex calculations which not all space actors will have. Hence, UNOOSA should take initiative for capacity building in this respect. However, third party liability insurance provides a short-

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[107] Moon Dialogs, *Research Salon #2: The Implications of Dust for Resource Contention and Lunar Policy* (May 7, 2020), recording can be found on this website: https://www.moondialogs.org/researchsalons (last visited Oct. 15, 2022).

[108] *Id.*

term solution and maybe even a longer-term solution. Hence, all missions to Moon should ideally be insured. In case of private operators, the national laws may cap the liability and, if the cap is exceeded, it would be paid by the government. Such approach will make the insurance premiums more affordable and encourage more space actors to participate.

With regards, supplying cargo to the Moon, one must remember that the Outer Space Treaty and other documents indicate that Moon should be used exclusively for peaceful use. This means that one cannot transport weapons to the Moon. However, if goods transported are later assembled to create weapon in Moon, the transporter's liability does not arise unless the transporter was grossly negligent in assessing the contents of the cargo. Transporting supplies to lunar installations may also attract export control laws of countries and such transportation may require waiver under export control laws.

In short, whereas the existing space laws serve a basis for human activities on Moon and the lunar orbit, there is much that is left unsaid. The international community should engage in international law making, perhaps beginning with soft laws, for the governance of the Moon.[109] What is necessary is a governance mechanism for sustainable and peaceful exploration and use of Moon and lunar orbit. This governance mechanism should include details about debris mitigation, lunar dust mitigation, benefits sharing, information sharing, registration of activities in and around Moon and define exclusively peaceful use of Moon.

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[109] There have been some attempts by organizations such as: *Best Practices for Lunar Activities*, 1 MOON VILL. ASS'N 4 (Oct. 19, 2020), https://moonvillageassociation.org/wp-content/uploads/2020/10/MVA-Best-Practices-Issue-1-19.10.2020-FINAL.pdf.