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Which liability regime for lunar reactors? Examining the next frontier of international nuclear law

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Nuclear reactors operated on the Moon (lunar reactors) are no longer a utopia. The USA, China and the Russian Federation are currently planning to deploy these advanced nuclear technologies. Lunar reactors are intended to power space mining and, later, human settlements. Lunar reactors are also envisaged as the first fleet of space reactors, with the next on Mars. As on Earth, any deployment of nuclear energy on the Moon must be accompanied by a transparent and robust legal framework. This article examines which legal framework applies when damage is caused by the radioactive or hazardous nature of nuclear materials used for power production in a lunar reactor.

Keywords: lunar reactor; nuclear liability; nuclear damages; *res communis*; global commons; space mining; nuclear law; space law

1. Introduction[1]

On 15 December 2025, an Executive Order titled 'Ensuring American Space Superiority' was adopted in the United States.[2] The order sets goals and tasks that the President of the United States of America imposes on his/her administration. Among these goals is the one that is the subject of this article:

> Developing and deploying advanced capabilities and approaches to enable the next century of space achievements by:
> (i) …
> (ii) enabling near-term utilisation of space nuclear power by deploying nuclear reactors on the Moon and in orbit, including a lunar surface reactor ready for launch by 2030 […].[3]

Afterwards, the US National Aeronautics and Space Administration (NASA) and the US Department of Energy (DoE) signed a memorandum of understanding (MoU) on 6 January 2026. This MoU anticipates deploying a fission surface power system on the Moon (a lunar reactor)[4] capable of producing safe, efficient and plentiful electrical

1 This is a written and much expanded version of my presentation given at the workshop of the INLA Working Group 2 – Nuclear Liability and Insurance, which was held on 19 March 2026 in Paris, France.
2 Executive Order 14369 of 18 December 2025 (*Ensuring American Space Superiority*)
3 *ibid*, s 2.d.ii
4 For further details on this advanced nuclear technology, see Joseph Bui, 'Electricity On The Moon Through Reactors' (NASA–Missouri Space Grant Consortium Grant Award 2023). Also see Alexander Q Gilbert, 'Nuclear for Space Propulsion and Surface Power' in Andrew Foss and Nicolaus Stauff (eds), *New Directions in Nuclear Energy. Innovation and Opportunities in Fission and Fusion for Global Decarbonization* (Woodhead Publishing 2026) 339

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power that can operate for years without refuelling. Deploying a lunar reactor will enable sustained future lunar missions by providing continuous, abundant power regardless of sunlight or temperature. Lunar reactors are intended (together with solar power plants) to supply electrical energy for the extraction of raw materials.[5] Also, the lunar reactor should supply electricity to Artemis Base Camp – a permanent human settlement on the Moon. According to the MoU, the nuclear mission on the Moon is not envisaged as the final frontier of the US space endeavours. Rather, the lunar mission is envisaged as a mere precursor to NASA's future deployment of nuclear power on Mars, where solar energy is much weaker.[6]

However, the USA is not the only player in the recent race to deploy a lunar reactor. China, the United States' main competitor in the new space race, is setting the pace for lunar exploration: together with Russia, it plans to launch a nuclear reactor by 2035. Roscosmos and the China Manned Space Agency (CMSA) signed the corresponding memorandum in May 2025.[7] Official information about the Chino–Russian project is limited. Both countries will likely use the lunar reactor to study and develop the Moon's south pole as part of the International Lunar Research Station (ILRS) project. The lunar reactor is expected to begin operations in 2036, with three missions to the Moon in 2033, 2034, and 2035.[8]

That said, plans for lunar reactors are not limited to superpowers such as the USA, China and the Russian Federation. In Italy, the SELENE (Sistema Energetico Lunare con l'Energia Nucleare) project has focused on developing the Moon Energy Hub (MEnH), which would provide a stable energy source for future lunar settlements, since 2024. The ASI (Agenzia Spaziale Italiana)-funded SELENE project is led by the Italian National Agency for New Technologies, Energy, and Sustainable Economic Development (ENEA), with contributions from the Department of Energy at the Polytechnic University of Milan and Thales Alenia Space Italia. Four ENEA research centres are involved in the project: Frascati, Casaccia, Bologna and Brasimone.[9] On 25 September 2025, the Italian ENEA and French Framatome signed an MoU to explore advanced technological solutions for designing nuclear reactors to power future lunar settlements.[10] Three areas of cooperation have been determined. The first focuses on studies of the fuel required for the reactor, with a view to ensuring both

5 See Jennifer M Dooren, 'NASA, Department of Energy to Develop Lunar Surface Reactor by 2030' *National Aeronautics and Space Administration* (13 January 2026) <www.nasa.gov/news-release/nasa-department-of-energy-to-develop-lunar-surface-reactor-by-2030/> accessed 25 May 2026

6 See Nimra Javed, 'A Nuclear Reactor on the Moon Will Be a Turning Point' *The Interpreter* (19 August 2025) <www.realcleardefense.com/2025/08/19/a_nuclear_reactor_on_the_moon_will_be_a_turning_point_1129568.html> accessed 25 May 2026

7 See Max Polyakov, 'How China, Russia, and the US are Competing to Place the First Nuclear Reactor on the Moon' *News* (19 February 2026) <https://maxpolyakov.com/how-china-russia-and-the-us-are-competing-to-place-the-first-nuclear-reactor-on-the-moon/> accessed 25 May 2026

8 See 'Russia Targeting Lunar Power Station by 2036' *World Nuclear News* (29 January 2026) <www.world-nuclear-news.org/articles/russia-targeting-lunar-power-station-by-2036> accessed 25 May 2026

9 See 'Italy Launches Moon Nuclear Reactor Project' (Nuclear Engineering International, 13 December 2024) <https://www.neimagazine.com/news/italy-launches-moon-nuclear-reactor-project/> accessed 21 September 2026

10 See 'Space: Framatome and ENEA Sign MoU to Explore Advanced Technological Solutions for Designing Lunar Nuclear Fission Reactors' (Framatome, 25 September 2025) <https://www.framatome.com/medias/space-framatome-and-enea-sign-mou-to-explore-advanced-technological-solutions-for-designing-lunar-nuclear-fission-reactors/> accesssed 21 September 2026

efficiency and safety; the second concerns new materials capable of withstanding the extreme conditions in space. The third area of cooperation is on the use of additive manufacturing for reactor components.[11]

Recently, it was argued that 'a reactor on the Moon would give states twice the operational duration to carry on with resource extraction and sustainment of human life support systems, compared to those relying on traditional power sources'.[12] While a nuclear reactor on the Moon might sound risky, existing designs aim to prioritise safety: they use passive cooling and low-enrichment uranium, making catastrophic failure extremely unlikely.[13] However, to achieve high political and societal acceptance of nuclear power for power production in outer space, any deployment of prospective lunar reactors must be accompanied by a transparent and robust legal framework. Beyond technological failure, we must also consider other potential causes of a lunar reactor accident, such as space terrorism,[14] military conflict or natural disasters (for example, a moonquake).[15] Thus, as with the governance of nuclear power on Earth, the legal framework for lunar reactors must establish a robust and transparent liability and compensation regime.

The strategic importance of nuclear energy in the forthcoming New Space Era (Space 4.0) is already reflected in extensive research on its legal aspects.[16]

This article presents a perspective on nuclear liability.[17] In this respect, this article will address which liability regime should apply to damages that may arise in the future from an accident in a lunar reactor. To tackle this question, this article will first

11 *ibid*

12 See Mustafa Bilal, 'Resources, Reactors and Rivalries Will Decide the New Moon Race' *SpaceNews* (31 October 2025) <https://spacenews.com/resources-reactors-and-rivalries-will-decide-the-new-moon-race/> accessed 25 May 2026

13 See Hayley Bennet, 'NASA Wants a Nuclear Reactor on the Moon. What Would Happen During a Meltdown?' *BBC Science Focus* (7 February 2026) <https://www.sciencefocus.com/space/moon-nuclear-reactor-meltdown> accessed 25 May 2026

14 See Anna M Brennan, 'The Threat of Space Terrorism Is No Longer Science Fiction, But We're Ill-Prepared to Combat It' *The Conversation* (4 November 2025) <https://theconversation.com/the-threat-of-space-terrorism-is-no-longer-science-fiction-but-were-ill-prepared-to-combat-it-268659> accessed 25 May 2026

15 See Georgia Jiang, 'Seismic Activity on the Moon Could Pose Risk to Long-Term Lunar Infrastructure' (phys.org, 30 July 2025) <https://phys.org/news/2025-07-seismic-moon-pose-term-lunar.html> accessed 25 May 2026

16 See Alexander Q Gilbert, 'Astronaut Nuclear Safety: A Concept for Managing Crew Risks When Using Space Nuclear Power Systems' [2025] Journal of Space Safety Engineering 266; Kuan Yang and Manzoor Hassan, 'International Regulation for the Use of Nuclear Power Sources in Outer Space: Status Quo, Shortcomings and Possible Ways Out' [2025] Acta Astronautica 128; Jie Long, 'Space Nuclear Power Sources' in Mahulena Hoffman and Percy J Blount (eds), *Elgar Concise Encyclopedia of Space Law* (Edward Elgar 2025) 284; Ya E Brazovskaya and DM Avdysh, 'Contemporary Legal Challenges in Mars Colonization: A Comprehensive Analytical Review of Regulatory Frameworks (2024–2025)' [2025] Moscow Journal of International Law 123 (in Russ.); Alexander Q Gilbert, 'Governance of Nuclear Energy in Outer Space' [2024] Nuclear Law Bulletin 7; Viviana Iavicoli, 'Nuclear Power Sources in Outer Space for Peaceful Purposes' in Claudia Cinelli (ed), *Regulation of Outer Space: International Space Law and the State* (Routledge 2024) 153; Ana Laura Vilicana, 'Nuclear Space Law: Past, Present, and Future Issues for Commercial Launch' (Association of Commercial Space Professionals 2024) <https://acsp.space/wp-content/uploads/2024/10/Nuclear-Space-Law-PPF.pdf> accessed 25 May 2026

17 The existing scholarship on this topic is still rather scarce. See eg Yunus Emre Bakiler and Günes Ünüvar, 'Nuclear Liability Beyond Earth: Who Pays for an Incident on the Lunar Surface', *EJIL: Talk! Blog of the European Journal of International Law* (Blog), 2 September 2026, <https://www.ejiltalk.org/nuclear-liability-beyond-earth-who-pays-for-an-incident-on-the-lunar-surface/> accessed 21 September 2026

analyse (Section 2 - International space law and Section 3 - International nuclear law) the liability frameworks that already exist in international space law and international nuclear law. In this respect, attention will be paid to:

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 (hereafter the Outer Space Treaty),[18]
2. The Convention on International Liability for Damage Caused by Space Objects (the Liability Convention),[19]
3. The Principles Relevant to the Use of Nuclear Power Sources in Outer Space (the Principles),[20]
4. The Vienna Convention on Civil Liability for Nuclear Damage (the Vienna Convention),[21]
5. The Convention on Supplementary Compensation for Nuclear Damage (the CSC),[22]
6. The Revised Paris Convention on Third Party Liability in the Field of Nuclear Energy (the Revised Paris Convention).[23]

The Vienna Convention and the CSC are selected as the two main stakeholders of the current race for the deployment of the lunar reactor – the USA and the Russian Federation are contracting parties to these conventions.[24] While the USA participates in the nuclear liability regime established under the CSC, the Russian Federation is a contracting party to the Vienna Convention. Given the ongoing French–Italian cooperation in space reactor development, this article will also address the potential applicability of the Revised Paris Convention vis-à-vis lunar reactors.

Second, this article will scrutinise the applicability of these instruments to a prospective lunar reactor. Because neither instrument was adopted to govern lunar reactors, this article will identify (Part 3) potential gaps for these technologies in the future.

Thirdly, this article will identify (Part 4) the major building stones upon which a future regime of liability for nuclear damage caused by lunar reactors must be constructed.

In the literature,[25] the following phases of a 'space nuclear mission lifecycle' are being distinguished:

18 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (adopted 19 December 1966, in force 27 January 1967) 610 UNTS 205

19 Convention on International Liability for Damage Caused by Space Objects (adopted 29 November 1971, in force 1 September 1972) 961 UNTS I-13810

20 UN General Assembly resolution Res 47/68, adopted on 14 December 1992

21 Vienna Convention on Civil Liability for Nuclear Damage (adopted 21 May 1963, in force 12 November 1977) 1063 UNTS I-16197

22 Convention on Supplementary Compensation for Nuclear Damage (adopted 12 September 1997, in force 15 April 2015) 3038 UNTS I-52722

23 Revised Paris Convention on Third Party Liability in the Field of Nuclear Energy (adopted 12 February 2004, in force 1 January 2022) 3471 UNTS 13706

24 Having said this, one must bear in mind that China does not participate in any of the existing multilateral frameworks on nuclear liability, but possesses its own national regime on nuclear liability.

25 See Alexander Q Gilbert, 'Lifecycle Mission Safety for Space Nuclear Systems' [2023] Journal of Space Safety Engineering 467

1. Design.
2. Supply chain (including testing and transportation).
3. Spaceport.
4. Launch.
5. Operations, and
6. End-of-life (waste storage and decommissioning).

For the sake of clarity, this article will address only liability issues arising in the fifth phase – that is, the surface operation of the lunar reactor.

2. International space law

2.1. *Outer Space Treaty*

The Outer Space Treaty sets out basic principles that states must follow when exploring and using outer space, the Moon and other celestial bodies. In this regard, however, the Outer Space Treaty also sets out several key rules that will apply to a potential nuclear accident in a lunar reactor.

Firstly, the Outer Space Treaty establishes rules governing ownership of property that might be damaged by a nuclear accident in a lunar reactor. These rules are as follows:

1. The Moon shall be the province of all mankind.[26] At the same time, the Moon is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means.[27] Thus, the Moon, including its natural resources (such as minerals, energy sources, and organic and non-organic substances), represents a *res communis omnium* (or *global commons*). Lunar resources sit outside the jurisdiction of any single nation; they are shared and belong to all humankind.[28] This also undeniably applies to water ice deposits on the Moon, which will likely be located near future lunar reactors.[29]
2. The Outer Space Treaty further declares that ownership of objects launched into outer space, including objects landed or constructed on a celestial body, and of their parts, is not affected by their presence in outer space or on a celestial body or by their return to the Earth.[30] Consequently, while the lunar resources represent a *res communis omnium,* future constructions on the Moon – such as research stations, infrastructure or industrial structures for space mining – will remain the property of the launching state.[31] Similarly, ownership of the lunar reactor will not change after being deployed on the Moon. If a state constructs, finances and launches the reactor, it will remain the state's property during its

26 Outer Space Treaty, art I
27 *ibid*, art II
28 See Nilufer Oral, 'The Common Heritage of Mankind under International Law: An Overview' in Virginie Tassin (ed), *Routledge Handbook of Seabed Mining and the Law of the Sea* (Routledge 2024) 33
29 See Clive Neal, 'NASA Wants to Put a Nuclear Reactor on the Moon by 2030 – Choosing Where Is Tricky' *The Conversation* (18 August 2025) <https://en.ain.ua/2025/09/02/nasa-plans-to-place-a-nuclear-reactor-on-the-moon/> accessed 25 May 2026
30 Outer Space Treaty, art VIII
31 See Eric Husby, 'Sovereignty and Property Rights in Outer Space' [1994] Journal of International Law and Practice 359

operation in outer space. This will apply similarly to ownership by private entities. Ownership will remain with the commercial entity after the lunar reactor is deployed on the Moon.

3. Also, the Outer Space Treaty provides that a state party to the treaty on whose registry an object launched into outer space is carried shall retain *jurisdiction* and *control* over such object, and over any personnel thereof, while it is in outer space or on a celestial body.[32] For a prospective deployment of a lunar reactor, this means the launching state's safety framework will govern the reactor. The launching state will also be competent to control the installation's nuclear safety through its competent regulatory body.[33]

Secondly, the Outer Space Treaty provides that each of its contracting parties that launches or procures the launching of an object into outer space, including the Moon and other celestial bodies, and each contracting party from whose territory or facility an object is launched, is internationally liable for damage to another contracting party to the treaty or to its natural or juridical persons by such object or its parts on the Earth, in air or in outer space, including the Moon and other celestial bodies.[34] With respect to the deployment of the lunar reactors, this provision will have the following consequences:

1. Liability for any damages caused by a nuclear accident in a lunar reactor will be borne by those states that launched the installation from their own territory. A state will also be liable if it, or private entities registered in that state, launches a lunar reactor from abroad.
2. Under the regime, as established by the Outer Space Treaty, the state itself will be liable for any damages that occur due to a nuclear incident in a lunar reactor. Thus, the Outer Space Treaty does not distinguish between a state and a private entity (a commercial corporation) as the lunar operator. Even if a commercial corporation operates a prospective lunar reactor, the launching state remains liable for nuclear damage under the Outer Space Treaty.

2.2. *Liability Convention*

The Liability Convention later elaborated the liability framework established by the Outer Space Treaty. The Liability Convention applies to damage caused by space objects launched by a state, irrespective of whether the space object causes damage on the surface of the Earth, to an aircraft in flight[35] or elsewhere.[36] The Liability Convention applies not only to successfully launched space objects, as damage caused by a failed launch still falls within the treaty's scope.[37] With respect to the future deployment of lunar reactors, the following provisions of the Liability Convention are of importance:

32 Outer Space Treaty, art VIII
33 Also see Gilbert, 'Nuclear for Space Propulsion and Surface Power' (n 4) 340
34 Outer Space Treaty, art VII
35 Liability Convention, art II
36 *ibid*, art III
37 *ibid*, art I(b)

Firstly, the Liability Convention does little to clarify the term 'space object', apart from stipulating that it includes parts of a space object, as well as the space object's launch vehicle and parts thereof.[38] From this, it follows that an object, such as an entire satellite or parts thereof, becomes a space object from the moment the launch countdown timer reaches zero. The academic scholarship has argued that the term 'space object' indicates that the object causing the damage must have both material and physical properties.[39] In this respect, the size of the space object is immaterial; it includes micro-debris already in outer space created by cascading collisions of objects in orbit (the so-called Kessler effect).[40] This broad, catch-all understanding of what constitutes a space object was settled.[41] Thus, while a prospective lunar reactor was obviously not envisaged as a 'space object' when the Liability Convention was adopted, several recent authors have already argued that it will also constitute a 'space object' under this convention.[42]

Second, the Liability Convention defines what kind of damages it covers.[43] They are as follows:

1. loss of life,
2. personal injury or other impairment of health,
3. loss of or damage to property of states or of persons, natural or juridical, or property of international intergovernmental organisations.

Thus, while the Liability Convention covers loss of life, impairment of health and property damage, other potential damages remain uncovered. For example, damage to the water ice deposit or to space resources is not foreseen to be covered by the Liability Convention.[44]

Further, the Liability Convention distinguishes the following two regimes of liability of the launching state:

1. A launching state shall be *absolutely* liable to pay compensation for damage caused by its space object on the surface of the Earth or to aircraft in flight.[45]
2. 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.[46]

38 *ibid*, art I(d)
39 See Kirsten Schmalenbach, 'Convention on International Liability for Damage Caused by Space Objects' in Peter Gailhofer, David Krebs, Alexander Proelss, Kirsten Schmalenbach and Roda Verheyen (eds), *Corporate Liability for Transboundary Environmental Harm. An International and Transnational Perspective* (Springer 2023) 523
40 *ibid*
41 *ibid*
42 See Yang and Hassan (n 16) 129
43 Liability Convention, art I
44 See Mohamed Abdelhamid and Guoyu Wang, 'Addressing the Liability Regime in the Space Convention: A Legal Reformation of the Concept of Damage and Its Application to Private Entities' [2024] US China Law Review 41
45 Liability Convention, art II
46 *ibid*, art III

This arrangement clearly reflects the realities of the 1970s, when neither durable industrial operations nor long-term human residence on the Moon was foreseen.[47] This is why much stronger protection is being guaranteed for victims who may suffer damage from a space object on Earth's surface.[48] In these cases, the liability of the launching state will be absolute. That means that the launching state will be liable regardless of fault, negligence or intent. The Liability Convention provides for only very restricted exonerations from the absolute liability of the state.[49] The same applies to damages caused by space objects to aircraft in flight.

In sharp contrast to damage that may occur on the earthly surface, the Liability Convention imposes much stricter conditions for establishing a launching state's liability in Outer Space. Here, *fault* is a basic prerequisite for state liability. This arrangement reflects the presumption that space activities would be reserved for entities prepared to bear an increased risk of damage.

Lastly, the provisions of the Liability Convention shall not apply to damage caused by a space object of a launching state to its own nationals. The same applies to foreign nationals during such time as they are participating in the operation of that space object.[50] The nationality rule reflects a generally accepted principle of diplomatic protection, under which claims by nationals of the responsible state are not subject to protection by another state. The second limitation, the exclusion of foreign participants, was introduced at the USSR's behest and reflects its longstanding practice.[51]

2.3. *The principles relevant to the use of nuclear power sources in outer space*

In stark contrast to both the Outer Space Treaty and the Liability Convention, the Principles do not represent a binding instrument of international space law.[52] The Principles also broaden the concept of the state's liability for nuclear power sources. In the ninth principle, it is provided that:

> each State which launches or procures the launching of a space object and each State from whose territory or facility a space object is launched shall be internationally liable for damage caused by such space objects or their parts. This fully applies to the case of such a space object carrying a nuclear power source on board.[53]

47 See William F Foster, 'The Convention on International Liability for Damage Caused by Space Objects' [1973] Canadian Yearbook of International Law 137

48 It is a matter of fact that the only occasion so far when the Liability Convention was used by one of the contracting parties was the Cosmos 954 case. Cosmos 954 was a reconnaissance satellite launched by the USSR in 1977. A malfunction prevented safe separation of its onboard nuclear reactor. Consequently, when the satellite reentered the Earth's atmosphere the following year (1978), it scattered radioactive debris over northern Canada, some of the debris landing in the Great Slave Lake, Northwest Territories. This prompted an extensive multiyear cleanup operation. The Canadian government claimed 6 million Canadian dollars. In the aftermath, Canada and the USSR settled the dispute, and the USSR eventually paid 3 million Canadian dollars in compensation.

49 Liability Convention, art VI

50 *ibid*, art VII

51 See Schmalenbach (n 39) 540

52 Viviana Iavicoli, 'Nuclear Power Sources in Outer Space for Peaceful Purposes' (n 16) 153

53 Principles, Principle 9.1

In this respect, compensation shall include reimbursement of the duly substantiated expenses for search, recovery and clean-up operations, including expenses for assistance received from third parties.[54]

At the same time, however, the technical scope of the Principles is very restrictive. Their preamble explicitly declares that this set of Principles applies to nuclear power sources in outer space devoted to generating electric power *on board space objects for non-propulsive purposes*, which have characteristics generally comparable to those of systems used and missions performed at the time of the adoption of the Principles.[55] Thus, the liability provisions, as laid down in the Principles, have been designed for nuclear power sources that generate power (and heat) inside the space ships, rather than for lunar reactors.

That said, the Principles also explicitly state that they will require revision in light of emerging nuclear power applications.[56] Thus, they represent a prospective platform for a future liability regime as a soft law instrument.

3. International nuclear law

3.1. *Vienna Convention on Civil Liability for Nuclear Damage*

The framework established under the Vienna Convention aims to harmonise the national laws of the contracting parties by setting minimum standards for financial protection against damage arising from certain peaceful uses of nuclear energy.[57] The convention is designed to ensure that all contracting parties have laws and regulations in place conforming to the legal regime for civil liability for nuclear damage provided for in the convention. The legal regime provided for in the convention is based on the following principles, which differ from the liability principles, as laid down in the instruments of international space law:

1. While the instruments of international space law provide for liability of those states which allowed the launch of the space object in question, the Vienna Convention links the liability for nuclear damages to the operator, rather than to the state that allowed the operation of a nuclear installation in its territory.[58]
2. While the Liability Convention differentiates between the cases of a state's absolute liability and liability based on fault, the Vienna Convention provides for operators' absolute liability, so that the injured party is not required to prove fault or negligence on the part of the operator.[59]
3. The Vienna Convention provides for a minimum amount of the operator's liability.[60] In contrast, the state's liability for damages caused by a space object is unlimited under the Liability Convention.

54 *ibid*, Principle 9.3
55 *ibid*, Preamble
56 *ibid*
57 The so-called low-risk installations, such as mining, are not covered by the liability regime of the Vienna Convention. Neither is the military use of nuclear energy covered.
58 Vienna Convention, art II.5
59 *ibid*, art IV.1
60 *ibid*, art V.1

4. Further, the Vienna Convention also provides for an obligation for the operator to cover liability through insurance or other financial security.[61]
5. Also, the Vienna Convention provides for a limitation of liability in time.[62] Lastly, the Vienna Convention also provides for an exclusive jurisdictional competence of the courts of the contracting party in whose territory the incident occurs or, in the case of an incident outside the territories of contracting parties (in the course of transport of nuclear material), of the contracting party in whose territory the liable operator's installation is situated.[63]

With respect to the outlined principles and to the prospective deployment of lunar reactors, one must take into consideration the following:

1. The Vienna Convention labels its own contracting parties 'Installation States'. Such a state is defined as 'the Contracting Party within whose territory that installation is situated or, if it is not situated (*within the territory of any State, the Contracting Party by which or under the authority of which the nuclear installation is operated*)'.[64] Thus, from its inception, the Vienna Convention has presumed that a reactor can be operated beyond the territory of any state. However, this wording focused on deploying a nuclear reactor in Antarctica, rather than in Outer Space.[65]
2. The Vienna Convention applies to nuclear accidents occurring with respect to the operation of 'any nuclear reactor other than one with which a means of sea or air transport is equipped for use as a source of power, whether for propulsion thereof or for any other purpose'.[66] In this respect, two different interpretations may arise regarding the applicability of the Vienna Convention to lunar reactors. Firstly, one may argue that the Vienna Convention does not apply to the reactors deployed on the Moon. The main argument against including reactors 'with which a means of sea or air transport is equipped' into the regime of the Vienna Convention was the fact that an accident due to these reactors may occur beyond the territory of the home state. Thus, the fathers of the Vienna Convention presumed that other instruments of international law would address this issue. In light of this argument, one may argue that the Vienna Convention does not apply to lunar reactors. However, another interpretation supports the Vienna Convention's applicability to lunar reactors as well. Such an interpretation would argue that, when firmly anchored on the surface of the Moon, the nuclear reactor does not constitute an installation 'with which a means of sea or air transport is equipped'.[67]

61 *ibid*, art VII.1
62 *ibid*, artVI
63 *ibid*, art XI
64 *ibid*, art I.1.d
65 At the time the Vienna Convention was adopted, the US Navy did operate a nuclear reactor to power the McMurdo Station located on the volcanic rock of Hut Point Peninsula on Ross Island. The reactor was operated from 1962 to 1972. For further details see Hanne EF Nielsen, 'Atomic Energy for Antarctica: The Rise and Fall of Nukey Poo' [2024] Polar Record e17.
66 Vienna Convention, art I.1.j.i
67 This line of interpretation has been expressed in the scholarship with respect to floating nuclear power plants. See eg Rüdiger Tscherning, 'Transportable Nuclear Power Plants – An Update on Regulatory Responses in International Nuclear Law' in Christian Raetzke (ed), *Nuclear Law in the EU and Beyond* (Nomos Verlag 2014), 175, 189–191.

3. The Vienna Convention provides that 'loss of life, any personal injury or any loss of, or damage to, property which arises out of or results from the radioactive properties or a combination of radioactive properties with toxic, explosive or other hazardous properties of nuclear fuel' are to be compensated.[68] As with the Liability Convention, the Vienna Convention does not cover potential damage to the lunar environment, such as ice and water deposits, nor does it cover lunar natural resources.

3.2. *Convention on Supplementary Compensation*

The CSC aims to establish a minimum national compensation amount and to further increase it through public funds made available by the contracting parties, should the national amount be insufficient to compensate for the damage caused by a nuclear incident. The convention is open not only to states that are parties to either of the existing liability conventions (including the Vienna Convention), but also to other states provided that their national legislation is consistent with uniform rules on civil liability laid down in the annex to the convention.

However, the CSC contains a provision on geographical scope that precludes its applicability to nuclear installations in Outer Space.[69] The funds, established under the CSC, are to be used exclusively to compensate damages suffered in the territory of a contracting party, in or above maritime areas beyond the territorial sea of a contracting party, in or above the exclusive economic zone of a contracting party or on the continental shelf of a contracting party, in connection with the exploitation or the exploration of the natural resources.

3.3. *Revised Paris Convention*

The Revised Paris Convention stands upon the same liability principles as the above-analysed Vienna Convention:

1. It is the operator of the nuclear installation, rather than the state which permitted the operation on its territory, who is liable for nuclear damages.[70]
2. In the same vein as the Vienna Convention, the Revised Paris Convention also provides for operators' absolute liability, so that the injured party is not required to prove fault or negligence on the part of the operator.[71]
3. The Revised Paris Convention provides that national legislation must provide for a minimum and may provide for a maximum liability amount.[72]
4. Further, as with the Vienna Convention, the Revised Paris Convention also provides for an obligation for the operator to cover liability through insurance or other financial security.[73]

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68 *ibid*, art I.1.k (thus, while the nuclear submarines frequently cruise international waters, they are not governed by the regime of the Vienna Convention).
69 CSC, art V
70 Revised Paris Convention, art 6.b
71 *ibid*, art 6.f
72 *ibid*, art 7
73 *ibid*, art 10.a

5. Also, the Revised Paris Convention provides for a limitation of liability in time.[74]
6. Lastly, the Revised Paris Convention also provides for an exclusive jurisdictional competence of the courts of the contracting party in whose territory the incident occurs.[75]

Like the Vienna Convention, the Revised Paris Convention was also tailor-made for Earth-based nuclear technologies. The following remarks can be made with respect to the potential applicability of this convention to lunar reactors:

1. The text of the Revised Paris Convention explicitly delimits its scope of geographical application. In this respect, the Convention provides that it shall apply to nuclear damage suffered in the 'territory of, or in any maritime zones established in accordance with international law of, or […], on board a ship or aircraft'.[76] Thus, as in the Vienna Convention, the geographical scope of the Revised Paris Convention is strictly limited to the Earth.
2. Further, the Revised Paris Convention applies only to damages arising from *reactors, other than those comprised in any means of transport*; factories for the manufacture or processing of nuclear substances.[77] Similar to the Vienna Convention, several interpretations may arise here as well. On the one hand, it can be argued that a lunar reactor is part of the means of transport (space rocket) and is therefore excluded from the convention's scope of application. On the other hand, one may argue that, when firmly anchored to the surface of the Moon, the lunar reactor falls within the convention's scope.
3. In this respect, one must bear in mind that the Revised Paris Convention provides that 'nothing shall prevent a Contracting Party in whose territory the nuclear installation of the operator liable is situated from providing for a broader scope of application of this Convention under its legislation'.[78] Thus, theoretically, the text of the Revised Paris Convention opens the possibility of enlarging its scope to the lunar environment as well.

4. **Gaps in existing legal frameworks**

All existing instruments of international public law analysed above were adopted when lunar reactors were not seriously considered. Consequently, none of the analysed instruments provides a framework tailored to lunar reactors. This creates myriad gaps in the prospective application of these instruments vis-à-vis the prospective deployment of nuclear reactors on the Moon and potential damages (nuclear damages) an accident in this installation may cause. This part aims to highlight the following points.

74 *ibid*, art 8
75 *ibid*, art 13
76 *ibid*, art 2.a
77 *ibid*, art 1.a.ii
78 *ibid*, art 2.b

4.1. *Potential conflict between two different liability frameworks*

The analysis above demonstrates that, regarding the future deployment of a lunar reactor, a conflict between two liability frameworks may arise. Given the Liability Convention's rather broad definition,[79] the lunar reactor may constitute a *space object* when deployed on the Moon. At the same time, the prospective lunar reactor might also be classified as a *nuclear installation* under the Vienna Convention. This may lead to two rather different liability regimes applying to damages arising from an accident in the lunar reactor that powers the ILRS. This is because the Russian Federation, which will participate in the ILRS, is a contracting party to both the Liability Convention and the Vienna Convention. The different liability regimes will also identify different liable parties (state vs private enterprise). But different liability schemes will apply. While the Vienna Convention provides that operators' liability is absolute, the Liability Convention provides that liability for damages occurring in Outer Space is always based on fault.

In this context, one may argue that any future deployment of lunar reactors must be accompanied by a transparent legal regime. A *patchwork* of applicable liability schemes does not represent such a regime. Thus, overcoming the present patchwork of liability regimes represents a serious challenge to any future use of outer space by nuclear power. Any future liability framework applicable to lunar reactors must be clear. It must clearly identify the liable party, the nature of the liability, the damages covered and the court competent to hear the claims. At the same time, given the Moon's legal status, the future framework must also address liability for environmental damage that belongs to all humankind.

4.2. *Problem of nuclear damage to the space environment*

Currently, both the Artemis Base Camp and the rival ILRS envisage deploying lunar reactors at the Moon's South Pole. The reason is clear: To be useful, a lunar reactor must be close to accessible, extractable and refinable water-ice deposits.[80] Based on available data, the Moon's South Pole is adjacent to permanently shadowed craters that contain precious subsurface ice. These ice water resources will be needed for the proper operation of lunar reactors. If the lunar reactor were placed near a permanently shadowed crater and leaked radioactive corium into the reserves, that game-changing resource could be rendered permanently unusable.[81]

That said, neither the Liability Treaty nor the Vienna Convention includes provisions to address compensation for radioactive contamination of lunar water-ice deposits. Both contain a limited catalogue of covered damages that does not include the *global commons.* Thus, a potential nuclear accident on the Moon and the subsequent radioactive release and contamination of water-ice deposits will not be covered by any existing

79 See Schmalenbach (n 39) 540

80 See Neal (n 29); also see 'Where on the Moon NASA Places its Nuclear Reactor Isn't Simple. The Nuclear Reactor Must Be Close to Accessible, Extractable, and Refinable Water Ice Deposits' *Fast Company* (21 August 2025) <https://www.fastcompany.com/91387627/moon-nasa-nuclear-reactor-location> accessed 25 May 2026

81 See Robin George Andrews, 'Why NASA Wants to Build a Nuclear Reactor on the Moon. To Build Its Moon Base, NASA Needs a Lot of Power' *Scientific American* (19 May 2026) <https://www.scientificamerican.com/article/nasa-dreams-of-a-nuclear-power-plant-on-the-moon-heres-why/> accessed 25 May 2026

liability regimes. Existing instruments also do not provide reimbursement for duly substantiated recovery and clean-up expenses.

The same gap will arise if radioactive contamination damages other space resources, such as space ores harvested by space mining.

4.3. *Nuclear damages caused by radioactive waste in outer space*

As with terrestrial nuclear installations, lunar reactors will also produce both power and radioactive waste.[82] Like nuclear fuel, radioactive waste has hazardous properties that may damage life, health, property or the space environment. While the Vienna Convention contains a liability regime that would also cover these damages,[83] the Liability Convention does not. The USA is not a contracting party to the Vienna Convention. Consequently, liability for nuclear damage that may result from a nuclear accident at the Artemis Base Camp will be exclusively governed by the Liability Convention.

However, the Liability Convention provides compensation only for damages caused by *space objects*.[84] The term space object *includes parts of a space object as well as its launch vehicle and parts thereof*.[85] However, despite this broad definition of 'space object', radioactive waste produced in the prospective lunar reactor would barely fall under it.

Thus, damages potentially caused by the hazardous properties of radioactive waste will not fall under the liability regime established under the Liability Convention. This is a major gap in the existing legal framework.

5. **Charting the course towards a future nuclear liability framework for outer space**

In current academic scholarship, two approaches to the future legal framework governing lunar reactors have been presented:

1. The first of them argues that such a future framework can be established by enlarging the geographical scope of application of the existing instruments.[86]
2. In contrast, the second approach recommends establishing a new legal framework by seeking inspiration in the legal frameworks governing *res communes* on Earth.[87]

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82 See Diana Nikitaeva and L Dale Thomas, 'Analysis of Small Modular Nuclear Reactor Construction on the Moon' in *73rd International Astronautical Congress (IAC), Paris, France, 18–22 September 2022* (International Astronautical Federation 2022)

83 See Vienna Convention, art I.1.k

84 Liability Convention, art I.d

85 *ibid*

86 See Yang and Hassan (n 16) 131

87 See eg Miraslava Kozlouskaya, 'In the Search for Improvements in Space Mining International Regulation: An Analogy with Other Regimes' in *Proceedings of the International Astronautical Congress, IAC* (International Astronautical Federation, IAF 2022); Edythe E Weeks, 'Lessons from International Space Law: The Role of International Relations in Governing Global Commons Regions' [2020] Yearbook of Polar Law 434; Matthew Schaefer, 'Analogues Between Space Law and Law of the Sea/International Maritime Law: Can Space Law Usefully Borrow or Adapt Rules from These Other Areas of Public International Law?' in *Proceedings of the International Astronautical Congress, IAC* (International Astronautical Federation, IAF 2012); also see Melissa de Zwart, 'Boots on the Moon: Managing the

In 2026, a questionnaire on the future legal framework for lunar reactors, prepared under the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS), reaffirmed the existence of these two distinct approaches.[88]

This article advocates for the second approach. The existing instruments of international space law and international nuclear law reflect yesterday's realities. They were not designed to address challenges arising from the forthcoming *post-terrestrial era*,[89] which will, inter alia, include deploying lunar reactors.[90] This article argues that a new framework is needed. In that respect, this section identifies key topics to consider when designing the future framework.

5.1. *Any future liability framework must reflect the realities of the Moon, rather than the realities of the Earth*

Neither the Vienna Convention nor the Liability Convention was adopted in light of the realities of the 1960s and 1970s. The Vienna Convention *primarily* presumes that the nuclear installation in question is situated within the territory of a contracting party. In this respect, it governs liability for those damages that possess a transboundary nature – that is, the origin of the damage (nuclear accident) occurred in one territory, while the damage was suffered in another territory. The Vienna Convention addresses issues arising from these transboundary damages – such as the competence of the court, recognition and enforcement of final judgements rendered by the competent court in all contracting parties, etc. Thus, the liability regime established by the Vienna Convention presumes that the Earth is divided into the territories of various states, separated by state borders. Consequently, at its very heart, the Vienna Convention provides for an Earth-fixed system of liability and compensation. So, the Vienna Convention's system cannot address the realities of a nuclear accident in the lunar reactor.

Neither does the Liability Convention provide a liability scheme capable of covering the risk of compensation for damages arising from a nuclear accident in the lunar reactor. Existing scenarios assume that, in the event of a nuclear accident in the lunar reactor, most of the damage will occur in the lunar environment.[91] Consequently, one may argue that a lunar reactor accident may primarily damage the nearby human settlement. Thus, radiation could harm both the settlement's personnel and the buildings, infrastructure, and other equipment stationed there. A nuclear accident in the lunar reactor may also harm the lunar environment, including water ice deposits, soil minerals and various volatiles.[92] However, the Liability Convention does not address these situations. The Liability Convention focuses *primarily* on damages that space objects may cause on the Earth's

Return of Humans to the Moon' in Anna M Brennan (ed), *The Future of Outer Space Law* (Routledge 2025) 93

88 See UNCOPUOS, Draft Policy Report on Lunar Nuclear Reactors, Sixty-ninth session, Vienna, 11 June 2026

89 See Anthi Koskina and others, 'Colonizing the Moon in the Post-Terrestrial Era? Challenges for the Management of the Commons' [2026] Frontiers in Political Science 1716742

90 See Anna M Brennan, 'Hypothesising the Future of Outer Space Law' in Anna M Brennan (ed), *The Future of Outer Space Law* (Routledge 2025) 246

91 See Bennet (n 13)

92 See Chang Wang and others, 'A Review of Lunar Environment and In-Situ Resource Utilization for Achieving Long-Term Lunar Habitation' [1973] Canadian Yearbook of International Law 137

surface or to an aeroplane in flight.[93] Further, the Liability Convention also governs cases where damage is caused 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.[94] This arrangement reflects the realities of the 1970s, when the convention's drafters anticipated potential collisions between space objects launched by two different states.[95] Thus, the Liability Convention establishes a regime governing liability when two space objects are in flight, and one causes damage to the other. This also includes damage to personnel and property aboard a space object. However, as with the Vienna Convention, the Liability Convention is unlikely to cover liability issues arising from deploying a nuclear reactor on the *lunar surface.*

In this respect, any future regulation of liability and compensation for nuclear damages in Outer Space must consider the following scenario:

1. A nuclear installation (lunar reactor) is operated to power a nearby human settlement or industrial operations continuously. This lunar reactor is firmly anchored to the lunar surface.
2. The lunar reactor is operated by a person holding the licence obtained from the competent regulatory authority of the launching state. At the same time, this regulatory authority will be competent to supervise the installation's safety.[96] One may expect that state operators will operate the very first lunar reactors.[97] However, as the space industry becomes more commercialised, one may also expect private operators to take over over a much longer period.
3. Despite this ongoing supervision, the hazardous nature of nuclear materials used in a lunar reactor may cause a nuclear accident in this installation.
4. For the time being, a comprehensive analysis of what impact such a nuclear accident will have is still absent. However, experts argue that, unlike Earth meltdowns, where steam, pressure and chemical explosions (of hydrogen gas, for example) cause catastrophic containment breaches, a lunar reactor accident would likely involve an initial thermal flash, followed by the fuel melting into a glowing, sluggish pool. Without an atmosphere to carry an explosive blast, the melted fuel would largely remain contained at the physical site, cooling and solidifying into a highly radioactive hunk of metal.[98] Because these advanced nuclear technologies are being developed for critical survival needs – like running life support systems, communicating and extracting resources during weeks-long lunar nights – a meltdown would mean an immediate, catastrophic loss of the base's primary power source.[99]

93 Liability Convention, art II
94 *ibid*, art III
95 See Abdullah Abdullatif, Jamal Barafi, and Sheer Abbas, 'Beyond Earthly Justice: Are Current Space Dispute Systems fit for the Final Fronties?' [2025] Jurnal Kajian Ilmu Hukum dan Syariah 511
96 See Outer Space Treaty, art VIII
97 See Jericho Locke and Bhavya Lal, 'Emergence of a Commercial Space Nuclear Enterprise' [2020] Nuclear Technology 1109
98 See Andrews (n 81)
99 *ibid*

One must bear in mind that what a nuclear accident on the Moon will look like is still unclear. Because the Moon lacks an atmosphere, a nuclear accident on the Moon will behave entirely differently from a disaster on Earth. However, existing projections of such an accident indicate that the following types of damage (lunar nuclear damages) will probably occur and must be covered by the prospective legal framework:

1. The area immediately surrounding the molten core would become a deadly exclusion zone. Astronauts could suffer serious health and life-threatening injuries. Also, damage to property, installations, infrastructure and equipment is to be expected at this location. The intensity of the radiation and heat would likely make the site unapproachable for generations.[100]
2. The vacuum and lack of wind would prevent radioactive ash from blowing across the Moon like Chornobyl or Fukushima fallout. However, fine, charged lunar regolith (dust) disrupted by the incident or disturbed by cleanup robots could be kicked up into *radioactive dust storms.* These storms may cause nuclear damage over a much wider area around the accident.
3. While damages to property, installations, infrastructure and equipment will be suffered by the individual (Earth-based) owner, damages to water-ice deposits will occur to *global commons.* A nuclear meltdown on the Moon would contaminate lunar water resources by melting and vaporising radioactive corium into the regolith. Because the Moon lacks an atmosphere and liquid groundwater, radiation and heavy radioactive isotopes would bind directly with polar ice, rendering vast reserves of critical drinking water and rocket propellant unusable.[101]

5.2. *Addressing lunar nuclear liability by national or international legislation?*

Both international space law and international nuclear law were created when space and nuclear technologies were in their infancy. This suggests these instruments do not address many issues that have arisen in recent decades from rapid technological development. The prospective deployment of lunar reactors is just one example of this dynamic development in space technologies. A similar absence of explicit rules also exists for mining minerals on celestial bodies (space mining). Over the past decade, international space law has increasingly addressed the lack of rules on space mining by adopting national legislation.[102]

The United States of America has pioneered this trend. In 2015, the US enacted new legislation establishing conditions under which American citizens and commercial corporations can search for and mine minerals in outer space.[103] The first, and so far only, European jurisdiction inspired by the American approach was the Grand Duchy of Luxembourg. Luxembourg adopted its own national legislation on space mining in 2017.[104] In addition to the United States and Luxembourg, the United Arab Emirates (2019) and Japan (2021) have also enacted national legislation on space mining.

100 *ibid*
101 See Bennet (n 13)
102 See Martin Svec, 'Outer Space, an Area Recognised as *Res Communis Omnium*: Limits of National Space Mining Law' [2022] Space Policy 101473
103 Commercial Space Launch Competitiveness Act of 2015
104 Loi du 20 juillet 2017 sur l'exploration et l'utilisation des ressources de l'espace

Legal scholarship has criticised national legislation governing space mining.[105] Because the intention to operate lunar reactors is often directly linked to the intention to mine minerals, some of these criticisms also apply to this article. This criticism is that outer space, including the Moon and other celestial bodies, was proclaimed *res communis omnium*. Their use should be pursued for the welfare of all countries, regardless of their levels of economic and scientific development. However, if the Moon is the property of all humanity, its use should reflect a consensus among individual states. National legislation certainly does not represent such a consensus. National legislation will always reflect one state's strategic, economic and military interests. Very recently, these concerns were shared also in the outcomes of the UNCOPUOS questionnaire on the future of lunar reactors' legal framework:

> Establishing new international treaties requires time for consensus-building and the gathering of technical expertise for meaningful results. By contrast, groups of like-minded countries (such as China and the Russian Federation), or even individual States (such as the USA), may be able (and decide) to move more quickly, particularly if pressured by strategic geopolitical competition. This creates a risk that deployments will occur in advance of agreed rules, opening the door to political contestation, fostering regulatory fragmentation, and reducing the level of safety and sustainability of actual operations.[106]

Consequently, international consensus should establish the rules for the prospective deployment of lunar reactors and enshrine them in a new multilateral instrument of space nuclear law. This is also true for a prospective framework for liability and compensation for lunar nuclear damages.

5.3. *Earthly models for space solutions*

Any future framework for lunar nuclear liability will require further research into how an accident in a lunar reactor could occur and what its consequences would be. That said, one may draw inspiration for this future framework from regimes that already govern *Earth's global commons*.

In this respect, the international framework established by the Protocol on Environmental Protection to the Antarctic Treaty[107] and its Annex VI on Liability Arising from Environmental Emergencies (Annex) may offer inspiration for addressing a future liability and compensation regime for lunar nuclear damage. This is because the Antarctic and lunar environments share certain common features,[108] which are as follows:

1. Firstly, both Antarctic and lunar environments represent *global commons* – environments belonging to the whole of humankind.

105 See Amanda M Leon, 'Mining for Meaning: An Examination of the Legality of Property Rights in Space Resources' [2018] Virginia Law Review 497; Laura C Byrd, 'Soft Law in Space: A Legal Framework for Extraterrestrial Minings' [2021] Emory Law Journal 801

106 See UNCOPUOS, Draft Policy Report on Lunar Nuclear Reactors, Sixty-ninth session, Vienna, 11 June 2026

107 Protocol on Environmental Protection to the Antarctic Treaty (adopted on 4 October 1991, came into force 14 January 1998)

108 See Mingyan Nie and Yun Zhao, 'Creating a Lunar-Centric Legal Regime to Preserve Peaceful and Sustainable Uses of Cislunar Space: Proposing Initial Measures' [2025] Acta Astronautica 856

2. Accidents may harm both the Antarctic and lunar environments due to the technological operations of an individual (referred to as the operator by the Annex), by acts of terrorism, war or natural disasters (such as earthquakes or moonquakes).
3. Accidents both in the Antarctic and on the Moon will occur at a considerable distance from the operator's home state. Thus, both preventive measures and response actions will require intensive international cooperation.

The annex applies to environmental emergencies[109] in Antarctica which relate to scientific research programmes, tourism and all other governmental and non-governmental activities. The regime, established by the annex, applies with respect to any accidental event that has occurred, having taken place after the entry into force of this Annex, and that results in, or imminently threatens to result in, any significant and harmful impact on the Antarctic environment'.[110] Consequently, the annex's scope of application is rather narrow and does not cover damages to life, health or property. Notwithstanding this rather narrow scope, the following measures of the annex might also be inspiring for the future international framework for lunar nuclear damages:

1. Prevention is in the first place. The annex provides that each party shall require its operators to undertake reasonable preventive measures designed to reduce the risk of environmental emergencies and their potential adverse impacts.[111] While the annex lists these preventive measures, any future regulation of lunar nuclear damage will require establishing a new, tailor-made list of measures that reflects the peculiarities of the lunar environment.
2. The annex provides that the operator is responsible in the first place to take *prompt* and *effective response* action to environmental emergencies arising from the activities of that operator.[112] Only if the operator does not take the required response action, the party of that operator and other parties are encouraged to take such action, including through their agents and operators specifically authorised by them to take such action on their behalf.[113]
3. The operator that fails to take the required response action as outlined above shall be liable to pay the costs of response action taken by the parties.[114] The operator's liability shall be strict.[115]
4. An operator shall not be liable[116] if it proves that the environmental emergency was caused by:

    a. an act or omission necessary to protect human life or safety,
    b. an event constituting in the circumstances of Antarctica a natural disaster of an exceptional character, which could not have been reasonably foreseen, either generally or in the particular case,

109 Annex, art 2.b
110 *ibid*
111 *ibid*, art 3.1
112 *ibid*, art 5.1
113 *ibid*, art 5.2
114 *ibid*, art 6.1
115 *ibid*, art 6.3
116 *ibid*, art 8.1

c. an act of terrorism; or
d. an act of belligerency against the activities of the operator.

One may argue that these liberations also apply to the lunar environment and should be reflected in the future legal regime governing lunar nuclear damages.

5. Each party shall require its operators to maintain adequate insurance or other financial security, such as the guarantee of a bank or similar financial institution, to cover liability under this Annex.[117]

Applying this regime also to damages potentially arising from an accident in a lunar reactor will establish a flexible regime, capable of covering both state and future private operators.

6. Conclusions

While a nuclear reactor on the Moon might sound too risky, existing designs aim to prioritise safety: they use passive cooling and low-enrichment uranium, making catastrophic failure extremely unlikely.[118]

Despite this, it would be irresponsible to deploy a nuclear reactor on the Moon without establishing a transparent framework for liability and compensation. This article argues that while existing instruments of international public law can address some potential issues, they cannot fully cover liability. This is because these instruments were adopted over time, and the deployment of lunar reactors was not then considered a viable option.

This article argues that a new framework for liability and compensation of lunar nuclear damages is needed. However, such a framework cannot be established by expanding existing liability frameworks in nuclear or space law. These were tailor-made for earthly circumstances and do not reflect the Moon's peculiarities. National legislation on liability for lunar nuclear damage also cannot provide a viable solution. This is because an accident in a lunar reactor will most probably impact the space environment – that is, the *global commons*, which belong to all humankind. A piece of national legislation can safeguard the interests of all humankind only so far.

Thus, this article argues that a new international framework for liability and compensation of lunar nuclear damages must be established. While this regime may draw some inspiration from regimes governing *global commons* on Earth, its final design will require deeper study of the dynamics of a prospective lunar nuclear accident.

Such a study is essential, and it will not only provide long-awaited answers for the design of international nuclear law for outer space. This is because Mars, not the Moon, represents the final frontier for international nuclear law.

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117 *ibid*, art 11
118 See Bennet (n 13)

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