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Nuclear Law in the New Space Era

Commercial Use of Outer Space and the Future of the Law of Nuclear Energy

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Abstract:

The entire world has entered the period of a New Space Era. Advanced space technologies have significantly reduced launch costs, and the number of actors launching satellites into orbit has increased continuously. Advanced space technologies have opened the door for nanosatellites and microsatellites, which bring the opportunity to enable missions that large satellites cannot accomplish - such as providing constellations for low data rate communications, in-orbit inspection of larger satellites, etc. All these technological advances have opened Outer Space for commercial use by private entities. In the New Space Era, the State has lost its previously established monopoly on exploring and using Outer Space. Having said this, the New Space Era also represents considerable challenges for the prospective deployment of nuclear technologies in Outer Space. For the time being, a myriad of advanced nuclear technologies is being researched and developed by established energy companies, innovators, and nuclear start-ups. Current projects include ultra-lightweight nuclear propulsion probes for deep space exploration and advanced portable microreactors for space applications, such as space mining and delivering power to human settlements in Outer Space. Taking into account the involvement of commercial entities in these projects, one may predict that the private sector will have considerable interest in the use of nuclear energy in space activities in the future. This article argues that nuclear law needs to reflect prospective

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challenges arising from the future commercialisation of nuclear use in Outer Space. The current legal framework has been reflecting an étatist approach to space activities, which has been primarily focused on government-led space projects. This approach, however, is not sufficient to address challenges arising from the prospective commercialisation and privatisation of nuclear activities in Outer Space. Future laws must address risks arising from the gradual emergence of private nuclear space corporations, innovators, and start-ups. At the same time, the New Space Era represents a challenge to the international discourse on nuclear law, which has neglected this topic so far.

Keywords:

nuclear law; space law; New Space Era; space commercialisation; advanced nuclear technologies

1. Introduction[1]

The entire world has entered the period of *the New Space Era*.[2] Launch costs have reduced significantly, and the number of actors launching satellites into orbit will continue to increase. Lower costs of space travel are opening the door to the establishment of extraterrestrial footholds. Experts have identified 17,000 asteroids which can be exploited for resource extraction, with one estimate putting the size of the space industry at $2.7tn per year by 2050. At the same time, the nanosatellites and microsatellites segments of the space industry have been increasing. Smaller and lighter satellites require smaller and cheaper launch vehicles and can sometimes be launched in multiples. Further, smaller and lighter satellites bring the opportunity to enable missions large satellites cannot accomplish, such as providing constellations for low data rate communications, in-orbit inspection of larger satellites, testing or qualifying new hardware before using it on a more expensive spacecraft, manufacturing of pharmaceutics under space conditions (space pharmacy), etc.

All these technological advances have opened the space for commercial use by private entities.[3] Thus, in the New Space Era, the State has lost its previously established monopoly on

[1] This is a written version of my presentation, delivered at the *XXVth Nuclear Inter Jura Congress*, which was organised by the International Nuclear Law Association (AIDN/INLA) in Warsaw, Poland, from November 3rd to 7th, 2024.

[2] See Golkar, A., Salado, A., *Definition of New Space,* "IEEE Journal on Miniaturization for Air and Space Systems", 2021, Vol. 2, at pp. 2 et seqq.

[3] See Denis, G., Alary, D., Pasco, X., Pisot, N., Texier, D., *From new space to big space: How commercial space dream is becoming a reality,* „Acta Astronautica", 2020, Vol. 166, at pp. 431 et seqq.

the exploration and use of Outer Space. In this respect, the *New Space Era* has been characterised both by intensive technological development and by gradual commercialisation and privatisation of space activities.

Having said this, the New Space Era also represents considerable challenges for the prospective deployment of nuclear technologies in Outer Space.[4] For the time being, a myriad of advanced nuclear technologies is being researched and developed by established energy companies, innovators, and nuclear start-ups. This leads to the gradual emergence of a commercial space nuclear market. Despite being in its infancy, one may already know Jericho Locke and Bhavya Lal1 have outlined[5] four distinctive components of this prospective market, which are as follows:

1. **Suppliers:** Potential suppliers range from recent startups to established suppliers, and most have an existing terrestrial power business. These companies are leveraging developments and trends in terrestrial technology, including small or microreactors, lower power levels, advanced fuels, high outlet temperatures, and off-site fabrication and assembly.[6]
2. **Fuel Developers:** Space fission systems require higher enrichment levels than their terrestrial counterparts to increase energy density, but enriching above 20% has proliferation and business challenges. Highly Enriched Uranium (HEU) has high safety and proliferation risks similar to Pu-238. The only privately owned facilities licensed to handle and manufacture HEU fuel are owned by BWXT, which supplies and services the Navy's nuclear reactors. For the time being, licensing facilities to handle HEU is potentially cost-prohibitive without government support.[7]
3. **Launchers:** In recent years, *United Launch Alliance* has launched nuclear payloads. The fact is, however, that these launches have so far research and development nature. Newer private companies—namely SpaceX and Blue Origin—are developing larger rockets and could, in principle, launch nuclear payloads as commercial providers in the future.[8]
4. **Users:** For the time being, private entities have shown considerable interest in using nuclear power in Outer Space. This interest covers the entire range of nuclear systems, including

[4] This article aims to address exclusively prospective peaceful uses of nuclear energy in Outer Space.
[5] See Locke, J., Lal, B., *Emergence of a Commercial Space Nuclear Enterprise*, in: *Nuclear and Emerging Technologies for Space, American Nuclear Society Topical Meeting Richland, WA, February 25 – February 28, 2019,* at pp. 2 et seqq.
[6] Ibid.
[7] Ibid.
[8] Ibid.

nuclear electric or thermal propulsion and surface reactors to support human and in situ resource utilisation operations (including space mining) on the surface of the Moon or Mars.[9]

Private space companies have a commercial interest in nuclear power, both to use its outputs (e.g., propulsion and power) and to provide those outputs by operating the systems. For the time being, however, a real boom of commercial nuclear projects for space use is expected in the decade to come.[10] It is crystal clear that commercial use of nuclear power in Outer Space will require a transparent and predictable legal framework, which will guarantee a high level of safety and transparency. Such a framework plays an important role both for the environment and the concerned public and for the private entities themselves, as many of them have identified the lack of clear rules as a significant obstacle to the further development of the nuclear project for space use.[11]

The fact is, however, that the discourse in nuclear law hasn't paid any considerable attention to the legal framework applicable to future commercial use of nuclear energy in Outer Space so far.[12] The following examples may demonstrate this more clearly: In 2022, Sweet & Maxwell published the 3rd edition of *The Law of Nuclear Energy,* authored by Helen Cook. While the author addresses[13] advanced nuclear technologies and their legal implications in extensive detail in her book, the issues of prospective nuclear use in Outer Space remain beyond the author's attention. Neither the *Principles and Practice of International Nuclear Law,* published[14] by the OECD/NEA in the same year, paid any attention to legal issues prospectively arising from nuclear use in Outer Space. The *Burges Salmon Guide to Nuclear Law*[15], published very recently by the leading British law firm, also remains silent regarding the legal framework applicable to uses of nuclear energy in Outer Space. This fact reflects, to some extent, that priority is being given to advanced nuclear technologies which are most likely to be deployed in the forthcoming decade, such as small modular reactors. At the same time, most of

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[9] See Vertadier, H., Gilbert, A., The importance of nuclear energy governance in establishing sustainable lunar settlements, in: Proceedings of the 74th International Astronautical Congress, IAC, 2023, paper 197475. Also see Borowski, S., The use of nuclear propulsion, power and "in-situ" resources for routine lunar space transportation and commercial base development, "Science and Technology Series", 2004, Vol. 108, at pp. 225 et seqq.
[10] See Locke, J., Lal, B., *Emergence of a Commercial Space Nuclear Enterprise*, at p. 5.
[11] See Locke, J., Lal, B., *Emergence of a Commercial Space Nuclear Enterprise*, at p. 4.
[12] For a salient exception, see Gilbert, A., Space, the Final Frontier of International Nuclear Law, Blog "Power and Resources", available at https://www.powerandresources.com/blog/space-the-final-frontier-of-international-nuclear-law .
[13] See Cook, H., *The Law of Nuclear Energy,* 3rd edition, London, Sweet & Maxwell – Thomson Reuters, 2022, at pp. 423 et seqq.
[14] See OECD/NAE (eds.), *Principles and Practice of International Nuclear Law,* Paris, OECD/NEA, 2022.
[15] See Salter, I., Truman, I. (eds.), *Burges Salmon Guide to Nuclear Law,* 3rd edition, sine loco, Burges Salmon, 2024.

the major international agreements adopted in the field of peaceful use of nuclear energy do limit their geographical scope of application to terrestrial technologies. Also, the presentations held at the *XXVth Nuclear Inter Jura Congress* have demonstrated the same degree of disinterest in the deployment of advanced nuclear technologies in Outer Space. While the overall theme of the Congress was *Nuclear New Build Renaissance: In Search for New Approaches to Legal and Regulatory Challenges,* almost exclusive attention was paid to the prospects of advanced nuclear technologies on Earth (small modular reactors) or at the High Seas (transportable nuclear power plants).

Neither discourse on space law has shown a different picture. Traditionally, the scholarship of space law has paid attention to legal implications arising from government-let nuclear use in Outer Space.[16] Also, those authors who addressed the future of space law have, in principle, paid only attention to the government-led use of nuclear energy in Outer Space.[17] The fact is, however, that very recently, the focus has been shifted towards legal issues arising from the commercial use of Outer Space.[18] Despite this, only a few authors[19] have addressed the phenomenon of space privatisation with respect to the prospective deployment of advanced nuclear technologies in Outer Space.

This article argues that nuclear law needs to reflect prospective challenges arising from the future commercialisation of nuclear use in Outer Space. The current legal framework has been reflecting an *étatist* approach to any activities in Outer Space. This approach is, in principle, focused on the obligations of the State *vis-á-vis* other States in the field of space exploration. It reflects the monopoly of the State on any space activities, including those where peaceful use of nuclear energy is being deployed. This approach, however, is not sufficient to address challenges arising from the prospective commercialisation and privatisation of

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[16] See MacAvoy, J., *Nuclear Space and the Earth Environment: The Benefits, Dangers, and Legality of Nuclear Power and Propulsion in Outer Space,* "William & Mary Environmental Law and Policy Review", 2004/5, Vol. 29, at pp. 191 et seqq., Malysheva, N., Chebotaryov, O., *International law and peaceful use of nuclear power sources in outer space,* in: *Proceedings of the 47th Colloquium on the Law of Outer Space,* 2005, at pp. 481 et seqq., Bouvet, I., *Use of nuclear power sources in Outer Space. Key technology legal challenges,* "Journal of Space Law", 2004, Vol. 30, at pp. 203 et seqq. Also see Kopal, V., *The Use of Nuclear Power Sources in Outer Space: A Net Set of United Nations Principles,* "Journal of Space Law", 1991, Vol. 19, at pp. 103 et seqq.

[17] See Mirmina, S., Den Herder, D., *Nuclear Power Sources and Future Space Exploration,* "Chicago Journal of International Law", 2005, Vol. 6, at pp. 149 et seqq.

[18] See Smith, L., Baumann, I., Wintermuth, S. (eds.), *Routledge Handbook of Commercial Space Law,* London, Routledge, 2024. Also see De Zwart, M., Henderson, S. (eds.), *Commercial and Military Uses of Outer Space*, Vienna, Springer International, 2021.

[19] See Venturini, G., *The Legal Regime of the Use of Nuclear Power Sources in Space Missions,* in: *Nuclear Non-Proliferation in International Law, Volume V.,* Springer International, Vienna, 2020, at pp. 73 et seqq. See also Zhao, Y., *Soft Laws Relating to Space Activities,* in: Bhat, S., Ukey, D., Variath, A. (eds.), *International Space Law in the New Space Era: Principles and Challenges,* Oxford: Oxford University Press, 2024, at pp. 183 et seqq.

activities in Outer Space. Future laws must address risks arising from the gradual emergence of private nuclear space corporations, innovators, and start-ups.

At the same time, the New Space Era represents a challenge to the international discourse on nuclear law, which has neglected this topic so far.

2. *Étatist* approach to nuclear activities in Outer Space

The *étatist* approach to nuclear activities in Outer Space has been enshrined in the *Principles Relevant to the Use of Nuclear Power Sources in Outer Space.*[20] This statement deserves further clarification: The fact is that the Preamble provides that:

> "in some missions in outer space nuclear power sources are particularly suited or even essential owing to their compactness, long life and other attributes."

Thus, the Preamble itself does not exclude commercial use of nuclear energy in Outer Space by private entities.[21] At the same time, the *Principles* provide that:

> "States shall bear international responsibility for national activities involving the use of nuclear power sources in outer space, whether such activities are carried on by governmental agencies or by non-governmental entities (…). When activities in outer space involving the use of nuclear power sources are carried on by an international organisation, responsibility for compliance with the aforesaid Treaty and the recommendations contained in these Principles shall be borne both by the international organisation and by the States participating in it."[22]

This wording has been influenced by the wording of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, which provides for the international responsibility of the States for space activities in general.[23] Having cited this provision, it is crystal clear that the *Principles* basically *admit* commercial use of nuclear energy in Outer Space not only within government-led projects but also by private entities (*non-governmental entities*).

When referring to the *étatist* character of the regulation, one refers to the fact that the *Principles* govern exclusively the mutual relations between the States. In this respect, the

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[20] Resolution adopted by the General Assembly of the United Nations. 48/67 *Principles Relevant to the Use of Nuclear Power Sources in Outer Space* (85th plenary meeting, 14 December 1992).
[21] See Quizhi, H., *Towards a New Legal Regime for the Use of Nuclear Power Sources in Outer Space,* "Journal of Space Law", 1986, Vol. 14, at pp. 95 et seqq.
[22] Principle 8.
[23] Article VI.

Principles use the term *launching State,* or *State launching,* to refer to the State that *exercises jurisdiction and control over a space object with nuclear power sources on board at a given point in time that is* relevant to the principle concerned.[24]

Thus, the *Principles* provide for a general rule, under which "in order to minimise the quantity of radioactive material in space and the risks involved, the use of nuclear power sources in outer space shall be restricted to those space missions which non-nuclear energy sources cannot operate in a reasonable way."[25] This general principle is subsequently elaborated in further obligations of the *launching States*:

1. States launching space objects with nuclear power sources on board shall endeavour to protect individuals, populations and the biosphere against radiological hazards.[26]
2. Further, a launching State shall ensure that a thorough and comprehensive safety assessment is conducted at the time of launch. This assessment shall cover all relevant phases of the mission and all systems involved, including the means of launch, the space platform, the nuclear power source and its equipment, and the means of control and communication between ground and space.[27]
3. Any State launching a space object with nuclear power sources on board shall, in a timely fashion, inform States concerned in the event this space object is malfunctioning with a risk of re-entry of radioactive materials to the Earth.[28] In this respect, the *Principles* also provide for obligations of States to mutual assistance in the case of an expected re-entry into the Earth's atmosphere of a space object containing a nuclear power source on board and its components.[29]
4. Lastly, the *Principles* also provide 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.[30]

Consequently, while a comprehensive set of rules has been established regarding mutual relations between States, a similar set of rules governing relations between the launching State and private entities aiming at nuclear use in Outer Space has been absent. This situation clearly reflects the overall situation in the past decades, where States possessed a monopoly on nuclear

[24] Principle 2.
[25] Principle 3.
[26] Ibid.
[27] Principle 4.
[28] Principle 5.
[29] Principle 7.
[30] Principle 9.

use in Outer Space.[31] However, with the gradual commercialisation and privatisation of Outer Space, one must expect the deployment of advanced nuclear technologies there also by private entities. In the future, such entities may be represented either by commercial nuclear corporations or by nuclear innovators and start-ups. A transparent and foreseeable legal framework applicable to these private entities will be urgently needed to ensure a very high degree of nuclear safety in Outer Space.

3. Modern approach to nuclear activities in Outer Space

Any prospective deployment of commercial ultra-lightweight nuclear propulsion probes for deep space exploration and advanced portable microreactors for space applications in the future will require an appropriate legal framework. Such a legal framework must address mutual relations between the *launching State* on the one hand and *the private entity* (*non-governmental entities* in the wording of the *Principles*) aiming to use nuclear power in Outer Space on the other commercially. The fact is that the *launching State* will still bear international responsibility for any launched space object bearing advanced nuclear technologies. This will most probably become the trigger for establishing new rules that will specify provisions for the safe operation of their technologies in Outer Space.

Having said this, one may ask to what extent the currently accepted principles of nuclear law[32] will apply to the future use of advanced nuclear technologies in Outer Space. The following paragraphs aim to address the applicability of the 1) permission principle, 2) sustainable development principle, and 3) compensation principle with respect to the future commercial deployment of advanced nuclear technologies in Outer Space.

Ad 1)

While the Convention on Nuclear Safety has provided the rules for authorisation, this Convention will not be applicable to any advanced nuclear technologies deployed in Outer Space – neither to those serving as means of propulsion nor to those which will serve as a source of power for space mining, or for human settlements. The Convention was designed exclusively to reflect the peculiarities of Earth-based nuclear installations. Consequently, its framework is not suitable for covering the specific nature of nuclear use in outer space. The use of nuclear

[31] See IAEA (ed.), *The Role of Nuclear Power and Nuclear Propulsion in the Peaceful Exploration of Space,* Vienna, IAEA, 2005, at pp. 2-7.
[32] Stoiber, C., Baer, A., Pelzer, N., Tonhauser, W., *Handbook on Nuclear Law,* Vienna, IAEA, 2003, at pp. 5-20.

power in outer space has unique safety considerations compared with terrestrial applications. Mission launch and outer space operational requirements impose size, mass, and other space environment limitations that are not present for many terrestrial nuclear facilities. For some applications, space nuclear technologies must operate *autonomously* at great distances from Earth in harsh environments. Potential accident conditions resulting from launch failures and inadvertent re-entry could expose these technologies to extreme physical conditions. These and other unique safety considerations for the use of space nuclear technologies are significantly different from those for terrestrial nuclear systems.[33] This is the reason why the Convention limits its technological scope to *land-based civil nuclear power plants under its jurisdiction, including such storage, handling and treatment facilities for radioactive materials as are on the same site and are directly related to the operation of the nuclear power plant*.[34]

In this respect, the *Safety Framework for Nuclear Power Source Applications in Outer Space,* which has been adopted jointly by the United Nations Committee on the Peaceful Uses of Outer Space Scientific and the IAEA, argues[35] that the permission principle must be applicable also *vis-á-vis* advanced nuclear technologies in Outer Space. In this respect, the *Safety Framework* provides that:

> "the government that oversees and authorises the launch operations for space NPS (=nuclear power sources) missions should establish a mission launch authorisation process focused on nuclear safety aspects. The process should include an evaluation of all four relevant information and considerations from other participating organisations. The mission launch authorisation process should supplement the authorisation processes covering non-nuclear and terrestrial aspects of launch safety. An independent safety evaluation (i.e. a review, independent of the management organisation conducting the mission, of the adequacy and validity of the safety case) should be an integral part of the authorisation process. The independent safety evaluation should consider the entire space NPS application – including the space NPS, spacecraft, launch system, mission design and flight rules – in assessing the risk to people and the environment from relevant launch, operation and end-of-service phases of the space mission."

In this respect, the *Safety Framework for Nuclear Power Source Applications in Outer Space* also argues that, unlike many terrestrial nuclear applications, space applications tend to be used infrequently, and their requirements can vary significantly depending upon the specific mission.[36] While this statement can be considered correct for the time being,

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[33] See UN/IAEA (eds.), *Safety Framework for Nuclear Power Source Applications in Outer Space,* Vienna, IAEA, 2009, at p. 1.
[34] Convention on Nuclear Safety, Article 2.i.
[35] See UN/IAEA (eds.), *Safety Framework for Nuclear Power Source Applications in Outer Space,* Vienna, IAEA, 2009.
[36] Ibid, at p. 1.

the future will most probably imply a more frequent space use of advanced nuclear technologies. Consequently, future laws will be able to distinguish between various types of advanced technologies and set specific rules to address safety considerations for each of them.

Having said this, one must remember that not only authorisation but also continuous control of nuclear technologies operated in Outer Space will need to be secured. In this respect, one has to seriously consider the future use of satellites for observation purposes by national regulatory authorities.

Ad 2)

Any prospective use of advanced nuclear technologies in Outer Space will imply the need to address the problem of nuclear waste. Small modular reactors deployed to power mining colonies or human settlements on space objects will produce nuclear waste, which needs to be stored and subsequently disposed of safely. The fact is that neither the *Principles Relevant to the Use of Nuclear Power Sources in Outer Space* nor the *Safety Framework for Nuclear Power Source Applications in Outer Space had explicitly addressed the issue of nuclear waste* arising from the use of nuclear technologies in Outer Space. Neither the provisions of the Joint Convention on the Safety of Spent Fuel Management nor the Safety of Radioactive Waste Management seem to be applicable to this type of waste, as the Joint Convention was adopted explicitly to complement the Convention on Nuclear Safety.

However, one may argue that the issue of nuclear waste mitigation and the obligation to use nuclear sources sustainably actually arise from the concept of the launching State's international responsibility, which has been enshrined in the *Principles Relevant to the Use of Nuclear Power Sources in Outer Space.*[37]

In this respect, one may argue that the sustainable development principle must be applicable to nuclear waste produced in Outer Space, in the same vein as it is currently applicable to nuclear waste produced on Earth. While the *launching State* will bear ultimate responsibility for waste produced under its jurisdiction, the authorisation holder will be primarily responsible. Consequently, the future law of nuclear energy must provide for obligations of the authorisation holders to bear responsibility for their waste in accordance with the *polluter pays principle*. Financial and other arrangements for the safe disposal of waste produced in Outer Space will be the obligation of the authorisation holder.

[37] Principle 8.

Having said this, one may add that the technical solution for the safe disposal of this waste remains open for the time being.[38] Future technological developments may imply a possibility for the disposal of nuclear waste in geological formations on space objects, which may represent a viable solution.

Ad 3)

The fact is that any commercial use of nuclear energy in Outer Space will represent a source of risk. Consequently, compensation arrangements must be provided by law. In this respect, a significant difference has arisen in space law on the one hand and in nuclear law on the other. Space law has traditionally followed the concept of international liability of the *launching State.* This has been enshrined in the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies[39] and in the Convention on International Liability for Damage Caused by Space Objects. Subsequently, this regime has also been reflected in the *Principles Relevant to the Use of Nuclear Power Sources in Outer Space,* which provide 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. Whenever two or more States jointly launch such a space object, they shall be jointly and severally liable for any damage caused, in accordance with Article V of the above-mentioned Convention (= Convention on International Liability for Damage Caused by Space Objects)."[40]

Under the scheme of international liability, the *launching State* bears liability for damages caused by launched space objects *vis-á-vis* other States. The liability scheme, as applicable in nuclear law, is somewhat different. Both the Paris Convention on Third Party Liability in the Field of Nuclear Energy and the Vienna Convention on Civil Liability for Nuclear Damage provide for the exclusive liability of the authorisation holder. The fact is, however, that this regime has been so far limited to terrestrial nuclear installations.

A future deployment of advanced nuclear technologies in Outer Space by commercial entities will imply a significant challenge for the *launching States.* Without any further legal measures, the *launching States* will be held liable for any damages caused by advanced

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[38] See Kim, H., Park, C., Kwoon, O., *Conceptual design of the space disposal system for the highly radioactive component of the nuclear waste,* "Energy", 2016, Vol. 115, at pp. 155 et seqq.
[39] Article VII.
[40] Principle 9.

nuclear technologies launched from their territory or launched by an entity under their jurisdiction. Such a situation will undeniably trigger the lawmakers' interest in channelling the liability directly to the authorisation holders and obliging them to provide appropriate insurance. This can be realised either by means of domestic legislation or in the form of a brand-new instrument of international law.

To summarise briefly what has been said, gradual commercialisation and privatisation of space activities also imply myriad challenges for nuclear law. While the attention of the community of nuclear law is being today paid in particular to legal issues arising from nuclear new build on Earth, the New Space Era opens a totally new perspective for the deployment of advanced space technologies at the final frontier of our Universe. A future commercial use of advanced nuclear technologies in Outer Space is highly probable. The law of nuclear energy must react to this future scenario and provide for a robust and comprehensive legal framework.

4. A way forward

Ten years ago, the *XXIst Nuclear Inter Jura* convened in the Palacio San Martín in Buenos Aires, Argentina. A comparison between the congress programme held in Buenos Aires and the one held ten years later in Warsaw demonstrates the dynamic development of the nuclear industry. While ten years ago, virtually no attention was paid to legal implications arising from advanced nuclear technologies, the *XXVth Nuclear Inter Jura* was almost entirely focused on challenges arising from small and microreactors to various fields of nuclear law. In this respect, one may ask what the focus of *Nuclear Inter Jura 2034* will be. The answer will depend on advances in nuclear technology and national energy strategies and also on the prospective occurrence or absence of a major nuclear incident. Reflecting on the current discussions, one may expect that the use of advanced nuclear technologies in Outer Space will represent one of the challenges discussed at the *Nuclear Inter Jura 2034.*

The challenges arising from the perspective of nuclear law are twofold. Firstly, the discussion on nuclear law must abstain from the purely terrestrial focus and must begin to realise that the final frontier of relations governed by the law of nuclear energy lies in Outer Space. Secondly, one must take into consideration that the use of nuclear power in Outer Space will impose distinctive risks and implications, which will require appropriate legal tools to be addressed. Thus, one may expect that the future law of nuclear energy, as used commercially in Outer Space, will not represent a mere duplication of the already existing legal framework but, to some extent, also a brand new set of rules.

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