Legal and Ethical Challenges of the Use of Nuclear Technologies in Space: Risks and Opportunities

Larysa Soroka

Professor, Doctor of Law, Scientific Institute of Public Law
(Kyiv, Ukraine)
E-mail: lsoroka_kw@ukr.net
https://orcid.org/0000-0002-6979-6049

Anna Danylenko

Ph.D. in Law, Researcher, Information Analysis Center for Aerospace Law
(Kyiv, Ukraine)
E-mail: a_danilenko07@ukr.net
https://orcid.org/0000-0001-8263-1364

Maksym Sokiran

Ph.D. in Law, Lawyer, Scientific and Research Institute of Public Law
(Kyiv, Ukraine)
E-mail: maxim.sokiran@gmail.com
https://orcid.org/0000-0002-1682-2012

Soroka, Larysa, Anna Danylenko, and Maksym Sokiran (2024) Legal and Ethical Challenges of the Use of Nuclear Technologies in Space: Risks and Opportunities. *Advanced Space Law*, Volume 14, 66-73. https://doi.org/10.29202/asl/14/6

The article examines the concept of threats and risks of using nuclear technologies in the space sphere. In particular, it has been stated that the presence of a nuclear arsenal can act as a deterrent, forcing potential aggressors to reevaluate their actions. At the same time, the countries that do not possess nuclear weapons but are under threat of armed aggression often face limited assistance due to the unwillingness of partner states to scale up conflict or be engaged in direct confrontation. The example of Israel demonstrates how the presence of a potential nuclear arsenal and the geopolitical importance of the region contribute to increased military and political support from the United States and other countries. In the case of Ukraine, which renounced nuclear weapons after the signing of the Budapest Memorandum, selective military support limited to efforts to avoid direct confrontation with Russia is

observed. The article emphasizes the interdependence between a country's status as a nuclear or non-nuclear one, the level of international aid, and the threats associated with the use of nuclear technologies for military and space purposes. Despite the economic advantages of using nuclear energy sources in space activities, the need to activate initiatives aimed at strengthening commitments to the complete abandonment of nuclear weapons both on Earth and in space.

Keywords: nuclear energy sources, space activity, space security, non-proliferation of nuclear weapons, war, international rules and principles, risk, danger, legal regulation.

Received: 04 December 2024 / Accepted: 18 December 2024 / Published: 30 December 2024

Introduction

On August 06, 1945 at 08:15 local time, in accordance with the ultimatum of the Potsdam Declaration of July 26, 1945 and Japan's refusal to fulfill the terms of this ultimatum, the Enola Gay, the American B-29 Superfortress bomber, piloted by Paul Tibbets and bombardier Thomas Ferebee, dropped the first atomic bomb called "Malysh" ("Little Boy") on Hiroshima. Consequently, the first atomic bomb in the history of mankind was dropped on the Japanese city of Hiroshima (Hiroshima, 2024).

The first article of the UN Charter (United, 1945), which established that ensuring peace and international security is the main goal and principle of the creation of this organization, was adopted right after this accident. This postulate (in which economic development, access to clean and renewable energy, as well as reducing inequality are part of the 17 Sustainable Development Goals) is continued in the 2030 Agenda (The 17 Goals, 2015), which was supported by all UN Member States in 2015.

Consequently, after the end of the "Cold War" and the long arms race started by the USA and the USSR, the world has chosen a path towards disarmament, nuclear proliferation control and prohibition of their use in outer space.

But after the successful launch of the lunar probe Chang-e 1 in October 2007 (China's, 2009), China has intensified the debate on the use of space nuclear power sources, using the UN platform for this purpose (Discussion, 2012: 2). Considering the above, and the importance of minimizing the safety risks associated with such power sources both on Earth and in space, the United Nations Office for Outer Space Affairs (OOSA) and the International Atomic Energy Agency (IAEA) have jointly published Framework for the Safety of Nuclear Power Sources in Space (Safety, 2009). The document provides guidance for the international community on the safe use of nuclear power sources (NPS) in outer space and contains administrative and technical recommendations for countries to safely advance their initiatives regarding these sources in outer space.

Currently, the main sources of energy that can be used in spacecraft are chemical, solar and nuclear energy. The main types of nuclear energy used for electricity production are radioisotopes and nuclear reactors (Discussion, 2012). It is worth noting that requirements for nuclear safety and procedures for the use of nuclear technologies or components are established for all stages of nuclear programs on design, production, transportation and testing (Voss, 2020). The only case where nuclear material can be outside of direct physical control and security measures is when operating in remote space, on the surface of a planet, or due to an emergency when a spacecraft with nuclear technology or components is launched or returned.

At first glance, it seems that everything is under control and there is a consensus among the countries regarding the use of nuclear energy sources and an agreement to prohibit the use of nuclear weapons in space. But what has changed in nuclear doctrines in recent years, taking into account the numerous military conflicts raging in different parts of the world, including in Ukraine?

In this regard, for example, CIA Director Bill Burns stated the following: "There was a moment in the fall [autumn] of 2022 when I think there was a genuine risk of potential use of tactical nuclear weapons by Russia in Ukraine", Burns said, but he believed such concerns should not be taken too seriously. "I never thought ... we should be unnecessarily intimidated by that," he added (Sabbagh, 2024). Therefore, it is the presence of nuclear weapons in Russia and Israel that forms different approaches and reactions of the world to the wars between Russia and Ukraine and Israel and Hamas. This means that the US, Europe and even some Arab countries are keen to ensure that Israel is never provoked enough to use it, or even use any serious conventional weapons against Iran. Therefore, European countries and the USA jointly protect Israel's airspace from Iranian missiles and drones. The Ukrainian sky, on the other hand, is protected by the Ukrainians themselves (Applebaum, 2024).

In addition to the above, the worsening of the situation in Russia's war against Ukraine has led to US President Joe Biden lifted the ban on strikes by ATACMS ballistic missiles on Russian territory. In response, Russia changed its nuclear doctrine and amended the Basic State Policy of the Russian Federation in the Field of Nuclear Deterrence (Putin, 2024). Russia, in turn, has changed its nuclear doctrine and amended the Basic State Policy of the Russian Federation in the Field of Nuclear Deterrence (Fundamentals, 2024). The category of states and military alliances, in respect of which nuclear deterrence is implemented, was expanded. The list of military threats that require such actions to neutralize them has been supplemented. The doctrine also states that the Russian Federation may use nuclear weapons in case of "critical threat" to the sovereignty and territorial integrity of itself and Belarus. The "launch of ballistic missiles" on the territory of Russia is among the conditions for the use of nuclear weapons by Russia. According to the doctrine, the decision to use nuclear weapons must be made by the Kremlin leader himself. The document expresses confidence that "the readiness and determination of the Russian Federation to use nuclear weapons will ensure nuclear deterrence."

There is concern that nuclear weapons or materials may be stolen or transferred to terrorist organizations, thereby necessitating the consolidation of efforts by a number of countries to improve overall nuclear safety and reduce the availability of nuclear materials for weapons.

In connection with the above, there was a need to study the existing risks and possibilities of using new nuclear technologies in outer space, as well as the role of legal frameworks in policies to contain nuclear proliferation both on Earth and in space.

The concept of threats and risks in the space sphere

Threat is interpreted as: "rude, bold promise to cause some evil, trouble; threats, praise" (Threat, 2023); "a variety of contradictions creating danger for the security system, the life support of its system-forming elements"; "danger of the transition from possibility to reality" (Dictionary, 2008). The authors of theoretical and methodological studies on security theory are unanimous in their opinion that threat is a category close in essence to the concept of "danger", but its distinctive feature is more specific form by the level of exposure to the object

of action (Romanchik, 2020). That is, the authors believe that first there is a danger, and then a specific threat.

But there are also completely opposite opinions. For example, O. Arefieva and T. Kuzenko understands threat as "a set of conditions, processes, factors preventing the implementation of national economic interests or creating danger for the latter and economic activity actors" (Aref'eva & Kuzenko, 2005: 30). That is, the author puts a threat at the beginning, after which danger arises.

Besides, the terms "risk" and "threat" are often equated. Thus, V. Lipkan defines threat as the risk that began to materialize on an undesirable option, or a adverse scenario beyond the notion of normal uncertainty in business conditions known in advance (Lipkan, 2006). O. Liashenko suggests that "threat" and "risk" reflect some current events, while "danger" indicates probable, that is, such events that may not happen (Lyashenko, 2015). At the same time, L. Kalinichenko emphasizes that risk and threat are forms of danger, which reduce the level of security only by their presence (Kalinichenko, 2014). We agree with the latter statement, as both risk and threat are factors preventing objects or entities from being safe.

Recognizing the critical importance of space assets and services in the face of evolving geopolitical dynamics and increased threats, a number of countries, including the US and the EU, have strategically identified space as a priority area of protection and action. For example, on March 24, 2022, the EU approved the Strategic Compass of the European Union (A Strategic, 2022), which sets out proactive measures to ensure the security of its space assets and mitigate potential threats.

As for modern risks and threats in the space sphere, the authors include the following: cyber-attacks (Van Camp & Peeters, 2021; European, 2023) the use of radio-electronic warfare, covering electronic and electromagnetic interference with the ability to disrupt or disable communication between ground bases and space means (Pinker & Smith, 1999; Reis, 2024); growing amount of space debris or micrometeorites (Polkowska, 2020); anti-satellite weapons on ground or space platforms (Way, 2019), the use of uncontrolled nuclear technologies (Henriquet, 2023; Cesari, 2024) and so-called "hybrid threats" (Reis, 2024).

It should be noted that on January 10, 2023, the EU and NATO signed the Joint Declaration on EU-NATO Cooperation (Joint, 2023), in which countering hybrid and cyber threats is defined as a priority for their cooperation at the current stage, along with issues of stability and space protection.

Regulatory framework and evolution of space nuclear security threats

Since the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) entered into force in 1970 Treaty on the Non-Proliferation (Treaty, 1968), the countries of the world were divided into those that are official owners of nuclear weapons and others. At the current stage, there are a total of five official owners: Great Britain, China, the Russian Federation, the USA and France. Most of the countries have voluntarily agreed to renounce the possession of nuclear weapons in accordance with the NPT. Such countries that have international recognition and are members of the UN (193 full members and two observers) are now 186 out of 195. A number of countries – India, Pakistan, Israel and North Korea – are the owners of limited arsenals of nuclear weapons outside the NPT (India, Pakistan and Israel did not join the Treaty;

the DPRK was a member of it as a non-nuclear state, but withdrew from the Treaty in 2003). Several countries are not parties to the NPT, but are de facto non-nuclear (Izhak, 2022).

A global regime of nuclear non-proliferation is impossible without the obligations of official nuclear states towards non-nuclear ones. The text of the NPT does not contain obligations of nuclear countries regarding the specific conditions for the use of nuclear weapons. However, it lays down the very philosophy of the non-proliferation regime. Article VI of the Treaty states that "each of the Parties to the Treaty undertakes to pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament, and on a treaty on general and complete disarmament under strict and effective international control" (Treaty, 1968).

Activities related to the use of nuclear energy sources in outer space are carried out in accordance with international law, including, in particular, the Charter of the United Nations and the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and other Celestial Bodies. But the only official international policy for the use of SBS for space energy is the UN Resolution 47/68 "Principles relevant to the Use of Nuclear Power Sources in Outer Space," which states that "in order to minimize 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 cannot be operated by non-nuclear energy sources in a reasonable way" (Principles, 1992). Besides, this document allows the use of nuclear energy sources (radioisotope/reactor).

Further, the Resolution specifies that "nuclear reactors may be operate: 1) on interplanetary missions; 2) in sufficiently high orbits; 3) in low-Earth orbits if they are stored in sufficiently high orbits after the operational part of their mission" (Article 2a) (Principles, 1992).

However, geopolitical conditions have significantly changed since the signing of the NPT. Nowadays, the Global Non-Proliferation Regime faces two key threats:

1. China is actively expanding its nuclear arsenal and increasing its technological level. The State avoids participation in arms control negotiations and has just recently started using satellites for missile warning and tracking.
2. Changes in China's nuclear doctrine and Russia's actions, which also includes the potential placement of nuclear weapons in space, create additional risks for strategic stability.

Given these challenges, existing deterrence mechanisms need to be modernized to meet new threats and provide an effective response to possible scenarios of limited nuclear use.

Thus, according to the Treaty on the Prohibition of Nuclear Weapons (NPT) (Treaty, 2017), which entered into force in 2021, its participants are non-nuclear countries. They have not withdrawn from the NPT, but by participating in the new treaty they declared that the commitment to universal renunciation of nuclear weapons should be more specific than the text of Article VI of the NPT (Izhak, 2022). This initiative is quite relevant, because as the Russia's war against Ukraine has indicated, the countries with a nuclear arsenal can act in a position of force towards the countries without it, disregarding international rules and principles enshrined in the Treaty on the Non-Proliferation of Nuclear Weapons. This poses serious risks to global security and calls into question the effectiveness of the existing nuclear deterrence system. Therefore, initiatives aimed at strengthening commitments to the complete abandonment of nuclear weapons are important steps towards strengthening the international legal order and ensuring equality in the security sphere.

If we talk about the economic benefit of using nuclear energy sources in space activities, the use, in particular, of highly enriched uranium (HEU), will allow to minimize the mass of power systems in spacecraft. This reduces the cost of launching and transporting cargo, which is a key factor in reducing the overall cost of missions. For the exploration of the Moon, Mars and other planets, a reliable energy supply is essential for establishing long-term bases and infrastructure. Nuclear technologies can guarantee a stable and uninterrupted power supply in environments where solar energy is limited.

In addition, access to nuclear energy sources may become an impetus for innovation in spacecraft design and new technology development, which contributes to strengthening scientific and technical potential of the country. Thanks to the high energy intensity of nuclear sources, countries can significantly reduce the costs of long-term missions, because the need for refueling or servicing of spacecraft is reduced.

Conclusion

Having summarized the material, we can claim that:

1. Lack of objectivity in the identification of the category "critical threat" causes an unprecedented situation, in which a "nuclear country", in particular, the well-known aggressor – Russia – gets the opportunity to use nuclear weapons without hindrance, contrary to all established general nuclear security rules;
2. Russia's potential use of nuclear weapons as a weapon of war in Ukraine should be considered as a critical threat to the collective security and stability from the standpoint of the EU and NATO, in particular the protection of outer space, which requires an immediate reaction from these organizations in the form of proactive actions – joint protection of air space of Ukraine;
3. Currently, it is extremely urgent to put on the agenda the issue of updating the official obligations of nuclear states in relation to non-nuclear ones in the aspect of providing the latter with security guarantees and support in case of actualization of nuclear threats. Moreover, China's practice of avoiding participation in arms control negotiations should be brought under control in the form of economic sanctions.

Thus, the use of nuclear technologies in space has significant advantages, but their importance is leveled by the awareness of risks and threats to the international legal order and ensuring equality in the field of security. As long as the world is not united, and each element of its structure will allow disregard for norms and principles enshrined in the UN Charter, there is no point in developing and implementing authorization rules for the use of nuclear technologies in space. Strict regulation of the specified legal relations should be an inviolable postulate, confirmation of the relevance of which we already have in today's conditions.

🕮 References

A Strategic Compass for Security and Defence (2022) European Union. Available online: https://www.eeas.europa.eu/sites/default/files/documents/strategic_compass_en3_web.pdf

Applebaum, Anne (2024) Why Did U.S. Planes Defend Israel but Not Ukraine? Atlantic. Available online: https://www.theatlantic.com/politics/archive/2024/04/ukraine-israel-war-comparison/678077/

Aref'eva, O.V., and Kuzenko T. B (2005) *Planning the economic security of enterprises.* European University Publishing House.

Cesari, Laetitia (2024) Buzzword or real threat? How concerns over nuclear capabilities in outer space can trigger the extension of space security discussions. *Note de la FRS*. No 09. Available online: https://www.frstrategie.org/en/publications/notes/buzzword-or-real-threat-how-concerns-over-nuclear-capabilities-outer-space-can-trigger-extension-space-security-discussions-2024

China's lunar probe Chang'e-1 impacts moon (2009) China National Space Administration. Available online: https://www.cnsa.gov.cn/english/n6465652/n6465653/c6478763/content.html

Dictionary of terms and definitions of the non-state security system of Ukraine (2008) Compiled by V. V. Krutov, P. Ya. Prygunov, O. I. Zakharov, V. A. Lipkan and others. Kyiv.

Discussion on the safety of space nuclear power sources. A/AC.105/C.1/2012/CRP.5 (2012) Committee on the Peaceful Uses of Outer Space Scientific and Technical Subcommittee. Available online: https://www.unoosa.org/pdf/limited/c1/AC105_C1_2012_CRP05E.pdf

European Union External Action, "Securing the future of Europe in space. Josep Borrell, High Representative of the European Union for Foreign Affairs and Security Policy (2023) Vice-President of the European Commission. Available online: https://www.eeas.europa.eu/eeas/securing-future-europe-space_en

Fundamentals of State Policy of the Russian Federation on Nuclear Deterrence (2024) Executive Order of the President of the Russian Federation No.991 of November 19, 2024. Available online: https://mid.ru/en/foreign_policy/international_safety/regprla/1434131/

Hiroshima and "Little Boy": A Historical Perspective (2024) Designed with WordPress. Available online: https://dirkdeklein.net/tag/little-boy/

Henriquet, Pierre (2023) The use of nuclear power in deep space exploration. Polytechnique-insights. Available online: https://www.polytechnique-insights.com/en/columns/space/the-use-of-nuclear-power-in-deep-space-exploration/

Izhak, Oleksii (2022) Nuclear deterrence and nuclear intimidation in russia's policy. *Strategic panorama*. Special Issue 2022: 111-122. Available online: https://niss-panorama.com/index.php/journal/article/view/138/138

Joint Declaration on EU-NATO Cooperation (2023) European Council. Available online: https://www.consilium.europa.eu/en/press/press-releases/2023/01/10/eu-nato-joint-declaration-10-january-2023/

Kalinichenko, L. L. (2014) Personnel security as a leading component in ensuring the economic security of an enterprise. *Economic security in the context of globalization of the world economy*. "FOP Drobyazko S.I." Vol. 2.

Lipkan, V.A. (2006) National Security of Ukraine. Condor.

Lyashenko, O. M. (2015) *Conceptualization of enterprise economic security management*. NISD.

Pinker, A, and C. Smith (1999) Vulnerability of the GPS signal to jamming. *GPS Solutions*. Volume 3: 19-27. https://doi.org/10.1007/PL00012788

Polkowska, Małgorzata (2020) Space situational awareness (SSA) for providing safety and security in outer space: implementation challenges for Europe. *Space Policy*. Volume 51. https://doi.org/10.1016/j.spacepol.2019.101347

Principles relevant to the Use of Nuclear Power Sources in Outer Space (1992) UN. General Assembly. Available online: https://digitallibrary.un.org/record/159141?v=pdf

Putin Approves Updated Russian Nuclear Doctrine After Biden's Missile Decision (2024) BBS NEWS. Available online: https://www.bbc.com/russian/articles/cx2l4wzkl0lo

Reis, João (2024) European union defense and security strategy for space and ground-based systems against hybrid threats. *Acta Astronautica*.Volume 225: 55-66. Available online: https://www.sciencedirect.com/science/article/pii/S0094576524004995#bib1

Romanchik T.V. (2020) Danger, threat, risk: analysis of the terminological apparatus of the theory of economic security. *Economic Bulletin of National Technical University of Ukraine " Kyiv Polytechnic Institute"* :257-267.

Sabbagh, Dan (2024) CIA boss says west should not be intimidated by Russia's nuclear threats. Guardian News. Available online: https://www.theguardian.com/world/article/2024/sep/07/cia-west-russia-nuclear-threats-putin

Safety Framework for Nuclear Power Source Applications in Outer Space (2009) United Nations Committee on the Peaceful Uses of Outer Space Scientific and Technical Subcommittee. Available online: https://www.unoosa.org/pdf/publications/iaea-nps-sfrmwrkE.pdf

The 17 Goals (2015) United Nations. Available online: https://sdgs.un.org/goals

Threat (2023) Online Dictionary. Available online: http://sum.in.ua/s/zaghroza

Treaty on the Non-Proliferation (1968) United Nations. Available online: https://disarmament.unoda.org/wmd/nuclear/npt/#:~:text=The%20NPT%20is%20a%20landmark,and%20general%20and%20complete%20disarmament.

Treaty on the prohibition of nuclear weapons (2017) United Nations. Available online: https://treaties.un.org/doc/Treaties/2017/07/20170707%2003-42%20PM/Ch_XXVI_9.pdf

United Nations Charter (1945) United Nations. Available online: https://www.un.org/en/about-us/un-charter

Van Camp, Charlotte, and Walter Peeters (2021) A World without Satellite Data as a Result of a Global Cyber-Attack. *Space Policy*. Volume 59: 101458. https://doi.org/10.1016/j.spacepol.2021.101458

Voss, Susan S. (2020) Nuclear Security Considerations for Space Nuclear Power: A Review of Past Programs with Recommendations for Future Criteria. *Nuclear Technology*. Volume 206, Issue 8: 1097-1108. https://doi.org/10.1080/00295450.2019.1706378

Way, Tyler (2019) Counterspace Weapons 101. Center for Strategic and International Studies. Available online: https://aerospace.csis.org/aerospace101/counterspace-weapons-101/