

## Problems of international legal mechanisms for control over nuclear and radiological materials

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■ **Abstract.** The purpose of this study was to investigate the problem of international legal mechanisms for controlling nuclear and radioactive materials. The paper used the formal legal method as the basic one, since it allows analysing legal norms, structures, and concepts. The study showed that the non-proliferation of nuclear weapons and weapons-grade nuclear materials was based mainly on the Treaty on the Non-Proliferation of Nuclear Weapons of 1968, which established strict rules for the use of civilian nuclear materials and technologies worldwide and was monitored by the International Atomic Energy Agency in Vienna. However, with the growth of the activity of international terrorist organisations in recent years, the current provisions on nuclear non-proliferation have proven to be imperfect and inadequate. The study stressed that security policies and civil defence should be based on the fact that terrorist organisations seek to obtain nuclear materials for attacks. Nuclear terrorism is widespread because the Non-Proliferation of Nuclear Weapons does not require its member states to protect nuclear materials and facilities from theft or terrorist sabotage. In fact, at the international level, the physical protection of nuclear weapons materials and civilian nuclear facilities (reactors, interim storage facilities, and fuel rod fabrication and reprocessing plants) varies considerably. Many countries do not have adequate protection for the transport, reprocessing, interim storage and disposal of usable and spent nuclear fuel, leading to loss, theft, smuggling, and illegal international trade in these materials. The practical significance of this issue lies in the fact that the analysis of the problems of international legal mechanisms for the control of nuclear and radioactive materials helps to assess the shortcomings of existing mechanisms and eliminate them, thereby ensuring the highest level of safety and control of nuclear and radioactive materials

■ **Keywords:** Treaty on the Non-Proliferation of Nuclear Weapons; nuclear weapons; security policy; terrorist threats; radioactive materials

### ■ Introduction

In conditions when a war is being waged on the territory of the independent state of Ukraine, and its 4 nuclear power plants with WWER type reactors: Zaporizhzhia, Rivne, Khmelnytskyi, and South Ukraine, which operate 15 nuclear power plants with a total installed capacity of 13,835 MW (Sharaevsky *et al.*, 2022), are under threat of destruction or capture by the aggressor army. The problem of ensuring international control over nuclear and radiological

materials should come to the fore. Such a challenge to security policy makes the issues of protection and radiation control of active sources used for civilian purposes in industry, research, and medicine around the world particularly pressing. Although radioactive sources are not suitable for the production of nuclear weapons, improper handling of them and some radiation protection measures can cause significant harm to people and the environment. Due to inadequate

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regulations for the protection and security of radioactive sources in some countries, there is a risk that criminals and terrorists could use these materials as radioactive weapons.

Under the influence of current international conflicts and the threat of terrorism, the scope of nuclear arms control policy has expanded from its original focus on preventing the proliferation of nuclear weapons to encompass the security and control of all nuclear technologies, including industrial and medical radiation technologies. This new responsibility has also had a significant impact on national internal security functions such as preventing technological hazards (radiation protection, disaster relief) and preventing crime.

For many years, the International Atomic Energy Agency (IAEA) has been working to strengthen and regulate the transport of nuclear and radioactive materials around the world, to monitor and account for existing facilities, and to implement border and security controls. However, it has proven difficult to fully expand the negotiating positions focused on the Treaty on the Non-Proliferation of Nuclear Weapons<sup>1</sup> (NPT) and its monitoring mechanisms, including the implementation of a comprehensive system for the implementation of the nuclear agreement. Therefore, other, more innovative regulatory instruments and non-standard approaches are required. The study by M. Elbaradei (2021) emphasised the key role of international institutions in supporting the nuclear non-proliferation regime and controlling the use of nuclear materials. P. Goldschmidt (2021) emphasised the need to strengthen international monitoring and introduce stricter procedures for verifying compliance with nuclear safety obligations.

The planned extension of the 1980 Convention on the Physical Protection of Nuclear Material<sup>2</sup> relies entirely on the own responsibility of the Member States, and the effectiveness of the agreement depends on the direct own interests of the Member States. In addition, the absence of treaty obligations is a distinctive feature of the new international rules governing the control of materials. These regulations have been replaced by non-binding guidelines, technical safety standards and agreements on the physical protection of radioactive sources, such as the IAEA Code of Conduct (in force since 2000) on the Safety and Security of Radioactive Sources<sup>3</sup>. One of the objectives of the new regulations is to incorporate

minimum standards of physical protection and nuclear security into national legislation and to harmonise national security measures at the international level.

Thus, the safeguards in international agreements to prevent the use of nuclear and radioactive materials for terrorism are less restrictive than traditional nuclear arms control measures. However, as stated by A. Zamula *et al.* (2025), the relevant regulations contain important minimum legal requirements and implementation details, responsibilities, obligations, and technical safety standards of regulatory authorities. Thus, the task of preventing nuclear terrorism is clearly defined and becomes a manageable issue within the framework of international security policy.

This new approach offers significant practical advantages and can be applied to Ukrainian security legislation. Even assuming that the current Ukrainian security strategy can be easily compared with the national defence strategy of other countries, the traditional technical solutions to the proliferation and use of weapons that weaken Ukraine's security cannot be ignored. As a result, Ukrainian security policy depends on a broader international consensus. However, according to V. Khalimonchuk *et al.* (2025), although Ukraine has significant resources, its energy infrastructure remains unstable and vulnerable. Specific tools to effectively meet national and international needs include:

- Ukrainian partnerships (technical, advisory, and financial) in cooperation and multilateral security activities;
- cooperation between Ukrainian business and research institutions, including specialised project organisations and clients in the field of nuclear and radiological security;
- strengthening Ukrainian consultative, support and coordination mechanisms between current and future EU research and security systems, drawing on its own defence policy, security standards and technical and scientific expertise.

For decades, limited, tightly controlled access to fissile nuclear material has been considered an essential measure against the international proliferation of nuclear weapons. This barrier was essentially established by the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) of 1968<sup>4</sup>. Its enforcement today relies on a comprehensive international regulatory framework developed over decades, consisting of contractual monitoring and verification measures

<sup>1</sup> Treaty on the Non-Proliferation of Nuclear Weapons. (1968, July). Retrieved from <https://disarmament.unoda.org/en/our-work/weapons-mass-destruction/nuclear-weapons/treaty-non-proliferation-nuclear-weapons>.

<sup>2</sup> Convention on the Physical Protection of Nuclear Material. (1980, October). Retrieved from <https://www-pub.iaea.org/MTCD/Publications/PDF/Pub615web.pdf>.

<sup>3</sup> Code of Conduct on the Safety of Research Reactors. (2004, September). Retrieved from [https://www-pub.iaea.org/MTCD/Publications/PDF/CODEOC-RR\\_web.pdf](https://www-pub.iaea.org/MTCD/Publications/PDF/CODEOC-RR_web.pdf).

<sup>4</sup> Treaty on the Non-Proliferation of Nuclear Weapons. (1968, July). Retrieved from <https://disarmament.unoda.org/en/our-work/weapons-mass-destruction/nuclear-weapons/treaty-non-proliferation-nuclear-weapons>.

(safeguards). These measures are coordinated, implemented, and evaluated worldwide by the International Atomic Energy Agency (IAEA).

However, with the end of the Cold War, the political and technical requirements for the control of nuclear weapons have changed significantly in several respects. International clandestine armies and terrorist organisations are now a key challenge for security policy, as noted by I. Les (2024). Their goals and activities, if not hinting at them, at least raise the fear that they are seeking to acquire nuclear weapons. However, since only states, not non-state organisations, are parties to the NPT, non-state actors in international politics are not subject to the technical and procedural standards of nuclear control and the provisions of the treaties. The purpose of this study was to examine the issue of international legal mechanisms for the control of nuclear and radioactive materials.

## ■ Materials and Methods

This study used a combination of general scientific and specialised legal research methods. The main method was formal legal analysis, the priority of which was given to the provisions of international law and the Treaty on the Non-Proliferation of Nuclear Weapons (NPT)<sup>1</sup> relating to the provision of international legal mechanisms for the control of nuclear and radiological materials, and documents, projects, and recommendations issued by the IAEA and individual states within the framework of bilateral cooperation. The comparative legal method was also used to investigate approaches to solving the problem of ensuring security policy in various regulatory legal acts and by various participating states. This included an analysis of national doctrines and international conventions such as the IAEA Safeguards<sup>2</sup>, the Additional Protocol to the Safeguards Agreements in force<sup>3</sup>, the International Basic Standards for Protection against Ionising Radiation and the Safety of Radiation Sources (ISRS)<sup>4</sup>, the Convention on Nuclear Safety<sup>5</sup>, the Convention on the Safety of Spent Fuel and Radioactive Waste<sup>6</sup>, etc. The results were interpreted using a normative and analytical

approach, according to which each observed fact or argument was assessed for compliance with applicable international legal norms. This interdisciplinary methodology, located at the intersection of international law, security, and technology, can be used to develop well-founded conclusions and policy recommendations.

The case study method was used to examine real incidents related to events that occurred in the 1990s, when it became known that Iraq and North Korea had nuclear weapons development programmes that violated the treaties, and the IAEA monitoring regime was incomplete. This conclusion was confirmed again when in early 2004 it became known about the pronounced nature of Pakistan's nuclear weapons proliferation. Back in 1997, the IAEA developed an Additional Protocol<sup>7</sup> to the existing safeguards agreements, which by July 2003 had been signed by 74 states, including Ukraine, and had entered into force for 35 states. It granted IAEA inspectors rights of access to information and verification that were broader than those granted under the original safeguards agreement. All sources were used in a multi-level analysis of the legal framework underlying the security of nuclear and radiological materials, exposing the risks associated with the operation of nuclear power plants, uranium enrichment, etc.

## ■ Results

Since the late 1990s, the International Atomic Energy Agency has been working to strengthen and regulate the physical protection of global radioactive sources, monitor, and account for existing radioactive sources, and implement border and export controls (Les, 2023). Initially, these efforts focused on improving protection against accidents and radiation disasters, but after the terrorist attacks of September 11, 2001 in New York, the main driving force shifted to the fight against terrorism.

The long-term goal of the International Atomic Energy Agency is to have strict and unified international control over the entire life cycle of radioactive sources, from production and use to final disposal, which

<sup>1</sup> Treaty on the Non-Proliferation of Nuclear Weapons. (1968, July). Retrieved from <https://disarmament.unoda.org/en/our-work/weapons-mass-destruction/nuclear-weapons/treaty-non-proliferation-nuclear-weapons>.

<sup>2</sup> IAEA Safeguards the Additional Protocol to the Safeguards Agreements in Force. (1997, May). Retrieved from [https://zakon.rada.gov.ua/laws/show/951\\_002#Text](https://zakon.rada.gov.ua/laws/show/951_002#Text).

<sup>3</sup> IAEA Safeguards the Additional Protocol to the Safeguards Agreements in Force. (1997, May). Retrieved from [https://zakon.rada.gov.ua/laws/show/951\\_002#Text](https://zakon.rada.gov.ua/laws/show/951_002#Text).

<sup>4</sup> International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources. (1996, September). Retrieved from [https://www.ilo.org/sites/default/files/wcmsp5/groups/public/@ed\\_protect/@protrav/@safework/documents/publication/wcms\\_152685.pdf](https://www.ilo.org/sites/default/files/wcmsp5/groups/public/@ed_protect/@protrav/@safework/documents/publication/wcms_152685.pdf).

<sup>5</sup> Convention on Nuclear Safety. (1994, June). Retrieved from <https://www.iaea.org/topics/nuclear-safety-conventions/convention-nuclear-safety>.

<sup>6</sup> Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. (1997, September). Retrieved from <https://www.iaea.org/topics/nuclear-safety-conventions/joint-convention-safety-spent-fuel-management-and-safety-radioactive-waste>.

<sup>7</sup> IAEA Safeguards the Additional Protocol to the Safeguards Agreements in Force. (1997, May). Retrieved from [https://zakon.rada.gov.ua/laws/show/951\\_002#Text](https://zakon.rada.gov.ua/laws/show/951_002#Text).

is of paramount importance. This study suggests that, under the influence of new international conflicts and threats, the mission of arms control policy, originally aimed at preventing the proliferation of nuclear weapons, has expanded to a comprehensive mission of protection and control, covering all nuclear technologies, including industrial and medical radiology. This expanded mission has profound implications for the responsibilities of states in the field of ensuring internal security, such as the prevention of technological hazards (radiation protection, disaster relief) and the prevention of crime. No state can delegate its responsibilities to an international body such as the IAEA, even considering the threat of terrorism, this mission largely corresponds to the main issues of international security (Silva, 2026).

Of particular concern is whether the traditional international regulatory system for nuclear safety is sufficiently comprehensive. Since the main components are the Treaty on the Non-Proliferation of Nuclear Weapons<sup>1</sup> and the IAEA Safeguards<sup>2</sup>, it is also questionable whether international arms control agreements can adequately cover physical protection and control of non-fissile materials.

This study focuses on two routes to international arms control agreements: treaty and non-treaty. Through treaties such as the Treaty on the Non-Proliferation of Nuclear Weapons<sup>3</sup>, partner states can assume legally binding obligations. Alternatively, partner states can mutually commit to providing services but are not obligated to perform those services; they can simply agree on guidelines or recommendations. From the perspective of all stakeholders, the negative consequences of not adhering to such guidelines or recommendations are less serious than the consequences of violating treaty provisions. Such agreements do not require complex ratification procedures and implementation provisions, and certainly no monitoring or verification. However, specific ways of controlling materials and their respective advantages are considered below.

It is quite predictable that due to the complexity and practically limitless nature of this problem, possible regulatory measures will always offer only more or less promising solutions and, at best, will achieve success only in the long term. On the other

hand, control of radioactive sources also has advantages over traditional non-proliferation measures of nuclear weapons, which international security policy can systematically use<sup>4</sup>. In addition to the question of what the outlined contractual and non-contractual regulations can achieve and where their limitations may be, questions arise about the need for action, opportunities for global security policy. This study proceeds from the fact that in order to protect against a specific terrorist attack using nuclear or radiological weapons, Ukraine can and should further improve its security infrastructure (physical protection of equipment and facilities, training of security personnel, civil defence, and disaster relief) (Flynn, 2024).

However, this study also indicates that the risk of nuclear and radiological proliferation, which poses a significant threat to Ukraine's security, depends less on Ukraine's own internal security measures than on the non-proliferation actions of other countries. Nuclear and radiological non-proliferation should be viewed as a chain of international agreements and measures, the strength of which depends on the weakest link. In this respect, Ukraine's security still depends on a broad international decision-making process and its effectiveness. Based on this premise, this paper assessed the need for action, the appropriateness of security policies, and the applicability of existing treaty and non-treaty international material control mechanisms. The Treaty on the Non-Proliferation of Nuclear Weapons<sup>5</sup> (NPT) is, first and foremost, an arms control treaty aimed at preventing the proliferation of nuclear weapons (Preamble, Articles I–III). In practice, this treaty represents an accounting and monitoring agreement for weapons-grade or enriched nuclear material normally held by non-nuclear-weapon states for peaceful purposes (Article III).

The International Atomic Energy Agency (IAEA) monitors these materials in non-nuclear-weapon states using established monitoring measures, namely, the aforementioned safeguards and surveillance. This is based on information provided by non-nuclear-weapon states to the IAEA on the type and quantity of their civilian nuclear material. The Vienna Convention on Civil Liability for Nuclear Damage<sup>6</sup> is responsible for accounting for the production, consumption

<sup>1</sup> Treaty on the Non-Proliferation of Nuclear Weapons. (1968, July). Retrieved from <https://disarmament.unoda.org/en/our-work/weapons-mass-destruction/nuclear-weapons/treaty-non-proliferation-nuclear-weapons>.

<sup>2</sup> IAEA Safeguards the Additional Protocol to the Safeguards Agreements in Force. (1997, May). Retrieved from [https://zakon.rada.gov.ua/laws/show/951\\_002#Text](https://zakon.rada.gov.ua/laws/show/951_002#Text).

<sup>3</sup> Ibidem, 1997.

<sup>4</sup> Order of the Ministry of Ecology and Natural Resources of Ukraine No. 241 "On Approval of the Rules for Ensuring the Safety of Nuclear Materials, Radioactive Waste, and Other Sources of Ionizing Radiation". (2000, December). Retrieved from <https://zakon.rada.gov.ua/laws/show/z0013-01#Text>.

<sup>5</sup> Treaty on the Non-Proliferation of Nuclear Weapons. (1968, July). Retrieved from <https://disarmament.unoda.org/en/our-work/weapons-mass-destruction/nuclear-weapons/treaty-non-proliferation-nuclear-weapons>.

<sup>6</sup> Vienna Convention on Civil Liability for Nuclear Damage. (1963, May). Retrieved from <https://zakon.rada.gov.ua/laws/show/2893-14#Text>.

and location of declared quantities. The accounting and reporting requirements are designed to prevent the diversion of nuclear energy from peaceful uses to nuclear weapons or other nuclear explosive devices (Article III, paragraph 1). In addition, under Article III, paragraph 2, all contracting parties are obliged to transfer fissile material and technical equipment necessary for its reprocessing to other states only on condition that these states comply with the safeguards and monitoring provided for in the Treaty on the Non-Proliferation of Nuclear Weapons<sup>1</sup>.

Since the signing of the Treaty on the Non-Proliferation of Nuclear Weapons in 1968<sup>2</sup>, the International Atomic Energy Agency has implemented the necessary monitoring measures with Member States and groups of countries by concluding a number of supplementary agreements and has published these measures in its announcements (information, circulars, verification notices and notifications to the Verification Information Centre, etc.). As the responsible verification agency, the IAEA focuses its activities on verifying the accuracy and completeness of information provided by Member States on their nuclear programmes (production, use, and storage locations of fissile material), and on increasing the confidence of the NPT States Parties in the peaceful use of nuclear weapons by their partner states or on promptly providing empirical evidence to confirm suspicions of treaty violations (early warning) (Zubair *et al.*, 2024). In particular, these measures include: analysis and verification of reports and data submitted by Member States through inspections of nuclear facilities and nuclear material stockpiles of Member States (surveillance, surprise, periodic and other inspections carried out by IAEA officials), sealing of containers protected from unauthorised access, and installation and maintenance of surveillance cameras. In the 1990s, after the nuclear weapons development programmes of Iraq and North Korea (Tereshchenko, 2020) were exposed in violation of treaty provisions, it was found that the International Atomic Energy Agency's surveillance mechanisms were not sufficiently effective. In early 2004, the seriousness of Pakistan's nuclear proliferation was further confirmed

(Azad & Shahid, 2021). As early as 1997, the IAEA developed an Additional Protocol<sup>3</sup> to the existing safeguards agreements. As of July 2003, 74 countries, including Ukraine, had signed the Protocol, of which 35 had entered into force. This Protocol gave IAEA inspectors broader information and verification powers than the original safeguards agreements. For example, the 1973 agreement (in force since 1977) between the IAEA, EURATOM and various European states, including Ukraine, under INF-CIRC/193<sup>4</sup>. The arms control mechanism under the Treaty on the Non-Proliferation of Nuclear Weapons was significantly expanded. A key aspect of the new provisions was that the International Atomic Energy Agency was no longer limited to inspecting declared materials, nuclear facilities, and civilian activities of member states. Instead, it was authorised to actively and almost without restriction investigate undeclared materials and clandestine nuclear programmes on the territory of the inspected state, subject to disagreements or in extraordinary circumstances, even if a treaty violation is suspected. In addition, IAEA inspectors are also authorised to use the most advanced measurement and communication technologies for their inspections.

The arms control provisions of the Treaty on the Non-Proliferation of Nuclear Weapons are complemented by a large number of technical regulations, standards, and recommendations of the International Atomic Energy Agency, covering the safe handling of nuclear materials at every stage, from use and transportation to processing, storage, and disposal. These include, among others:

- International Basic Standards for Protection against Ionising Radiation and the Safety of Radiation Sources<sup>5</sup>. These contain recommendations on protection against nuclear radiation, which the IAEA has been developing since the early 1960s together with the International Commission on Radiological Protection and which are constantly being adapted to new requirements.

- Convention on Nuclear Safety of 1994<sup>6</sup>. This agreement aims to achieve and maintain a high level of global nuclear safety through the improvement of national measures and international cooperation,

<sup>1</sup> Treaty on the Non-Proliferation of Nuclear Weapons. (1968, July). Retrieved from <https://disarmament.unoda.org/en/our-work/weapons-mass-destruction/nuclear-weapons/treaty-non-proliferation-nuclear-weapons>.

<sup>2</sup> *Ibidem*, 1968.

<sup>3</sup> Additional Protocol to the Existing Safeguards Agreements. (1997, May). Retrieved from <https://www.iaea.org/topics/additional-protocol>

<sup>4</sup> Additional Protocol to the Agreement between Ukraine and the International Atomic Energy Agency on the Application of Safeguards in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons. (2000, September). Retrieved from [https://zakon.rada.gov.ua/laws/card/951\\_002](https://zakon.rada.gov.ua/laws/card/951_002).

<sup>5</sup> International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources. (1996, September). Retrieved from [https://www.ilo.org/sites/default/files/wcmsp5/groups/public/@ed\\_protect/@protrav/@safework/documents/publication/wcms\\_152685.pdf](https://www.ilo.org/sites/default/files/wcmsp5/groups/public/@ed_protect/@protrav/@safework/documents/publication/wcms_152685.pdf).

<sup>6</sup> Convention on Nuclear Safety. (1994, June). Retrieved from <https://www.iaea.org/topics/nuclear-safety-conventions/convention-nuclear-safety>.

including technical cooperation related to safety (Article I, paragraph 1).

▪ Convention on the Safety of Spent Fuel and Radioactive Waste<sup>1</sup>; this agreement establishes fundamental safety requirements for the entire life cycle of spent nuclear fuel and nuclear waste up to their final disposal<sup>2</sup>.

As their names suggest, these agreements are not aimed at preventing the proliferation of nuclear weapons and responding to international threats, but rather at preventing nuclear accidents. However, they remain important from a security policy perspective for two reasons: first, they establish technical and operational measures to prevent accidents and also limit the possibility of terrorist misuse of nuclear and radioactive materials. For example, restricting access to temporary storage facilities designated for radiation protection makes it more difficult for terrorist organisations to steal spent fuel elements. This is a desirable side effect of security policy. Second, although these agreements are not yet fully implemented, they have made a significant contribution to international standardisation of nuclear security. The Convention on the Physical Protection of Nuclear Material<sup>3</sup>, mentioned above, goes even further in this regard. As the only such convention to date, it regulates the physical protection of nuclear material in accordance with international standards to prevent its misappropriation and misuse. However, the convention requires special protection only for the transboundary transport of nuclear material or temporary storage during transport, and does not require such protection for processing, storage, or transport within the territory of the contracting parties.

Furthermore, the required physical protection only concerns theft, and potential terrorist attacks and sabotage of nuclear facilities are not covered. Compared to the safeguards and monitoring of the Treaty on the Non-Proliferation of Nuclear Weapons<sup>4</sup>, this agreement is very general in nature. It does not provide for any verification measures, does not establish a voluntary regulatory reporting system, and does not provide for international supervision of

the regulation and technical control of nuclear weapons transfers by the contracting parties.

In view of the above, the IAEA has attempted to fill some of the gaps left by the Convention on the Physical Protection of Nuclear Material and Facilities<sup>5</sup> by publishing a comprehensive recommended catalogue entitled “Physical Protection of Nuclear Material and Facilities”. This catalogue covers technical and operational measures for the protection of nuclear facilities and nuclear material, reflects the state of the art and recommends standardised methods for the analysis of risks associated with threats to nuclear security.

These protective measures are designed to prevent theft of materials and damage to facilities. They are distributed according to the protection needs of the protected facilities, which are, in turn, classified by threat levels (concern). Large quantities of highly radioactive weapons-grade materials are at the highest threat level, while smaller quantities of materials, and fissile materials with lower radioactivity and purity (low enrichment, non-weapons-grade) are classified at lower protection levels. These measures also apply to the use, storage, and transport of materials within a country, but their main goal is to achieve international standardisation of national protective measures.

The UN Security Council Resolution<sup>6</sup> provided the legal basis for international efforts to combat nuclear proliferation and for physical protection. Among other things, the resolution established the mandatory rules set out in Chapter VII of the UN Charter<sup>7</sup>, according to which all states must take physical security measures during the production, use, storage, and transport of nuclear, chemical, and biological weapons-grade materials. The resolution calls on states to adopt legislation prohibiting non-governmental organisations from producing, distributing or using weapons of mass destruction and their delivery systems, or to take measures to prevent such activities. It also provides for the appropriate control and accumulation of stockpiles of nuclear, chemical and biological weapons-grade materials.

<sup>1</sup> Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. (1997, September). Retrieved from <https://www.iaea.org/topics/nuclear-safety-conventions/joint-convention-safety-spent-fuel-management-and-safety-radioactive-waste>.

<sup>2</sup> Additional Protocol to the Agreement between Ukraine and the International Atomic Energy Agency on the Application of Safeguards in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons. (2000, September). Retrieved from [https://zakon.rada.gov.ua/laws/card/951\\_002](https://zakon.rada.gov.ua/laws/card/951_002).

<sup>3</sup> Convention on the Physical Protection of Nuclear Material. (1980, October). Retrieved from <https://www-pub.iaea.org/MTCD/Publications/PDF/Pub615web.pdf>.

<sup>4</sup> Treaty on the Non-Proliferation of Nuclear Weapons. (1968, July). Retrieved from <https://disarmament.unoda.org/en/our-work/weapons-mass-destruction/nuclear-weapons/treaty-non-proliferation-nuclear-weapons>.

<sup>5</sup> Convention on the Physical Protection of Nuclear Material. (1980, October). Retrieved from <https://www-pub.iaea.org/MTCD/Publications/PDF/Pub615web.pdf>.

<sup>6</sup> Resolution of Security Council of the UN No. 1540. (2004, April). Retrieved from <https://digitallibrary.un.org/record/520326?v=pdf>.

<sup>7</sup> United Nations Charter. (1945, October). Retrieved from <https://www.un.org/en/about-us/un-charter>.

Within six months of the adoption of the resolution, each UN Member State must submit a preliminary report to the Security Council Committee on the implementation of the resolution. This resolution<sup>1</sup> aimed to fill a gap in the international regulatory framework on the non-proliferation of weapons of mass destruction (nuclear weapons), since not all UN Member States are parties to the relevant non-proliferation treaties. However, this Security Council resolution indirectly brought them under the non-proliferation mechanism. Even if they are not regulated in themselves, they are at least linked to the objectives of its security policy. The intention of the Security Council on this issue is very clear, it repeatedly and explicitly referred to the non-proliferation treaties and emphasised that its resolution “affirms” the objectives of these treaties (Bibik *et al.*, 2025). However, the resolution did not address the regulation of radioactive materials and their civilian uses.

Article II, paragraph 2 of the Treaty on the Non-Proliferation of Nuclear Weapons<sup>2</sup> provides that States Parties shall transfer nuclear materials and equipment suitable for military use to non-nuclear-weapon states for peaceful purposes only, provided that such dual-use materials and technology are subject to safeguards and monitoring in accordance with Article III, paragraph 1, in the importing state. The States Parties have been aware from the outset that this provision provides for export controls and would therefore require them to be applied by states that sell nuclear technology internationally for civilian purposes.

Shortly after the Treaty on the Non-Proliferation of Nuclear Weapons<sup>3</sup> entered into force, two export control mechanisms emerged, and nuclear-weapon exporting states still use both mechanisms, partly in parallel. The first mechanism was developed in 1971 by the Zangger Commission, named after its long-time chairman, the Swiss professor Claude Zangger. The Zangger Committee defined nuclear exports using a “trigger” list, i.e., a list of critical materials and equipment that automatically activate the safeguards of the NPT Safeguards System in non-nuclear-weapon States (Herrera, 2025).

A second approach to control the export of nuclear products is based on the Guidelines of the so-called Nuclear Suppliers Group (NSG) (Lozova, 2020). The NSG Guidelines also include “trigger” lists and comprehensive safeguards, but their requirements are stricter. They require physical protection of nuclear facilities, written assurances from countries accepting special safeguards, special care in handling

nuclear equipment and fissile materials, and special measures for technology transfer. However, the export control measures described are based solely on unilateral declarations of intent by supplier countries, which in some cases may be legally binding, agreed between supplier countries or unilaterally notified to the International Atomic Energy Agency, but no country is contractually obligated to comply with these declarations.

In the broadest sense, the control of nuclear materials and technology, which includes not only proliferation prevention but also the physical protection and control of non-fissile but radioactive materials, is supported by several international security policy initiatives, some of which have proven quite effective in their respective limited areas of activity.

Two of the most important initiatives are the G8-backed Global Partnership and the US-led Proliferation Security Initiative (PSI) (Ivanytskyi, 2023). The PSI aims to stop the international trade in weapons of mass destruction by extending existing border and export controls to international shipments (e.g., searching aircraft and ships carrying suspicious cargo, seizing illicit weapons or delivery systems). The PSI focuses on securing and disposing of weapons of mass destruction, including nuclear materials and their radioactive waste, which are still in the possession of some countries.

Since 2002, the IAEA has been implementing an action plan to prevent nuclear terrorism. In addition to strengthening the physical protection of nuclear materials, radioactive sources and nuclear facilities by IAEA Member States, the plan’s activities include combating the international black market trade in radioactive materials and providing IAEA experts with advice on security and nuclear law to relevant organisations and facility operators. The plan costs approximately EUR 12 million per year, shared between several Member States and private organisations such as the Nuclear Threat Initiative (Newell, 2022). These activities essentially complement some of the IAEA’s previous security assurance programmes, expanding their scope to include the prevention of terrorism. The Global Threat Reduction Initiative (GTRI), launched by the U.S. Department of Energy (DOE) in May 2004 and supported by the IAEA, is of a similarly complementary and complementary nature. Its main objectives include the identification of nuclear and radiological materials and related equipment not yet covered by existing threat reduction measures. In particular, GTRI aims to organise the return of spent

<sup>1</sup> Resolution of Security Council of the UN No. 1540. (2004, April). Retrieved from <https://digitallibrary.un.org/record/520326?v=pdf>.

<sup>2</sup> Treaty on the Non-Proliferation of Nuclear Weapons. (1968, July). Retrieved from <https://disarmament.unoda.org/en/our-work/weapons-mass-destruction/nuclear-weapons/treaty-non-proliferation-nuclear-weapons>.

<sup>3</sup> Communication Received from the Permanent Mission of the Netherlands on Behalf of the Member States of the Nuclear Suppliers Group. (2000, April). Retrieved from <https://www.iaea.org/sites/default/files/infcirc539r1.pdf>.

highly enriched uranium from third countries to the supplying countries – the Russian Federation and the United States (International Partners' Conference, 2004). A further long-term goal is to convert all research reactors in the world to operate with low-enriched uranium, provided that they currently operate with highly enriched uranium.

## ■ Discussion

The issue of the effectiveness of international legal mechanisms for controlling nuclear and radiological materials is actively studied in contemporary scientific literature, which allows for a comparative analysis of the results obtained with the conclusions of other researchers. In particular, a significant contribution to the study of the nuclear non-proliferation system was made by Mohamed ElBaradei, Pierre Goldschmidt, Matthew Bunn, and Graham Allison.

Thus, the researcher of M. ElBaradei (2021) emphasises the effectiveness of the International Atomic Energy Agency safeguards system and considers it one of the main instruments of international security. However, the above analysis shows a slightly different picture, since modern threats associated with the activities of terrorist organisations and the illegal circulation of radioactive materials largely go beyond the conventional control mechanisms. In this aspect, the results of this study partially complement the researcher's position, indicating the need to expand international control instruments.

A similar opinion was expressed by P. Goldschmidt (2021), who in his research emphasised the need to strengthen international monitoring and introduce more stringent procedures for verifying the implementation of nuclear security obligations by states. The conclusions drawn by the researcher are quite relevant, since the results of the analysis also confirmed the existence of significant gaps in the international control system, in particular, regarding the physical protection of nuclear materials and their transportation.

Furthermore, G. Allison (2009) and M. Bunn *et al.* (2021) focused primarily on the threat of nuclear terrorism and the risks of illicit trafficking of nuclear materials. Their research proved that the most vulnerable link in the global security system is the insufficient level of physical protection of nuclear facilities in some states. These conclusions are largely consistent with the results of the study (Allison, 2009). However, the researchers' assertions that the main problem lies exclusively in national security systems seem debatable, since the above analysis also indicates the presence of institutional shortcomings at the international level (Bunn *et al.*, 2021).

The reason for the different interpretations may lie in different methodological approaches to analysing the problem: while the aforementioned

researchers mainly focused on security and political aspects, this study paid more attention to international legal regulatory mechanisms. In this regard, the conclusions of these researchers, considering the results of this study, can be considered in a broader context that combines legal, institutional, and security aspects of control over nuclear and radiological materials.

Despite the valuable scientific achievements of the aforementioned researchers, the current study focused on the problems of international legal mechanisms for controlling nuclear and radiological materials precisely in conditions of unforeseen dangers, such as theft, terrorism, etc. Radioactive materials are not suitable for the production of weapons of mass destruction, but if they are crushed or dispersed in liquid form in the open environment, or if they enter the soil, air or water, or if they are inhaled or swallowed, they can cause radiation damage to the population and the environment. Since radioactive materials have a wide range of civilian applications and are widely distributed, the rules for their protection and control vary greatly from country to country, and these rules are often poorly implemented. It is therefore foreseeable that terrorist organisations will seek to obtain radioactive materials through theft and illicit trade to use them as radioactive weapons, thereby achieving the greatest terrorist impact with relatively little technological and organisational investment.

In an international agreement on the physical protection of nuclear materials and facilities, the degree of cooperation between individual states is always a decisive factor in effectiveness, along with technical and organisational criteria. This is especially true of the expanded CPPMN. In this light, this project is by no means less effective than its alternatives. It represents a relative optimum, combining technical and regulatory efficiency with the widest possible international acceptance of the expanded CPPMN, while avoiding a compromise between the two.

The contracting parties may violate the agreement through negligence, lack of technical expertise or insufficient resources, but they have no strategic interest in violating the convention, since violating the treaty does not improve their chances of success in a military conflict. Rather, it can always be assumed, to a good approximation, that the treaty objective of the expanded CPPMN corresponds to the common interests of all member states. In this respect, the problem of (lack of) CIMO monitoring and verification is of a completely different nature than the problem of arms control verification. If a state fails to fulfil its CIMO obligations or is unable to do so under the circumstances, it is primarily putting its own security at risk. Accordingly, in such a case, the appropriate response should not be through

treaty verification, but in accordance with the IAEA's concept of providing advice and support to that state on technical, organisational, and nuclear law issues. Experience has shown that technical advice and assistance from the IAEA and expert groups from high-tech countries is usually met with a high degree of cooperation from the recipient states.

The effectiveness of the Code of Conduct on the Safety and Protection of Radioactive Sources should also be assessed based on the extent to which non-binding guidelines and recommendations can contribute to addressing international security policy issues through the control of civil materials and the management of operational safety. The European regulatory framework is still largely dependent on radiation protection and accident prevention requirements (Hans, 2025). Measures specifically aimed at combating the systematic, organised misuse of radiological sources for criminal and terrorist purposes should be considered more frequently from a security policy perspective. The security policy challenges and solutions outlined demonstrate that international control of nuclear and radiological materials requires new rules compared to the control of conventional nuclear weapons. New approaches in this respect do not have the strict requirements of the NPT regime.

## ■ Conclusions

The subject of the research was the investigation of the problems of international legal mechanisms for controlling nuclear and radiological materials in conditions of unforeseen risks, such as official negligence, theft, terrorism, etc. The current study has allowed reaching these conclusions, given the circumstances the world is currently in. Given the threat of terrorism, the current rules on nuclear non-proliferation are insufficient. The Non-Proliferation Treaty on the Non-Proliferation of Nuclear Weapons does not oblige the contracting parties to protect nuclear materials and facilities from theft or terrorist sabotage. Therefore, the level of physical protection provided by the contracting parties to the NPT to nuclear weapons materials and civilian nuclear facilities (reactors, temporary storage facilities, plants for the production and reprocessing of nuclear fuel rods) varies significantly. There are also significant differences between developed and developing countries in the technological and

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financial resources available to implement effective protection measures. For example, the Russian Federation still stores thousands of tonnes of plutonium, uranium, and high-level spent nuclear fuel intended for civilian and military use. These materials, a legacy of the Soviet Union, are so large that their quantitative inventory, monitoring, and physical protection against misuse are extremely complex. In many other countries, security issues regarding civilian use (research, energy production), transportation, reprocessing, interim storage, and disposal of usable and spent nuclear fuel remain unresolved. In these circumstances, even within the constraints of the Nuclear Non-Proliferation Treaty, these materials are highly vulnerable to theft, smuggling, and entry into international illicit trade.

Although the International Atomic Energy Agency and other international organisations have worked for decades to promote the monitoring, protection and export control of nuclear technology and materials through subsequent treaty arrangements (such as the 1980 Convention on the Physical Protection of Nuclear Material), technical assistance programmes, international cooperation and other large-scale activities, these activities, together with the support of organisations such as the Committee on the Prevention and Prohibition of Nuclear Medicine, still need to be based on internationally standardised procedures. However, the international nuclear medicine system remains fragmented in key areas. In recent years, its shortcomings have become truly apparent with the escalation of security threats from terrorism. Another new challenge facing security policy is the protection and control of radioactive sources used in civilian sectors such as industry, research, and medicine. These sources consist of non-fissile, non-concentrated materials, but without the necessary radiation protection measures they can still be highly radioactive, causing serious harm to people and the environment.

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## ■ Conflict of Interest

None.

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## Проблеми міжнародно-правових механізмів контролю за ядерними та радіологічними матеріалами

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■ **Анотація.** Це дослідження мало на меті вивчення проблем міжнародно-правових механізмів контролю за ядерними та радіоактивними матеріалами. У статті як основний використано формально-правовий метод, оскільки він дає змогу аналізувати правові норми, структури та концепції. Дослідження засвідчило, що нерозповсюдження ядерної зброї та збройових ядерних матеріалів ґрунтується переважно на Договорі про нерозповсюдження ядерної зброї 1968 року, який встановлює суворі правила використання цивільних ядерних матеріалів і технологій у всьому світі та контролюється Міжнародним агентством з атомної енергії у Відні. Однак унаслідок підвищення активності міжнародних терористичних організацій останніми роками чинні положення щодо ядерного нерозповсюдження виявилися недосконалими й неадекватними. У дослідженні зазначено, що політика безпеки та цивільної оборони повинна ґрунтуватися на тому факті, що терористичні організації прагнуть отримати ядерні матеріали для нападів. Ядерний тероризм є поширеним, оскільки Договір про нерозповсюдження ядерної зброї не вимагає від держав-членів захищати ядерні матеріали й об'єкти від крадіжки або терористичного саботажу. Фактично на міжнародному рівні фізичний захист матеріалів ядерної зброї та цивільних ядерних установок (реакторів, сховищ для тимчасового зберігання та заводів з виготовлення та переробки паливних стрижнів) істотно різниться. Чимало країн не мають належного захисту для транспортування, переробки, тимчасового зберігання та захоронення придатного для використання та відпрацьованого ядерного палива, що призводить до втрат, крадіжок, контрабанди й незаконної міжнародної торгівлі цими матеріалами. Практичне значення цього дослідження полягає в тому, що аналіз проблем міжнародно-правових механізмів контролю за ядерними та радіоактивними матеріалами дає змогу оцінити недоліки наявних механізмів й усунути їх, тим самим забезпечуючи найвищий рівень безпеки та контролю за ядерними і радіоактивними матеріалами

■ **Ключові слова:** Договір про нерозповсюдження ядерної зброї; ядерна зброя; політика безпеки; терористичні загрози; радіоактивні матеріали