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IAEA and Nuclear Security: An Evolutionary Perspective

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ABSTRACT

Since 1957, the International Atomic Energy Agency (IAEA) has expanded its role in nuclear security. While it was only intended to focus on promoting the peaceful use of nuclear energy in line with safeguards implementation to prevent nuclear proliferation, its mandate has, in time, evolved to address the emerging threats to nuclear technology, i.e., nuclear terrorism and illicit trafficking of nuclear materials. In this historical perspective, the article analyses the development of the IAEA's nuclear security framework. Over time, there have been key points, such as the need for physical protection in the 1970s and the establishment of comprehensive security measures after the 9/11 terrorist attacks. Currently, the IAEA's nuclear security program consists of guidance, training, and international cooperation efforts, which are only available upon the request of Member States. More recently, it has expanded its nuclear security efforts to provide technical assistance and monitor nuclear safety and security in conflict zones. However, this expansion has not been easy for the IAEA as it has challenges such as funding limitations and the tension between national sovereignty and international oversight. Ultimately, the IAEA's nuclear security role as the global platform shows its critical importance in enhancing international efforts to mitigate nuclear security threats. However, while the IAEA has made important progress in nuclear security, structural and political limitations constrain its effectiveness.

Keywords: Physical Protection, Nuclear Security, IAEA, Nuclear Material, Nuclear Facility

1. Introduction

Nuclear security is defined as “the prevention of, detection of, and response to criminal or intentional unauthorized acts involving or directed at nuclear material, other radioactive material, associated facilities, or associated activities”[1]. However, this definition has evolved since the early days of nuclear technology. Referred as physical protection at first in the 70s, the protection of nuclear material and later on, nuclear facilities have gradually become one of the main focuses of the International Atomic Energy Agency (IAEA). As a result, the mandate of the IAEA in nuclear security has evolved, including guidance, training, and international cooperation efforts aimed at strengthening nuclear security worldwide.

However, the IAEA’s role in nuclear security remains limited as the responsibility for nuclear security rests entirely with member state. As a result, there is no legally binding rule or inspection to ensure effective measures are in place. In other words, nuclear security relies on recommendations and guidance rather than a set of standards, as in nuclear safety, or inspections, as in nuclear safeguards [2]. This is because nuclear security, from the beginning, has been perceived as an exclusively sovereign and, thus, a national responsibility.

In this context, this article provides a historical perspective on the IAEA’s evolving role in nuclear

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security, analyzing key turning points, challenges, and prospects. The next section covers the early recognition of the need for physical protection in the 1970s and explores the historical developments that have shaped the contemporary nuclear security understanding. Following an analysis of how the dissolution of the Soviet Union affected physical protection, the paper will examine how the 9/11 attacks shaped today's understanding of nuclear security. Finally, the article will examine the ongoing challenges that the IAEA faces in nuclear security, including funding, sovereignty issues, and its effort to address nuclear security in conflict zones. It is argued that while the IAEA has made important progress in nuclear security, structural and political limitations constrain its effectiveness.

2. Physical Protection to Nuclear Security

2.1 Need for Physical Protection

In 1957, the IAEA was officially established after painstaking diplomacy following US President Eisenhower's "Atoms for Peace" speech in 1953. Although a United Nations (UN) body was envisioned in this 1953 speech, the idea of creating such an agency dates back to 1946 with Dean Acheson's Report on the International Control of Atomic Energy and Bernard Baruch's Baruch Plan [3]. In his presentation to the UN Atomic Energy Commission (UNAEC) in June 1946, Baruch stated the need for an international mechanism to ensure the peaceful use of atomic energy and the preclusion of its use in military means [4]. However, the Baruch Plan faced the challenges of the Cold War and two new nuclear weapon states, namely the Soviet Union (1949) and the United Kingdom (1952). As a response to the failed Baruch Plan, Eisenhower's speech created the basis of a UN agency that might promote peaceful nuclear cooperation in exchange for a verified pledge not to develop nuclear weapons.

As a result, the idea of an international body began to take shape largely as a Western project, with the initial Soviet hostility toward the idea. However, the Soviet Union started to participate in the negotiations on the Agency Statute in July 1955. It was just weeks before the First Geneva Conference on Peaceful Uses of Atomic in August 1955. The conference had an important role in shaping the idea of international scientific cooperation through the IAEA. Thus, the role of the IAEA was codified as a "receiver, distributor, broker and safeguarder of nuclear material" [5].

The establishment process of the IAEA experienced Cold War crises, such as the Hungarian Revolution and the Suez Canal crisis. However, both the Soviet Union and the US agreed to establish the IAEA under the aegis of the United Nations so that the Security Council would be the sole authority to address non-compliance. Therefore, the initial focus that the founders of the IAEA had was on the obligation not to divert nuclear materials for military purposes so that the right to peaceful use of nuclear technology could be achieved. The role of the IAEA was primarily concerned with verifying the peaceful use of such materials [3].

In this process, the IAEA's framework did not define a concept that was similar to nuclear security in the early years. When the IAEA's safeguards system was developed in the late 1950s, the focus was on accounting for nuclear materials, not their physical protection. However, there was a change in approach to physical protection in the early 1970s. During this time, the IAEA started working on physical protection as an offshoot of the development of the safeguards system.

The period beginning in 1970 was very related to the The Non-Proliferation Treaty (NPT), which had been concluded and entered into force in March 1970. During this period, the IAEA realized that without a physical protection program, the containment and surveillance dimension of safeguards would not work. It resulted in a need to develop recommendations for physical protection, which was the "Grey Book" in June 1972. In the upcoming years, the Grey Book evolved into the IAEA Document INFCIRC/225 in 1975 and has been revised five times per the changing requirements in 1977, 1989, 1993, 1997, and finally in 2011 [6]. INFCIRC/225, or the Recommendations for the Physical Protection of Nuclear Material, became a prominent guidance document in the following years. The Nuclear Suppliers Group (NSG) also used INFCIRC/225 as a baseline for its physical protection guidelines for supplier and recipient states during usage, storage, or transit [7]. In the same period, negotiations about the Convention on the Physical Protection of Nuclear Material (CPPNM) started in Vienna in 1977 and were concluded in 1980 [8]. It established a legally binding framework for international cooperation on the physical protection and control of nuclear materials during international transport.

While these initial steps were considered as sufficient, the dissolution of the Soviet Union in the early 1990s introduced new physical protection challenges. Because there were new threats, such as potential "loose nukes" and the illicit trafficking of nuclear materials. As a result, in order to increase international cooperation for timely response and mitigate misuse of nuclear materials, the IAEA established the Incidents and Trafficking Database (ITDB) in 1995 and the Office of Physical Protection and Material Security in 1999 to coordinate international

efforts [9]. These were important steps because ITDB came out of Member States' commitment to fight against illicit trafficking and physical protection of nuclear materials. The IAEA started to keep a record of illicit trafficking incidents at the ITDB and share these with Member States and relevant international organizations. Over time, Member States found the recorded data in the ITDB useful for analyzing and identifying trends in illicit trafficking incidents [7]. These developments also demonstrated the IAEA's institutional readiness to expand its support when member states advocated for new activities to counter emerging threats. One more example to this was the introduction of the International Physical Protection Advisory Service (IPPAS). The IPPAS was designed to guide Member States in enhancing their nuclear security measures [8].

There was also an increase in terrorist attacks in the 1990s, which resulted in negotiations in the UN for the International Convention for the Suppression of Acts of Nuclear Terrorism (ICSANT) in 1996. The negotiations were supported by both the US and Russia due to their security concerns. The approach of both American and Russian sides to nuclear terrorism was reiterated in the Moscow Summit on Nuclear Safety and Security in 1996 with a particular focus on the physical protection of all nuclear materials, which was called "nuclear security" in 1996 for the first time at the presidential level summit [10].

Taken together, these early efforts to protect nuclear materials created the foundation for what would eventually become a broader concept of nuclear security. The next section examines how physical protection evolved into a more comprehensive approach, particularly in the wake of pivotal global events.

2.2 Expanding into Nuclear Security

The 9/11 terrorist attacks marked a critical point for the evolution of physical protection into nuclear security. Although these attacks did not involve nuclear material or facilities, the 9/11 attacks reinforced the idea that terrorist groups might seek nuclear material or sabotage nuclear facilities. Indeed, before the 9/11 attacks, there had long been concerns how far terrorists would go to inflict mass casualties, given the attacks in the 1990s (i.e., the World Trade Center bombing and the US embassy bombings in East Africa). As a result, the attacks resulted in a renewed focus on the intentions and capabilities of terrorist groups such as al-Qaeda. There were two reasons for this. First, al-Qaeda was reported to have shown interest both in Weapons of Mass Destruction (WMD) and in chemical, biological, radiological, and nuclear (CBRN) material. Second, al-Qaeda was reported to be trying to obtain nuclear material on the black market and to have a military committee that was planning operations involving CBRN materials [11].

For these reasons, IAEA Director General Mohamed ElBaradei often referred to 9/11 as a wake-up call for the nuclear community. As a result, the 9/11 attacks reinforced the analysis that future attacks might involve nuclear or radiological materials if non-state actors had access to them [12]. These potential threats connected to a large number of nuclear facilities globally led to a restrengthening of security measures, developing into the international nuclear security regime.

The focus on potential nuclear terrorism led the efforts to be more than on the physical protection of nuclear material. The result was not surprising. These efforts led to legally binding instruments such as conventions, resolutions, and treaties. These include UN Security Council resolutions 1373 and 1540, the CPPNM's 2005 Amendment, broader participation in ICSANT, and the Convention for the Suppression of Unlawful Acts Against the Safety of Maritime Navigation's (SUA Convention) 2005 Protocol. These efforts have been supported by organizations or initiatives, such as the Global Initiative to Combat Nuclear Terrorism (GICNT), the Nuclear Security Summits (NSS), and the Proliferation Security Initiative (PSI). In addition, non-governmental organizations (NGOs) such as the Nuclear Threat Initiative (NTI), the World Institute for Nuclear Security (WINS), the Vienna Center for Disarmament and Non-Proliferation (VCDNP), and the International Nuclear Security Forum (INSF) have strengthened these efforts to develop, implement and sustain norms and nuclear security culture [11].

While these efforts took place internationally, the IAEA intensified its focus on coordinating international efforts to mitigate the threat of nuclear terrorism. The IAEA's role in coordinating international efforts to secure nuclear materials became increasingly prominent, as highlighted by the Nuclear Security Summits (NSS) initiated by President Barack Obama [13]. The Office of Physical Protection and Material Security was moved in 2002 from the Department of Safeguards to the Department of Nuclear Safety with a new name "Office of Nuclear Security." IAEA resolutions were introduced in terms of "security of nuclear materials" or "nuclear security" (since 2002).

The IAEA Director General established an Advisory Group on Nuclear Security in January 2002 while creating the Nuclear Security Fund (NSF) to reinforce its nuclear security programs [14]. One of the key

contributions of the group was to introduce the definition of nuclear security that is used today. With this, the transition from physical protection to nuclear security was completed, and it showed how resilient and open the IAEA is to transformation against evolving threats. Because the statute of the IAEA does not have the wording of "nuclear security" or even "security", except for the references to the Security Council, on the other hand, the word "secure" has been used several times with different meanings, i.e., to secure the greatest benefit or necessary financing [8]. In fact, the words "nuclear" and "security" have had different meanings for decades. For instance, a declassified U.S. Central Intelligence Agency report (1984) analyzed the trends in South Africa's Nuclear Security Policies and Programs. The report focuses on South Africa's security policies regarding the production of highly enriched uranium (HEU) and its nuclear test capability. Apparently, the report does not discuss the security of nuclear materials or nuclear facilities. Furthermore, international nuclear security was used to refer to the international security situation in the world as related to nuclear weapons [8].

In March 2002, the IAEA Secretariat announced a number of nuclear security activities with "Protection against Nuclear Terrorism: Specific Proposals." This proposal outlines steps to enhance the capacity of Member States' to protect nuclear facilities, such as increasing the number of IPPAS missions, Design Basis Threat (DBT) methodology reviews, training for better detection and response to incidents, and material accountancy and control systems as well as emergency preparedness and response against nuclear emergencies [8]. The IAEA also led the process of the renegotiation of the CPPNM, given the shared understanding of Member States that the convention should be strengthened. As a result, the amended convention, which has provisions to protect nuclear material during all phases, not only during international transport, was completed in 2005. In addition, the NSS process highlighted the essential role of the IAEA in coordinating international efforts, while the fact that responsibility for nuclear security rests with the Member State restated. During the post-9/11 period, nuclear security became much more prominent in the IAEA's program and budget. The Office for Nuclear Security became a Division in 2014, and regular budget funding increased from €1.1 million per year in 2009 to €7.3 million in 2025 [15].

By expanding its focus from physical protection to broader nuclear security, the IAEA demonstrated its adaptability to evolving threats. However, global crises revealed new vulnerabilities, which set the stage for understanding nuclear security in conflict zones—a topic explored in the next section.

2.3 Nuclear Security and Armed Conflict

Nuclear security is again at an important turning point as the IAEA has been taking a leading role in addressing an unprecedented challenge. The Russian invasion of Ukraine in 2022 brought a new dimension and has been testing the limits of nuclear security. Because protecting nuclear facilities in active conflict zones was not something that the international community was prepared for. As a result, it pointed out the need for a more dynamic and adaptable approach to nuclear security, as the risks associated with armed conflict extend far beyond traditional scenarios [16].

Many different incidents have directly impacted nuclear safety and security in Ukraine since the beginning of the invasion. These include but are not limited to, shelling, drone attacks, staffing shortages, deteriorating working conditions, and the loss of off-site power. Russian military forces occupied two Ukrainian nuclear sites: the Chornobyl Nuclear Power Plant (from 24 February to 31 March 2022) and the Zaporizhzhia Nuclear Power Plant (ZNPP), which has been under occupation since 4 March 2022. These events have created an unprecedented nuclear security crisis, which required immediate reaction [17].

In response, the IAEA has shown flexibility and resilience, as has previously happened. It has provided technical assistance to stabilize the nuclear safety and security situation in Ukraine with the sole purpose of preventing a potential nuclear accident. From the outset of the conflict, the IAEA has closely monitored and assessed the situation on a daily basis, providing technical assistance and guidance to mitigate risks.

To address the unique challenges posed by the conflict, the IAEA developed the 'Seven Indispensable Pillars' of nuclear safety and security. These are introduced as a framework for assessing and responding to nuclear safety and security risks in armed conflict zones. However, the IAEA recognized the need for more specific measures, given the fragile situation at the ZNPP. Accordingly, the IAEA introduced the "Five Concrete Principles" tailored to the ZNPP in 2023 [17]. These principles reflect the IAEA's ability to adapt its guidance to unique circumstances.

The IAEA's efforts in Ukraine are a showcase of its capacity to operate under conditions far beyond what its founders could have envisioned. The idea of the IAEA working in a war zone was unimaginable either at the

time of its establishment or a few years back. However, the IAEA has risen to the challenge, which reinforced its position as the global platform to address nuclear security threats, even in the most extreme conditions [14].

As seen in Ukraine, armed conflict presents unprecedented risks for nuclear security, which have been long ignored. As a result, this new threat requires the IAEA to operate under far more complex conditions than ever envisioned. The following section will analyze the reasons for these structural and political challenges—along with potential opportunities—that influence the IAEA's capacity to counter these evolving threats.

3. Challenges and Opportunities in Nuclear Security

The IAEA's role in nuclear security has evolved over the decades. Nevertheless, it continues to face structural challenges. The main challenge is the tension between national sovereignty and the need for collective security measures. Many states remain wary of the IAEA's involvement in nuclear security, fearing it could infringe upon their sovereign rights. It is stated in numerous IAEA documents that nuclear security is an inherently national responsibility. However, while it is the sovereign responsibility of a Member State to enforce regulations, create penalties for smugglers, or control nuclear material transfers within its jurisdiction, there is also a legitimate expectation of being assured about the nuclear security behavior of its neighbor ally or enemy [13]. It requires Member States to share their nuclear security practices without revealing classified information so that other Member States can be assured of the nuclear security architecture. Yet, there is an ongoing tension between sovereignty on the one hand and assurances on the other, with the IAEA caught in the middle [13].

Another challenge is the evolution of technology, which presents both opportunities and threats. In terms of opportunities, advanced technologies such as artificial intelligence and blockchain offer new tools for enhancing nuclear security practices. However, the increasing frequency of cyberattacks or drone attacks on nuclear facilities points out the vulnerabilities of modern nuclear infrastructure. This creates a situation where the IAEA must navigate in complex landscape. The IAEA is to assist Member States in adapting to emerging threats while leveraging technological advancements to strengthen nuclear security measures.

Despite these challenges, the IAEA's unique position as a global platform for nuclear cooperation offers significant opportunities. By fostering dialogue and collaboration among Member States, the IAEA can help build a more cohesive international framework for nuclear security. This is also evident in the IAEA's evolution from a limited role in physical protection to a central player in global nuclear security governance.

Balancing national sovereignty with international needs and leveraging technological advances for higher security protocols remain at the core of the IAEA's future action. The conclusion will reflect on how these ongoing challenges influence the IAEA's evolving role and highlight possible paths forward for the global nuclear security framework.

Conclusion

The IAEA's nuclear security approach reflects its ability to adapt to evolving global challenges and its commitment to ensuring the safe and secure use of nuclear materials. From its early focus on physical protection to its current role as a global platform for nuclear security, the IAEA has demonstrated flexibility and resilience. However, significant challenges remain, particularly in balancing national sovereignty with the need for collective security measures and addressing the risks posed by emerging technologies.

The IAEA's efforts to foster international collaboration, provide technical assistance, and promote best practices have been critical in advancing nuclear security. Yet, the IAEA needs to be free from constraints by structural and political limitations to be fully effective in nuclear security. To overcome these obstacles, member states must recognize that strong nuclear security measures are in their collective interest and work toward a more inclusive framework under the IAEA's coordination. It is important to acknowledge that while the IAEA's nuclear security framework is still governed by recommendations and guidance rather than standards or inspections, its work has gained significant political attention in recent years.

Looking ahead, the IAEA's role in nuclear security will likely continue to evolve. The IAEA's ability to adapt to new challenges will be essential in ensuring the safety and security of nuclear materials and facilities worldwide. By building on its existing achievements and fostering greater international cooperation, the IAEA can help create a more robust and effective global nuclear security architecture. Ultimately, the success of these efforts will depend on the willingness of Member States to embrace a shared vision of nuclear security beyond their national boundaries.

Conflict of Interest

The authors have no conflict of interest.

References

[1] IAEA, Objective and Essential Elements of a State's Nuclear Security Regime, IAEA Nuclear Security Series No. 20, International Atomic Energy Agency, Vienna, 2013.

[2] F.P. Joseph, An interview with the Director General, in: F.P. Joseph (Ed.), The International Atomic Energy Agency: Historical Reflections, Current Challenges and Future Prospects, Routledge, Oxford, 2021, pp. 13-24.

[3] F.P. Joseph, Introduction, in: F.P. Joseph (Ed.), The International Atomic Energy Agency: Historical Reflections, Current Challenges and Future Prospects, Routledge, Oxford, 2021, pp. 1-12.

[4] B. Baruch, Statement of United States Policy, presented to the United Nations Atomic Energy Commission (UNAEC) by U.S. Representative, 1946.

[5] A.S. Gill, Nuclear Security Summits: A History, Cham, Switzerland, Cham, Switzerland, 2019.

[6] IAEA, Nuclear Security Recommendations on Physical Protection of Nuclear Material and Nuclear Facilities (INFCIRC/225/Revision 5), IAEA Nuclear Security Series No. 13, International Atomic Energy Agency, 2011.

[7] M.A. Alkış, Nuclear Security and Nuclear Security Culture: An Overview, Journal of Nuclear Sciences 8 (2022) 17-21. https://doi.org/10.1501/nuclear.2023.58

[8] P.d. Klerk, How nuclear security arrived at the IAEA, in: F.P. Joseph (Ed.), The International Atomic Energy Agency: Historical Reflections, Current Challenges and Future Prospects, Routledge, Oxford, 2021, pp. 189-201.

[9] Incidents of Nuclear and Other Radioactive Material Out of Regulatory Control: 2016 Fact Sheet, International Atomic Energy Agency, Incident and Trafficking Database, 2016.

[10] M.A. Alkış, Non-Western approach to nuclear security, Journal of Radiation Research and Applied Sciences 16 (2023) 100535. https://doi.org/10.1016/j.jrras.2023.100535

[11] M.A. Alkış, Armed Conflict and Nuclear Security: Implications for Europe, EU Non-Proliferation and Disarmament Consortium, Stockholm, 2023.

[12] M. Bunn, Twenty years after 9/11, terrorists could still go nuclear, (2021).

[13] L. Holgate, Nuclear security advocacy following the nuclear security summits: The nuclear security contact group, in: F.P. Joseph (Ed.), The International Atomic Energy Agency: Historical Reflections, Current Challenges and Future Prospects, Routledge, Oxford, 2021,pp. 215-226 https://doi.org/10.4324/9781003160205

[14] T. Findlay, The IAEA's Critical Role in Nuclear Security, in: C. Hobbs, S. Tzinieris, S.K. Aghara (Eds.), The Oxford Handbook of Nuclear Security, Oxford University Press2024, pp. 0.

[15] IAEA, The Agency's Budget Update for 2025, The International Atomic Energy Agency, Vienna, 2024.

[16] R.M. Grossi, IAEA Director General's Introductory Statement to the Board of Governors, International Atomic Energy Agency, 2022.

[17] IAEA, Nuclear Safety, Security and Safeguards in Ukraine, The International Atomic Energy Agency, 2025.