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Nuclear weapons and artificial intelligence: a balance between automation and the human factor

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Abstract:

At the core of strategic stability lies a delicate balance between technological automation and human decision-making. The integration of artificial intelligence (AI) in the nuclear sphere brings significant improvements in early warning systems, information analysis, and cybersecurity; however, it also opens the door to new risks. This document contrasts the potential of AI to enhance security with the challenges it poses when incorporated into critical areas of international security. It argues for the need to preserve human oversight, strengthen verification mechanisms, and promote international agreements regulating the use of AI in this context. Only then will it be possible to reap its benefits without compromising global security and stability.

Keywords:

Artificial intelligence, nuclear weapons, cybersecurity, automation, dual-use technology, weapons of mass destruction (WMD).

Introduction

Artificial intelligence (AI) and nuclear weapons are, separately, two of humanity's most remarkable and disturbing advances. One symbolizes the pinnacle of technological innovation; the other, the abyss of destructive potential. But what happens when these two forces converge? The possibility of autonomous systems making decisions in a nuclear context raises ethical and strategic questions, calling into question the fundamental principles of global responsibility and stability.

From a technical perspective, artificial intelligence encompasses a broad spectrum of methods aimed at replicating human capabilities such as reasoning, learning, and decision- making. Among these approaches, machine learning stands out for its use of algorithms capable of identifying complex patterns and establishing meaningful relationships within large volumes of information. In turn, *deep learning* represents an evolution of this technique, employing artificial neural networks that simulate the structure and functioning of the human brain by interconnecting units called artificial neurons.

Technological advances in recent decades have allowed these networks to scale to unprecedented levels, with millions of artificial neurons operating simultaneously in increasingly complex systems. Although these networks are still far from matching the complexity of the human brain, their ability to process data autonomously has driven significant progress in the development of modern AI, consolidating its role as a strategic technology with disruptive potential in multiple sectors, including the military[1].

The integration of AI in the military sphere has gained relevance thanks to its ability to analyze massive amounts of data in real time and improve decision-making effectiveness in demanding and dynamic operational contexts. Its application in the security and defense sector has transformed military strategies through system automation, cybersecurity, and threat recognition: on the one hand, system automation optimizes

[1] Reinhold, T. *et al*. "Artificial Intelligence, Non-Proliferation And Disarmament: A Compendium On The State Of The Art," *EU Non-Proliferation and Disarmament Consortium*, Non-Proliferation and Disarmament Papers No. 92, January 2025.

command and control, reducing human intervention in strategic decisions and favoring the development of autonomous systems capable of assessing threats and executing defensive responses independently. On the other hand, in the field of cybersecurity, AI plays a crucial role in protecting critical military infrastructure by detecting and neutralizing cyberattacks that could compromise the security of highly sensitive networks, such as those controlling nuclear arsenals. Furthermore, with regard to threat recognition, artificial intelligence has been used in surveillance and early warning systems, enabling the identification of behavior patterns that could indicate imminent risks. By analyzing data from satellites, radars, and other intelligence sources, these systems help anticipate the strategic movements of hostile actors, thereby redefining the way states manage their security.

In the specific context of nuclear deterrence, AI has already been integrated into various areas related to security and nuclear arsenal management. Countries such as the United States and Russia have developed AI-powered early warning systems that monitor potential threats and suggest strategic responses in the event of a possible nuclear attack[2]. Likewise, the modernization of nuclear arsenals has incorporated advances in AI to improve the accuracy and responsiveness of missile systems. Among the most relevant applications are the optimization of ballistic missile guidance, the development of advanced defense systems for the detection and interception of threats, and the integration of algorithms into command-and-control systems that allow for the analysis of behavior patterns and the prediction of conflict scenarios[3].

While these innovations may strengthen nuclear deterrence and reduce the likelihood of preemptive strikes, they could also encourage a new arms race based on technological superiority. The possibility of autonomous systems participating in nuclear decision-making raises concerns about the reliability of algorithms, the risk of technical failures, and vulnerability to cyberattacks[4].

[2] Fink, A. “Russian Thinking on the Role of AI in Future Warfare,” *NATO Defense College,* 2021, available at https://www.ndc.nato.int/russian-thinking-on-the-role-of-ai-in-future-warfare/

[3] Wang, W. *et al*. "Integrated Guidance-and-Control Design for Three-Dimensional Interception Based on Deep-Reinforcement Learning," *Aerospace* 10, no. 2: 167. https://doi.org/10.3390/aerospace10020167

[4] Mishra, S y Reiner, P. K. “Artificial Intelligence in Nuclear Command, Control & Communications: A Technical Primer”, *The Institute for Security and Technology*, 2025, disponible en https://securityandtechnology.org/wp-content/uploads/2025/09/Artificial-Intelligence-in-Nuclear-Command-Control-Communications.pdf

This opinion paper provides a structured analysis of the interaction between artificial intelligence and the nuclear sphere, assessing its implications for international security. First, it examines the relationship between the two technologies and the ethical and strategic challenges posed by their convergence. It then addresses both the risks associated with the loss of human control in critical decisions and the potential benefits of AI in preventing nuclear crises. Finally, it considers the urgent need to adapt international regulatory frameworks to ensure responsible and safe use of AI in nuclear contexts.

The relationship between nuclear weapons and AI

Advances in artificial intelligence have been compared to the development of nuclear weapons because of their dual potential: on the one hand, their ability to generate progress in different areas; on the other, their threat to global security. Public figures such as Elon Musk have warned about the dangers of AI, pointing out that it could pose a risk even greater than nuclear weapons. Along the same lines, UN Secretary-General António Guterres has proposed the creation of an international agency similar to the International Atomic Energy Agency (IAEA) to regulate the development and safe use of AI[5].

In general, access to and development of nuclear weapons is restricted by the availability of fissile materials such as uranium and plutonium. AI, on the other hand, depends on more accessible technological inputs, such as advanced chips and graphics processing units (GPUs[6]). This difference poses a significant challenge in terms of regulation, since, while nuclear proliferation has been the subject of international treaties, the development of AI is decentralized and driven by both governments and private actors.

Another distinctive, yet shared, aspect lies in the duality of their applications. Both nuclear weapons and artificial intelligence have dual-use characteristics: they can be used for peaceful or military purposes. In the case of nuclear weapons, their components can

[5] Piliero, R. and Klyman, K. "AI and the A-bomb: What the analogy captures and misses," *Bulletin of Atomic Scientists*, 2024, available at: https://thebulletin.org/2024/09/ai-and-the-a-bomb-what-the-analogy-captures-and-misses/.

[6] Also known as *Graphics Processing Units* or GPUs.

have civilian applications, for example, in power generation or medicine, and are therefore subject to strict control regimes. Artificial intelligence, as a general-purpose technology, poses particular challenges for distinguishing between civilian and military uses. An AI system developed for pharmaceutical research, for example, could also be used in the creation of biological or nerve agents, highlighting its dual-use potential and the complexity this entails for its regulation.

The dual-use aspect of artificial intelligence lies not only in its civil and military applicability, but also in its inherent functional ambiguity. Unlike other clearly defined weapons technologies, such as ballistic missiles or nuclear submarines, AI algorithms can be integrated almost invisibly into a wide range of systems. This functional flexibility means that the same AI architecture can be used for both beneficial and lethal purposes, such as missile guidance, mass surveillance, or even autonomous decision-making in lethal weapons systems.

This dual-use nature raises ethical and legal dilemmas, particularly regarding responsibility for its use. In a hypothetical scenario where an autonomous system, developed for border surveillance, decides to neutralize a perceived threat with lethal consequences, the question arises: who is responsible? The developer, the programmer, the government, or the machine itself? The difficulty of tracing decisions calls into question the fundamental rules of international humanitarian law, and in nuclear contexts, can have catastrophic consequences.

This situation highlights the dual-use nature of artificial intelligence: the same technology capable of improving logistics or defense processes can also be adapted to intervene in critical decisions related to the use of nuclear weapons, significantly increasing the risk of errors with potentially catastrophic consequences. AI applications can range from constructive to destructive purposes, depending on both the context and the strategic interests that guide their implementation. In this context, a relevant debate arises around the capacity of existing regulatory frameworks to adequately address these types of technologies.

For example, the recent European Union Artificial Intelligence Act, passed on March 13, 2024[7], establishes a risk classification system for AI systems, dividing them into four categories: minimal, limited, high, and unacceptable. However, this legislation has raised questions about its applicability to dual-use technologies, i.e., those that can be used for both civilian and military purposes. Although the law explicitly excludes military products, it is not entirely clear whether this exclusion also extends to systems that, despite being developed for civilian purposes, can be adapted to strategic contexts such as the control of nuclear systems. The absence of clear legal criteria in this regard leaves a gap that could weaken regulatory efforts in the face of a technology that, in the wrong hands or under geopolitical pressure, could have destabilizing consequences[8].

	ARTIFICIAL INTELLIGENCE	NUCLEAR WEAPONS
DIFFERENCES	It is general purpose.	They are specific-purpose (mass destruction).
	Recent and partial regulation.	More widespread and consolidated international regulation.
	It is decentralized.	They are centralized and controlled by governments.
SIMILARITIES	Both present catastrophic risks.	
	Both are dual-use technologies.	
	Both are rapidly evolving technologies.	
	Both can have global impact.	

Based on Goudarzi, S. "AI and the A-bomb: What the analogy captures and misses - Bulletin of the Atomic Scientists." *Bulletin Of The Atomic Scientists*, 2024, available at: https://thebulletin.org/2024/09/ai-and-the-a-bomb-what-the-analogy-captures-and-misses/

Given this scenario, a fundamental question arises: can artificial intelligence accelerate the development of nuclear weapons and increase global risks? While some experts

[7]COM 2021/206 final, *Proposal for a Regulation of the European Parliament and of the Council laying down harmonized rules on artificial intelligence (Artificial Intelligence Act) and amending certain Union legislative acts*, April 21, 2021.
[8] Reinhold, T. *et al*. "Artificial Intelligence, Non-Proliferation And Disarmament: A Compendium On The State Of The Art," *op. cit*.

argue that AI can contribute to greater stability by reducing the margin for human error, others warn that reliance on automated systems could increase the likelihood of catastrophic errors and uncontrolled escalation of conflicts.

Different technologies; the same threat?

For decades, nuclear arms control has depended on the human ability to assess risks, interpret signals, and make decisions under pressure. The incorporation of artificial intelligence in this field transforms this paradigm, not only by introducing new technological tools, but also by altering who, or what, participates in decision-making processes. It is no longer just a question of how powerful technology is, but how its operating logic could replace the political and strategic judgment that has historically guided nuclear deterrence since the Cold War[9].

This dilemma has set off alarm bells among international security experts, who believe that the integration of AI into military operations could significantly alter the nature of armed conflicts.

As Horowitz and Scharre[10], automation in nuclear contexts poses a silent threat: the possibility of algorithms acting on their own creates ambiguity about real intentions, thus increasing the risk of unintended escalations. In this sense, AI and nuclear weapons, although different in nature, can converge in a common threat by introducing uncertainty and loss of human control in critical decisions.

[9] On this issue see Chinchilla Adell, M. “La efectividad de la teoría de la disuasión en la proliferación de armas nucleares en Oriente Medio”, *Instituto Español de Estudios Estratégicos, 2*/2018, January 23, 2018, p. 3.

[10] Horowitz, M. and Scharre, P. "AI and International Stability: Risks and Confidence-Building Measures," *Center for a New American Security*, 2021, available at https://www.cnas.org/publications/reports/ai-and-international-stability-risks-and-confidence-building-measures.

Potential risks of AI in nuclear development: loss of the human factor?

The advancement of AI in the military sphere has had a significant impact on the modernization and optimization of nuclear systems. In particular, its integration into strategic planning and the development of nuclear weapons poses challenges in terms of global stability, arms control, and risks associated with miscalculations or automated decisions.

One of the main effects of AI on the arms race is the acceleration of nuclear technology development. Thanks to its ability to optimize processes, analyze large amounts of information, and improve strategic decision-making, AI allows states to improve the accuracy and efficiency of their nuclear systems. However, the use of AI in the nuclear field carries serious risks.

First, the possibility of miscalculation increases when AI systems misinterpret conventional military maneuvers as imminent threats. This unreliability could lead to an unintended escalation of conflicts, especially if an automated system issues false alerts or recommends disproportionate military responses. Second, the integration of AI into nuclear arsenals faces technical and strategic challenges. The vulnerability of these systems to cyberattacks poses an additional threat, as malicious actors could manipulate training data or intervene in real time to alter military decisions. Furthermore, compatibility with legacy military infrastructure and the availability of classified data limit the operational effectiveness of AI in this field.

Despite these obstacles, several powers have made progress in automating their nuclear systems: Russia has developed the Poseidon underwater drone, capable of operating autonomously; North Korea has promoted the integration of AI into nuclear torpedoes and drones; and the United States is in the process of manufacturing the B-21 Raider strategic bomber, designed to operate both manned and autonomously[11].

[11] Chernavskikh, V. "Nuclear Weapons and Artificial Intelligence: Technological Promises and Practical Realities," *Stockholm International Peace Research Institute*, SIPRI Background Paper, September 2024, p. 6.

One of the most controversial debates at the intersection of AI and nuclear weapons is the delegation of strategic decision-making to automated systems. Traditionally, these decisions have been under the exclusive control of political leaders and high-level military advisors. However, the development of autonomous systems capable of assessing threats and suggesting retaliation has raised ethical and strategic concerns. The central question is whether artificial intelligence can improve global stability by reducing the margin for human error or, conversely, whether it increases the risk of accidental nuclear war due to its reliance on data that could be erroneous or manipulated.

This dilemma becomes even more relevant when considering that AI is also being used in cybersecurity to protect critical military infrastructure. However, given that nuclear weapons rely on highly secure networks, the sophistication of cyberattacks could compromise the integrity of these systems, increasing the possibility of catastrophic errors.

Another critical aspect of increasing automation in the nuclear field is the risk of reducing human oversight in strategic decisions[12], which could compromise global stability. As artificial intelligence systems play key roles in threat detection and military decision-making, there is a possibility that humans will place excessive trust in these systems, a phenomenon known as *automation bias*[13]. This trend, observed in sectors such as autonomous driving, could carry over into the nuclear field, where misinterpretation of data could trigger military escalation without proper contextual assessment.

AI models, being trained on historical data, can reproduce and amplify human biases. In the nuclear context, this could translate into an overestimation of threats from certain countries or groups, influencing decision-making in potentially dangerous ways. Previous examples in the private sector, such as Amazon's personnel selection system that

[12] Parke, M. "Prevenir el Armagedón nuclear de la IA," *Project Syndicate*, November 8, 2023, available at: https://www.project-syndicate.org/commentary/dangers-of-artificial-intelligence-ai-applications-nuclear- weapons-by-melissa-parke-2023-11/spanish

[13] Scharre, P. and Depp, M. "Artificial Intelligence and Nuclear Stability," *War on the Rocks*, January 16, 2024, available at: https://warontherocks.com/2024/01/artificial-intelligence-and-nuclear-stability/.

discriminated against female candidates due to biased data[14] demonstrate how AI can generate undesirable results. In the military sphere, an AI-based early warning system could automatically classify certain countries as threats without considering the geopolitical context, thereby increasing the risk of disproportionate responses or unnecessary escalations.

While automation can improve the speed and accuracy of threat detection, autonomous systems lack the ability to interpret situations with a holistic understanding. Decision-making in crisis scenarios requires human judgment, as algorithms operate based on pre- established patterns without considering political, strategic, or psychological factors that only humans can evaluate[15].

Potential benefits: AI as a crisis prevention tool

Despite the risks, AI can also be used as a beneficial tool for prevention of nuclear crisis, as it offers important applications for risk mitigation. Thanks to their speed and accuracy, AI systems can support real-time strategic decision-making processes, especially in contexts where human error or misunderstandings can trigger catastrophic consequences.

One of the most promising capabilities of AI in the nuclear field is its ability to analyze large volumes of data from different sources: satellite images, radiation sensors, surveillance networks, and intelligence databases. Automated analysis makes it possible to detect irregular patterns, suspicious movements, or physical changes in nuclear facilities with greater speed and accuracy than traditional methods. Its ability to process enormous data flows and detect irregular behavior can improve transparency and verification mechanisms related to weapons of mass destruction (WMD), helping to reduce the risks of proliferation and use of such weapons[16].

[14] Dastin, J. "Amazon scraps secret AI recruiting tool that showed bias against women" in *Ethics of Data and Analytics*, Martin K. (ed.), Auerbach Publications, 2022, pp. 296-300.
[15] Chernavskikh, V. "Nuclear Weapons and Artificial Intelligence: Technological Promises and Practical Realities," *op. cit*. pp. 2-3.
[16] Meier, O. “The fast and the deadly: When Artificial Intelligence meets Weapons of Mass Destruction”, *European Leadership Network*, 2024, available at: https://europeanleadershipnetwork.org/commentary/the-fast-and-the-deadly when-artificial-intelligence-meets-weapons-of-mass-destruction/.

For example, AI can be used to perform advanced simulations that model potential nuclear conflict scenarios, evaluating different variables such as military deployments, early warnings, and strategic movements of state and non-state actors. These simulations allow policymakers to design more rational and less impulsive responses in high-tension situations. Similarly, AI optimizes decision-making in critical situations, as illustrated by the case of the United States Strategic Command[17], which is exploring its use to identify the most efficient communication routes for nuclear orders, contributing to a more effective response to threats.

Some international organizations, such as the IAEA, have begun to explore the use of artificial intelligence to process data from remote sensors, thereby improving systems for verifying compliance with non-proliferation treaties[18]. For example, machine learning algorithms can identify changes in the infrastructure of a nuclear plant that could suggest a shift toward non-peaceful purposes. In this way, AI acts as a key ally in increasing transparency and strengthening multilateral verification mechanisms.

AI also plays a crucial role in protecting against cyberattacks[19], helping to strengthen cyber defenses by identifying suspicious activity and responding quickly to potential incidents. AI- based systems such as those that implement techniques like *machine learning* can learn normal network traffic patterns and detect deviations that could indicate an attack. This capability is vital, as many cyberattacks occur covertly and progressively, as demonstrated by the *Stuxnet* attack in 2010[20]. Although not a direct example of AI, cases such as this underscore the need to protect critical systems using advanced detection and response technologies.

[17] Defense Innovation Unit, “DIU’s Thunderforge Project to Integrate Commercial AI-Powered Decision-Making for Operational and Theater-Level Planning,” March 5, 2025, available at: https://www.diu.mil/latest/dius- thunderforge-project-to-integrate-commercial-ai-powered-decision-making.

[18] International Atomic Energy Agency, “Artificial Intelligence For Accelerating Nuclear Applications, Science And Technology,” 2022, pp. 5–8.

[19] Hewes, M. "Cómo la inteligencia artificial cambiará la seguridad informática y la seguridad física de la información en el mundo nuclear," *International Atomic Energy Agency*, IAEA Bulletin, June 2023.

[20] Wajsman, G. "Ciberguerra Entre Israel e Irán: Desde Stuxnet Hasta Los Ciberataques Actuales", IRI Yearbook on International Relations, Universidad Nacional de la Plata, 2022, pp. 1296-1307.

Balance between automation and human prevention

Having analyzed the risks and opportunities of integrating AI into the nuclear field, the question arises: how can we ensure an appropriate balance between automation and human intervention? To achieve this, it is important to ensure that AI systems act as tools to assist, rather than replace, human judgment, especially in high-pressure situations such as those involving nuclear weapons. It therefore seems essential to maintain human presence in the decision-making process, particularly with regard to the launch of nuclear weapons. Critical decisions must be verified and validated by multiple human instances to reduce the possibility of erroneous automatic responses. This measure ensures that any such action is the result of careful human analysis, avoiding hasty or misguided responses.

Another key aspect is the implementation of robust security protocols to protect AI systems against failures and cyberattacks. Protecting nuclear systems against external manipulation is essential to ensure the integrity of decision-making processes and to minimize the impact of potential technical errors. These protocols must include preventive measures that ensure the continuity of human oversight, even in extreme circumstances[21].

The joint work of AI and humans can also be of great help in verifying and assessing threats. By integrating AI systems into the data validation process before making critical decisions, human operators can ensure that the information is correct and accurate, reducing the risk of errors. In addition, AI can be used to simulate possible scenarios, helping decision-makers understand the implications of different courses of action. However, the final decision must always rest with people, who can consider political and diplomatic factors that a machine cannot evaluate.

Therefore, the key to the proper use of artificial intelligence in the nuclear field lies in striking a balance between automation and human oversight. This ensures that critical

[21] Rautenbach, P. "On Integrating Artificial Intelligence With Nuclear Control," *Arms Control Association*, September 2022, available at: https://www.armscontrol.org/act/2022-09/features/integrating-artificial-intelligence-nuclear-control.

decisions are made with a full understanding of the context and implications of those decisions. Integrating AI with human oversight protocols and robust security measures can significantly improve the ability to respond to nuclear threats without compromising global security and stability.

Towards necessary international regulation?

Although the international community has developed legal instruments around the non-proliferation of nuclear weapons, the emergence of new tech like artificial intelligence calls for a deep review of these mechanisms. Indeed, as discussed above, the potential use of AI in strategic decision-making and in the autonomous operation of nuclear systems increases the complexity of the global scenario, as it introduces risk variables that are difficult to predict, verify, and control. Thus, there is a need to reflect on how to adapt current regulatory frameworks to prevent this technology from eroding international stability.

In this sense, Lamberth and Scharre emphasize that the main obstacles to regulating AI revolve around its dual nature (civil and military), its rapid evolution, and the difficulty of verification between systems with and without AI[22]. This approach reinforces the urgency of establishing specific international standards and designing new legal tools that ensure human oversight and compliance with common ethical and strategic standards based on cooperation between states.

Current legal framework relevant to nuclear non-proliferation

The international legal framework governing nuclear weapons is essential to ensuring global stability and security. Key institutions such as the United Nations (UN), the IAEA, and various international agreements play a fundamental role in promoting nuclear non-proliferation and disarmament, contributing to the maintenance of a secure and stable international order.

[22] Lamberth, M. and Scharre, P. "Arms Control for Artificial Intelligence," *Texas National Security Review*, Vol. 6, Issue 2, spring 2023, pp. 95-110.

The UN has been a central player in formulating policies and adopting resolutions aimed at preventing the proliferation of WMD. In this context, Security Council Resolution 1540 (2004) requires Member States to implement strict measures to prevent non-state actors from acquiring nuclear, chemical, or biological weapons[23]. This resolution reinforces control over sensitive materials and delivery systems, a crucial step in ensuring that nuclear materials do not fall into the wrong hands. In addition, Security Council Resolution 1887 (2009), among others, reaffirms the commitment of States Parties to the Treaty on the Non- Proliferation of Nuclear Weapons (NPT), promoting a world without nuclear weapons and underscoring the importance of international stability and security for the international community.

The IAEA, established in 1957 as an autonomous agency within the UN system, plays a vital role in promoting the peaceful use of nuclear energy. Its primary mission includes preventing the use of nuclear energy for military purposes. To this end, the IAEA implements safeguards that verify that nuclear materials are not diverted to the development of nuclear weapons. In addition, it conducts regular inspections of nuclear facilities and provides technical assistance to Member States to ensure safety and security in the use of nuclear energy, contributing significantly to the strengthening of the non- proliferation regime.

Apart from the NPT, there are several international agreements that complement global efforts to prevent nuclear proliferation. For example, the Treaty of Rarotonga (1985) establishes a Nuclear-Weapon-Free Zone in the South Pacific, prohibiting the possession, use, and testing of nuclear weapons in the region[24]. Similarly, the Bangkok Treaty (1995) creates a Nuclear-Weapon-Free Zone in Southeast Asia, contributing to regional peace and stability. In Africa, the Pelindaba Treaty (1996) establishes a Nuclear-Weapon-Free Zone, prohibiting the research, development, manufacture, and possession of nuclear weapons on the continent. Similarly, the Treaty on a Nuclear-Weapon-Free Zone in Central Asia (2006) creates a Nuclear-Weapon-Free Zone in

[23] United Nations Security Council Resolution 1540 (2004).
[24] Papadimitropoulos, T. “El Tratado de Rarotonga: enfoque regional de la no proliferación en el Pacífico Sur”, *International Atomic Energy Agency*, IAEA Bulletin 1/1988, 1988, pp. 29-31.

Central Asia, promoting regional cooperation in the peaceful use of nuclear energy and strengthening the non-proliferation regime.

While the primary objective of the NPT is to prevent the horizontal proliferation of nuclear weapons, there are other arms limitation treaties, such as the New START Treaty[25], which establishes verifiable limits on the number of deployed nuclear warheads and strategic delivery systems in the United States and Russia, in addition to promoting transparency and mutual confidence-building measures between the two countries. This bilateral treaty, however, was stalled in February 2023, when Vladimir Putin announced Russia's suspension of participation[26].

It is also worth noting the Comprehensive Nuclear-Test-Ban Treaty (CTBT), adopted in 1996, which prohibits all nuclear tests, both military and civilian, with the aim of halting the qualitative development of nuclear weapons and strengthening the commitment to disarmament. Although it has been signed by a large number of states, it has not yet entered into force, as it requires ratification by certain key states in order to achieve its disarmament objectives. Despite the fact that its final implementation is on hold, the CTBT represents a fundamental pillar of the international nuclear non-proliferation regime and requires continuous efforts on the part of the international community.

In this context, it is also worth mentioning the Treaty on the Prohibition of Nuclear Weapons (TPAN), adopted in 2017 and in force since January 2021. This treaty seeks the total elimination of nuclear weapons, prohibiting their development, possession, use, and threat of use, as well as the transfer or support of these activities[27]. As of September 2024, 73 states, mainly from the Global South, have ratified it. Although no nuclear-weapon-state or member of nuclear alliances such as NATO has signed the treaty, this instrument has gained increasing normative and political value, exerting diplomatic pressure and stigmatizing the use and possession of such weapons.

[25] United States Department of State, “New START Treaty", available at: https://www.state.gov/new-start-treaty
[26] Bugos, S. (2023) Russia Suspends New START, *Arms Control Today*, https://www.armscontrol.org/act/2023-03/news/russia-suspends-new-start.
[27] UNODA – United Nations Office for Disarmament Affairs, “Treaty on the Prohibition of Nuclear Weapons”, https://disarmament.unoda.org/wmd/nuclear/tpnw/

The progressive regulatory adaptation to the challenges of AI

Despite international efforts to prevent nuclear proliferation, significant challenges remain. Recently, Russia has expressed its strong opposition to the possibility of Germany developing a nuclear arsenal[28]. It should also be remembered that in 2023, Vladimir Putin revoked his ratification of the CTBT, withdrawing his formal commitment not to conduct nuclear tests, which raised international concerns about a possible resumption of atomic testing and the weakening of the global non-proliferation regime[29]. In addition, French President Emmanuel Macron suggested strengthening the sovereignty and independence of French military defense, offering France's nuclear deterrent capability as an "umbrella" for the European Union. This proposal, which seeks to guarantee security against external threats, has sparked debate about the implications it would have for the nuclear non- proliferation regime[30]. Added to this complex international context in the nuclear field is the threat posed by technological development, and specifically, the implication of AI for nuclear proliferation.

It is worth highlighting some interesting initiatives to address this situation of uncertainty, such as the recent statement issued by the US government on the responsible use of AI in the military sphere[31]. This statement reflects the US's attempt to establish a set of ethical principles to guide the development and use of emerging technologies in war contexts, thereby seeking to minimize the associated risks and promote a framework of international responsibility.

Considering this international context, the Spanish Ministry of Defense has carried out strategic initiatives aimed at the ethical and safe use of artificial intelligence in the military sphere. Among the most notable is the *Strategy for the Development, Implementation, and Use of AI,* aligned with NATO and European Union principles, which contemplates

[28] EFE. "Rusia advierte que nadie permitirá a Alemania hacerse con un arsenal nuclear", SWI Swiss Info, March 7, 2025, available at: https://www.swissinfo.ch/spa/rusia-advierte-que-nadie-permitirá-a-alemania-hacerse-con-un-arsenal-nuclear/88976883?utm_source.

[29] MacFarquhar, N. "Russia pulled out of a nuclear Test Ban Treaty. Here's what that means," *The New York Times*, 2 November, 2023, available at: https://www.nytimes.com/2023/11/02/world/europe/russia-nuclear-test-ban-treaty.html.

[30] Schofield, H. "France has a nuclear umbrella. Could its European allies fit under it?", *BBC*, March 6, 2025, available at: https://www.bbc.com/news/articles/c871e41751yo.

[31] US Department of State, *Policy Statement on Responsible Use of Artificial Intelligence and Autonomy in the military*, available at: https://www.state.gov/declaracion-politica-sobre-uso-responsable-de-inteligencia-artificial-y-autonomia-en-el-ambito-militar.

applications in fields such as mobility, cyber defense, the autonomy of unmanned systems, and electronic warfare[32]. Spain also has the Spanish Agency for the Supervision of Artificial Intelligence (AESIA) and has actively participated in multilateral forums on the responsible use of artificial intelligence in defense, such as the REAIM 2024 Summit, where it endorsed the need to establish common standards for the use of AI in military operations[33]. This institutional involvement reinforces Spain's commitment to the responsible development of emerging technologies and the need to always ensure human oversight in strategic decision-making processes.

Given the complex challenges that AI poses for international security, it is imperative that the international community address these issues through specific regulations that limit the use of AI, promoting strategic stability and global security. Although there are already some international standards in this regard, such as the European Artificial Intelligence Regulation, and some initiatives for its responsible use, these do not specifically address the implications of its integration into nuclear systems. Therefore, there is a need to create an international agreement that addresses key aspects such as the explicit prohibition of the use of autonomous AI in nuclear decisions, the establishment of human oversight requirements at all stages of the process, and the implementation of enforcement mechanisms, accompanied by sanctions in case of infringement. These measures would not only reduce the risk of catastrophic errors, but also promote the responsible and ethical use of AI in a field as sensitive as nuclear energy.

The need for international cooperation

With the goal of preventing nuclear proliferation, both vertical and horizontal, driven by technological development and AI applications, it seems essential to resort to international cooperation based on the modernization of global institutions and the strengthening of the existing regulatory framework. In this regard, it is essential that relevant international organizations such as the UN and the IAEA take an active role in

[32] Ministry of Defense, *Official Bulletin of the Ministry of Defense (BOD)*, No. 131, Sec. V, July 6, 2023, p. 19131.
[33] EFE, "Secretaria de Estado destaca necesidad de normas comunes en cumbre sobre uso militar de IA", *Diario ABC*, 9 September, 2024, available at: https://www.abc.es/ciencia/secretaria-estado-destaca-necesidad-normas-comunes-cumbre-20240909120313-vi.html.

supervising and regulating emerging technologies such as AI, considering their applications in the nuclear field. This would include strengthening their capacities to address new technological threats but also promoting mechanisms that foster transparency and nuclear disarmament, which are essential elements in preventing a new arms race.

One aspect under debate is the need to strengthen the international nuclear arms control regime, particularly the NPT, and adapt it to technological advances[34]. In this context, it would be necessary to establish rules or, at least, guidelines for action, which limit the automation of nuclear decisions, ensuring that there is always effective human control in the decision-making process. On the other hand, although the Treaty on the Prohibition of Nuclear Weapons has not yet been adopted by any nuclear-weapon State, its progressive universalization could help strengthen the international commitment to disarmament and provide a useful framework for addressing the new challenges posed by emerging technologies such as artificial intelligence. However, for such a treaty to have an effective impact in this area, it would be necessary to promote its wider acceptance and update its provisions in light of these technological developments.

International cooperation must also focus on developing new multilateral agreements that address emerging technologies. These agreements could establish specific clauses on transparency in the development and implementation of AI-based nuclear technologies, limiting their expansion. Diplomatic relations between nuclear actors must be fundamental to this process, especially in politically unstable regions. But in addition, collaboration between international bodies and organizations, such as the UN, the UN Security Council, and the IAEA, will be essential to creating agreements that limit access to these technologies and foster mutual trust between countries.

[34] Cronberg, T. “For Survival, the NPT Has to Be Renegotiated,” *European Leadership Network*, May 14, 2021, available at: https://europeanleadershipnetwork.org/commentary/for-survival-the-npt-has-to-be-renegotiated/.

Conclusions

Throughout this analysis, we have considered the dual role of AI as both a threat in the nuclear sphere and an opportunity to improve strategic security. Although there are significant limitations in terms of the transparency and reliability of AI technologies developed by nuclear-weapon states, their integration into the military spectrum, especially in areas such as intelligence, surveillance, and reconnaissance (ISR)[35], as well as missile defense and anti-submarine warfare, is an increasingly present reality.

AI offers a number of opportunities, such as the ability to process large volumes of data in real time and detect complex patterns; it enables, for example, the implementation of advanced detection and early warning systems that could identify threats before they materialize. In the field of cybersecurity, AI has the potential to anticipate and mitigate attacks on critical nuclear infrastructure, such as power plants. In addition, by optimizing the management of strategic resources, AI could improve the efficiency of nuclear operations, reducing the likelihood of human error in decision-making and strengthening defenses against external threats.

However, the implementation of AI in nuclear systems also poses significant risks that must be carefully managed. Excessive automation of these systems could increase the risk of catastrophic errors, as flawed or poorly designed algorithms could misinterpret a threat, triggering disproportionate responses. The lack of human oversight in critical decisions could also facilitate the escalation of conflicts, increasing the likelihood of impulsive military responses. In addition, the vulnerability of AI systems to cyberattacks poses another risk, as they could be manipulated to cause nuclear security failures and jeopardize global stability.

It is therefore imperative to reap the benefits of AI without compromising human control in critical decisions. A balanced approach requires the careful integration of AI systems in particularly sensitive sectors, such as nuclear weapons and technology. This does not mean dismissing the potential of AI, but rather leveraging it within established regulatory

[35] Initials in English: Intelligence, Surveillance, and Reconnaissance.

frameworks, ensuring that ultimate responsibility always rests with humans. This includes developing robust regulatory frameworks that set limits on the autonomous use of AI. Collaboration between states, international organizations, and experts in technology, ethics, and public policy is essential to designing systems that combine algorithmic power with human prudence.

There is no doubt that AI is redefining the dynamics of military and strategic power. Although the magnitude and sophistication of weaponry, particularly nuclear weaponry, remains a vitally important strategic element, the ability of states to effectively integrate AI is also gaining importance, increasing precision and speed of response, but also generating uncertainty regarding deterrence capabilities.

In short, although AI presents a valuable opportunity to improve strategic security in the nuclear sphere, its integration into such sensitive systems must be treated with caution. Its potential benefits must be balanced against the risks inherent in its development and use, while also considering the possibility that these technological capabilities could be employed by non-state actors. It is therefore essential to establish rigorous regulation, constant human oversight, and advanced protective measures to prevent it from becoming a threat to global security.

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