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Nuclear Weapons and the Growing Need for AI Detection Tools: Crucial Components of Nuclear Deterrence in the Future

Syeda Nawshin Nishat[1]

INTRODUCTION

Nuclear arsenals remain central to both national defence and global security, acting as a foundation for regional stability and international diplomacy. With the rapid advancement of technology, especially artificial intelligence (AI), traditional nuclear deterrence strategies are undergoing major transformations. AI offers powerful tools for enhancing deterrence through advanced surveillance, real-time monitoring, and predictive modelling. As nuclear weapons and their delivery systems grow more sophisticated, conventional tracking methods often fall short in detecting fast, hidden, or unexpected threats. AI-driven algorithms help fill this gap by analyzing vast amounts of data, identifying suspicious patterns, and enabling quicker, more accurate decision making.

Source: *Strategic council on Foreign Relations*

These capabilities enhance government's ability to detect nuclear developments, enforce regulations, and uncover illicit activities. However, the integration of AI into nuclear systems

[1] Syeda Nawshin Nishat has completed her BSS in International Relations from Gopalganj Science and Technology University (GSTU)

raises serious ethical, legal and strategic concerns. Questions around Machine-led choices, liability, and the risk for miscalculation remain unresolved. This commentary explores the escalating presence of AI in missile detection and nuclear deterrence, weighting its benefits against its risks. It also highlights the need for international cooperation and strict oversight to ensure AI is applied responsibly, lawfully, and in ways that promote global security rather than undermine it.

AI DETECTION TOOLS: TRANSFORMING NUCLEAR DETERRENCE CAPABILITIES

Containing artificial intelligence (AI) in nuclear deterrent procedures has profoundly converted the surveillance and reaction to nuclear Peril. Traditional techniques, such as satellite surveillance, signals intelligence (SIGINT), and human intelligence (HUMINT), have been consequential. Although AI has tranquillized defects and proclivities in nuclear decision-making, it synchronously raises consternation. If AI's shortcomings are not amended, they may result in ruinous ramifications, undoubtedly authorizing nuclear operations to emerge concealed and without apprising.[2] As nuclear deterrents become more digital, operations and strategic stability must grasp how AI-driven parts work together. Artificial intelligence is now utilized to enhance critical decisions, identify real-time hazards, and defend processes. Relying on U.S. Air Force Nuclear Weapons Center excellence, the following notion portrays how NC3 provisions are connected in an intricate network. This vision illustrates how AI technologies are contained at all levels of the structures, from compliance and data collection to threat detection and choice-making.

[2] Wilner, Alex, and Casey Babb. "New technologies and deterrence: Artificial intelligence and adversarial behaviour." *NL ARMS Netherlands Annual Review of Military Studies 2020: Deterrence in the 21st Century—Insights from Theory and Practice* (2021): 401-417.https://library.oapen.org/bitstream/handle/20.500.12657/43303/2021_Book_NLARMSNetherlandsAnnualReviewO.pdf?sequence=1#page=412

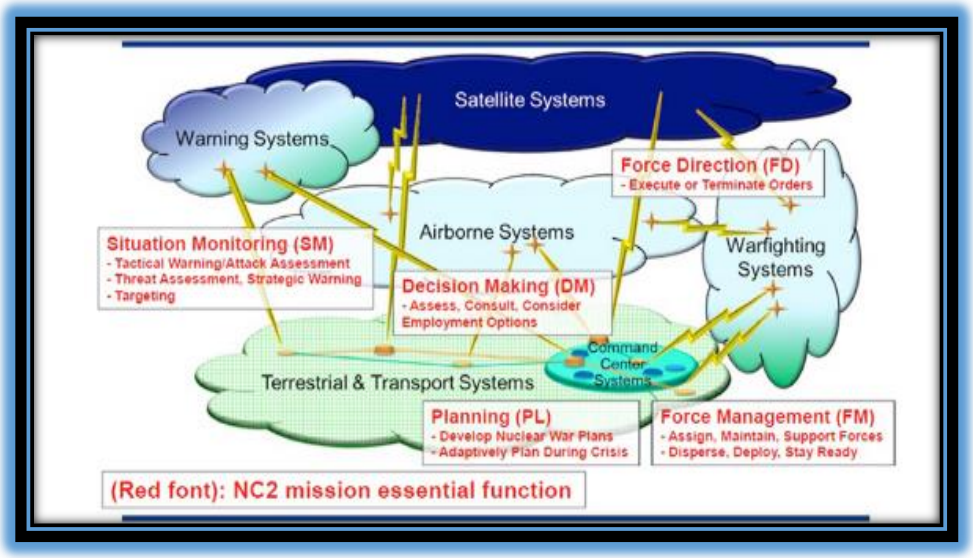

Figure: U.S. Air Force Nuclear Weapons Centre estimates NC3 component interactions.

Source: *Arms Control Association*

The Role of AI in Real-Time Monitoring and Detection

Artificial intelligence facilitates missile interception by concurrently processing extensive intelligence sets. Conventional approaches are confronted by the vast quantity of documentation pertaining to nuclear threats, encompassing data collected by sensors, aerial imagery, recorded communications, and environmental information. Large databases are promptly analyzed by AI, and abnormalities or patterns suggesting hidden nuclear facilities or attack strategies are identified.

Enhancing Early-Warning Systems

Artificial intelligence enhances early-warning systems, which are essential for nuclear deterrents. By identifying feasible nuclear strategies or covenants, these advancements enable nations to act preemptively before a mishap occurs. These algorithms have historically depended on passive synthesis or human-operated servers, which may be expendable on erroneous disruptions and misinterpretations.

AI in Satellite and Remote Sensing Technologies

In nuclear surveillance, spacecraft and remote sensing photography have been crucial for monitoring weapon assessment, verifying agreements, and detecting signs of nuclear proliferation. These innovations have become significantly more advantageous through AI, enabling the analysis

of outstanding imagery from space and detecting subtle alterations in equipment that may indicate nuclear-related activity. For instance, a single observatory can capture images of North Korea in twelve 150-kilometer by 150-kilometer swaths during a single sortie, encompassing all routes and vital areas repeatedly before traversing the expanse of space.[3] A circumstance contemplation by the University of Missouri Centre for terrain data analysis exemplifies the potential of a machine learning model administered by analysts to determine surface-launched missile inductions across 90,000 square kilometers in southeastern China. The AI conducted the undertaking in 42 minutes, 80 times better expeditiously than human-conducted graphical searches. The program acquired a detection of precision 90%, identical to that of adept human critics. This analysis signifies that AI can recast geospatial intelligence procedures by enhancing efficiency and scalability while conserving analytical accuracy. AI detection tools help militaries spot hidden threats more easily, even in Blue or gray zone. Companies like BlackSky and ICEYE use satellite data to track nuclear sites and strengthening Nuclear Deterrence. [4] These credentials enhance computerized monitoring, but they also grow apprehension about over-reliance on AI methods in important decision-making cases, underlining the condition for human delinquency in AI-integrated nuclear frameworks, highlighting the demand for human supervision in AI-integrated nuclear frameworks.

Incorporating Human Oversight into Artificial Intelligence

Woods et al. (2024) support integrating AI dominion methods with human determination consent to alleviate the hazards analogous to autonomous decision-making. Their procedure emphasizes human-in-the-loop configuration, wherein AI sustains human assessment. This technique engages AI while retaining human principles and accountability.[5] Nevertheless, human surveillance alone cannot address AI's strategic and lawful provocations. Determining these issues necessitates a

[3] Lieber, Keir A., and Daryl G. Press. "The new era of counterforce: Technological change and the future of nuclear deterrence." *International Security* 41, no. 4 (2017): 9-49.https://direct.mit.edu/isec/article/41/4/9/12158/The-New-Era-of-Counterforce-Technological-Change

[4] Sandra Erwin, " With Commercial Satellite Imagery, Computer learns to Quickly Find Missile Sites in China," *SpaceNews*, October 27, 2017,https://spacenews.com/with-commercial-satellite-imagery-computer-learns-to-quickly-find-missile-sites-in-china/

[5] Woods, Walt, Alexander Grushin, Simon Khan, and Alvaro Velasquez. "Combining AI control systems and human decision support via robustness and criticality." In *Disruptive Technologies in Information Sciences VIII*, vol. 13058, pp. 172-190. SPIE, 2024.https://www.spiedigitallibrary.org/conference-proceedings-of-spie/13058/130580J/Combining-AI-control-systems-and-human-decision-support-via-robustness/10.1117/12.3016311.short

cohesive global strategy, prioritizing international collaboration in regulating AI within nuclear deterrence.

THE ROLE OF INTERNATIONAL COOPERATION

AI-enabled nuclear supervision and control systems is accompanied by ethical dilemmas concerning accountability. Delegating detection and selection to AI obscures accountability for shortcomings, hence heightening global threat perceptions. As artificial intelligence progresses, the likelihood of nuclear warfare may diminish, prompting greater severity or extensive assaults. Examining and supervising AI systems necessitate conjunction among governments, international organizations, and transnational initiatives to mitigate dangers and assure equilibrium.

The Need for Global Frameworks and Standards

Communities worldwide must establish uniform frameworks, specifications, and legislation to regulate the improvement and vigilance of AI in nuclear deterrence. The infrastructure for developing a multinational device to distort AI underneath the confines of nuclear weapons may also be provided by international conventions such as the Comprehensive Nuclear-Test-Ban Treaty (CTBT) and the Non-Proliferation Treaty (NPT). [6]

Promoting Transparency and Bridge -Building Measures

International cooperation is crucial for enhancing comprehension and methodologies that bolster trust in applying AI-driven instruments for nuclear deterrents. Considerations regarding the dependability of AI-driven systems are raised by the possibility of misunderstandings and mistakes. AI-driven collaboration in Arms Control and Non-Proliferation aligns with the fundamental principle of equilibrium, with conversations aimed at reconciling objectives and fostering harmony. This **figure** shows how to regulate this method. [7]

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[6] Gibbons, Rebecca Davis, and Stephen Herzog. "Durable institution under fire? The NPT confronts emerging multipolarity." *Contemporary Security Policy* 43, no. 1 (2022): 50-79. https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=Gibbons%2C+Rebecca+Davis%2C+and+Stephen+Herzog.+%22Durable+institution+under+fire%3F+The+NPT+confronts+emerging+multipolarity.%22+Contemporary+Security+Policy+43%2C+no.+1+%282022%29%3A+50-79.&btnG=

[7] Kim, Hyunsoo. "Suggestions for the Role of AI in the Arms Control and Non-Proliferation of WMD." *Robotics & AI Ethics* 7, no. 2 (2022) https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=suggestions+for+the+role+of+AI+in+the+arms+control+and+non+proliferation+of+WMD&btnG=

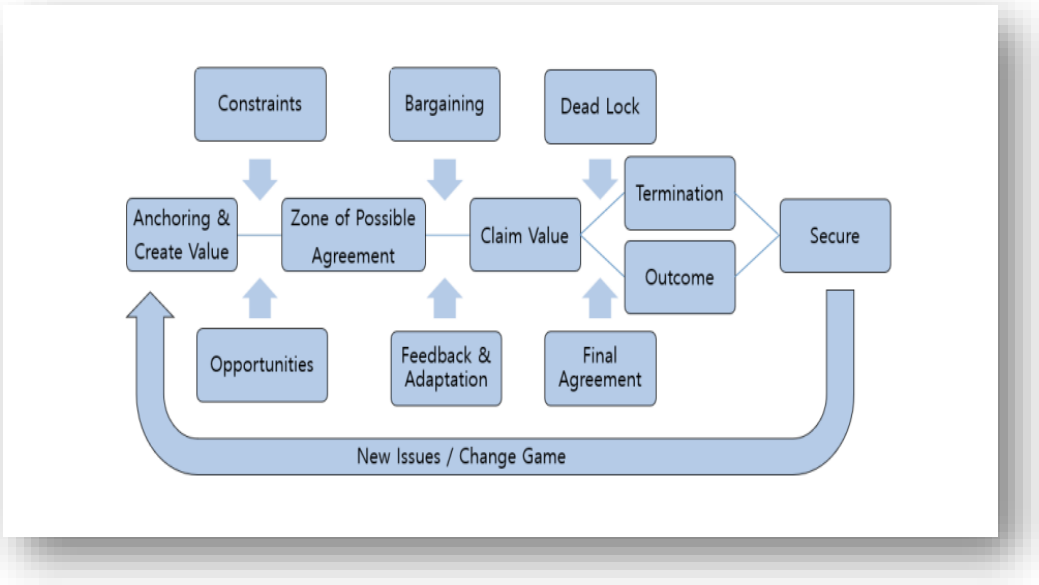

Figure: AI simulating multi-issue negotiating discussions of cooperative Military armament control and non-proliferation structure.

Source: *J-Institute*

International Collaboration on AI Research and Development

An organizational preference for competence significantly impacts collaboration by individual researchers. The ability to shape standards with potential de facto or de jure worldwide impact is given to advisors in prerequisite bodies, unlike other world leadership frameworks like the UN Groups of Legislative Professionals, which merely provide advisory contributions. National and international standards bodies possess greater breadth and validity than small self-regulatory initiatives. Collaboration among nations is essential for constructing algorithms that enhance nuclear detection and surveillance tactics rather than depending on unstable, inconsistent, or error-prone frameworks. The oversight of AI technologies pertinent to nuclear deterrents is conducted by principal entities such as the International Atomic Energy Agency (IAEA) and the United Nations (UN). These organizations must be modified to align with the changing technical environment to ensure AI's legitimate, feasible application in the nuclear domain.[8]

[8] Cihon, Peter. "Standards for AI governance: international standards to enable global coordination in AI research & development." *Future of Humanity Institute. University of Oxford* 40, no. 3 (2019): 340-342.https://www.fhi.ox.ac.uk/wp-content/uploads/Standards_-FHI-Technical-Report.pdf

Table: Current AI Detection Tools and Capabilities in Nuclear Deterrence (Hypothetical Data)

AI Tool	Function	Application in Nuclear Deterrence	Current Implementations
Convolutional Neural Networks (CNNs)	Image Recognition	Detects nuclear infrastructure changes	Satellite-based [9]reconnaissance systems
Anomaly Detection Algorithms	Data Pattern Analysis	Identifies unusual nuclear activities	Treaty compliance [10]verification programs
Predictive Modeling	Threat Prediction	Projects potential nuclear escalations	[11]Geopolitical risk assessment platforms
Natural Language Processing (NLP)	Text and Signal Analysis	Analyzes communications for nuclear threats	[12]Strategic communications monitoring
Autonomous Drones	Surveillance and Reconnaissance	Provides real-time monitoring	[13]Border and critical site surveillance

[9] Heng, Leo. "Strategic Overview of Applying Artificial Intelligence on the Future Battlefield." (2024).https://jyx.jyu.fi/jyx/Record/jyx_123456789_95024

[10] Chaudhary, Abhishek, Junseo Han, Seongah Kim, Aram Kim, and Sunoh Choi. "Anomaly Detection and Analysis in Nuclear Power Plants." *Electronics* 13, no. 22 (2024): 4428.https://www.mdpi.com/2079-9292/13/22/4428

[11] Horowitz, Michael C., and Paul Scharre. "AI and international stability." *Center for a New American Security. https://s3. us-east-1. amazonaws. com/files. cnas. org/documents/AI-and-International-Stability-Risks-and-Confidence-Building-Measures. pdf* (2021)**.**https://s3.us-east-1.amazonaws.com/files.cnas.org/documents/AI-and-International-Stability-Risks-and-Confidence-Building-Measures.pdf

[12] Allen, Greg, and Taniel Chan. *Artificial intelligence and national security*. Vol. 132. Cambridge, MA: Belfer Center for Science and International Affairs, 2017.https://csdsafrica.org/wp-content/uploads/2020/06/AI-NatSec-final.pdf

[13] Mohammed, Rahimoddin, and Prasanna Pasam. "Autonomous Drones for Advanced Surveillance and Security Applications in the USA." *NEXG AI Review of America* 1, no. 1 (2020): 32-53.https://www.researchgate.net/profile/Rahimoddin-Mohammed/publication/383603733_Autonomous_Drones_for_Advanced_Surveillance_and_security_Applications_in_the_USA/links/66d339f5fa5e11512c43210c/Autonomous-Drones-for-Advanced-Surveillance-and-Security-Applications-in-the-USA.pdf

FUTURE DIRECTIONS IN AI-ENHANCED NUCLEAR DETERRENCE

AI applications are being developed and incorporated into military renovation projects by the US, China, Russia as well as other countries. Chinese AI formed a rebellious research algorithm that can distinguish weapons of mass destruction from counterfeits. This is the foremost AI-driven weapons ordinance confirmation mechanism, which might stimulate China's role in the arsenal demilitarization talks. The technology regulates clandestine data, geopolitical issues, and skepticism about traditional verification mechanisms. Authorized "Verification Technical Scheme for Deep Learning Algorithm Based on Interactive Zero Knowledge Protocol," the AI method operates a stratified process merging steganography and nuclear physics. Researchers used Monte Carlo replications to acquire a deep learning network on neutron flux practices to induce Large-scale synthetic nuclear parameters—some comprising enriched uranium and plutonium stockpiles camouflaged with lead or low-mass coverings.[14] Additionally**,** China's geostationary Tongxin Jishu Shiyan (TJS) satellites aid missile alerts and intelligence communications. The Huoyan-1 series satellites are China's first geostationary missile detection system, improving missile detection and response.[15] Operations in the United States have been commenced by Northrop Grumman. Integrated into Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) systems, these programs include autonomy, neural networks, and machine learning. With its specially designed nose, the B-21 Raider can fly past sophisticated defenses and land pinpoint strikes anywhere in the world. The B-21 is considered the inaugural sixth-generation aircraft to achieve flight, symbolizing the future of deterrence. Although designed for complimentary flying, it is presently managed by human pilots, with AI serving as an intermediary system.[16] "AI will reinforce decision-making in command and control methods but will not supersede human delinquency in nuclear procedures."—Gen. Anthony J. Cotton (2024–2025) said in the Department of Defense in the USA. The USA usually doesn't

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[14] ET Online, "AI vs Nukes: How China's New Tech Could Shake Up Global Arms Control," *The Economic Times*, May 30, 2025,https://economictimes.indiatimes.com/news/defence/ai-vs-nukes-how-chinas-new-tech-could-shake-up-global-arms-control/articleshow/121506557.cms?from=mdr

[15] Chen, David. "China's Space Capability and What This Means for the West." https://www.airuniversity.af.edu/Portals/10/CASI/documents/Research/Space/2024-06-03-2%20Chinas%20Space%20Capability%20and%20what%20it%20means%20for%20the%20West.pdf

[16] Northrop Grumman, "B-21 Raider," *Northman Grumman***.** https://www.northropgrumman.com/what-we-do/air/b-21-raider

divulge what identical tools it could use to construct deterrence as it doesn't want to relinquish its autonomy in the world. The U.S. strives to amplify deterrence by operating AI detection devices, making opponents' probes incapable of functioning in secrecy. This visibility can correspondingly alter how wars are prepared and may generate attacks from some adversaries. Eventually, the method pursues to negate divulging hazards without escalating battles. [17] Furthermore, In March 2025, North Korean leader Kim Jong Un experimented with AI-equipped "suicide attack drones," underlining the implication of unmanned systems and AI in warfare. AI-powered drones determine and select terrestrial targets without manual oversight. This development shows North Korea can undertake optimized autonomous operations in the future, deterring enemies. [18] On the other hand, Russia is using the legacy "Perimeter" system, also called "Dead Hand", which is being updated with AI for enhanced deterrence by 2030, enabling a retaliatory strike even if human leadership is incapacitated, with AI assessing battlefield data, communication status, and sensor inputs to decide on nuclear retaliation autonomously.[19]

So, major powers like the U.S, China and Russia are increasingly relying on AI detection tools to boost their nuclear deterrence. Following their lead, countries like India, Pakistan and France are also beginning to adopt similar technologies.

CONCLUSION

Recent advances in Artificial intelligence are reshaping nuclear deterrence, offering both major benefits and serious challenges. AI-driven tools are improving how nuclear threats are detected and managed – using satellite imagery, internet activity, and news sources to spot early warning signs and subtle anomalies. These technologies also support arms control by enabling real-time monitoring, reducing deception, and increasing transparency. However, giving algorithms too much control over critical decisions raises ethical and strategic risks. As AI becomes more

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[17] Gen. Anthony J. Cotton, "*2024 Department of Defense Intelligence Information System Worldwide Conference keynote address," U.S. Strategic command*, October 28, 2024,https://www.stratcom.mil/Media/Speeches/Article/3965392/2024-department-of-defense-intelligence-information-system-worldwide-conference/

[18] AI Jazeera, "North Korea's Kim Jong Un Oversees Tests of New AI-Equipped Suicide Drones," *Al Jazeera*, March 27, 2025, https://www.aljazeera.com/news/2025/3/27/north-koreas-kim-jong-un-oversees-tests-of-new-ai-equipped-suicide-drones

[19] Mad Scientist Laboratory, *"Russia and the convergence of AI, Battlefield Autonomy, and Tactical Nuclear Weapons,"* U.S. Army TRADOC, August 10, 2023, https://madsciblog.tradoc.army.mil/532-russia-and-the-convergence-of-ai-battlefield-autonomy-and-tactical-nuclear-weapons/

embedded in nuclear systems, its impact on global security will depend on responsible use, strong oversight, and international cooperation. With careful implementation, AI could help reduce nuclear risks and strengthen global stability.