POLICY BRIEF

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Integration of Artificial Intelligence in Nuclear Systems and Escalation Risks

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MAY 2025

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INTEGRATION OF ARTIFICIAL INTELLIGENCE IN NUCLEAR SYSTEMS AND ESCALATION RISKS

INTRODUCTION

The contemporary global nuclear landscape is dotted with several nuclear risks.[1] Geopolitical conflagrations, coupled with nuclear modernisation efforts by major nuclear-armed states and the strategies of brinkmanship, are increasing the risks of miscalculation and unintended escalation. Emerging technologies such as cyber weapons, artificial intelligence (AI) and autonomous systems exacerbate those risks. The great power competition, which the United States (US) officials describe as one characterised by "near-peer competitors,"[2] has acted as a structural catalyst fuelling security dilemmas for the US, Russia and China to pursue advanced technology in warfare and gain competitive advantage. However, in this quest, the element of 'ever-accelerating automation in warfare' has become the only constant, whose implications transcend great power competition.

Technological advancements have improved precision, lethality, range autonomy, and effect, which in turn have upgraded nuclear and non-nuclear capabilities.[3] Alongside the nuclear modernisation and doctrine-related developments, there is enough evidence to highlight the integration of conventional and nuclear capabilities leading to the emergence of dual-capable and dual-role weapon systems.[4] Besides, as part of modernisation efforts, several states are considering the potential integration of AI in their nuclear command, control, and communications (NC3), including early warning systems to enhance operational efficiency. This integration, however, is not without risks, as it increases the prospects of faulty judgment and false warnings of attack among other miscalculations.[5]

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[1] Andrew J. Futter, Erika Castelli, William C. Hunter, Oliver Samuel, Andrea Silvestri, and Lora Zala, *The Global Third Nuclear Age: Clashing Visions for a New Era in International Politics* (London: Routledge, 2025).

[2] Jim Garamone, "Dempsey: U.S. Forces Must Adapt to Deal With Near-Peer Competitors," *U.S. Department of Defense*, March 5, 2015, accessed March 15, 2025, https://www.jcs.mil/Media/News/News-Display/article/613868/dempsey-us-forces-must-adapt-to-deal-with-near-peer-competitors/

[3] Rajeswari Pillai Rajagopalan and Sameer Patil, "Future Warfare and Critical Technologies: Evolving Tactics and Strategies," *Observer Research Foundation*, February 2024, accessed March 14, 2025, https://www.orfonline.org/research/future-warfare-and-critical-technologies-evolving-tactics-and-strategies

[4] SIPRI (@SIPRIorg), "Dual-capable missiles and non-nuclear missiles with strategic effect," YouTube, December 12, 2022, https://www.youtube.com/watch?v=-_ofJJi8x6E.

[5] European Leadership Network, Nuclear Threat Initiative, and Russian International Affairs Council, "Advancing Global Nuclear "Fail-Safe," February 2023, accessed March 15, 2025,

The plausibility of these scenarios has reshaped the analytical community's understanding of escalation risks, strategic stability and the deterrence dynamics associated with the nuclear-conventional entanglement.[6] This policy brief reviews the escalation risks arising from the integration of AI in nuclear systems and offers some thoughts on how to mitigate these risks. The brief also examines how these technological developments, specifically AI, could influence India's nuclear arsenal.

EMERGENT INTERFACE BETWEEN AI AND NC3

Given its potential applicability in both conventional and nuclear warfighting domains, AI is one of the most debated emerging technologies. At the heart of AI and its applications lies the capability to address complex challenges and solve problems that traditionally required human cognition. This entails utilising sophisticated algorithms and machine learning methods to process and analyse vast datasets, derive insights from them, and generate informed decisions or predictions. By yielding correlations within the provided datasets, the algorithms can identify patterns that are particularly valuable for humans when dealing with complex and voluminous data.

The underlying presumption of integrating AI in the nuclear domain is that it is meant to produce a competitive advantage over adversarial forces. Indeed, the integration of AI can certainly provide several advantages in NC3 through enhanced decision-making, improved monitoring and verification (particularly early-warning systems and pre-launch detection activities) and operational efficiency.[7] To begin with, AI's ability to sift through vast amounts of data gathered from multiple sources and sensors, much quicker than humans, is particularly useful in crisis situations where time is of utmost importance. It can also provide much more accurate information, potentially offering an opportunity for reduced human bias and enhanced decision-making. This can improve the performance of early-warning systems, reduce instances of false alarms and potentially prevent accidental launches.[8] These factors collectively improve situational awareness.

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https://securityconference.org/assets/01_Bilder_Inhalte/03_Medien/01_News/EASLG_Statement_GNFS_FINAL.pdf

[6] Thomas Reinhold, Elisabeth Hoffberger-Pippan, Alexander Blanchard, Marc-Michael Blum, Filippa Lentzos, and Alice Saltini, *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), accessed March 15, 2025, https://www.sipri.org/sites/default/files/2025-01/eunpdc_no_92_0.pdf

[7] Peter Rautenbach, "On Integrating Artificial Intelligence With Nuclear Control," *Arms Control Today*, September 2022, accessed March 15, 2025, https://www.armscontrol.org/act/2022-09/features/integrating-artificial-intelligence-nuclear-control

[8] Alice Saltini, "AI and Nuclear Command, Control, and Communications: P5 Perspectives," *European Leadership Network Report*, November 13, 2023, accessed March 15, 2025, https://europeanleadershipnetwork.org/report/ai-and-nuclear-command-control-and-communications-p5-perspectives/

Most nuclear-armed states, including the P5 have embarked on integrating AI in their NC3 systems, driven by strategic competition and the desire for technological advantage. Information about the precise details of AI integration in NC3 remains sparse, but the application of autonomous systems in conventional weapons deployment and decision-making, combined with the 'mission-mode' approach when it comes to AI-related research and development (R&D), offers a glimpse of how major militaries are thinking about military applications of AI and its integration with NC3.

Distinguishing between Autonomy and Automation

A distinction between autonomy and automation needs to be drawn for better conceptual clarity in the context and framing of the operationalisation of the AI component in the nuclear domain.

Indeed, automation has long existed in weapon systems, with the human as the ultimate controller or end agent. For instance, militaries have relied on automatic technologies for decades, such as missile defence interceptors or perimeter security systems that do not rely on AI. The Soviet era 'Dead Hand' is another good example of existing automation cases in the nuclear domain. The system was a semi-automatic nuclear response system for active use only if and when the country was attacked.[9]

By contrast, AI systems behave autonomously but are not necessarily automatic. Automatic systems are reactive, whereas AI-enabled systems are more proactive. These systems can sift, sort, identify, and offer an initial conclusion on what something means. This increased autonomy raises the risk of erosion of the human agency in the decision-making process, which requires a more contextual understanding of a specific environment.

In the near future, more militaries will likely deploy more autonomous systems for nuclear and conventional warhead delivery.[10] With such deployment, they aim to exert greater pressure on their adversaries by obstructing the interception of weapon system trajectories. This adds complexity[11] to the decision-making process by causing uncertainty among policymakers. Given the absence of existing methods to test the safety and reliability of machine learning and other AI tools in nuclear weapons technology, integrating AI into nuclear systems may have a destabilising effect, potentially undermining confidence in deterrence capabilities or creating additional vulnerabilities in nuclear systems and decision-making.

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[9] David E. Hoffman, *The Dead Hand: The Untold Story of the Cold War Arms Race and Its Dangerous Legacy* (New York: Penguin Random House, 2010).

[10] Beyza Unal and James Johnson, "Artificial Intelligence and Nuclear Weapons: Challenges and Opportunities for Strategic Stability," *The RUSI Journal* 167, no. 2 (2022), pp. 16–27, https://doi.org/10.1080/25751654.2022.2047360.

[11] Complexity in decision-making is exacerbated by the elements including, but not limited to, perceptions, beliefs, culture, religion and learning.

Whither Humans in AI-Nuclear Emergent Ecosystem?

The indispensable role of humans in the command and control ecosystem is under debate with increased automation in technology-based systems. This section discusses the incentives and trade-offs between human-machine interaction in decision-making as it remains critical owing to the AI element in the NC3 infrastructure.

The cautious strand of thinking on automation provides the rationale for not overlooking or eroding the critical human element in the decision-making process. Based on this logic driven by scepticism, the machines are trained and learn, in the process, to make more scripted decisions or, in some contexts, follow a more linear way of decision-making. On the other hand, the human mind(s) provides room for consideration of a broader context in the calculations. Such a holistic and macro-micro approach to the context helps shape the form of the solution to a specific decision-making problem. Thus, the human element in the loop provides for a less escalatory approach and, in case of inadvertent escalation, a means to de-escalate the conflict.

The technology-optimists, on the other hand, build a strong case about automation enhancing the self-sustaining decision-making capabilities of military systems. They argue that human intervention will be redundant for informed decision-making, as the operators will eventually rely on the vast amount of data gathered by the sensors and processed by the individual military system. Consequently, "the autonomous systems can be scaled up to accommodate a higher number of interactive and complex tasks."[12]

In the realm of nuclear-related decision-making, the context of deployment and operationalisation of the weapons, technology and decision-cycle becomes different, given the high stakes involved in case of miscalculation and the post-facto effects and fallouts for all the parties involved, if there is a nuclear escalation. The threat and use of nuclear weapons is also perceived with extreme seriousness by policymakers, weighing their decisions with far greater restraint and caution. In such cases, the crisis learning throughout decades by the policymakers with authority over nuclear weapons, that is characterised by pragmatic restraint despite the challenging circumstances, is a critical consideration for the role of human agency. States should only use AI to the extent of taking suggestions wherever required in the operationalisation (as operationalisation of the nuclear weapons is the threshold of the nuclear deterrence and warfighting domain) rather than to let AI models and integrated systems take independent decisions on behalf of policymakers.

The application of AI for conducting operations in the conventional military domain cannot and should not be equated with the application of AI for operationalising nuclear

[12] Sebastian Elbaum and Jonathan Panter, "AI Weapons and the Dangerous Illusion of Human Control: America Must Let Autonomous Systems Operate More Freely in War"*, Foreign Affairs,* December 6, 2024, , accessed March 15, 2025, https://www.foreignaffairs.com/united-states/ai-weapons-and-dangerous-illusion-human-control

weapon strategies. In the conventional warfighting domain, the restraint on the 'autonomous' part of the AI systems may be even counter-productive to strategic objectives and victory and the delay in response time can hamper the initiative on the battlefield. On the other hand, policymakers are capable and will be better placed to find alternate means and methods around the conditions for the actual use of nuclear weapons in most of the plausible scenarios. Historical understanding of past crises and measured wisdom with an amount of luck has brought states here without any single instance of use of nuclear weapons since Hiroshima and Nagasaki episode. Overall, the approach marked by 'suggestion, not action' through AI systems is a positive and non-escalatory way to enforce stability in the nuclear domain. This approach also ensures that the ethical and normative dimensions of the nuclear taboo are kept intact in the age of technology.

Notably, there is now an implicit consensus among major nuclear-armed states that nuclear decision-making should not be left to a fully autonomous process. This idea was endorsed at the 2020 Nuclear Non-Proliferation Treaty Review Conference, which stated that states will maintain "human control and involvement for all actions critical to informing and executing sovereign decisions concerning nuclear weapons employment."[13] Therefore, we can reasonably expect the human element to be inseparable to their NC3. However, as intent evolves and capabilities advance, the future is indeed uncertain.

PLAUSIBLE PATHWAYS TO ESCALATION

Indistinguishability of Nuclear from Strategic Non-Nuclear Capabilities

The entanglement of nuclear and strategic non-nuclear capabilities (conventional and cyber) complicates decision-making for the state being targeted. For instance, the state that possesses an inventory of nuclear and strategic non-nuclear weapons has an advantage of *access,* whereas the state being targeted is under enormous pressure, more than ever before, to develop *denial* measures against the attacking state. The attacking state may choose a more selective, targeted and ambiguous pathway to infuse risk and escalation in the defending state's calculus, compelling the latter to drift away from the rational model of escalation mitigation and to switch to a tit-for-tat model of escalation in anticipation of incoming NC3 targeted attacks from the attacking state. This intensifies the problem of strategic stability and promotes the pursuit of technologies contributing to counterforce strike capabilities.

The increasing entanglement of nuclear and strategic non-nuclear capabilities and their integration with AI exacerbate such threats for escalation. For example, the satellite-

[13] United Nations, "Principles and responsible practices for Nuclear Weapon States," 2020 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons, Document no. NPT/CONF.2020/WP.70, July 29, 2022, https://documents.un.org/doc/undoc/gen/n22/446/53/pdf/n2244653.pdf

based sensors will provide credible evidence of any nuclear strike preparations by regional adversaries.[14] In another scenario, a nuclear first-strike aimed at taking out the nuclear inventory or strategic targets may put the AI-based NC3 into a higher alert mode. In these cases, the space for limited, calibrated and responsible non-escalatory response would become hard to frame. AI-dominant NC3 may probably choose to target and advance for an escalatory pathway in the form of a significant nuclear response due to the inherent tendency to favour escalation.[15]

Operational-cum-Technical Flaws and Judgement

The inherent advantages of technologies like AI in the nuclear domain may keep policymakers alert. At the same time, their inherent vulnerabilities also open up possibilities for operational escalation in the conventional-nuclear realm. For instance, given the vulnerability of the AI models (either of an independent AI model or a (sub)system reliant on an AI model for decision-making) a *malfunction* arising from a cyberattack, could lead to operational dysfunction as an immediate outcome. If not mitigated effectively, it could lead to an accidental launch against one or more enemy targets.

Another possibility of escalation arises from the lack of sufficient training of the AI model to meet unforeseen circumstances, which may even test the confidence and understanding of decisionmakers aimed at controlling the escalation. Therefore, excessive pressure may come on individuals in the chain of command to determine the specific nature of the response for non-kinetic but strategic attack on the AI component in NC3.

AI-enabled Disinformation and Fog of War

Finally, one more dimension of potential escalation that has not received much attention is the AI-enabled disinformation campaigns. By leveraging deepfake technology[16] to create hyper-realistic content like text, imagery, audio, and synthetic data, these campaigns can contribute to the 'fog of war'. Deepfake content can make it harder for decisionmakers to discern genuine threats from fabricated ones, increasing the likelihood of catastrophic miscalculation. Additionally, AI-generated deepfakes can undercut trust in official narratives, complicating efforts to verify threats and to assess adversary's intentions.

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[14] Bharat Karnad, *India's Nuclear Policy* (Westport, CT: Praeger, 2008), pp. 94-96.

[15] Juan-Pablo Rivera, Gabriel Mukobi, Anka Reuel, Max Lamparth, Chandler Smith, and Jacquelyn Schneider, "Escalation Risks from Language Models in Military and Diplomatic Decision-Making," *The 2024 ACM Conference on Fairness, Accountability, and Transparency (FAccT 24), June 3-6, 2024,* Rio de Janeiro, Brazil, 2024, https://doi.org/10.1145/3630106.3658942.

[16] Deepfake technology is a type of artificial intelligence used to create synthetic fake images, videos and audio recordings. The greatest danger posed by deepfakes is their ability to spread false information that appears to come from trusted sources.

CHALLENGES AND CONSTRAINTS OF AI INTEGRATION

There are four key issues arising from the integration of AI into nuclear systems:

1. First, there is the **element of unreliability** due to AI's inherent ability to produce hallucinations. As a result, AI systems can produce a more confident set of outcomes even in the absence of robust training datasets, thereby offering false positive conclusions for decisionmakers.

2. Second is the black box problem arising from the **inherent opacity**, owing to the lack of understanding about the underlying epistemological process by which AI develops a causal chain and reaches a certain conclusion.[17] There are debates about how AI calculates or establishes the causal chain between the cause and the effect. Without knowing the logic of the process, it has limited utility in building trust among the human users.

3. Third is the **susceptibility to cyber threats**, including cyberattacks that disrupt training, data and processes, which may be difficult to trace.[18] These attacks can alter the system's functioning without showing the initial signs of breakdown or deviation from standard operating procedures.

4. Fourth is the **likelihood of misalignment** between the human pattern of thinking and the AI-based systems.[19] When it comes to conflict situations, the AI model may rationalise and respond on its own and may likely choose escalation instead of showing restraint like human agents do, with implications for not just one's own capabilities but for humanity.[20] AI may not consider such out-of-the-training instructions for a doomsday scenario but may make these calculations aimed toward achieving superiority and competitive advantage over the adversary.

Despite these shortcomings, AI has been assessed as an important and valuable technology by states and policymakers in the arena of NC3 and improvising their operational readiness and efficiency through the humans in the loop.

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[17] Prateek Tripathi, "The AI Black Box Conundrum," *Observer Research Foundation*, November 29, 2023, accessed March 16, 2025, https://www.orfonline.org/expert-speak/the-ai-black-box-conundrum
[18] Alice Saltini, "Assessing the implications of integrating AI in nuclear decision-making systems," *European Leadership Network* Policy Brief, February 2025, accessed March 15, 2025, https://europeanleadershipnetwork.org/wp-content/uploads/2025/02/25_02_11_AINC3policybrief.pdf
[19] Leonard Dung, "Current Cases of AI Misalignment and Their Implications for Future Risks," *Synthese* 202, no. 5 (2023): 1–20, https://doi.org/10.1007/s11229-023-04367-0.
[20] Rivera *et al.*, "Escalation Risks from Language Models in Military and Diplomatic Decision-Making," 2024.

THE INDIAN SCENARIO

In light of the preceding analysis, a nuanced examination of India's approach on the integration of AI in NC3 is warranted. India occupies a unique position among nuclear armed states: it is the only major nuclear-armed state that is simultaneously engaged in active border disputes with two other two nuclear armed neighbours – China and Pakistan. The periodic episodes of tensions with them have profoundly shaped India's nuclear posture and the evolution of its strategic capabilities. Moreover, it is only one of the two nuclear-armed states, besides China to formally adhere to the No First Use (NFU) policy. Therefore, a pragmatic and prudent approach guides India's navigation of the third nuclear age. The differing conception of emerging technologies for major nuclear armed states like the United States, Russia and China shapes this approach. Technologies that are considered legacy technologies by nuclear weapons states such as hypersonic weapons or Multiple Independently-targetable Re-entry Vehicle are still emerging for India. Broadly, it is developing strategic non-nuclear capabilities to deter and respond to adversarial threats in the warfighting domain. On nuclear weapons, the Indian politico-bureaucratic enclave remains in favour of the role of nuclear weapons primarily for deterrence purposes. Toward this end, India is developing and acquiring technologies to achieve a robust nuclear triad for an effective deterrent.

No such prospects exist in the short to mid-term for automation in NC3 infrastructure in India's nuclear deterrence posture primarily due to politico-military priorities and resource limitations. Moreover, India's own defence AI ecosystem is at a nascent stage.[21] However, there is an integration of nuclear and non-nuclear capabilities as evident from its combining precision-strike weapons, advanced satellite-based target identification and tracking, and airborne sensor technology.[22] This would require additional steps like training of personnel and putting in place other necessary procedures to avoid any operational mishap.

India is taking active steps by participating in debates and discourse on the development and integration of AI in the military domain and advocating for an overall responsible use of AI. Given India's quest to develop strategic non-nuclear capabilities, people (training of personnel) and processes related to the management and operationalisation of the nuclear forces will eventually have the converging role of managing dual-role and dual-capable weaponry. This intersection will create pressures and require important steps to manage the risks of (inadvertent) escalation and fail-safe problems.

[21] Shimona Mohan, "Passive Ambitions, Active Limitations: Defence AI in India," in David E. Hoffman, Heiko Borchert, Torben Schütz and Joseph Verbovszky (eds.), *The Very Long Game. Contributions to Security and Defence Studies* (Cham: Springer, 2024), p. 451.
[22] Frank O'Donnell, "India's nuclear counter-revolution: nuclear learning and the future of deterrence," *The Nonproliferation Review* 26, no. 5–6 (2019): 423, https://doi.org/10.1080/10736700.2019.1715018.

RECOMMENDATIONS: MANAGING (IN)ADVERTENT ESCALATION RISKS THROUGH FAILSAFE MEASURES

As a first step, the stakeholders need to **understand and categorise the (potential) variable threats** and **prepare their risk limitation strategies** with the integration of AI in the existing nuclear infrastructure. Such categorisation & gradation may help to distinguish the character of threats, which may come from either a conventional military attack or a nuclear first-strike preceded by non-kinetic attacks on the NC3 infrastructure. The amount of damage that such escalation can cause to the operational readiness of the AI component – in terms of the assigned core tasks, including the management of the degree of automation, human-machine interaction and incentives for the targeted state to frame the response – however, comes into question.

States, therefore, need to **develop a whole set of threat assessments and decision matrices** to include the impact of AI-related processes on the human element of the decision-making and the functioning of the AI component in its intact and under-targeted conditions.

The first two steps, if implemented, would be used as a basis for a **prospective scenario to develop best practices**. Such practices would ensure that states **adopt standards with proven risk mitigation** and explore other measures required in the age of AI such as risk-based categorisation, **establishing human-in-the-loop protocols, and mitigating cybersecurity risks**, to establish a robust nuclear failsafe compliance safeguard in place. This will help largely mitigate the risk(s) of (in)advertent escalation.

Given the advantage of failsafe measures to mitigate risks and to avoid unnecessary risks leading to any form of escalation at one's own end, the idea of failsafe has the potential for standardisation as a core norm among nuclear states. A robust nuclear failsafe is like a unilateral assurance measure like the NFU policy or the nuclear testing moratorium with clear signalling to the other party that despite the option of operational readiness of the nuclear forces, the policymakers are committed to prioritise de-escalation and stability in case of any crisis.

Channels of dialogue and other means need to be developed to raise key stakeholders' awareness of the risks posed by AI integration in the nuclear domain. With the presence of such dialogue, stakeholders can develop the necessary will to reduce and mitigate risks, and numerous steps can be undertaken to jettison uncertainty and achieve stability.

Another step would be the **development of regulations** through ethical frameworks emerging from discussions with key stakeholders from the concerned states to **establish ethical guidelines** for the use of AI in nuclear systems. This includes addressing concerns about accountability, transparency, and decision-making processes.

Finally, the **simulations with plausible scenarios** involving AI in nuclear decision-making processes could help stakeholders visualise outcomes and prepare for various contingencies. This will help improve the human component by reducing the complexity of the decisionmaking. Such measures could help mitigate the uncertainty among key stakeholders and state actors to reduce the chances of (in)advertent or asymmetric escalation, especially as nuclear modernisation and evolving doctrines of nuclear powers already pose significant risks.

CONCLUSION

The Cold War wisdom that "a nuclear war cannot be won and must never be fought"[23] holds relevance even today and will continue to do so as long as nuclear weapons remain relevant for statecraft. And so, risk reduction measures become not just a prerogative but a priority and responsibility for nuclear armed states to avert the risk of escalation.

The factors including nuclear multipolarity and a complex geopolitical environment could become more exacerbated with the introduction of AI and autonomy in NC3 infrastructure. It could result in reducing the stability and increase the tendency for (in)advertent escalation.

A narrow understanding of what the integration of an emerging technology like AI in the nuclear domain could do, can have serious implications for conflict escalation. It should be noted that all AI models, with their varying nature of training and utility, pose a varying level of uncertainty and risk for decision-making. Policymakers should be able to distinguish between the degree of autonomy attributed to the system or process, inherent vulnerabilities and the degree of dependency and reliability of a specific AI-based technology for a specific task in the nuclear domain.

Thus, questions like how do states integrate the AI-based NC3 into their nuclear posture, and with their existing capabilities while navigating the geopolitical environment remain a key line of enquiry to examine the effects of escalation and its associated risks.

[23] European Leadership Network, "Impact case study: The P5 affirm that a nuclear war cannot be won and must never be fought", January 12, 2022, accessed March 15, 2025, https://europeanleadershipnetwork.org/case-study/impact-case-study-the-p5-affirm-that-a-nuclear-war-cannot-be-won-and-must-never-be-fought/

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