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AI IN CHINESE, INDIAN AND US NUCLEAR POSTURES, NORMS AND SYSTEMS

LORA SAALMAN

STOCKHOLM INTERNATIONAL PEACE RESEARCH INSTITUTE

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STOCKHOLM INTERNATIONAL PEACE RESEARCH INSTITUTE

Signalistgatan 9
SE-169 70 Solna, Sweden
Telephone: +46 8 655 97 00
Email: sipri@sipri.org
Internet: www.sipri.org

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Executive summary

This backgrounder surveys the integration of artificial intelligence (AI) into the nuclear postures, norms and systems of China, India and the United States, as documented in official sources and secondary sources such as technical, media and industry reports. In the absence of official postural and normative clarity, these reports are crucial for comparing AI-enabled functions to examine the points at which all three states may be applying 'meaningful control', 'human judgement' and 'human control' across their nuclear and nuclear-related systems.

AI in nuclear posture and norms

AI enhances China's command, control, communications, computer, intelligence, surveillance and reconnaissance functions. Chinese technical journals examine US advances in generative intelligence, swarm intelligence, human–machine hybrid intelligence and embodied intelligence. While pursuing similar capabilities, Chinese experts raise concerns over AI's potential to weaken nuclear deterrence, intensify escalation and arms races, challenge strategic stability, complicate accountability, increase collateral damage, lower the threshold of proliferation, and lead to nuclear use and misuse. On norms, China advocated human control of 'relevant weapon systems' in 2021 at the United Nations; emphasized responsible behaviour in AI military development at a 2023 Global AI Governance Initiative; and in 2024, affirmed with the USA the importance of human control over the decision to use nuclear weapons. Within the framework of the UN Convention on Certain Conventional Weapons (CCW), China stressed in 2024 that classifying acceptability of autonomous weapons systems (AWS) requires a legal instrument. Yet China has not supported AI military norms at the Responsible AI in the Military Domain (REAIM) summits. Moreover, in 2025 China released an arms control white paper that returned to a broader formulation of human control over 'relevant weapon systems', rather than explicitly nuclear ones.

In India, retired military experts advocate for human oversight, transparency and confidence-building measures, while academic reviews focus on escalation resulting from AI integration into nuclear systems and nuclear power facilities. Rather than discussing nuclear concerns, India's official releases primarily pertain to AI-enabled uncrewed systems to combat border incursions, terrorist activities, illegal immigration, drug trafficking and natural disasters, while engaging in anti-aircraft, anti-submarine and other forms of conventional warfare. On norms, India has led the Global Partnership on Artificial Intelligence summits, whose broad scope includes references to lessons from nuclear disarmament, emphasizing responsible use. Yet these nuclear references are disappearing from online sources. Moreover, while India argued at the CCW in 2025 that human judgement and oversight over AWS are essential, like China, it has not endorsed the REAIM declarations.

The US 2022 Nuclear Posture Review states that the USA will maintain a human 'in the loop' for all actions critical to informing and executing decisions to initiate and to terminate nuclear weapon employment. Still, there remains an academic debate over what constitutes 'meaningful human control'. While officially affirming the need for 'human control' in nuclear decision making, the USA advocates 'human judgement' over the use of force on conventional weapons. On norms, the USA has promoted the 2023 Political Declaration on Responsible Military Use of Artificial Intelligence and Autonomy and the REAIM declarations, shunned by China and India. At the CCW, the USA also sought to clarify the human's role in AWS classification. Still, while President Donald J. Trump's administration's 2025 AI Action Plan recognizes that AI systems

pose novel national security risks, including in radiological and nuclear weapons, it prioritizes AI competitiveness over regulation indicating that these postures and norms may be changing. The absence of an official 2025 review of nuclear posture complicates this determination.

AI in nuclear and nuclear-related systems

China has integrated precision-guidance and manoeuvrability in the DF-26 missile and hypersonic glide vehicles; decision making and situational awareness in radars, early warning platforms, and Hong-6N (H-6N) and H-20 bombers; and simulation and modelling in the Jilin-1 satellite and Taijing-4 03 five-satellite constellation. On autonomy and swarm, China has produced the stealth Changying BZK-005 uncrewed aerial vehicle (UAV), Hongdu GJ-11 uncrewed combat aerial vehicle (UCAV), Changjian CJ-10 subsonic dual-capable land-attack cruise missile, JARI uncrewed surface vessel and uncrewed underwater vehicles (UUVs).

Official sources on India's nuclear systems tend to concentrate on civil nuclear plants or theoretical applications, but there are indications of AI applications within India's nuclear force production. Manufacturing and management incorporate AI in the production of nuclear-capable Agni, Prithvi and Akash missile variants, as well as its hypersonic platforms. On imagery and reconnaissance, India's Rafale F3-R features the Thales' cortAIx accelerator. The Indian Navy factors AI into its Integrated Platform Management System for next-generation warships, including nuclear vessels. On predictive analytics and modelling, India has AI-enabled facial and voice recognition, threat pattern evaluation and large language models. On autonomy and surveillance, India has the Ghatak UCAV, Indrajaal, Multi Agent Robotics Framework, and a range of UAVs. India also has worked on UUVs for surveillance, decoy and strike operations.

Many of the USA's official and unofficial nuclear reports indicate areas in which AI may have been and are being integrated into US nuclear forces. These include mission assurance and diagnostics (e.g. global aircrew strategic network terminal, NC3 weapon system (AN/USQ-225), nuclear certification and surety, nuclear effects, and the FACET-II at the SLAC National Accelerator Laboratory); maintenance and planning (e.g. the B-52H Stratofortress, including in AgilePods with AI-driven sensor payloads); predictive analytics and testing (e.g. the F-35 Lightning II and the Fast Open X-Platform for real-time data analysis, threat replication training, crewed–uncrewed teaming and machine learning); stockpile management and security (e.g. the National Nuclear Security Administration's Genesis Mission and the use of OpenAI models by the US National Laboratories); and developing AI agents and testing uncrewed systems that can be deployed in tandem with and in support of nuclear platforms (e.g. the AI-piloted Kratos XQ-58A Valkyrie UCAV and X-62 VISTA).

Based on this survey, the USA provides the most extensive official AI–nuclear nexus coverage, with China trailing a distant second. While both have advocated human control, their differing levels of NC3 transparency complicate evaluating the stages of nuclear decision making at which it would apply. China's rapid advances in AI and nuclear modernization and recent return to a more general declaration of human control over 'relevant weapon systems' suggest that its posture is subject to ambiguity and change. Such fluctuations are also visible in the USA, which has unshackled its AI advances, and refrained from releasing an official 2025 review of nuclear posture. In India, AI task forces and envoys are reluctant to discuss nuclear applications, much less commitments. In contrast to opacity and shifts on postures and norms, technical, media and industry reports provide greater symmetric transparency on AI-enabled functions in nuclear- and nuclear-related systems. Thus, this survey—in particular of AI-enabled functions—provides a more targeted and comparable foundation for engagement and confidence-building measures.

1. Overview

China, India and the United States are each engaged in rapid advances in artificial intelligence (AI) and nuclear systems, yet country-specific mappings of the nexus between these developments remains limited.[1] To fill this gap, this backgrounder presents a systematic survey of the extent to which these states have integrated AI into their respective nuclear postures, norms and systems.

On postures—that is, national policies and positions—China and India have released limited official information regarding their nuclear command, control and communications (NC3) structure, while the USA has issued prolific government documents. By contrast, all three have issued numerous pronouncements relating to AI and even its military applications. Nevertheless, the USA dominates the field when it comes to connecting AI and nuclear posture, while China's and India's national documents tend to concentrate on AI applications in development goals and broader military aims.

On norms—that is, shared rules of conduct—both China and India have refrained from joining the 58 signatories of the Responsible AI in the Military Domain (REAIM) 2023 Call to Action, and the 63 countries endorsing the 2024 Blueprint for Action that pursue norms on military AI governance.[2] Despite this, China and the USA have jointly advocated 'human control' over the decision to use nuclear weapons, although China's definition of 'human control' remains unclear. While the USA applies 'human control' to decision making in nuclear systems, it limits this constraint to 'human judgement' in conventional systems, potentially complicating norms around dual-capable platforms. Some of India's AI frameworks highlight lessons from nuclear disarmament, but it has largely eschewed detail or related nuclear commitments.

On systems—that is, weapons platforms—China and the USA have made significant strides in integrating AI into nuclear and nuclear-related equipment. India's AI-related weapons advances are not strongly nuclear-related but have the potential for future nuclear uses, in part driven by their advances in generative AI and uncrewed systems.

Informing these points of intersection, this backgrounder provides an overview of China's, India's and the USA's evolving integration of AI into their respective nuclear postures, norms and systems. Chapter 2 covers how AI is impacting each country's nuclear posture, NC3 structure, and domestic and multilateral normative frameworks. Chapter 3 explores nuclear and nuclear-related systems that are thought to incorporate AI to enhance such functions as precision guidance, manoeuvrability, decision making, situational awareness, simulation, modelling, remote sensing, autonomy, swarm, reconnaissance, surveillance, predictive analytics, diagnostics, planning, stockpile management, security and testing. In doing so, this backgrounder is intended to serve as a baseline for future engagement with and among China, India and the USA on AI and nuclear confidence-building measures.

[1] For an early effort at AI–nuclear mapping by country see Boulanin, V. et al., *Artificial Intelligence, Strategic Stability and Nuclear Risk* (SIPRI: Stockholm, June 2020).

[2] Responsible AI in the Military Domain (REAIM) Summit, 'REAIM 2023 Call to Action', 16 Feb. 2023; and REAIM Summit, 'Blueprint for Action', 11 Sep. 2024.

2. AI in nuclear posture and norms

China's, India's and the USA's early official releases on AI integration into national systems contained limited to no mention of nuclear applications. For example, China's 2017 New Generation Artificial Intelligence Development Plan features only a brief reference advocating 'intelligent security platforms to support nuclear power security operations', while nuclear applications are absent from its 2017 Three-Year Action Plan for Promoting Development of a New Generation Artificial Intelligence Industry (2018–2020).[3] India's Ministry of Defence task force report in 2018 makes reference to AI integration in aviation, naval, land systems, cyber, nuclear and biological warfare, but does not provide any specifics.[4] The US Department of Defense (DOD) AI Strategy of 2018, which promotes centralized infrastructure for AI development, military ethics and AI safety, similarly omits nuclear integration.[5]

Despite these lacunae, Chinese, Indian and US official coverage of AI–nuclear integration has grown exponentially over the past few years. This chapter examines these shifts with an overview of each country's NC3 structure, AI integration into NC3 systems, and role in shaping or adhering to developing normative frameworks around AI–nuclear integration.

China

NC3 structure

China's official releases on its nuclear force structure have historically offered more guiding principles than operational specifics. While the Science of Military Strategy 2020 issued by China's People's Liberation Army (PLA) provides information on China's nuclear posture and deterrence strategy, it contains few concrete details on its NC3 structure.[6] China's May 2025 and November 2025 white papers both declare that China remains committed to 'no first use' and that China will 'unconditionally' not use or threaten to use nuclear weapons against non-nuclear weapon states and nuclear-weapon-free zones, emphasizing that China maintains its nuclear forces and capabilities at the 'minimum level required for national security'.[7] While there is more specificity in China's November white paper—which describes efforts to build 'a lean and effective nuclear force system' with 'capabilities in strategic early warning, command and control, missile penetration, and rapid response' and survivability 'to ensure the safety, security, reliability and effectiveness of its nuclear weapons and deter other countries from using or threatening to use nuclear weapons against China'—the

[3] 国务院 [Chinese State Council], '新一代人工智能发展规划的通知' [Notice on the Development Plan for the New Generation of Artificial Intelligence], 8 July 2017; and Webster, G. et. al., 'Full translation: China's "New Generation Artificial Intelligence Development Plan" (2017)', DigiChina Project, Stanford University, 1 Aug. 2017, box 3 para. 3. Translation of the 'Three-Year Action Plan for Promoting Development of a New Generation Artificial Intelligence Industry (2018–2020)' is available in Triolo, P., Kania, E. and Webster, G., 'Translation: Chinese government outlines AI ambitions through 2020', New America, 26 Jan. 2018.

[4] Indian Ministry of Defence, 'Raksha Mantri inaugurates workshop on AI in national security and defence', Press release, 21 May 2018.

[5] US Department of Defense (DOD), '2018 DOD artificial intelligence strategy', Fact sheet, 12 Feb. 2019.

[6] China Aerospace Studies Institute (CASI), *In Their Own Words: Science of Military Strategy 2020* (CASI: Montgomery, AL, Jan. 2022).

[7] Chinese Ministry of Defence, '新时代的中国国家安全' [China's national security in the new era], State Council Information Office white paper, 12 May 2025; 国务院 [Chinese State Council], '"新时代的中国军控、裁军与防扩散"白皮书' ['China's arms control, disarmament, and nonproliferation in the new era' white paper], Ministry of Foreign Affairs, 27 Nov. 2025, (Official Chinese version); and Chinese State Council, 'China's arms control, disarmament, and nonproliferation in the new era', in Ministry of Foreign Affairs, 'China releases white paper on arms control in new era', 27 Nov. 2025, (Official English version).

majority of information and analysis on China's NC3 structure still tend to come from secondary sources within and outside of China.[8]

Among these, a report prepared for the US-based China Aerospace Studies Institute maintains that while PLA Rocket Force (PLARF) contributes to conventional campaigns, nuclear authority rests with the Central Military Command (CMC) under a 'dual deterrence, dual operations' mission requirement.[9] The PLARF is integrated into China's efforts to build a joint command structure, while for a nuclear campaign 'command would most likely flow from the CMC directly to the nuclear launch units, bypassing Joint Campaign Command and ensuring swift launch capabilities'.[10] Command decisions come from the Joint Operations Command Centre in Beijing, with theatre-level and service command posts in either hardened underground, road-mobile or airborne facilities.[11] To assist in nuclear decision making, China is thought to be fielding an increasingly capable layered network of sensors. These include alleged development of 'over-the-horizon radars, counter-lower-observable radars, and satellite early warning systems, as well as radar systems designed to detect low-flying cruise missiles', with the information to be 'collected, analyzed and disseminated at joint theatre command posts'.[12] As this joint command structure and early warning system evolves, AI integration would ostensibly enhance the capabilities of the PLARF to rapidly sift through vast amounts of data and to communicate timely information and analysis, while improving its overall command, control, communications, computer, intelligence, surveillance and reconnaissance (C4ISR) infrastructure.

AI integration into NC3

In academic analyses relating to AI integration into NC3, some Chinese experts have expressed optimism that AI can be a stabilizing factor. A 2018 report from the Centre for International Security and Strategy (CISS) at Tsinghua University argued that where there is insufficient mutual trust among nuclear-armed countries and difficulty in guessing each other's intentions, more efficient reconnaissance capabilities can provide decision makers with more credible information. It also claimed that 'at the technical level, AI-induced strategic instability is not completely unsolvable', using the example of a country increasing the ability of its missile silos to withstand a first strike and retaining the strategic power of the second strike as a strategic deterrent. The report suggested AI can also play a role in the supervision and verification of nuclear facilities in disarmament and denuclearization.[13]

Similarly, an academic from Dalian Maritime University in 2022 highlighted the role of AI in nuclear risk reduction through enhanced (*a*) efficiency of nuclear arsenal review to strengthen the constraints of arms control agreements on all parties; (*b*) reliability of early warning and detection to reduce the potential for misjudgement; and (*c*) performance of nuclear missile early warning systems, NC3 systems and autonomous nuclear

[8] 国务院 [Chinese State Council], ' "新时代的中国军控、裁军与防扩散"白皮书' ['China's arms control, disarmament, and nonproliferation in the new era' white paper] (note 7). Compare the official English version: Chinese State Council, 'China's arms control, disarmament, and nonproliferation in the new era' (note 7). For context on China's nuclear-related military pursuits from a recent US official source see US Department of War (DOW), *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2025* (DOW: Washington, DC, 23 Dec. 2025), pp. 6, 11, 16, 17, 28-31, 61, 86.

[9] Wood, P., Stone, A. and Corbett, T., *Chinese Nuclear Command, Control and Communications*, BluePath Labs report (CASI: Montgomery, AL, Mar. 2024), p. 3.

[10] Wood, Stone and Corbett (note 9), pp. 3, 25. See also Chinese Ministry of Defence (note 7).

[11] Wood, Stone and Corbett (note 9), pp. 3, 25. See also Chinese Ministry of Defence (note 7).

[12] Wood, Stone and Corbett (note 9), pp. 3.

[13] 陈琪 [Chen Q.] and 朱荣生 [Zhu R.], '不确定性：为何担心人工智能冲击国际安全?' [Uncertainty: Why are we worried about the impact of artificial intelligence on international security?], Centre for International Security and Strategy (CISS) International Security and Strategy Studies Report no. 8, Aug. 2018, p. 8.

delivery platforms.[14] Still, the uncertainty and opacity brought about by AI integration into weapon systems—particularly nuclear weapons—punctuates many of these analyses.[15] Among these, a former head of the Cyberspace International Governance Research Centre cites the lack of transparency in AI-enabled 'critical national security facilities such as nuclear control systems' as complicating the decision-making process and contributing to doubts about the systems' decisions during emergencies.[16]

Moreover, the above 2018 CISS report also included broader concerns about AI's impact on China's second-strike capability, noting that nuclear-armed countries must deploy powerful second-strike capabilities to ensure that opponents dare not launch a first strike at the risk of being destroyed.[17] The report's authors claimed that AI technology does not need to completely destroy the foundation of the 'strategic game' between major powers when it is enough to weaken the credibility of nuclear retaliation. They contended that AI's powerful reconnaissance capabilities have increased Chinese and Russian concerns that the USA's development of technology to track and lock mobile missile launchers will threaten their retaliatory capabilities. If the concealment and penetration potential of uncrewed weapons and equipment is strong enough, countries will have attack options with lower risks and higher strike effectiveness, giving them a greater strategic advantage. They further argued that decision makers will face greater pressure to launch a first strike. Alternatively, countries will develop more dangerous weapons to balance the lack of deterrence. The resulting arms race could force countries to deploy unsafe AI systems and further increase strategic instability. The authors suggested that for defenders, there are other options for contending with these challenges: attack the enemy's detection devices, generate adversarial networks or adopt strategic deception to prevent the other side from attacking their own retaliatory forces. They noted that such efforts would enhance the concealment and security of their own nuclear retaliatory facilities. However, the authors also pointed to the intensification of this security dilemma, leading to accidental escalation and increasing the complexity and misjudgement of strategic deployment decisions. Ultimately, they stated that nations will face the 'dilemma' of launching an attack prematurely or losing the war.[18]

Given that these academic analyses in China are informed by Western writings and advances in AI and nuclear systems, particularly from the USA, it is important to recognize their impact on the direction of Chinese scientific research and development, whether in countering or pursuing similar capabilities. In fact, US systems are featured prominently in collaborative scientific papers published by Chinese academics from a multitude of institutions, including the Electronic Science Research Institute of China, China Electronics Technology Group Corporation, China Electronics Technology Institute of Intelligent Technology, Military Science Information Research Centre of the Academy of Military Science, China's PLA School of Computer Science and Technology at Beijing Jiaotong University, Tsinghua University, City University of Macau, China Foreign Affairs University, Peking University, and the School of Electronic Countermeasures of the National University of Defence Technology.[19]

[14] 张东冬 [Zhang D.], '人工智能军事化与全球战略稳定' [Militarization of artificial intelligence and global strategic stability], 国合中心 [International Cooperation Centre], no. 2, 1 Nov. 2022.

[15] 陈琪 [Chen] and 朱荣生 [Zhu] (note 13); 杨智睿 [Yang, Z.], '简析人工智能在核武器系统中的应用' [A brief analysis of the application of artificial intelligence in nuclear weapons systems],科技理论与实践 [*Theory and Practice of Science and Technology*], vol. 5, no. 2, 17 Dec. 2024; and 鲁传颖 [Lu C.], '人工智能重塑国家安全的范式和逻辑' [Artificial intelligence reshapes the paradigm and logic of national security], 人民论坛 [*People's Forum*], no. 2 (2025).

[16] 鲁传颖 [Lu] (note 15).

[17] 陈琪 [Chen] and 朱荣生 [Zhu] (note 13), p. 3.

[18] 陈琪 [Chen] and 朱荣生 [Zhu] (note 13), pp. 4–5.

[19] See e.g. 王亚珅 [Wang Y.] et al.], '2024年军事智能领域科技发展综述' [Overview of technological developments in the field of military intelligence in 2024], 安全内参 [*Security Insider*], 24 Apr. 2025; 朱荣生 [Zhu R.] et al., '人工

These Chinese analyses examine US advances in generative intelligence, swarm intelligence, human–machine hybrid intelligence and embodied intelligence for such activities as: autonomous perception and cross-domain collaboration of intelligent uncrewed platforms; human-like mathematical and causal logic reasoning; global and local collaborative model training; edge-side low-resource model deployment and reasoning; and flexible fusion implementation of large and small models in military intelligence. They also feature overviews of Western reports on the ability of AI to improve detection, tracking, targeting and strike capabilities, as well as statements citing the importance of human control over nuclear decision making. These Chinese experts raise a host of concerns over AI, including its potential to weaken nuclear deterrence, intensify escalation and arms races, challenge strategic stability, complicate accountability, increase collateral damage, lower the threshold of proliferation, and lead to nuclear use and misuse.[20]

Normative frameworks

Considering the above concerns, China has increasingly sought to stand at the forefront of shaping AI norms. In December 2021, it issued a position paper at the United Nations advocating for the application of 'AI technology in the military field in a prudent and responsible manner', such that 'relevant weapon systems must be under human control and efforts must be made to ensure human suspension at any time', followed by various Ministry of Foreign Affairs statements advocating for responsibility, auditability, supervisability, traceability, predictability and trustworthiness to ensure that AI is safe, reliable and controllable.[21] In its October 2023 Global AI Governance Initiative, China's Ministry of Foreign Affairs further emphasized that 'All countries, especially major countries, should adopt a prudent and responsible attitude to the research, development, and application of AI technologies in the military field.'[22] While these official documents did not specify to which weapon systems human control would apply, by November 2024 China's Chairman Xi Jinping and then US President Joseph Biden 'affirmed the need to maintain human control over the decision to use nuclear weapons', stemming from their AI dialogues held in May of the same year and marking an advance in officially recognizing AI norms relating to nuclear systems.[23]

智能的国际安全挑战及其治理' [International security challenges and governance of artificial intelligence], 中国科技论坛 [*Forum on Science and Technology in China*], no. 3, Mar. 2023; 文力浩, 龙坤 [Wen L. and Wang K.], '人工智能与网络的结合将如何影响核安全' [How the combination of AI and cyber will affect nuclear safety], 安全内参 [*Security Insider*], 19 June 2020; 贾子方, 王栋 [Jia Z. and Wang D.], '人工智能技术对战争形态的影响及其战略意义' [The impact of artificial intelligence technology on the forms of war and its strategic significance], 国际政治研究 [*International Political Studies*], no. 6, Jan. 2020; and 龙坤, 徐能武 [Long K. and Xu N.], '人工智能军事应用的国际安全风险与治理路径' [International security risks and governance paths of military applications of artificial intelligence], 国际展望 [*Global Review*], no. 5, Sep. 2022.

[20] 朱启超 [Zhu Q.], '人工智能武器化的发展趋势及治理策略' [The development trend and governance strategy of weaponization of artificial intelligence], 人民论坛 [*People's Tribune*], 5 Feb. 2025; and 张东冬 [Zhang] (note 14). See also Su, F. and Yuan, J., 'Chinese thinking on AI integration and interaction with nuclear command and control, force structure, and decision-making', European Leadership Network, Nov. 2023.

[21] Convention on Certain Conventional Weapons (CCW), Sixth Review Conference, 'Position paper of the People's Republic of China on regulating military applications of artificial intelligence (AI)', Working paper submitted by China, CCW/CONF.VI/WP.2, 20 Dec. 2021; Chinese Ministry of Foreign Affairs, '中国关于加强人工智能伦理治理的立场文件' [China's position paper on strengthening ethical governance of artificial intelligence], Jan. 2024; Chinese Ministry of Foreign Affairs, '人工智能全球治理上海宣言(全文)' [Shanghai Declaration on Global Governance of Artificial Intelligence (full text)], 4 July 2024; Chinese Ministry of Foreign Affairs, '人工智能能力建设普惠计划' [AI capacity building and inclusiveness plan], Dec. 2024; Chinese Ministry of Foreign Affairs, '全球人工智能治理倡议' [Global AI Governance Initiative], 20 Oct. 2023; and Chinese Mission to the United Nations, '张军: 中国将继续坚定推动国际核裁军与核不扩散进程' [Zhang Jun: China will continue to firmly promote the international nuclear disarmament and nuclear non-proliferation process], 18 Mar. 2024.

[22] Chinese Ministry of Foreign Affairs, 'Global AI Governance Initiative', Communiqué, 20 Oct. 2023.

[23] 'Readout of President Joe Biden's meeting with President Xi Jinping of the People's Republic of China', US Embassy in Peru, 17 Nov. 2024; and 李亚琦, 何文翔 [Li Y. and He W.], '美国观察: 中美人工智能政府间首次对话, 最前沿的合

These constraints are emerging in more concrete form with conventional systems that could have nuclear impacts. The State Council's white paper of May 2025 on 'China's national security in the new era' declares that China has 'proactively optimized and adjusted its uncrewed vehicle export control policy and banned the export of all civilian uncrewed vehicles for military purposes'.[24] Moreover, China has actively participated in UN discussions on autonomous weapons systems (AWS) within the Convention on Certain Conventional Weapons (CCW) framework, where in 2024 it emphasized that classifying AWS as 'unacceptable' or 'acceptable' would require, respectively, a legal instrument to prohibit them and risk mitigation measures.[25]

On nuclear systems, despite the China–USA joint statement in 2024 on human control in nuclear decision making, when it comes to Western-driven multilateral forums on AI military norms such as the REAIM summits—even when co-hosted by South Korea—China has largely refrained from declaring its support. China has not endorsed the multilateral REAIM 2023 Call to Action, which includes appropriate safeguards and human oversight of the use of AI systems, nor the 2024 Blueprint for Action, which emphasizes human control over nuclear weapons use.[26] In its November 2025 white paper on arms control, disarmament and non-proliferation—while introducing a new term, 'human primacy', in its official English translation—China returns to a broader formulation of human control over 'relevant weapon systems', rather than explicitly focusing on nuclear ones. The white paper states that the military application of AI should 'ensure that human beings take the ultimate responsibility and that all relevant weapons systems are under human control to prevent unauthorized actions', and that it 'must be conducted in accordance with International Humanitarian Law and other applicable international laws'.[27]

India

NC3 structure

India's official releases on its nuclear posture tend to be limited and dated, contributing to much of the coverage coming from secondary sources to an even greater extent than in China.[28] Nevertheless, in 2003, India's Ministry of External Affairs did issue a concise, but informative, official document on its NC3 structure.[29] This document stated that India's NC3 structure is under civilian control, with a Nuclear Command Authority that includes a Political Council chaired by the Prime Minister and an Executive Council chaired by the National Security Advisor. It also noted that the Political Council is

作效果如何?' [US Observation: The first intergovernmental dialogue on artificial intelligence between China and the United States, what is the effect of the cutting-edge cooperation?], 负担发展研究院 [Fudan Development Institute], 24 May 2024.

[24] Xinhua, ' "人工智能+": 硬核科技加速走进产业竞技场' ["Artificial intelligence+": Hard-core technology accelerates into the industrial arena], State Council of China, 6 Mar. 2025; China Energy Network, '积极稳健推进核能领域人工智能开发应用' [Actively and steadily promote the development and application of artificial intelligence in the nuclear energy field], 13 Feb. 2025; and Chinese Ministry of Defence (note 7).

[25] United Nations, General Assembly, 'Lethal autonomous weapons systems', Report of the Secretary-General, A/79/88, 1 July 2024, p. 37.

[26] REAIM Summit, 'REAIM 2023 Call to Action' (note 2); and REAIM Summit, 'Blueprint for Action' (note 2).

[27] 国务院 [Chinese State Council], ' "新时代的中国军控、裁军与防扩散"白皮书' ['China's arms control, disarmament, and nonproliferation in the new era' white paper] (note 7). Compare the official English version: Chinese State Council, 'China's arms control, disarmament, and nonproliferation in the new era' (note 7).

[28] For academic reviews of India's NC3 structure see e.g. Ramana, M. V. and Borja, L., 'Command and control of nuclear weapons in India', Technology for Global Security Special Report, Institute for Security and Technology, 1 Aug. 2019; and Hayes, P., 'Nuclear command, control, and communications (NC3) in Asia-Pacific', NAPSNet Special Report, 21 Sep. 2021.

[29] Indian Ministry of External Affairs, 'The Cabinet Committee on Security reviews [o]perationalization of India's nuclear doctrine', Press release, 4 Jan. 2003.

'the sole body which can authorize the use of nuclear weapons', while the Executive Council 'provides inputs for decision making by the Nuclear Command Authority and executes the directives given to it by the Political Council'.[30]

As part of nuclear planning, according to the release, the Indian Cabinet Committee on Security (CCS) reviews existing command and control structures, state of readiness, targeting strategy for a retaliatory attack and operating procedures for various stages of alert and launch. It also approves the appointment of a Commander-in-Chief, Strategic Forces Command, to manage and administer all Strategic Forces; and reviews and approves the arrangements for alternative chains of command for retaliatory nuclear strikes in all eventualities. Bearing some similarities to China's nuclear posture, established elements of India's nuclear weapons policy include maintaining a credible minimum deterrent and a no-first-use posture. Under this posture, nuclear retaliation to a first strike is designed to be massive and to inflict unacceptable damage. India also commits to non-use of nuclear weapons against non-nuclear weapon states. Yet, in the event of a major attack against India, or Indian forces anywhere, by biological or chemical weapons, India—unlike China—retains the option of retaliating with nuclear weapons.[31]

AI integration into NC3

On AI integration into India's NC3 structure, retired Indian military experts have made recommendations on the need for human oversight, transparency and confidence-building measures, while Indian academic reviews tend to focus on the impact on escalation of AI integration into nuclear systems and nuclear power facilities.[32] By contrast, India's official releases on military AI—such as those from the Indian Ministry of Home Affairs, Ministry of External Affairs and National Congress—are largely concerned with using the technology to secure India's borders from incursions and protect against terrorism.[33] While border protection and terrorism possess a nuclear dimension—since they pertain to planning vis-à-vis its nuclear-armed neighbours China and Pakistan—this focus means India's military AI applications primarily use AI-enabled uncrewed systems to combat border incursions, terrorist activities, illegal immigration, drug trafficking and natural disasters, while engaging in anti-aircraft, anti-submarine and other forms of conventional warfare.[34]

A July 2022 report from India's Department of Defence Production illustrates this official exclusion of public nuclear considerations of AI applications in that it does not contain even the word 'nuclear' when covering a wide range of AI applications in automation; autonomous, uncrewed and robotic systems; C4ISR; cybersecurity; human behaviour analysis; intelligent monitoring systems; internet of things; AWS; logistics

[30] Indian Ministry of External Affairs (note 29), paras 3–4.

[31] Indian Ministry of External Affairs (note 29), para. 2(VI).

[32] Ali, T., 'The role of artificial intelligence in nuclear command and control systems', United Service Institution of India Strategic Perspective, 21 Feb. 2025; Menon, P., 'India should declare that AI will not be used to autonomously launch nuclear weapons', *The Print*, 16 May 2023; Patil, S. and Rawat, R., 'Integration of artificial intelligence in nuclear systems and escalation risks', Asia-Pacific Leadership Network policy brief, 15 May 2025; and Nuclear Business Platform (NBP), 'Exploring the potential of artificial intelligence in the Indian nuclear energy sector', NBP Insight, 9 Oct. 2023.

[33] See Saalman, L., 'China and India: Two models for AI military acquisition and integration', eds K. Bajpai, S. Ho and M. Chatterjee Miller, *Routledge Handbook of China–India Relations* (London: Routledge, 2020); Indian Ministry of Home Affairs, 'Union Home Minister and Minister of Cooperation, Shri Amit Shah chairs the second day of the two-day National Security Strategies Conference—2024 in New Delhi', Press release, 14 Sep. 2024; and Indian National Congress, 'National security', *Nyay Patra: Lok Sabha Elections 2024* [Manifesto for 2024 general election], 2024.

[34] Saalman, 'China and India: Two models for AI military acquisition and integration' (note 33).

and supply chains; and manufacturing and maintenance.[35] Accordingly, Indian discussion of AI integration into nuclear systems and the impact of AI-enabled conventional systems on nuclear operations continues to be largely driven by academics and retired military experts.

Normative frameworks

As its military AI applications have expanded, India has pursued international norms through its leadership role within the Global Partnership on Artificial Intelligence (GPAI) summit—a grouping of governments, experts and stakeholders that seeks to guide responsible AI development and use. Its key outcomes have included ministerial declarations, expert discussions on topics like trustworthy AI, and commitments to international collaboration.[36] While GPAI summits are broad in scope, reporting has included references to lessons from nuclear disarmament and space exploration, emphasizing responsible use; however, present reports are not publicly accessible and much past coverage has vanished.[37] Similarly, from the author's interactions with Indian envoys to the UN, there has been a concerted refusal to engage on the nexus between AI and nuclear issues.[38]

Nevertheless, with the prevalence of AI in India's overall development, several umbrella bodies have come to play a cross-sectoral role, including the Bureau of Indian Standards, which routinely drafts AI standards.[39] Policymakers from abroad have also highlighted the value of India's governance model, including at the Global Technology Summit 2023 during which India's ministerial representative recommended policy enablers and guardrails, and Indian industry leaders presented a use-case-led AI strategy.[40] Despite its active engagement with the issues, India—like China—has not endorsed the REAIM 2023 Call to Action nor the 2024 REAIM Blueprint for Action.[41] However, India has actively participated in the AWS debates at the CCW, where in May 2025 India argued that 'Human judgement and oversight in the use of [AWS] are essential.'[42] India elaborated on this point: 'Full autonomy for [AWS] broadly refers to "human out of loop" in the cumulative execution of critical functions in the "kill chain", viz., target identification, selection, and engagement . . . Any possible framework should exclude weapons systems which are already in use with either "human in the loop" or "human on the loop". Uncrewed vehicles should also be excluded from the scope.'[43]

United States

NC3 structure

Of the three countries surveyed, the USA offers the most extensive official documentation on its NC3 structure. Presidential directives and memorandums detail planning,

[35] Indian Ministry of Defence, Department of Defence Production, *Artificial Intelligence in Defence: The New Age of Defence—Presenting AI Preparedness in the Country in Defence* (Ministry of Defence: New Delhi, July 2022.

[36] Jeevanandam, N., 'Global Partnership on Artificial Intelligence (GPAI) Summit—2023', IndiaAI, 3 May 2024.

[37] Global IndiaAI Summit, New Delhi, 3–4 July 2024; and Jeevanandam, N., 'Global IndiaAI Summit 2024 concludes, paving way for India's leadership in AI innovation', IndiaAI, 9 July 2024.

[38] Indian officials participating in the SIPRI project on AI and nuclear risk, Interviews with the author, 2018. For the project's final report see Boulanin et al. (note 1).

[39] Bureau of Indian Standards, 'LITD [Electronics and Information Technology Department] 30: New Standards List', [n.d.].

[40] See '2023 Global Technology Summit' at Carnegie India and Indian Ministry of External Affairs, 'About GTS', [n.d.].

[41] REAIM Summit, 'REAIM 2023 Call to Action' (note 2); and REAIM Summit, 'Blueprint for Action' (note 2).

[42] CCW, Group of Governmental Experts on Emerging Technologies in the Area of Lethal Autonomous Weapons (GGE on LAWS), Working paper submitted by India, CCW/GGE.1/2025/WP.3, 16 May 2025, para. 5(e).

[43] CCW, GGE on LAWS, CCW/GGE.1/2025/WP.3 (note 42), para. 6(c)–(d).

posture and strategic objectives regarding nuclear employment; US DOD guidance outlines how to implement presidential directives and memorandums; the Chairman, Joint Chiefs of Staff (CJCS) issues military guidance to commanders on the development and coordination of nuclear operations plans; and the US National Security Strategy, National Defense Strategy and Nuclear Posture Review delineate US nuclear policy, strategy, capabilities and force posture.[44] While there are shifts in how this information is conveyed—for example, a review of nuclear posture was not released in 2025—US official coverage of its NC3 structure tends to be timely and detailed in terms of roles and responsibilities.[45]

This official documentation reveals that the US president holds sole authority to authorize the use of nuclear weapons, reflecting the role of Commander-in-Chief. While the US president makes the ultimate decision, he relies on advice from senior military leaders, including the Secretary of Defense, the CJCS and commanders. Within their roles, US Strategic Command (USSTRATCOM) and other commands nominate, vet and select adversary strategic facilities and capabilities as targets.[46] Among these, the Air Force Global Strike Command is 'responsible for lead command management and centralized organize, train, and equip functions of the [US Air Force] NC3 weapon system (AN/USQ-225), comprising terminals, radios, direct ancillary communications devices, and support equipment for the execution of NC3'.[47]

AI integration into NC3

In April 2021 the National Security Commission on Artificial Intelligence released a strategy for the use of AI for national security and defence.[48] Among its nuclear-related findings, the strategy recommends that the USA should 'clearly and publicly affirm existing U.S. policy that only human beings can authorize employment of nuclear weapons and seek similar commitments from Russia and China' to 'prevent unintended nuclear conflict due to AI-enabled launch authorization'.[49] The DOD's 2022 Nuclear Posture Review also states: 'In all cases, the United States will maintain a human "in the loop" for all actions critical to informing and executing decisions by the President to initiate and terminate nuclear weapon employment.'[50] Demonstrating bipartisan support, multiple US Congressional members introduced a bill in the House of Representatives and the Senate, in April and May 2023 respectively, 'To prohibit the use of Federal funds to launch a nuclear weapon using an autonomous weapons system that is not subject to meaningful human control, and for other purposes'.[51]

Still, there remains an ongoing debate in the USA over what constitutes 'meaningful human control' and how to implement such constraints.[52] At the official level,

[44] US Office of the Under Secretary of Defense, Acquisition & Sustainment (A & S), *Nuclear Matters Handbook 2020*, revised edn (A & S: Washington, DC, 2020), chapter 2; US DOD, *2022 National Defense Strategy of the United States of America, including the 2022 Nuclear Posture Review and the 2022 Missile Defense Review*, 27 Oct. 2022; and White House, 'National Security Strategy of the United States of America', Nov. 2025.

[45] Nelson, A., 'Trump and the new era of US nuclear ambiguity', *New America*, 24 Sep. 2025.

[46] US Office of the Under Secretary of Defense, Acquisition & Sustainment (A & S) (note 44).

[47] US Air Force, *Nuclear Operations*, Air Force Doctrine Publication 3-72, 4 Aug. 2025, pp. 12–14.

[48] National Security Commission on Artificial Intelligence, Final Report, Apr. 2021.

[49] National Security Commission on Artificial Intelligence (note 48).

[50] US DOD, *2022 National Defense Strategy* (note 44), p. 13.

[51] US Congress, 118th Congress, 'Block Nuclear Launch by Autonomous Artificial Intelligence Act of 2023', House of Representatives Bill HR 2894, 26 Apr. 2023; and US Congress, 118th Congress, 'Block Nuclear Launch by Autonomous Artificial Intelligence Act of 2023', Senate Bill S. 1394, 1 May 2023.

[52] See Roff, H. M., 'Magnifying human confusion: Meaningful human control and the ongoing debate on autonomous weapons', The Rule of Law Post, 6 May 2024; Devitt, S. K., 'Meaningful human command: Advance control directives as a method to enable moral and legal responsibility for autonomous weapons systems', *arXiv* (preprint), 13 Mar. 2023, published in Mecacci, G. et al. (eds), *Research Handbook on Meaningful Human Control of Artificial Intelligence Systems* (Edward Elgar: Cheltenham, 2024); and Wehsener, A. et. al., 'AI–NC3 integration

this plays out in distinctions between controls on AI in conventional systems versus nuclear systems. The former US Deputy Assistant Secretary of Defense for Force Development and Emerging Capabilities, Dr Michael Horowitz, who was involved in the drafting of DOD Directive 3000.09 Autonomy in Weapon Systems, which came into effect in January 2023, has emphasized that this document intentionally does not include the terminology of humans being 'in', 'on' or 'out of' the 'loop'.[53] He maintains that 'loop' falsely implies continuous human oversight over a weapon platform from launch to impact—something that is near impossible due to technical and operational constraints.[54] Instead, the DOD focus is on allowing 'commanders and operators to exercise appropriate levels of human judgment over the use of force'.[55]

In line with Directive 3000.09, an October 2023 report of the International Security Advisory Board within the US Department of State notes that the USA favours the phrasing 'appropriate levels of human judgment'.[56] The report urges the USA to resist the formulation 'human control' used by other countries, since it 'implies a degree of direct supervision to the point of impact of a weapon that is inconsistent with decades of [international humanitarian law], and established practice'.[57] However, this argument highlights the complications posed by generative AI and large language models (LLMs), which can be used in malicious manipulation of training or embedded data, as well as by the example of precision-guided munitions that are launched by humans but 'often have their own guidance systems' and usually lack 'direct human supervision to the point of impact'.[58]

Still, when it comes to nuclear systems, the language of 'human control' dominates. USSTRATCOM Commander, General Anthony Cotton, calls AI machine learning (ML) 'a force multiplier', claiming that US '[information technology] and AI superiority allows for a more effective integration of conventional and nuclear capabilities, strengthening deterrence', enabling 'seamless coordination with our global networks of allies and partners', but he also emphasizes that 'Robust cybersecurity measures are critical to protect NC3 systems from adversary attacks or manipulation'.[59] General Cotton also stresses that 'AI will enhance our decision-making capabilities, but we must never allow artificial intelligence to make those decisions for us. Advanced systems can inform us faster and more efficiently, but we must always maintain a human decision in the loop'.[60] While this might seem to contradict the avoidance of 'loop' terminology in Directive 3000.09, it remains in line with the 2022 Nuclear Posture Review on nuclear weapon systems. It also supports Dr Horowitz's contention that the DOD distinguishes between conventional and nuclear systems on the basis of 'human judgement' versus 'human control'.[61]

Regarding other nuclear applications of AI, in October 2023, Biden signed Executive Order 14110, Safe, Secure, and Trustworthy Development and Use of Artificial

in an adversarial context: Strategic stability risks and confidence building measures', Institute for Security and Technology, Feb. 2023, pp. 29–30.

[53] Horowitz, M., 'Autonomous weapon systems: No human-in-the-loop required, and other myths dispelled', *War on the Rocks*, 22 May 2025.

[54] Horowitz (note 53).

[55] US DOD, Office of the Under Secretary of Defense for Policy, 'Autonomy in weapon systems', DOD Directive 3000.09, 25 Jan. 2023 para. 1.2(a).

[56] US Department of State, International Security Advisory Board (ISAB), *Report on the Impact of Artificial Intelligence and Associated Technologies on Arms Control, Nonproliferation, and Verification* (ISAB: Washington, DC, Oct. 2023, p. 26.

[57] US Department of State, ISAB (note 56), p. 26.

[58] US Department of State, ISAB (note 56), p. 26.

[59] Cotton, A., Keynote address, 2024 Department of Defense Intelligence Information System Worldwide Conference, Omaha, NE, 28 Oct. 2024.

[60] Cotton (note 59).

[61] Horowitz (note 53).

Intelligence, which highlights the need 'to better understand and mitigate the risk of AI being misused to assist in development or use' of chemical, biological, radiological and nuclear (CBRN) threats.[62] In June 2024 the US Department of Homeland Security produced a report that aimed to evaluate 'the potential for AI to be misused to enable the development or production of CBRN threats', as well as the 'benefits and application of AI to counter these threats'.[63] However, the report 'only addresses nuclear and radiological threats insofar as they share common features in ideation, production, and dissemination with chemical and biological agents and toxins', rather than focusing on NC3.[64]

Beyond threats, the USA also conducts research into beneficial applications of AI–nuclear integration.[65] In March 2024 the National Nuclear Security Administration (US NNSA) within the US Department of Energy (DOE) released the Artificial Intelligence for Nuclear Deterrence Strategy 2023 which explored the use of AI and ML, including in nuclear security.[66] The strategy details the use of AI and ML in (*a*) accelerating the design and production of systems that support the US nuclear stockpile and nuclear deterrence, including in discovering and manufacturing sustainable materials, enhancing data, and nano- and meso-scale computational simulation; (*b*) improving design exploration and optimization through faster modelling and simulation to improve manufacturability, longevity, reliability and cost; (*c*) facilitating manufacturing and certification through the collection of inspection and testing data, and comparison to computational simulations; and (*d*) engaging in nuclear stockpile maintenance and surveillance.

While recognizing positive aspects, US documents also express concerns over the adverse impact of AI and other emerging technologies on nuclear forces. A 2024 report from the Lawrence Livermore National Laboratory highlighted threats to the sea leg of the US nuclear triad due to breakthroughs in anti-submarine warfare technology, enhanced by AI, quantum computing, advanced sensing and autonomous systems.[67] The report cited experts who argue that 'degradation of the global threat environment coupled with the rapid advancement of emerging technologies underscores the necessity for a system that enhances the guaranteed second-strike capability of the nuclear ballistic missile submarine (SSBN) fleet'.[68] It concluded that 'the rapid pace of technological advances and the increasingly volatile global security landscape [suggest that] a mobile ICBM [intercontinental ballistic missile] system is one potentially useful avenue to explore' to 'not only supplement the U.S. nuclear deterrent but also address vulnerabilities exposed' by AI and advanced sensors that 'threaten the survivability' of the US SSBN fleet.[69]

Arising from this evolution in US thinking on AI and nuclear nexus, in October 2024, the White House issued its first-ever national security memorandum on AI, tasking the DOE with nuclear risk assessments, in coordination with the Department of Commerce

[62] White House, 'Executive Order 14110 of October 30, 2023: Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence', *Federal Register*, vol. 88, no. 210 (1 Nov. 2023) 75191, sec. 4.4 (Executive Order 14110).

[63] US Department of Homeland Security, 'Department of Homeland Security report on reducing the risks at the intersection of artificial intelligence and chemical, biological, radiological, and nuclear threats', 26 Apr. 2024, p. 1.

[64] US Department of Homeland Security (note 63), p. 3.

[65] Lin, H., 'AI and nuclear weapons: A commonsense approach to understanding costs and benefits', *Texas National Security Review*, vol. 8, no. 3 (2025); and Lin, H., 'AI and the US nuclear weapon enterprise', Stanford Center for International Security and Cooperation, YouTube, 18 Mar. 2025.

[66] US Department of Energy (DOE), National Nuclear Security Administration (NNSA), 'Artificial Intelligence for Nuclear Deterrence Strategy 2023', 11 Mar. 2024.

[67] Christenson, R., 'Supplemental secondstrike: Road-mobile ICBMs in the two-peer environment', Center for Global Security Research, Lawrence Livermore National Laboratory, May 2024.

[68] Christenson (note 67), p. 2.

[69] Christenson (note 67), pp. 13–14.

acting through the US AI Safety Institute (AISI)—an organization within the National Institute of Standards and Technology focused on advancing AI safety and mitigating AI-related risks.[70] In this capacity, AISI was to conduct sector-specific classified evaluations of current and near-future AI systems for cyber, nuclear and radiological risks. The memorandum further appointed the DOE, acting through the US NNSA and in coordination with AISI and the National Security Agency (NSA), with systematic testing of AI models of nuclear and radiological risks, followed by summaries and recommendations.

In November 2024 AISI announced the formation of the Testing Risks of AI for National Security Taskforce to coordinate research and testing of advanced AI models across critical national security and public safety domains, including radiological and nuclear security, chemical and biological security, cybersecurity, critical infrastructure and conventional military capabilities. The taskforce was to collaborate on the development of new AI evaluation methods and benchmarks, as well as conduct joint national security risk assessments and red-teaming exercises, with representatives from the DOD, the Chief Digital and Artificial Intelligence Office (CDAO), the NSA, the DOE and 10 of its national laboratories, the Department of Homeland Security, the Cybersecurity and Infrastructure Security Agency (CISA), and the National Institutes of Health.[71]

Recognizing the ever-increasing role of AI in warfighting, by December 2024, the DOD announced that the CDAO's Artificial Intelligence Rapid Capabilities Cell would partner with the Defense Innovation Unit to execute four initial frontier AI pilots that will 'accelerate and scale generative AI tools across 15 warfighting and enterprise management use cases ranging from command and control and decision support to software development and cyber security'.[72] In March 2025 USSTRATCOM Commander General Cotton also testified that:

> USSTRATCOM will use AI/ML to enable and accelerate human decision-making. To fully utilize the potential of AI, USSTRATCOM requires data scientists with expertise in AI and advanced platforms across multiple classifications. Opportunities exist to leverage the emerging digital engineering environment to bridge the gap toward adopting AI/ML into the nuclear systems architecture. AI will remain subordinate to the authority and accountability vested in humans. In all cases, the United States will maintain a human 'in the loop' for all actions critical to informing and executing decisions by the President to initiate and terminate nuclear weapon employment.[73]

While US declaratory statements continue to emphasize human control in nuclear decision making, there have been shifts in other areas in which AI is applied that may impact NC3 in the future. As one example, in January 2025 AISI released voluntary guidelines on managing misuse risk for dual-use foundational models, identified in Executive Order 14110 as an AI model that could lower 'the barrier of entry for non-experts to design, synthesize, acquire, or use chemical, biological, radiological, or nuclear (CBRN) weapons' to improve the safety, security and trustworthiness of dual-use models.[74] In the same month, President Donald J. Trump's Executive Order

[70] White House, 'Memorandum on advancing the United States' leadership in artificial intelligence; harnessing artificial intelligence to fulfill national security objectives; and fostering the safety, security, and trustworthiness of artificial intelligence', Presidential Memorandum, 24 Oct. 2024.

[71] US Department of Commerce, 'US AI Safety Institute establishes new US Government taskforce to collaborate on research and testing of AI models to manage national security capabilities & risks', Press release, 20 Nov. 2024.

[72] Clark, J., 'DOD's Chief AI Officer launches rapid capability cell, frontier AI pilots to accelerate adoption of cutting edge tech', US DOD News, 12 Dec. 2024.

[73] Cotton, A. J., Commander of the US Strategic Command, Statement before the US Senate Armed Services Committee's Subcommittee on Strategic Forces, 26 Mar. 2025, p. 17.

[74] US AI Safety Institute, 'Managing misuse risk for dual-use foundation models', NIST AI 800-1 2pd, Jan. 2025; and White House, Executive Order 14110 (note 62), sec. 3(i).

14179 revoked this executive order, citing it as a barrier to US leadership in AI.[75] While Executive Order 14179 did not make reference to AI applications in CBRN threats, it effectively removed Executive Order 14110's constraints on mitigating them. Since the Trump administration did not issue a 2025 review of nuclear posture, it is unclear whether the 2022 version's advocacy for 'a human "in the loop" for all actions critical to informing and executing decisions by the President to initiate and terminate nuclear weapon employment' remains.[76] Still, this posture has not, as of yet, been explicitly overturned.

The US government has, however, introduced other regulatory changes that could impact the speed and breadth with which AI is integrated into nuclear and non-nuclear systems. Citing burdensome compliance requirements for US companies, in May 2025 the Trump administration rescinded the Biden administration's January 2025 AI Diffusion Rule that had introduced enhanced export controls to cover the most advanced AI models and large clusters of advanced computing integrated circuits.[77] In place of this, the Trump administration issued three lines of guidance on (*a*) the risks of using China's advanced computing integrated circuits, including specific Huawei Ascend chips; (*b*) the potential consequences of allowing US AI chips to be used for training of Chinese AI models; and (*c*) how to protect supply chains against diversion tactics.[78] In June 2025 the Trump administration also announced plans to merge AISI into the Center for AI Standards and Innovation (CAISI) to stimulate AI technological advances, despite claims that this could undermine AISI's previous efforts toward AI safety.[79] Launched in November 2025 under a White House executive order, the Genesis Mission within the US NNSA seeks to spur innovation with AI applications in such areas as advanced manufacturing, biotechnology, critical materials, nuclear fission and fusion energy, quantum information science, and semiconductors and microelectronics.[80]

Normative frameworks

In contrast to its 2025 unshackling of numerous regulatory constraints, the USA has historically played a role in bilateral and multilateral normative frameworks controlling military and nuclear applications of AI. In November 2023 the US Department of State released a Political Declaration on Responsible Military Use of Artificial Intelligence and Autonomy that stated: 'Military use of AI capabilities needs to be accountable, including through such use during military operations within a responsible human chain of command and control.'[81] This declaration has been endorsed by 60 countries, yet not by China and India.[82]

[75] White House, 'Executive Order 14179 of January 23, 2025: Removing Barriers to American Leadership in Artificial Intelligence', *Federal Register*, vol. 90, no. 20 (31 Jan. 2025) 8741.

[76] US DOD, '2022 US Nuclear Posture Review', p. 13, *2022 National Defense Strategy* (note 44); and Nelson (note 45).

[77] US Department of Commerce, Bureau of Industry and Security (BIS), 'Framework for Artificial Intelligence Diffusion', BIS Rule, *Federal Register*, vol. 90, no. 9 (15 Jan. 2025) 4544; and US Department of Commerce, BIS, 'Department of Commerce rescinds Biden-era Artificial Intelligence Diffusion Rule, strengthens chip-related export controls', Press release, 12 May 2025.

[78] US Department of Commerce, BIS, 'Guidance on application of General Prohibition 10 (GP10) to People's Republic of China (PRC) advanced-computing integrated circuits (ICs)', 13 May 2025; US Department of Commerce, BIS, 'BIS policy statement on controls that may apply to advanced computing integrated circuits and other commodities used to train AI models', 13 May 2025; and US Department of Commerce, BIS, 'Industry guidance to prevent diversion of advanced computing integrated circuits', 13 May 2025.

[79] Brewster, T., 'The Wiretap: Trump says bye to the AI Safety Institute', *Forbes*, 3 June 2025.

[80] US DOE, NNSA, 'NNSA demonstrates swift action on Genesis Mission', 1 Dec. 2025; and White House, 'Launching the Genesis Mission', Executive Order, 24 Nov. 2025.

[81] US Department of State, Bureau of Arms Control, Deterrence, and Stability, 'Political Declaration on Responsible Military Use of Artificial Intelligence and Autonomy', 9 Nov. 2023.

[82] US Department of State, Bureau of Arms Control, Deterrence, and Stability, 'Political Declaration on Responsible Military Use of Artificial Intelligence and Autonomy', 9 Nov. 2023; and US Department of State, Bureau of Arms

The USA is also a signatory to the REAIM 2023 Call to Action and the 2024 REAIM Blueprint for Action, to which China and India, again, are not parties.[83] As noted above, the USA has also been an active participant at the AWS discussions at the CCW, where it seeks to concretize classification of autonomous functions (e.g., identification, selection and engagement of targets via 'fire and forget' or 'lock-on-after launch') and systems (e.g., loitering munitions, close-in weapon systems, active protection systems and air defense systems), to clarify the human's role in controlling such systems.[84] At a broader level, the Trump administration's July 2025 AI Action Plan also recognizes that 'AI systems may pose novel national security risks in the near future in areas such as cyberattacks and the development of chemical, biological, radiological, nuclear, or explosives (CBRNE) weapons, as well as novel security vulnerabilities.'[85] That the same document prioritizes AI competitiveness in a range of areas, including nuclear fusion and fission, throws into question the extent to which the Trump administration would be willing to constrain or limit advances in AI.

Throughout US AI-related nuclear initiatives—whether in terms of controls or advances—China remains an integral factor. Recognizing this, both countries held their first intergovernmental meeting on AI in May 2024. This meeting did not yield concrete deliverables nor a joint statement, reportedly in part due to the fact that the USA sought to advance responsible management of competition, while China sought to mitigate US limits on the transfer of advanced technologies and to pursue joint AI-related research and development projects.[86] Despite their differing objectives, in November 2024 Biden and Xi affirmed the need for (*a*) human control over the decision to use nuclear weapons; (*b*) consideration of potential risks; and (*c*) prudent and responsible development of AI military technologies.[87] Unless rescinded, this pledge remains consistent with the above-quoted March 2025 testimony from USSTRATCOM Commander, General Cotton, issued during the second Trump administration.

Control, Deterrence, and Stability, 'Endorsing States: Political Declaration on Responsible Military Use of Artificial Intelligence and Autonomy', 9 Nov. 2023.

[83] REAIM Summit, 'REAIM 2023 Call to Action' (note 2); and REAIM Summit, 'Blueprint for Action' (note 2).

[84] CCW, GGE on LAWS, 'The autonomy aspect of lethal autonomous weapon systems', Working paper submitted by the USA, CCW/GGE.1/2025/WP.6, 2 Sep. 2025.

[85] White House, 'Winning the race: America's AI action plan', July 2025, p. 22.

[86] Weitz, R., 'China and the United States begin official AI dialogue', China–US Focus, 14 June 2024.

[87] 'Readout of President Joe Biden's meeting with President Xi Jinping of the People's Republic of China' (note 23).

3. AI in nuclear and nuclear-related systems

Despite varying degrees of transparency on China's, India's and the USA's respective NC3 structures, information on their nuclear and nuclear-related systems is more readily available from technical, media and industry reports. These secondary sources provide a more symmetrical foundation for evaluating whether AI has been integrated into these weapon systems, although the exact nature of AI enablement is not always available. Relying on open sources from each of the three countries, this chapter provides an overview of the nuclear and nuclear-related systems with the strongest potential for AI integration, and highlights the functional capabilities that AI is thought to be enhancing in each system.[88]

China

Precision guidance and manoeuvrability

When it comes to China's nuclear forces and its fleet of delivery systems that include the Dongfeng (DF) series of intercontinental, intermediate-range, medium-range and short-range ballistic missiles (respectively, ICBMs, IRBMs, MRBMs and SRBMs), AI has the potential to enhance precision guidance and target selection, navigation by ensuring accurate and precise flight paths, and decision making by automating certain processes to determine the best course of action when faced with missile defences.[89] For example, the DF-26 IRBM relies on precision-strike capability that would be enhanced by AI pattern recognition to strike moving naval vessels.[90]

As hypersonic glide vehicles (HGVs) are incorporated into China's dual-capable missile fleet, the chances of incorporating AI for manoeuvrability, autonomous control and counter-intercept increase exponentially. For example, China's Air Force Early Warning Academy has reportedly worked on integrating AI to predict the course of HGVs.[91] The DF-27 ICBM has also been listed as carrying a HGV, making it a prime candidate for AI enhancement.[92] In August 2021 China tested a HGV mounted on a fractional orbital bombardment system (FOBS), which flew through low-orbit space before cruising towards its target for ostensibly nuclear missions.[93] China's DF-ZF HGV can be used for conventional or nuclear payloads and has reportedly been deployed on the DF-17 and DF-21 MRBMs, and may be eligible for the DF-11 and DF-15 SRBMs.[94]

Decision making and situational awareness

Throughout China's military enterprise, C4ISR occupies a significant portion of China's AI applications.[95] Much of this can be applied to nuclear planning, surveillance, deployment, decision making and response. As early as 2015, the China Aerospace Science and

[88] For a breakdown of specific AI functions and categories in the nuclear and nuclear-related arena see Lin, 'AI and the US nuclear weapon enterprise' (note 65); and Boulanin et al. (note 1).

[89] Kristensen, H. M. et al., 'Chinese nuclear weapons, 2025', Nuclear Notebook report, *Bulletin of the Atomic Scientists*, 12 Mar. 2025.

[90] Missile Threat (CSIS Missile Defense Project), 'DF-26', *Missiles of the World*, 23 Apr. 2024.

[91] Chen, S., 'Chinese researchers say they have developed AI to predict course of hypersonic missiles', *South China Morning Post*, 1 June 2022.

[92] Sevastopulo, D. and Hille, K., 'China tests new space capability with hypersonic missile', *Financial Times*, 16 Oct. 2021.

[93] Missile Defense Advocacy Alliance (MDAA), 'DF-27', *Missile Threat and Proliferation*, Apr. 2023.

[94] MDAA, 'DF-ZF hypersonic glide vehicle', *Missile Threat and Proliferation*, 13 Jan. 2023; and 张广胜, 田玲 [Zhang G. and Tian L.], '生成式AI如何影响未来战争' [How generative AI will impact future warfare], 国防部网 [Ministry of National Defense Network], 中国军网 [China Military Network], 18 Apr. 2023.

[95] 王若影, 邱晨辉 [Wang R. and Qiu C.], '当导弹遇上人工智能' [When missiles meet artificial intelligence], 中国青年报 [*China Youth Daily*], 23 Apr. 2018; and 李奇, 秦大国, 王军 [Li Q., Qin D. and Wang J.], '人工智能在空天防御中的应

Industry Corporation (CASIC) began work on target detection and recognition based on deep learning, deep neural network compression and smart sensors to combine data from multiple radars.[96] In November 2020 the PLA Strategic Support Force (PLASSF) reportedly awarded a contract for an AI-based cyber threat sensing and early warning platform to EverSec, which serves as a Cybersecurity Emergency Service Support Unit for China's National Computer Network Emergency Response Technical Team/Coordination Centre.[97]

The PLA Ground Force has also awarded a contract to 4Paradigm, which advertises the Sage HyperCycle, an automated ML platform for decision making and modelling, and two contracts for 'foreign military equipment intelligent document data resources'.[98] A PLASSF unit has ordered a multilingual intelligent text-processing system from Nanjing Glaucus-Tech.[99]

China's Julang-2 (JL-2) and JL-3 submarine-launched ballistic missiles do not feature in its AI-related discussions, but its Hong-6N (H-6N) and H-20 bombers may have some level of AI inclusion in terms of automated decision aids, accelerated decision making in time-sensitive situations like air and missile defence, and enhanced situational awareness by processing and fusing data from various sensors. Given that the H-20 is a stealth bomber, AI inclusion could also improve its effectiveness in signature management and reduction.[100]

Simulation and modelling

Much of the open-source discussion in China focuses on civil nuclear applications within its own National Nuclear Safety Administration (China's NNSA), the China Atomic Energy Authority, the China National Nuclear Corporation (CNNC), the China Nuclear Energy Association (CNEA), the Chinese Nuclear Society, and even data service providers like GDS Holdings.[101] The CNNC provides guidelines for integrated development of AI and nuclear technology, and China's NNSA features scientific reports on AI in nuclear engineering, but both agencies tend to make generalized references to big data, cloud computing, the internet of things and digital twin technology,

用分析' [Analysis on the application of artificial intelligence in air and space defense], 国防科技 [*National Defence Technology*], vol. 41, no. 2 (Apr. 2020).

[96] 王若影, 邱晨辉 [Wang and Qiu] (note 95).

[97] Fedasiuk, R., Melot, J. and Murphy, B., 'Harnessed lightning: How the Chinese military is adopting artificial intelligence', Center for Security and Emerging Technology (CSET), Oct. 2021; and EverSec, Website page captured 2 July 2021, Perma.cc.

[98] Fedasiuk, Melot and Murphy (note 97), p. 19; and 4Paradigm, '4Paradigm Sage HyperCycle: An automatic machine learning platform', [n.d.].

[99] Fedasiuk, Melot and Murphy (note 97), p. 19.

[100] Larson, C., 'China's new H-20 bomber has a message for the US Air Force', *19FortyFive*, 3 May 2025.

[101] 经济日报 [Economic Times], '人工智能助核科技安全高效' [Artificial intelligence helps nuclear technology be safe and efficient], 国家核安全局 [National Nuclear Safety Administration], 14 Nov. 2019; 中核集团 [China National Nuclear Corporation (CNNC)], '最强大脑！中核这个工地有"智慧"' [The most powerful brain! This construction site of CNNC has 'wisdom'], 国家原子能机构 [China Atomic Energy Authority], 12 Apr. 2023; 中国核工业报 [China Nuclear Industry News], '当人工智能与核结合' [When AI and nuclear combine], 中国核能行业协会 [China Nuclear Energy Association], 18 July 2024; 中国核工业集团有限公司 [CNNC], '国内首个核领域数字生产力平台"龙吟万界"发布!' [The first digital productivity platform in the nuclear field in China, 'Longyin Wanjie', was released!], 13 Mar. 2024; '中国核电(601985.SH):核睿AI平台成功接入DeepSeek大模型' [CNNC (601985.SH): Herui AI platform successfully connected to DeepSeek big model], 新浪财经 [Sina Finance], 2 Apr. 2025; 中国核学会 [Chinese Nuclear Society], '中国核学会数字化与人工智能分会第二次会员代表大会暨第二届理事会第一次会议、常务理事会第一次会议召开' [The second member representative conference of the Digitalization and Artificial Intelligence Branch of the Chinese Nuclear Society and the first meeting of the second council and the first meeting of the executive council were held], 9 Dec. 2024; and 中国核工业集团有限公司 科创局 [CNNC, Science and Technology Innovation Bureau], '中核集团:加快数字化转型 推动核工业高质量发展' [CNNC: Accelerate digital transformation and promote high-quality development of the nuclear industry], 国务院国有资产监督管理委员会 [State-owned Assets Supervision and Administration Commission of the State Council (SASAC)], 4 Feb. 2021.

rather than specific nuclear integration.[102] Even technical reports provide overviews of categories rather than concrete AI applications.[103] Yet these reports feature data on AI uses in nuclear facility maintenance, performance, predictive analysis, monitoring, simulations, modelling, optimization and safety that could be interpreted as dual use. Such competitions as the 'Xinghe Cup' Nuclear Energy Artificial Intelligence Application Skills Competition in Shanghai indicate that work on AI applications in nuclear facilities is underway.[104]

Facilities with pronounced nuclear force functions are also undertaking AI-related research, including many collaborative projects.[105] For example, the Chinese Academy of Engineering Physics (CAEP) has published AI research on generative AI, neural networks for 3D holographic particle field imaging, chemical materials research, deep learning in debris cloud simulation, and held events on AI-driven research in fields such as materials science.[106] Beyond collaboration with CAEP, Tsinghua University's Department of Engineering Physics held the large-scale AI Empowers Nuclear Disciplines Co-construction and Development Forum in 2025 and has been building an AI centre within the Beijing Yanqi Lake Institute of Applied Mathematics.[107]

In addition, several commercial initiatives are focused on wargaming and other training applications. For example, Chinese technology company DataExa is a PLA

[102] See e.g. 中国核工业集团有限公司 科创局 [CNNC, Science and Technology Innovation Bureau] (note 101); 谭思超 [Tan S.] et al., '关于人工智能在核能领域应用的若干思考' [Thoughts on the application of artificial intelligence in the nuclear energy field], 核动力工程 [*Nuclear Power Engineering*], vol. 44, no. 2 (Apr. 2023); and 易鑫文, 谢芬, 冯荣健 [Yi X., Xie F. and Feng R.], '核工程中人工智能技术的应用展望' [Prospects for the application of artificial intelligence technology in nuclear engineering], 当代化工研究 [*Modern Chemical Research*], 8 Oct. 2024.

[103] See e.g. 中国核工业集团有限公司 [CNNC], '全国政协委员卢铁忠: 牢牢抓住"核能+人工智能"双向赋能机遇 推动核能产业高质量发展' [CPPCC member Lu Tiezhong: Seize the opportunity of 'nuclear energy + artificial intelligence' to promote high-quality development of the nuclear energy industry], 聚焦政府工作报告 [Focus on the Government Work Report], 国务院国有资产监督管理委员会 [SASAC], 11 Mar. 2025; and 张恒 [Zhang H.] et al., '核电人工智能应用:现状、挑战和机遇' [Applications of artificial intelligence in nuclear power: Current status, challenges and opportunities], 核动力工程 [*Nuclear Power Engineering*], vol. 44, no. 1 (2023).

[104] 陆辉, 郭俞 [Lu H. and Guo Y.], '智领核能，创新未来！"星和杯"首届核能人工智能应用技能大赛圆满落幕' [Leading nuclear energy with intelligence, creating a new future! The first 'Xinghe Cup' nuclear energy artificial intelligence application skills competition came to a successful conclusion], 上海核工程研究设计院有限公司 [Shanghai Nuclear Engineering Research and Design Institute], 21 Oct. 2024.

[105] Facilities undertaking collaborative research include National Model Microelectronics College, Northeastern University, Tsinghua University, Xi'an Jiaotong University, East China Normal University, Sichuan University, Chengdu Science Center and Graduate School, Chengdu University of Technology, and the Second, Third, Fifth, Seventh, Eighth and Ninth Institutes of the Chinese Academy of Engineering Physics.

[106] '包立君副教授发表人工智能研究动态粒子场表征新成果' [Associate Professor Bao Lijun publishes new results in artificial intelligence research on dynamic particle field characterization], 电子科学与技术学院(国家示范性微电子学院) [School of Electronic Science and Engineering (National Microelectronics College)], 3 Mar. 2022; 徐勇 [Xu Y.], '从量子力学到材料发现:第一性原理遇见人工智能' [From quantum mechanics to materials discovery: First principles meet artificial intelligence], 百旺青年论坛第四期 [Fourth Session of the Baiwang Youth Forum], 中国工程物理研究院研究生院 [Graduate School of the China Academy of Engineering Physics (GSCAEP)], 4 Mar. 2025; 中国工程物理研究院 [China Academy of Engineering Physics], '招聘职位' [Recruitment positions], [n.d. (accessed 19 June 2025)]; 文永 [Wen Y.] et al., '基于深度学习的超高速碰撞碎片云模拟' [Application of deep learning in simulation of ultra-high speed collision debris clouds], 固体力学学报 [*Chinese Journal of Solid Mechanics*], vol. 41, no. 5 (2020); 中国工程物理研究院研究生院 [GSCAEP], ' "人工智能驱动的材料科学研究"研讨班成功在成都举办' [Artificial Intelligence–driven Materials Science Research seminar was successfully held in Chengdu], 新闻 [News], 31 Aug. 2023; and 成都理工大学 [Chengdu University of Technology], 数理学院 [School of Mathematics and Physics], '中国工程物理研究院成科中心下一代智能通信产业研究院杨波院长来我院开展科研合作与座谈交流' [Director Yang Bo from the Next Generation Intelligent Communication Industry Research Institute of Chengke Center of China Academy of Engineering Physics came to our institute to carry out scientific research cooperation and discussion], 学术动态 [Academic News], 28 June 2021.

[107] 清华大学 [Tsinghua University], 工程物理学院 [Department of Engineering Physics], 'AI赋能核学科共建发展论坛在清华大学举行' [AI-Empowered Nuclear Discipline Development Forum held at Tsinghua University], 新闻动态 [News & Events], 6 May 2025; and 清华大学 [Tsinghua University], 工程物理学院 [Department of Engineering Physics], '求真书院、工程物理系共探跨学科人才培养新路径' [Qiuzhen College and the Department of Engineering Physics jointly explore new paths for interdisciplinary talent training], 新闻动态 [News & Events], 28 Mar. 2025.

supplier that has created an AI-based wargaming simulator called AlphaWar.[108] A team from the PLA's Information Engineering University is reportedly using AI to conduct simulations in which the 'results assist human decision-making . . . and can be used to refine the machine's combat knowledge reserve and further improve its combat cognition level'.[109] Chinese firms are exploring ChatGPT-like applications, such as Baidu's Ernie Bot and iFlytek's Spark. PLASSF researchers have also tested an experimental military AI system on Ernie Bot and Spark to teach it 'more about facing unpredictable human enemies'.[110] The PLA is also using China's DeepSeek AI for non-combat support.[111] The PLA's focus is on seven military applications: human–machine interaction, decision making, network offensive and defensive warfare, cognitive domain, logistics, space domain and training.[112]

These efforts are significant in that there have been multiple studies and even wargames outside of China on the potential of LLMs to not only speed decision making, but also to contribute to conflict escalation or lead to nuclear use.[113] This research has shown that escalation, or even nuclear exchange, could occur if LLMs are integrated into NC3. The open-source data for training LLMs lacks historical case examples of the devastating consequences of nuclear launch and contains more literature on how escalation happens than on de-escalation, with the result that in rapid, high-pressure conflict scenarios, LLMs show a bias towards escalation rather than de-escalation.[114]

Remote sensing and analysis

A number of the PLA's AI-based contracts concern remote sensing and geospatial imagery analysis.[115] Throughout 2020 China Aerospace Science and Technology Corporation (CASC) institutes and PLASSF units placed orders for polarized surface detection, imagery analysis, distance measurement and multisource data fusion systems to be embedded in satellites.[116] In August 2020 the PLASSF awarded a contract for 'a geospatial information perception and intelligent analysis subsystem' to Beijing Uxsino Software.[117] CASC subsidiaries are also developing microsatellites with AI integration.[118] Among these, Shenzhen Aerospace Dongfanghong HIT Satellite 'advertises a constellation of 80 "intelligent autonomous operation and management" MV-1 microsatellites capable of "full color, multi-spectral, and hyperspectral imaging" at resolutions of 1 to 5 meters'.[119]

[108] DataExa, 'AlphaWar兵棋推演：虚拟硝烟中的AI指挥艺术与决胜智慧' [AlphaWar Wargame Simulation: The AI art of command and decisive wisdom in virtual gunfire], 13 Mar. 2020.

[109] McFadden, C., 'China train AI-general to predict "enemy humans" on the battlefield', Interesting Engineering, 14 Jan. 2024.

[110] Chen, S., 'China's military lab AI connects to commercial large language models for the first time to learn more about humans', *South China Morning Post*, 12 Jan. 2024.

[111] Wang, A., 'China's PLA is using DeepSeek AI for non-combat support. Will actual combat be next?', *South China Morning Post*, 23 Mar. 2025; and Hu X., 'ChatGPT, 我们该怎么看?' [ChatGPT, how should we view it?], 国防部网 [Ministry of National Defense Network], 中国军网 [China Military Network], 21 Mar. 2023.

[112] Baughman, J., 'China's ChatGPT war', CASI, 21 Aug. 2023.

[113] Rivera, J.-P. et al., 'Escalation risks from language models in military and diplomatic decision-making', *FaccT '24: Proceedings of the 2024 ACM Conference on Fairness, Accountability, and Transparency* (ACM: 5 June 2024); and Chew, A. and Hemrajani, A., 'Will AI enhance decision-making in the use of nuclear weapons?', S. Rajaratnam School of International Studies (RSIS) Commentary No. 068, 2 Apr. 2025.

[114] Chew and Hemrajani (note 113), pp. 2–3; and Rivera et al. (note 113), pp. 837, 840, 844.

[115] US Defense Intelligence Agency (DIA), *Challenges to Security in Space* (DIA: Washington, DC, Jan. 2019), pp. 19–20.

[116] Fedasiuk, Melot and Murphy (note 97), p. 17.

[117] Fedasiuk, Melot and Murphy (note 97), p. 17–18; and 张忆楠 [Zhang Y.], '国产数据库发展与优炫软件实践' [Development of domestic databases and implementation of Uxsino software], OSG China, 29 Mar. 2021.

[118] Qin Y., 'The development and application of remote sensing micro-satellite', Paper presented at the United Nations/Brazil Symposium on Basic Space Technology, Natal, Brazil, 11–14 Sep. 2018; and 张忆楠 [Zhang] (note 117).

[119] Fedasiuk, Melot and Murphy (note 97), p. 18.

In August 2020 the PLA Academy of Military Sciences awarded a contract for 'intelligent satellite simulation software' to Hunan Gaozhi Technology, and CASC institutes signed contracts for an 'on-orbit satellite data acquisition and prediction subsystem', and for 'intelligent or automatic inclination adjustment, high-precision attitude determination, and small satellite positioning systems'.[120] In April 2022 China equipped its Jilin-1 commercial Earth observation satellite with AI, achieving a 95 per cent precision rate in identifying small objects.[121] In May 2022 a Chinese AI-powered satellite tracked the *USS Harry S. Truman* aircraft carrier, while in May 2024 details also emerged of China's Taijing-4 03 radar imaging satellite capturing images of Naval Station Norfolk in the USA.[122] The Taijing-4 03 is believed to be part of a five-satellite constellation equipped with synthetic aperture radar and AI processors for rapid identification of targets.

Autonomy and swarm

Chinese experts have been working on bee colony algorithms and swarm technologies for well over a decade, relying on autonomy as a means of achieving coordinated guidance control of adjacent space platforms, including 'cooperative guidance and control of hypersonic vehicle autonomous formation'.[123] In the air, China possesses and exports a vast array of uncrewed systems that could have impacts on nuclear forces in terms of surveillance, disruption or even attack, depending on payload and mission. For example, the stealth Changying BZK-005—a medium, high-altitude, long-range, reconnaissance uncrewed aerial vehicle (UAV)—has conducted patrol flights in the East China Sea.[124] The Tianying TYW1 UAV, based on the BZK-005, began production in November 2017. In 2020 multiple PLA units and CASC institutes awarded contracts for UAV clusters and subsystems used in swarms, including 'self-organizing UAV communications systems, group node management and control software, AI-based radar coincidence imaging, and collision avoidance sensors'.[125]

In 2020 the Shenyang Institute of Automation of the Chinese Academy of Sciences was awarded contracts to supply a '3D intelligent collision avoidance system' for the CASC and AI-enabled 'self-flying machinery' for the PLA Air Force.[126] Several Chinese universities have also conducted swarm-related research, including Beihang University, Nanjing University of Aeronautics and Astronautics, and Zhejiang University's Institute of UAV System and Control Technology, with studies on contesting and jamming US military swarms.[127] China also has a test model of the Hongdu GJ-11 uncrewed combat aerial vehicle (UCAV), in which AI can enhance signature management, autonomous operations and situational awareness.[128] The Changjian CJ-10 is a subsonic land-attack cruise missile, which is purportedly dual-capable and potentially incorporates

[120] Fedasiuk, Melot and Murphy (note 97), p. 17.

[121] Honrada, G., 'China's AI makes its satellites spies in the sky', *Asia Times*, 11 Apr. 2022.

[122] Honrada (note 121).

[123] Qiang X. and Duan H., 'Aerodynamic parameter identification of hypersonic vehicle via Pigeon-inspired optimization', *Aircraft Engineering and Aerospace Technology*, vol. 89, no. 3 (2 May 2017). For more examples see Saalman, L., 'China's artificial intelligence–enabled offense: Hypersonic glide vehicles and neural networks', ed. N. D. Wright, *AI, China, Russia, and the Global Order: Technological, Political, Global, and Creative Perspectives* (Air University Press: Maxwell AFB, AL, 2019).

[124] Li, J., 'Artificial intelligence technology and China's defense system', *Journal of Indo-Pacific Affairs*, Mar.–Apr. 2022.

[125] Fedasiuk, Melot and Murphy (note 97), p. 15.

[126] Fedasiuk, Melot and Murphy (note 97), p. 15.

[127] See e.g. 罗海龙, 武剑, 王新 [Luo H., Wu J. and Wang X.], '无人机蜂群作战的几点思考' [Some thoughts on UAV swarm warfare], 军民两用技术与产品 [*Dual Use Technologies and Products*], no. 429 (July 2019); and Zhejiang University, School of Aeronautics and Astronautics, 'Institute of Unmanned Aerial Vehicle System and Control Technology', [n.d.].

[128] Satam, P., 'China's GJ-11 Sharp Sword UCAV captured flying', *The Aviationist*, 25 Aug. 2024.

AI to enhance its manoeuvrability, targeting and stealth.[129] The high-altitude Jiutian SS-UAV is believed to integrate 'cutting-edge technologies like quantum-encrypted communications, hydrogen propulsion, AI swarm control, and supermaterial stealth design' to deploy multiple small UAVs or missiles.[130]

At sea, the state-owned China Shipbuilding Industry Corporation has developed JARI, a multi-purpose uncrewed surface vessel (USV) designed for use by the PLA Navy (PLAN) and also intended for export as a warship.[131] It has also unveiled a prototype for the 'world's first' uncrewed, armed amphibious combat vessel, purportedly capable of autonomous navigation.[132] In 2020 the PLASSF placed orders for autonomous underwater vehicles (AUVs) from Xi'an Tianhe Defense Technology, which is emerging as a 'national champion' in uncrewed underwater vehicles (UUVs).[133] Chinese suppliers are also developing small- and medium-sized AUVs, including the ZF-01, which 'can apparently dive to 100 meters with a towed sonar array'.[134] In July 2020 the PLAN awarded an ocean mapping contract to StarTest Marine, which offers such products as the GeoSide1400, 'a side-scanning UUV . . . that could be used to detect [an adversary's] undersea forces in a crisis'.[135] The Shenyang Institute of Automation has also confirmed its researchers are developing extra-large UUVs.[136] Some suggest that these AUVs and UUVs may be part of China's alleged pursuit of an 'Underwater Great Wall' to gather intelligence, deploy mines and engage in anti-submarine warfare, with plans to station them at chokepoints to work with crewed vessels in drawing fire, exposing adversaries' positions and even ramming targets.[137]

India

Manufacturing and management

Official sources on India's AI integration into nuclear systems tend to concentrate on civil nuclear plants or theoretical applications.[138] Even when the Indian government releases information on nuclear security, the documents rarely mention AI applications.[139] Still, there are indications of AI applications within India's nuclear force production. In February 2025 the Director of India's Defence Research and Development Laboratory stated that the laboratory is using AI to streamline missile production, including its Agni, Prithvi and Akash missile variants that are used to carry

[129] MDAA, 'DH-10 / CJ-10', *Missile Threat and Proliferation*, Jan. 2023.

[130] 'China's Jiutian SS-UAV spooks US, challenges its air superiority, but can it outfly latest air defenses?', *Economic Times*, 18 May 2025; CCTV 13, '什么？中国"空中无人机航母"真的要起飞了？"九天"无人机最新消息发布:即将首飞!' [What? Is China's 'air drone carrier' really going to take off? The latest news about the 'Jiutian' drone is released: It will take its first flight soon!], 军迷天下 [Military Enthusiast World], YouTube, 19 May 2025.

[131] Army Recognition Group, 'AAD 2018: China's CSOC unveils "JARI" unmanned surface combatant—USV', *Global Defense News*, 23 Sep. 2018.

[132] 'CSIC develops world's first armed amphibious drone attack boat', *Maritime Executive*, 15 Apr. 2019.

[133] 中国海博会 [China Marine Economy Expo], '西安天和防务蓄势待发 助力2017中国海洋经济博览会' [Xi'an Tianhe Defense is ready to support the 2017 China Marine Economy Expo], 搜狐 [Sohu], 29 Nov. 2017.

[134] Fedasiuk, Melot and Murphy (note 97), p. 16; and YouUAV.com, 'KHI 管道检测 AUV' [KHI Pipeline Inspection AUV], 8 June 2019.

[135] Fedasiuk, Melot and Murphy (note 97), p. 18; and StarTest Marine, 'GeoSide 1400 高分辨率侧扫声呐' [GeoSide1400 high resolution side-scan sonar], Product manual, [n.d.].

[136] Chen, S., 'China military develops robotic submarines to launch a new era of sea power', *South China Morning Post*, 22 July 2018; Glass, P., 'China's robot subs will lean heavily on AI: Report', *Defense One*, 23 July 2018; and Sutton, H. I., 'China's new extra-large submarine drones revealed', *Naval News*, 16 Sep. 2022.

[137] Wong, C., ' "Underwater Great Wall": Chinese firm proposes building network of submarine detectors to boost nation's defence', *South China Morning Post*, 19 May 2016; and Sutton (note 136).

[138] Raja, A., 'Analyzing AI applications in nuclear power plants', IndiaAI, 4 July 2023; and Raja, A., 'Here is how AI accelerates nuclear science applications', IndiaAI, 29 Sep. 2022.

[139] See e.g. Indian Ministry of External Affairs, 'Nuclear security in India', [n.d.].

nuclear warheads.[140] From conceptual design to final assembly, AI algorithms can analyse datasets that include material properties, aerodynamic models and propulsion dynamics to predict performance, identify flaws and suggest improvements in real time. Precision manufacturing has enabled the integration of new sensors, propulsion and warhead upgrades that can be applied to hypersonic platforms.

AI has been known to aid in missile lifecycle management and adaptability upgrades from inertial navigation to laser-guided systems, and to circumvent such countermeasures as electronic jamming and uncrewed systems. The Agni-V ICBM and potentially the Agni-VI ICBM and Agni-P MRBM are to be equipped with multiple independently targetable re-entry vehicles (MIRVs).[141] While MIRVs are not thought to employ AI, such advancements are being integrated into missile systems to enhance capabilities like target selection, manoeuvring and defence. Still, discussion within India of AI integration into missile defence is limited to a few academic analyses that explore its potential.[142]

Imagery and reconnaissance

India possesses nuclear- and dual-capable platforms that appear to have some degree of AI integration. India's Rafale fighter jets are nuclear-capable and are listed among India's nuclear forces.[143] The Rafale F3-R, delivered between 2016 and 2022, includes the Thales' cortAIx accelerator that processes airborne imagery up to 100 times faster than previous models.[144] The level to which AI has been integrated in older aircraft such as the Mirage-2000 and the Jaguar IS remains unclear.[145] Nevertheless, France's upgrades of its own Mirage fleet with AI for enhanced targeting and tactical reconnaissance suggest that some AI may have been integrated into India's variants.[146]

In April 2025 India acquired 26 AI-enabled Rafale Marine (Rafale-M) aircraft that can be used to deliver nuclear bombs, bolstering its second-strike capability.[147] While the exact nature of this AI integration is unclear, it is likely being employed in enhancing tactical advice, survivability, data fusion and predictive maintenance. The Indian Navy is thought to be incorporating AI into its Integrated Platform Management System (IPMS) for its next-generation warships, including nuclear vessels.[148] IPMS is a comprehensive control and monitoring system that integrates various shipboard systems, including propulsion, electrical, auxiliary and damage control into a single, unified framework to provide real-time data, condition-based control and diagnostics.

[140] AFI, 'DRDO deploys AI for ballistic missile manufacturing', Indian Defence Research Wing, 6 Mar. 2025.

[141] Indian Ministry of Defence, 'DRDO successfully conducts Mission Divyastra: Indigenously developed Agni-5 missile makes maiden flight with MIRV', Press release, 11 Mar. 2024; and Shukla, A., 'New generation ballistic missile Agni Prime successfully test-fired', *Business Standard*, 4 Apr. 2024.

[142] Ghoshal, D., 'The application of artificial intelligence to missile defense: Scope for India?', *Revue Défense Nationale*, vol. 868, no. 3 (Mar. 2024).

[143] Kristensen, H. M. et al., 'Indian nuclear weapons, 2024', Nuclear Notebook report, *Bulletin of the Atomic Scientists*, 5 Sep. 2024.

[144] Bano, S., 'India's procurement of AI based weapons, challenges, and way forward for Pakistan', *South Asia Journal*, 13 June 2023; 'Air-Sol Moyenne Portee-Ameliore weapon system, France', Airforce Technology, 29 May 2024; and Charpentreau, C., 'Thales enhances Rafale reconnaissance with AI-driven Talios pod upgrade', Aero-Time, 29 Nov. 2024.

[145] 'HAL flies first FOC upgraded Mirage-2000 aircraft', Airforce Technology, 31 July 2016.

[146] Army Recognition Group, 'France quietly expands the fleet of upgraded Mirage 2000D RMV fighter jets as Ukraine's needs grow', *Global Defense News*, 31 Mar. 2025.

[147] Army Recognition Group, 'India and France officially sign $7.5 billion agreement for 26 Rafale Marine jets to modernize carrier strike capabilities', *Global Defense News*, 29 Apr. 2025; Sagar, P., 'Indian Navy poised to rule with Rafale Marines', *India Today*, 28 Apr. 2025.

[148] Pant, H. V. and Bommakanti, K., 'Towards the integration of emerging technologies in India's Armed Forces', Observer Research Foundation Occasional Paper No. 392, 24 Feb. 2023.

Predictive analytics and modelling

India has made strides in AI-enabled data processing in facial and voice recognition, threat pattern evaluation and predictive analytics, as well as in LLMs, all of which could have applications in nuclear planning and deployments. India has also engaged in expanding semiconductor fabrication facilities with AI-related investments.[149] Semiconductors can be used in high-performance computing to model nuclear explosions and other complex processes, in development of advanced weapon systems with radiation-hardened chips for reliable performance in extreme conditions, in nuclear security with radiation detection systems, and in ion implantation studies that simulate nuclear damage in materials.[150]

India reportedly has an interest in accelerating progress towards the realization of nuclear fusion by using expanding AI-based methods that maximize the amount and applicability of information extracted from experimental and simulation data.[151] If borne out, AI applications in nuclear fusion can contribute to such areas as (*a*) powering spacecraft and military vehicles; (*b*) conducting advanced weapons research and simulations as with inertial confinement fusion to simulate thermonuclear reactions for development and refinement of nuclear weapons; (*c*) enhancing tactical fusion power generators for military operations; (*d*) engaging in weapons stockpile management; and (*e*) creating intense neutron beams that can be used in radiation hardening of electronic components and materials.[152]

Autonomy and surveillance

India has worked to field a range of AI-enabled uncrewed systems in air, land, sea and space, with an overarching focus on addressing challenges to its borders. While nuclear missions have not been defined for India's UCAVs, its development of such platforms—such as the Ghatak, a stealthy, jet-powered UCAV being developed by the Indian Defence Research and Development Organisation (DRDO)—could contribute to conventional, and even nuclear, escalation.[153] Indrajaal from Grene Robotics is an AI-enabled autonomous system used to counter UAVs and thus safeguard critical facilities such as nuclear installations and oil rigs.[154] The DRDO's Centre for Artificial Intelligence and Robotics has also been developing the Multi Agent Robotics Framework, which would enable the Indian Army's battlefield robotic combat vehicles to collaborate on surveillance and reconnaissance, while developing special UAVs to detect contamination and radiation from CBRN threats.[155]

India also has projects on UUVs for potential undersea surveillance, including monitoring of nuclear vessels. Larsen & Toubro showcased three UUVs at the Indian defence expo in 2020, one with an endurance of eight hours and 'an operational depth of 1500 feet under the sea'.[156] India's state-run Mazagon Dock Shipbuilders is working

[149] 'India sets strategic path for AI growth with nuclear energy investments', *Economic Times*, 24 Feb. 2025.

[150] See Slyline Orbit, 'Silicon shield: Role of semiconductors in modern warfare', 17 July 2025.

[151] Raja, 'Here is how AI accelerates nuclear science applications' (note 138).

[152] See Arnold, P., 'New AI model advances fusion power research by predicting the success of experiments', Phys.org, 20 Aug. 2025; Rickey, T., 'Scientists investigate use of AI to speed analysis of nuclear materials', Pacific Northwest National Laboratory, 22 July 2025; and Hutterer, E., 'AI can help scientists get the nuclear data they need for vital simulations', Los Alamos National Laboratory, 31 Mar. 2025.

[153] Kunde R., News Beat and IDRW.org, 'ADE advances 13-Ton Ghatak UCAV development amid funding wait, builds on SWiFT-TD success', Indian Defence Research Wing, 21 Mar 2025.

[154] Army Recognition Group, 'Grene Robotics from India unveils Indrajaa first Indian AI-powered anti-drone system', *Global Defense News*, 4 Sep. 2023.

[155] Ray, T., 'Slow and steady: India's tentative steps into the AI race', *The Diplomat*, 14 July 2018; and Mahajan, N., 'Artificial intelligence and robotic soldiers will dominate the future battlefield', *Raksha Anirveda*, 14 Aug. 2022.

[156] Natarajan, S. G., 'Autonomous underwater vehicles—a force multiplier to India's maritime security', Defence Research and Studies, 6 Sep. 2023; and 'MATSYA 6000 joins the elite club of underwater vehicles', IndiaTIES,

on developing extra-large UUVs and autonomous underwater vehicles (AUVs) with swarming capabilities.[157] The DRDO is also contributing to UUV development with its uncrewed vehicles that operate both underwater and in the air, and are designed for launch from submarines for enhanced surveillance, decoy and potential conventional strike operations.[158] Given Indian concerns over China's and Pakistan's naval vessels traversing the Indian Ocean, such UUVs can play a role in both detection and even nuclear escalation if intentional or unintentional collision occurs.[159]

United States

Mission assurance and diagnostics

The USA issues prolific official and unofficial nuclear reports, many of which indicate areas in which AI may have been and is being integrated into US nuclear forces.[160] Among these, the US Air Force Nuclear Weapons Center lists the potential for AI integration into such systems as the very low frequency receiver, advanced beyond line-of-sight terminals, the global aircrew strategic network terminal, the NC3 weapon system (AN/USQ-225), presidential and national voice conferencing, acquisition intelligence, future concepts, mission assurance, nuclear certification and surety, and nuclear effects.[161]

More explicitly, the DOE's Los Alamos National Laboratory and Lawrence Berkeley National Laboratory are developing a new ML technique for compact particle accelerators that uses real-time data from accelerator diagnostics to continuously change the model and to guide an advanced generative AI diffusion. This process creates virtual views of accelerators' beams as they change over time and can be applied to large-scale accelerators such as FACET-II at the SLAC National Accelerator Laboratory.[162] These advances can benefit a variety of areas, including missile defence. Furthermore, the Genesis Mission within the NNSA supports its work through AI integration, including in nuclear fission and fusion.[163]

Maintenance and planning

There are no explicit mentions of AI applications on the UGM-133A Trident II D-5/LE, but it has a post-boost control system that manoeuvres the missile in flight to allow the celestial navigation subsystem to update its inertial system.[164] Similarly, the US LGM-30G Minuteman III ICBM is not programmed to learn or adapt in the same way as an AI system, even though it uses a sophisticated inertial navigation system and global pos-

29 Oct. 2021.

[157] Mazagon Dock Shipbuilders, 'AUV swarm drones', [n.d.]; and Indian Defence Analysis, 'MDL is planning to construct unmanned submarine—XLUUV | understanding XLUUV design and contenders', YouTube, 16 Apr. 2022.

[158] AFI, 'DRDO developing submarine-launched ULUAVs and underwater drone swarms to bost India's undersea warfare capabilities', Indian Defence Research Wing, 6 July 2025.

[159] Sagar, P., 'How India's submarine gap draws concern amidst face-off with Pakistan', *India Today*, 30 Apr. 2025; and Maqbool, R. and Sharma, A., 'India launches submarine, warships to counter China in Indian Ocean', *DefenseNews*, 15 Jan. 2025.

[160] See e.g. US Department of War, 'America's nuclear triad', [n.d.]; US DOE, NNSA, 'The US nuclear weapons stockpile', [n.d.]; Congressional Budget Office, 'Projected costs of US nuclear forces, 2025 to 2034', Apr. 2025; Fink, A. L., 'Defense primer: Strategic nuclear forces', Congressional Research Service In Focus no. IF10519, 15 Aug. 2025; and Kristensen, H. M. et al., 'Indian nuclear weapons, 2025', Nuclear Notebook report, *Bulletin of the Atomic Scientists*, 13 Jan. 2025.

[161] US Air Force Nuclear Weapons Center, 'Focus areas', [n.d.].

[162] US DOE, Office of Science, 'Adjusting accelerators with help from machine learning', 14 Nov. 2024.

[163] US DOE, NNSA (note 80); and White House (note 80).

[164] Keller, J., 'Lockheed Martin to build submarine-launched nuclear ballistic missiles with inertial and celestial guidance', *Military+Aerospace Electronics*, 11 Nov. 2024; and US DOD, 'Trident II (D-5) Sea-Launched Ballistic Missile UGM 133A (Trident II Missile)', Defense Acquisition Management Information Retrieval report, Dec. 2019.

itioning system updates for guidance and navigation.[165] However, there are indications that the B-52H Stratofortress employs AI to enhance various aspects of its operation, including maintenance, intelligence-gathering, decision making and communications. Due to similar requisite capabilities, such advances are likely also employed with the B-2A Spirit.[166]

These AI applications include (*a*) integration of the Supporting Engagement with Maintenance Personnel (SEMPRE) transportable unit that is hardened against electromagnetic pulses and combines a 5G cellular network, decentralized hybrid cloud and satellite gateway in remote and contested environments; (*b*) use of uncrewed vehicles, like those provided by Skydio and Near Earth Autonomy, to collect surface data on the B-52, improving maintenance efficiency and safety; (*c*) analysis of data to optimize various aspects of the B-52's operation, such as mission planning and resource allocation; and (*d*) integration into the B-52 Quad Crew Program to 'streamline operations' and to improve the bomber's functionality.[167] In 2023 the US Air Force announced plans to equip B-52s with AgilePods—modular systems that can be adapted for various missions and that incorporate AI-driven sensor payloads, as well as advanced radar and communication systems.[168]

Predictive analytics and testing

The F-35 Joint Strike Fighter Program Office has selected the C3 AI platform to develop and deploy predictive analytics applications to improve the mission capability and aircraft readiness of the F-35 Lightning II.[169] The office has established a joint Centre of Excellence with C3 AI, comprising an executive steering committee and a standardized training curriculum for over 1000 developers and data scientists.

The US Air Force is also implementing AI projects focused on testing combat systems. The 96th Test Wing at Eglin Air Force Base has led collaborative efforts as part of the Autonomy Data and Artificial Intelligence Experimentation proving ground, a joint venture between AFWERX and the CDAO.[170] This work has included the Viper Experimentation and Next-gen Ops Models (VENOM) under which Eglin F-16s will be modified into airborne flying test beds to evaluate increasingly autonomous strike package capabilities. The Fast Open X-Platform (FOX) project seeks 'to establish an open software enclave to install apps directly onto aircraft without altering proprietary source code', enabling real-time data analysis, threat replication for training, crewed–uncrewed teaming and ML.[171]

Stockpile management and security

AI can also be applied in nuclear stockpile research and development, predictive maintenance, pattern monitoring, strategic planning and deployment. AI already augments key aspects of the US NNSA's mission of maintaining the safety, security and reliability of the nuclear stockpile through modelling and simulations; transforming the nuclear weapons lifecycle from the discovery of new materials to design optimization, manu-

[165] US Air Force, 'LGM-30G Minuteman III', Fact sheet, Feb. 2019.

[166] US Air Force, 'B-2 Spirit', Fact sheet, Dec. 2015.

[167] Daigle, T., '307th Bomb Wing jets get innovative treatment', Air Force Global Strike Command, 24 July 2024; and Taylor, D., 'B-52 modernization to be spearheaded by L3Harris for US Air Force', Military Embedded Systems, 7 June 2024.

[168] Jacobs, N., 'AgilePod demo expands B-52 communications', US Air Force Global Strike Command, 11 May 2023.

[169] C3 AI, 'Improving F-35 mission capability with the C3 AI platform', [n.d.].

[170] Lowell, N., 'Eglin Air Force Base unit leads AI technology testing program', Potomac Officers Club, 8 Mar. 2023; and US Air Force Materiel Command, 'Eglin steps up as proving ground for digital modernization effort', News, 7 Mar. 2023.

[171] US Air Force Materiel Command (note 170).

facturing and ongoing surveillance; and enhancing non-proliferation through detecting and characterizing illicit nuclear activities worldwide with the analysis of vast quantities of data from diverse sources.[172]

In January 2025 OpenAI announced that up to 15 000 scientists at the US National Laboratories will be using its latest AI models, including the reasoning-focused o1 series, for scientific research and nuclear weapons security.[173] OpenAI will also work with Microsoft to deploy one of its AI models on the Los Alamos National Laboratory supercomputer, Venado. The new partnership includes work on nuclear weapons 'focused on reducing the risk of nuclear war and securing nuclear materials and weapons worldwide' through OpenAI researchers with security clearances.[174]

Autonomy and testing

The USA has made breakthroughs in developing AI agents and testing uncrewed systems that can be deployed in tandem with and in support of nuclear platforms. AI agents developed by the Autonomous Air Combat Operations team from the Air Force Research Laboratory have piloted the Kratos XQ-58A Valkyrie, an experimental UCAV that has flown in formation with the nuclear-capable F-15E Strike Eagle.[175] In May 2024 US Air Force Secretary Frank Kendall rode in the AI-piloted X-62 VISTA—a modified F-16D Fighting Falcon—'reaching speeds exceeding 550 miles per hour and coming within 1,000 feet of a second, human-controlled F-16 to test the AI's proficiency with aerial dogfighting'.[176]

The X-62 VISTA also reportedly provides a test bed for integrating AI into kinetic systems.[177] From a nuclear standpoint, this is significant since the X-62 'was originally used to test what would become the precursor to the F-22 Raptor's thrust vectoring capability', both of which are technically nuclear-capable platforms.[178] The VENOM-AFT will integrate AI, ML and autonomous systems into modified F-16 platforms, allowing an onboard pilot to monitor and govern the autonomous systems during testing, which the 85th Test and Evaluation Squadron Commander, Lieutenant Colonel Joe Gagnon, describes as 'human-on-the-loop' operational testing.[179] These tests indicate that uncrewed systems, even if not nuclear-armed, are being developed and tested in coordination with nuclear platforms and even potentially for future nuclear missions.

[172] US DOE, 'Artificial intelligence for national security', [n.d.].

[173] Field, H., 'OpenAI partners with US National Laboratories on scientific research, nuclear weapons security', NBC News, 30 Jan. 2025.

[174] Field (note 173).

[175] F-35 Lightning II, 'Future fighters: Pilots, planes and AI', US Air Force, 10 Dec. 2024; US Air Force Research Laboratory, 'AI agents pilot XQ-58A Valkyrie', [n.d.].

[176] Harpley, U. L., 'Photos: Air Force Secretary flies in an AI-piloted F-16, a "significant step" for CCA', *Air & Space Forces Magazine*, 6 May 2024.

[177] Eddins, J. M., 'The United States Air Force's focus on AI research and development', *Airman Magazine*, 21 May 2024.

[178] Eddins (note 177).

[179] Eddins (note 177).

4. Conclusions

Surveys of China, India and the USA indicate that the impact of AI integration on nuclear postures, norms and systems has received the greatest official attention within the USA and China, with the latter trailing behind on official coverage. While these two countries jointly affirmed the importance of human control in 2024, their different levels of NC3 transparency make it difficult to evaluate the stages of nuclear decision making at which this would apply. Moreover, recent changes to official documentation issued by both countries indicate that these postures may be shifting.

In the USA, despite its greater official clarity on its NC3 structure and distinction between its posture on 'human judgement' in conventional systems and 'human control' in nuclear systems, there remains an academic debate over the application of 'meaningful control'. Such US debates are further complicated by AI-enabled dual-capable systems—conventional and nuclear—that are present in both the USA and China. With new executive orders and sea changes in official documents released from one US administration to the next, such AI-related postures are in flux, complicating longer-term norm formation. As the USA pursues AI competitiveness, its willingness to constrain or limit its advances through arms control, whether in the nuclear or other arenas, also remains in question.

China tends to be more consistent in its official declarations, but its expansive nuclear modernization and rapid AI advances suggest that it is also undergoing significant shifts. The level to which Chinese officials recognize, much less debate, distinctions between AI applications in conventional versus nuclear systems remains unclear. Despite Xi's November 2024 affirmation of the need to maintain human control over the decision to use nuclear weapons, China's return to the formulation of human control of 'relevant weapon systems' in its November 2025 white paper suggests an ongoing lack of clarity. Given China's applications of AI in HGVs mounted on both missiles and FOBS—alongside conventional UAVs, UUVs and UCAVs in air, land, sea and space that can complicate, obstruct or even destroy nuclear operations and deployments—the areas in which humans are able to exercise judgement, much less control, becomes even less apparent.[180]

In India, despite its sizeable nuclear arsenal and ongoing AI developments, its AI task forces and envoys have often explicitly eschewed discussing nuclear issues, resulting in a significant imbalance among the three countries in official information released on AI integration into nuclear postures and norms.[181] India has been active on AI governance within the GPAI and the UN but its omission of nuclear systems in its discussion of human control—combined with its exclusion of 'uncrewed vehicles' and systems in which humans are 'in the loop' or 'on the loop' in its AWS definition—suggests a narrow formulation of AI applications. This makes it difficult to evaluate India's commonalities with the USA and China on AI-related nuclear restraint.

Despite these differences, secondary sources from China, India and the USA offer a sizeable amount of information on their nuclear- and nuclear-related systems, enabling a greater degree of symmetric transparency. These technical, media and industry reports elucidate a select set of AI-enabled functions integrated into nuclear- and nuclear-related systems—such as precision guidance, manoeuvrability, decision making, situational awareness, simulation, modelling, remote sensing, autonomy, swarm, reconnaissance, surveillance, predictive analytics, diagnostics, planning,

[180] See Dahlgren, M. and MacKenzie, L., 'Ukraine's drone swarms are destroying Russian nuclear bombers. What happens now?' Center for Strategic and International Studies, 4 June 2025; Boulanin et al. (note 1); and Saalman, L., 'Fear of false negatives: AI and China's nuclear posture', *Bulletin of the Atomic Scientists*, 24 Apr. 2018.

[181] See Saalman, 'China and India: Two models for AI military acquisition and integration' (note 33).

stockpile management, security and testing. In the absence of postural clarity, this specificity and comparability is crucial in better understanding the points at which all three countries may be applying 'meaningful control', 'human judgement' and 'human control' across their nuclear and nuclear-related systems.

In sum, the above profiles on AI integration into nuclear postures, norms and systems in China, India and the USA—when focused on their integration of AI-enabled functions into their nuclear- and nuclear-related systems—can provide a more targeted and comparable foundation for further engagement and future confidence-building measures.

About the author

Dr Lora Saalman is an Associate Senior Fellow within SIPRI's Armament and Disarmament and Conflict, Peace and Security research areas. She also serves as a member of the Committee on International Security and Arms Control. Her research focuses on China's cyber, nuclear and advanced conventional weapon developments in relation to India, Russia and the United States.

STOCKHOLM INTERNATIONAL PEACE RESEARCH INSTITUTE
Signalistgatan 9
SE-169 72 Solna, Sweden
Telephone: +46 8 655 97 00
Email: sipri@sipri.org
Internet: www.sipri.org

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