Global Challenges Foundation

Weapons of Mass Destruction

BY WILFRED WAN*

Mounting geopolitical tensions and rapid technological advances are eroding long-standing safeguards against weapons of mass destruction. As global regimes falter and enforcement weakens, the world faces growing risks of proliferation, misuse, and strategic instability. Understanding these shifts is essential for strengthening governance and preventing catastrophic escalation in an increasingly volatile security landscape.

What is the risk?

Hostile geopolitical relations and the deteriorated strategic context are eroding the structures that govern the world's most destructive capabilities. The decades-old regimes that are meant to curb the spread of weapons of mass destruction (WMD) — mainly, the Nuclear Non-Proliferation Treaty (NPT), the Biological Weapons Convention and the Chemical Weapons Convention — face myriad challenges. Tensions among key players are hindering compliance and enforcement efforts and undermining institutional structures. All of this is being exacerbated by rapid technological developments that can lower barriers to WMD access, delivery and use. Global governance of WMD is at a crossroads.

What is at stake?

While chemical and biological weapons are prohibited under international law, the normative barrier against their use shows signs of strain. Widespread and repeated chemical weapon use was seen in the Syrian Civil War by both government and opposition forces, despite global condemnation. Governance of chemical and biological weapons has been further undermined by years of deadlock between permanent members of the UN Security Council and the inability of the Organisation for the Prohibition of Chemical Weapons (OPCW) and the UN Security Council to investigate, attribute or hold guilty parties accountable in a timely manner. In a separate case, the OPCW has found evidence of repeated use of riot control agents in the war in Ukraine[1]. Dutch and German intelligence agencies also claim that Russia is increasingly using a wide spectrum of chemical weapons in that context.

A particular challenge in the chemical and biological space is the changing nature of threat. Scientific research in these fields is critical to global health and sustainable development, as seen in the response to the COVID-19 outbreak. Yet the pace of technological advances and the wider availability of dual-use tools, materials and expertise increase the risk of mistakes and deliberate misuse. Governance frameworks that rely on national implementation and slow diplomatic negotiation are poorly matched to fast, decentralised innovation cycles. Without updated risk management tools, today's treaty regimes will complicate detection and continue to fall behind the

The *Global Catastrophic Risks Report* by the Global Challenges Foundation is a publication that analyses the greatest threats to humanity's future. The purpose of the report is to raise awareness of these dangers and to encourage international cooperation to prevent them. It also highlights the need for stronger global institutions and innovative governance models to effectively address these complex challenges.

Read the full report here.

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technologies they aim to govern. It remains to be seen whether common interest in tackling the shifting threat landscape can overcome geopolitical hurdles.

What is being done to govern this risk and where are there gaps?

There is unfortunately little indication that states can disentangle nuclear issues from the broader strategic context. Russia justified its suspension of the bilateral New Strategic Arms Reduction Treaty (New START) by referring to the United States' desire to inflict strategic defeat on Russia; it has consistently used nuclear coercion to shape the conflict in Ukraine.[2] China cited US arms sales to Taiwan in breaking off arms control dialogue.[3] Experts believe that the global nuclear stockpile — an estimated 12,241 nuclear weapons with Russia and the US holding over 90 per cent of them — is on the verge of rising.[4] Barring an extension of New START before February 2026, there will soon be no limits on the world's two largest nuclear arsenals. Extensive nuclear modernisation programmes being undertaken by nearly all of the nine nuclear-armed states underscores the potential for uninhibited arms racing.

Adherence to non-proliferation principles also appears under threat. Recent developments suggest a growing willingness among states to sidestep established norms and mechanisms of restraint, as military action, new defence alignments and shifting security doctrines take precedence over diplomatic engagement. Israeli and US attacks against Iranian nuclear facilities were condemned by UN procedures experts as a violation of international legal and normative frameworks.[5] Saudi Arabia signed a mutual defence pact with Pakistan, also a non-NPT nuclear-armed state, that in their view "encompasses all military means".[6] In response to the war in Ukraine, some states are not only calling for the expansion of extended deterrence arrangements, but even revisiting the question of acquiring independent nuclear capabilities. Prospects for a constructive 2026 NPT Review Conference appear bleak as nuclear-armed and nuclear-allied states continue to shun the 2017 Treaty on the Prohibition of Nuclear Weapons.

Recognition of these trends has driven multilateral attention on practical action to reduce the risk of nuclear weapon use. Existing efforts have focused on bolstering the crisis prevention and management toolkit as means to reestablish minimal levels of predictability and stability. These are essential steps. But the nuclear risk landscape itself is fundamentally changing because of the impact of emerging technologies and developments across domains and capabilities — both nuclear and conventional. Indeed it is because of these changes that some states have established a wider scope for nuclear use in their doctrines and security strategies. Only by navigating these developments can nuclear-armed states and other key actors properly reduce risk and begin to reinvigorate arms control and disarmament.

[1] Dutch Ministry of Defence, Russia further intensifies its use of chemical weapons in Ukraine, 4 July 2025. https://english.defensie.nl/latest/news/2025/07/04/russia-further-intensifies-its-use-of-chemical-weapons-in-ukraine

[2] Ministry of Foreign Affairs of the Russian Federation, Foreign Ministry statement, 21 February 2023. https://mid.ru/en/foreign_policy/news/1855184/

[3] Reuters, China says it has halted arms-control talks with US over Taiwan, 17 July 2024. https://www.reuters.com/world/china/china-says-it-has-halted-arms-control-talks-with-us-over-taiwan-2024-07-17/

[4] SIPRI Yearbook 2025

[5] UN experts condemn United States attack on Iran and demand permanent end to hostilities, OHCHR, 26 June 2025 https://www.ohchr.org/en/press-releases/2025/06/un-experts-condemn-united-states-attack-iran-and-demand-permanent-end

[6] Shah, S., and M. El Dahan, Saudi pact puts Pakistan's nuclear umbrella into Middle East security picture, 19 September 2025, Reuters. https://www.reuters.com/business/aerospace-defense/saudi-pact-puts-pakistans-nuclear-umbrella-into-middle-east-security-picture-2025-09-19/

RISK 3

Multi-domain escalation risk

BY WILFRED WAN

Rapid technological advances and expanding multi-domain warfare are reshaping global security, blurring lines between nuclear and conventional conflict. As cyber, space, artificial intelligence (AI) and disinformation capabilities converge, escalation risks grow increasingly unpredictable. Understanding these dynamics is essential for strengthening governance, preventing miscalculation, and reducing the mounting danger of nuclear use in a volatile strategic environment.

Recent and ongoing conflicts demonstrate the increasingly complex nature of contemporary warfare. Modern warfare now encompasses multiple operational domains and features the convergence of advanced technological capabilities. For instance, on the eve of the full-scale Russian invasion of Ukraine in February 2022, a massive cyber operation was attributed to Moscow by the European Union, the United Kingdom and the United States. The operation targeted Viasat's KA-SAT network — disrupting broadband satellite access, internet access and critical infrastructure across Ukraine. In the ensuing war, Ukraine has arguably achieved its greatest battlefield success through the large-scale use of drones likely trained by AI. For instance, a June 2025 attack from Ukraine resulted in damage to over 40 Russian strategic bombers in airfields across the country — undermining Russia's nuclear forces in the process.[1] Israel's military campaign in Gaza since October 2023 has reportedly included AI-enabled decision-support systems to inform targeting decisions. The May 2025 military conflict between India and Pakistan also featured a wave of AI-generated content.

Disinformation campaigns are meant "to intensify tensions, legitimise retaliatory military actions, and compel both governments to adopt increasingly belligerent stances", as Nabiya Khan, Kaushik Raj and Zenith Khan argue in their analysis.[2] Indeed, the deployment of AI and other capabilities, particularly involving nuclear-armed states, is fundamentally changing notions of escalation. Warfighting on the ground, at sea and in the air could spill over into space and cyber domains or be triggered by ongoing dynamics there. One reason for the multi-domain nature of contemporary warfare is that modern weapons are increasingly reliant on space-based assets and digital communications technology, creating new vectors of vulnerability.

Multi-domain operations that escalate introduce potential for nuclear weapon use — a scenario that is heightened in the current global context. Increasing interactions between nuclear and non-nuclear strategic capabilities, including those linked to cyber and space domains, can blur the distinction between intended military targets, amplify potential conflicts and raise questions as to the strategic rationale behind operations. This opens the door for potential miscalculations,

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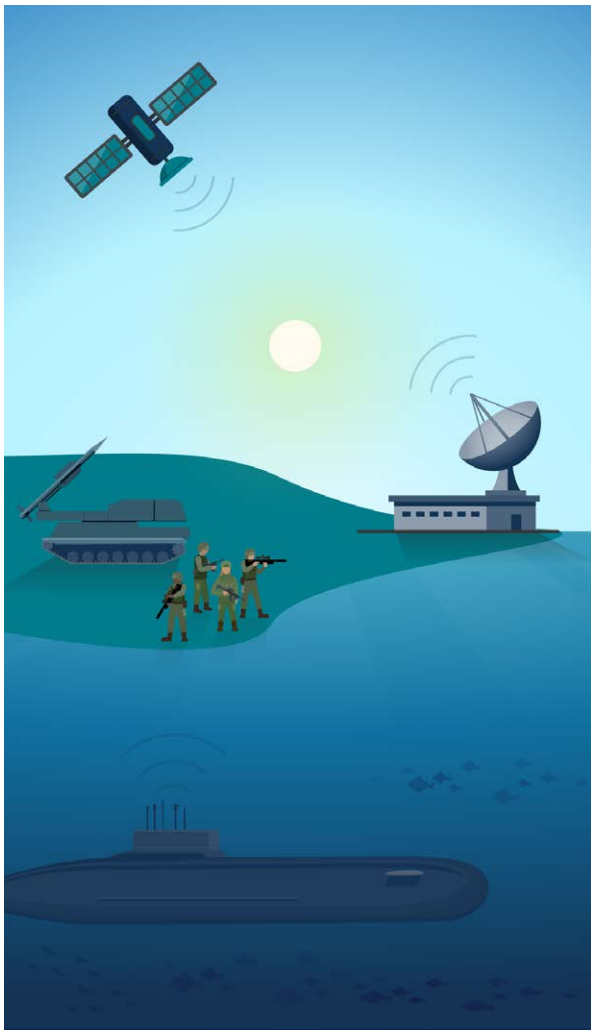
misperceptions and misunderstandings, with escalation in these circumstances taking place in an "accelerated and decidedly non-linear" fashion.[3] This challenge is compounded by the "lack of collective experience, common understandings and established behavioural norms" that might otherwise deescalate tense situations. These gaps are particularly evident when new technologies or domains are involved.[4] For instance, had Russia perceived a deliberate intent by the West to undermine its nuclear forces as means of inflicting "strategic defeat" — a declared objective — through Ukraine's June 2025 drone operation, the results could have been more escalatory and catastrophic, potentially breaching the firewall between conventional and nuclear warfare.

The presence of multi-domain operations and the impact of new technologies is also paradoxically driving greater reliance on nuclear capabilities, feeding into arms race dynamics and longer-term destabilisation. Policymakers and military officials across the nine nuclear-armed states are increasingly using provocative nuclear language and making threats, threatening the longstanding normative taboo against nuclear use.[5] Some have amended their official policies to widen the circumstances in which they would consider nuclear use, including as response to non-nuclear strategic attacks or to pre-empt aggression by non-nuclear armed states. Widespread recognition of complex escalation pathways is not inspiring risk mitigation or the diffusion of tensions. On the contrary, there is a dangerous tendency among states to believe they can control escalation with their advanced capabilities. This "false sense of supremacy" tends to lead to more aggressive behaviour.[6] Overall, nuclear-armed states are pursuing strategic



advantages through new technologies, further worsening the dynamics that define the deteriorated strategic context.

Given these circumstances, it is especially concerning that global governance appears ill-equipped to address this more complex security environment: both in terms of preventing multi-domain escalation pathways from materialising and by reversing longer-term trends and thinking regarding strategic capabilities. Multilateral deliberations on nuclear, cyber and outer space domains remain siloed with limited engagement across communities. Exploration of the intersection between nuclear weapons and emerging and disruptive technologies has thus far been narrowly focused — notably on the integration of AI into nuclear command, control and communications systems. While this is an important topic, arguably more concerning are the broader trends that contribute to the entanglement of conventional and nuclear missions and the risk of multi-domain escalation. Moreover,

dialogue platforms for strategic — and nuclear — issues centre on traditional powers, leaving little space for civil society, private sector and even non-nuclear weapon states to engage. The strategic implications of conventional operations in Ukraine, Gaza and South Asia underscore the need for a more inclusive conversation.

Pragmatic steps to reduce the risk of multi-domain escalation alone will not resolve any underlying geopolitical tensions or arms racing dynamics. But ensuring the relevance of de-escalation mechanisms, and creating new ones, is a necessary and urgent endeavour that can help prevent worst case scenarios while rebuilding much-needed trust and confidence among nuclear-armed adversaries. This centres around developing a shared strategic value structure: for instance, in the outer space domain, where kinetic operations are unprecedented, or in the cyber domain, where operations have increased in frequency and intensity. It is imperative that states maintain common understandings on thresholds, including those pertaining to nuclear use. Exchanging views on actions seen as escalatory can establish behavioural parameters, constituting a new approach to arms control.[7] This can also facilitate the outlining of procedures to address risky or provocative behaviours that are seen to take place. Additional tools, such as hotlines, pre-notifications and information exchange, can also be implemented.

At the same time, there is a need to reform the global governance system so that it is more adept and fit-for-purpose in addressing these new strategic realities. This includes a more forward-looking approach to tackling technological developments in nuclear structures: for instance, through systematic evaluation and exchange in a subsidiary body of the Nuclear Non-Proliferation Treaty review process. The Scientific Advisory Group of the Treaty on the Prohibition of Nuclear Weapons provides a model, as do other examples outside the nuclear space: for instance, ongoing discussions of a science and technology review mechanism in the context of the Biological Weapons Convention. This also highlights the importance of including the private sector and industry actors, who are not only responsible for driving many of these technological developments but will likely be involved in multi-domain operations on the battlefield — as seen in the role of SpaceX and the war in Ukraine. Engaging these parties in key conversations — such as at the national security level and in multilateral governance fora — can help mitigate inadvertent escalation scenarios linked to third-party involvement.

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Further changes to global governance will require revisiting the concepts and assumptions that have long guided the current post-World War II system. This includes reckoning with increasingly potent advanced precision-strike capabilities that are bridging the conventional-nuclear divide and considering these in future nuclear arms control negotiations and frameworks. It requires reconsidering not only how new technologies can impact the vulnerability of nuclear forces and upend strategic stability and deterrence stability, but also revisiting how key states — nuclear and non-nuclear armed states alike — define those concepts in the context of multi-domain realities. It includes leveraging existing UN forums — such as those on autonomous and outer space systems — to raise issues of cross- and multi-domain issues. At the same time, it involves gauging the political viability of creating new, dedicated platforms that encompass a more comprehensive approach to addressing escalation risk and strategic instability.

Multi-domain escalation risk has become part and parcel of the nuclear landscape. To date, nuclear-armed and nuclear-allied states have responded largely by expanding the scope of deterrence and the role of nuclear weapons. But doing so can widen strategic and operational ambiguity in a manner that makes risk

unmanageable. States need to reconsider how their actions can set into motion action-reaction cycles with long-lasting destabilising effects. To begin, states need to refocus on avoiding the worst possible outcome. By identifying opportunities to reduce multi-domain escalation risks, by explicitly addressing new pathways through updated, innovative and encompassing risk reduction mechanisms, states and other stakeholders can begin to concretely account for increasing asymmetries across capabilities. Yet, this constitutes only a short-term solution. At the same time, states will need to build a foundation for comprehensive frameworks that not only rebuild confidence and enhance military transparency, but help account for the more complex security environment. This can be achieved through more inclusive platforms, prescribing additional modalities of action and reflecting new strategic value structures. Only this more ambitious approach to global governance can facilitate longer-lasting solutions and the revitalisation of arms control and disarmament efforts.

References

[1] Bego, K. 2025 June 6. Ukraine's Operation Spider's Web is a game-changer for modern drone warfare. NATO should pay attention. https://www.chathamhouse.org/2025/06/ukraines-operation-spiders-web-game-changer-modern-drone-warfare-nato-should-pay-attention

[2] Khan, N., K. Raj, and Z. Kahn. 2025. Inside the Misinformation and Disinformation War Between India and Pakistan. https://www.csohate.org/2025/05/16/india-pakistan-digital-war/#

[3] Hersman, R. (2020). Wormhole Escalation in the New Nuclear Age. The Strategist. https://tnsr.org/2020/07/wormhole-escalation-in-the-new-nuclear-age/

[4] US Department of Defense, 2022 Nuclear Posture Review. https://media.defense.gov/2022/Oct/27/2003103845/-1/-1/1/2022-NATIONAL-DEFENSE-STRATEGY-NPR-MDR.pdf

[5] Tannenwald, N. (2018). The Vanishing Nuclear Taboo? How Disarmament fell Apart. Foreign Affairs.

[6] Favaro, M. & H. Williams (2022). False Sense of Supremacy: Emerging Technologies, the War in Ukraine, and the Risk of Nuclear Escalation. Journal for Peace and Nuclear Disarmament, vol. 6 (1). https://doi.org/10.1080/25751654.2023.2219437

[7] Kühn, U., & Williams, H. (2024). Behavioral Arms Control and East Asia. Journal for Peace and Nuclear Disarmament, 7(1). https://doi.org/10.1080/25751654.2024.2337965

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