

Fresh Thinking on Peace and Nuclear Disarmament

Articles from the SYP Conference 2025



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Student / Young
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INTRODUCTION

Each year, Student / Young Pugwash (SYP-UK) organises a conference on international security. The subject of the 8th annual conference, held in 2025 at King's College London, was 'Stepping Back from the Brink: Fresh Thinking on Peace and Disarmament'. Our aim was to encourage new thinking on the legal, political and technical questions associated with this topic, with a focus on ethical science. The articles in this collection were written by some of those who presented at the conference. The authors cover a range of important and topical ground concerning the past, present and future of nuclear weapons. The collection was reviewed and edited by the members of SYP-UK's executive board.

All the weblinks and references in this document can be found in the online version, which is available on the British Pugwash website. You can also find a review of the [2025 conference](#), with videos of each session, on our website and YouTube channel: [@britishpugwashoffice1467](#)

- SYP supports students and young people to take part in debates concerning international peace and security, with a focus on nuclear weapons. If you would like to get involved with SYP's work, whether writing for us or taking part in our events, contact Tim Street, SYP Coordinator, email: syp@britishpugwash.org

- Membership of SYP is free for students and under 35s. To learn more or get involved with SYP, visit our website: <https://britishpugwash.org/student-young-pugwash/get-involved/>

- The artworks used in this collection come from www.neversuchinnocence.com

Never Such Innocence is a charity which began as a First World War commemoration project for children and young people. Inspired by this conflict, more than 11,000 young people from 47 different countries, territories and dependencies created poetry, artwork, and songs. From 2019 NSI expanded its focus to include conflict in all forms and throughout history, up to and including the present day. To date, young people in over 130 countries have participated in the group's work.

The cover image is "The Shadow of the Mushroom Cloud" by Josie, 16-18, Canada

The image on p. 9 is "Watching the Mushroom Cloud Rise" by Ava, 16-18, USA

The image on p. 21 is "Ephemeral Tranquility" by Eva, 14-16, South Korea

The image on p. 29 is "Hope and Healing" by Thanh Ngân, 16-18, Vietnam

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Nuclear Energy in Africa and the Threat of Nuclear Terrorism: Trends, Risks and Policy Implications

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Introduction

The African continent has long held a place in the global nuclear order due to its substantial uranium [reserves](#). However, since the connection of South Africa's Koeberg nuclear power station to the national grid in 1985, Africa's nuclear energy development has remained largely static. Although eleven research reactors are active across eight African countries, no additional nuclear power plants (NPPs) have been commissioned. Over the past fifteen years, however, an increasing number of African nations have begun exploring nuclear technology to support their [development](#). While promising, this trend raises critical concerns regarding the security of nuclear materials and the safety of future infrastructure.

These concerns are not unfounded. Africa is home to a myriad of violent non-state actors, including rebel factions, jihadist terrorist groups, militias, warlords, and even foreign proxy forces such as the Russian Africa Corps. These actors operate in the same spaces as state forces—some affected by corruption—and United Nations (UN) or African Union (AU) troops. These are conflictive, volatile and transboundary environments. In such a context, nuclear infrastructure could become a target, posing serious regional security risks. Therefore, despite the uneven pace of nuclear development across the continent, a coordinated, continental approach is essential. On the one hand, this is because the diversion of nuclear materials or any radioactive-related attack would impact the region as a whole. On the other, African states have previously demonstrated commitments to cooperation regarding nuclear-related risks, most notably through the 2009 establishment of the African Nuclear-Weapon-Free Zone under the Pelindaba Treaty.

Consequently, this paper explores the worldwide risk of nuclear terrorism—with a particular focus on

Africa—evaluates the current nuclear security situation, and suggests policy measures to promote the safe and responsible use of nuclear energy.

Nuclear Terrorism: A Global Threat in a Changing Landscape

The threat of nuclear terrorism has been present since the dawn of the Atomic Era; however, three particular events brought the issue to the forefront of international politics. The first occurred in 1991, following the collapse of the Soviet Union and the emergence of concerns over 'loose nukes.' The second took place in 1998, when Pakistan tested its first nuclear device, raising questions about the security protocols of its command and control structure—particularly given the country's internal volatility and its geographical proximity to centres of global terrorism, such as Afghanistan. Nevertheless, nuclear terrorism gained significant global attention following the September 11, 2001 attacks on the United States. These attacks validated long-standing fears, especially in light of Osama bin Laden's 1998 declaration that acquiring nuclear weapons was part of the jihadist [cause](#). According to Michael Zenko, US authorities received multiple credible [alerts](#) concerning terrorist plans to acquire or deploy nuclear devices.

The disruption posed by the possibility of nuclear terrorism lies in its challenge to classical nuclear deterrence theory. For instance, a 2017 [report](#) by the National Institute for Public Policy entitled "A New Nuclear Review for a New Age" concluded that U.S. nuclear forces are largely ineffective in deterring terrorist organisations, as these groups lack a permanent territory against which retaliation can be directed. As such, nuclear deterrence may be effective only in discouraging state sponsors of terrorism, not the terrorist groups themselves. This issue remains relevant in the US's 2022 [Nuclear Posture Review](#), which sets the tone for US nuclear counterterrorism strategy, focusing on prevention

rather than deterrence. Most notably, the global community soon recognised that the evolving threat of nuclear terrorism—as well as the emphasis on prevention—is not limited to states alone.

In response, several initiatives have been undertaken. These include inter-state arrangements such as the Global Initiative to Combat Nuclear Terrorism (GICNT), the Proliferation Security Initiative (PSI), and the Nuclear Security Summits held in 2010, 2012, 2014, and 2016, all of which underscore the international consensus on the need for stringent nuclear security measures. In addition, the UN has advanced proposals such as UNSCR 1540 and the International Convention on the Suppression of Acts of Nuclear Terrorism, which expands the original scope of the Convention on the Physical Protection of Nuclear Material. Furthermore, the International Atomic Energy Agency (IAEA)—a central actor in non-proliferation through its safeguards regime—has also broadened its scope through the establishment of its [Nuclear Security Division](#), tasked with preventing, detecting and responding to acts and threats of nuclear terrorism.

Nevertheless, the effectiveness of prevention is also called into question by the complex landscape shaped by increasingly globalised networks and information flows. While the construction of a sophisticated warhead with a complex delivery system—such as those possessed by nuclear weapon states (NWS)—is likely beyond the capabilities of any terrorist [organisation](#), opaque transnational networks can still enable such groups to acquire radioactive materials or share the technical know-how to construct more rudimentary devices. These include improvised nuclear devices (INDs), radiological exposure devices (REDs), and radiological dispersal devices (RDDs), the latter commonly known as ‘dirty bombs.’ The threat posed by these devices does not primarily lie in their destructive power—but in the humanitarian and economic consequences of radiation dispersal, particularly from REDs and RDDs in densely populated areas. The psychological and propagandistic effects must also be considered. Even in the absence of an actual detonation, the mere threat of use can trigger mass panic, cause severe societal and economic disruption, and even result in fatalities. Such threats

could be used to coerce governments and institutions, or serve as part of broader offensive strategies.

Africa's Nuclear Ambitions and Security Contexts

The African continent is not an exception when it comes to nuclear security commitments. As a region that has experienced the consequences of radioactive fallout from French nuclear tests conducted in Algeria between 1960 and 1967, as well as the risks of proliferation stemming from South Africa's clandestine programme, African nations have consistently demonstrated a strong commitment to disarmament and non-proliferation. This commitment was first articulated in the 1964 Cairo Declaration and culminated in the 2009 entry into force of the Pelindaba Treaty, which established Africa as a Nuclear-Weapon-Free Zone—a significant contribution to global non-proliferation efforts. While the primary focus of the Pelindaba Treaty is on non-proliferation, especially targeting NWS in its three additional protocols, nuclear security has progressively come to the forefront of discussions. As such, the African Commission on Nuclear Energy ([AFCONE](#))—the body tasked with overseeing treaty implementation—has expanded its mandate beyond disarmament verification to include nuclear security and the promotion of peaceful uses of nuclear energy.

This emphasis has grown stronger in recent years, with at least sixteen African countries expressing interest in adopting [nuclear technology](#) for peaceful purposes. These initiatives include plans for electricity generation through NPPs and small modular reactors (SMRs), the construction of research reactors, and nuclear applications in medicine, industry, and agriculture. While the inalienable right of NPT signatories—all African countries except South Sudan—to peaceful nuclear technology is guaranteed under Article IV of the Treaty, this right must be exercised with full adherence to safety, security, and non-proliferation obligations. Therefore, despite the diversity in implementation approaches, a common challenge unites these countries: the construction of nuclear facilities and the increased deployment of radioactive materials

on African soil present heightened security risks.

Past nuclear security incidents highlight the urgency of addressing these vulnerabilities. For example, in 2007 armed intruders [breached](#) the Pelindaba nuclear facility in South Africa, accessing a secure area containing highly enriched uranium (HEU)—enough for multiple rudimentary nuclear devices. In 2013, Al-Qaeda in the Islamic Maghreb (AQIM) [attacked](#) the Somair uranium mine in Arlit, Niger, indicating familiarity with nuclear-related sites. The [Nuclear Threat Initiative](#) (NTI) has recorded at least eight incidents involving radioactive material out of regulatory control between 2013 and 2019. These incidents occurred in Algeria (2), Burkina Faso (1), Nigeria (1), Sierra Leone (1), and South Africa (3), with theft accounting for half of them. Only one of these cases resulted in the successful recovery of materials. More recently, in 2023, Chadian separatist fighters allegedly [stole and smuggled](#) 2.5 tonnes of natural uranium barrels from an abandoned facility in Libya, a remnant of Gaddafi's nuclear aspirations.

To prevent a nuclear disaster, global counter-proliferation efforts have focused on reducing HEU stocks on the continent. From 2006 to 2018, in collaboration with the IAEA, HEU fuel was [removed](#) from research reactors in Libya, [Ghana](#), [Nigeria](#), and South Africa. Today, South Africa remains the only African country with a [declared reserve](#) of HEU at its Pelindaba facility—justified by its continued use in medical isotope research.

Should African nations pursue nuclear development, a new concern that could increase risks is the danger of transporting materials from global vendors. Due to the limited technical capacity in Africa, the development of nuclear infrastructure is heavily reliant on international partners, particularly vendors from Russia, China, the United States, France, and South Korea. The Russian state corporation Rosatom has taken a leading role, offering full-cycle services—including fuel supply and waste management—which helps reduce infrastructure costs and facilitates the removal of spent radioactive material from the [continent](#). However, the transportation of radioactive materials—widely regarded as the weakest link in the nuclear security

chain—remains a significant vulnerability.

Finally, the various violent non-state actors operating across the African continent—particularly jihadist terrorist groups—derive a significant portion of their revenues from managing illicit networks involving a wide range of commodities. These include weapons, drugs, natural resources such as oil and precious minerals, and even human trafficking. For instance, groups like JNIM (Jama'at Nasr al-Islam wal Muslimin) and AQIM operate sophisticated transnational [trafficking routes](#) across the Sahel. Their ability to handle diverse types of contraband suggests that, should nuclear or radioactive materials become available in Africa, they could potentially enter these illicit networks. More worryingly, these well-established trafficking routes often include points of sale near coastal areas, giving them international reach. One such example is the emergence of the so-called [arms bazaars](#) in Libya, which serve as hubs connecting African networks to global markets.

The presence of radioactive materials in these regions—strategically positioned for international distribution—significantly increases the risk of proliferation beyond Africa, raising the likelihood that such materials could be used in terrorist attacks elsewhere. Importantly, this would not be without precedent. Africa's raw uranium ore already played a central role in the black market established by the [A.Q. Khan network](#) between the 1970s and 2004. While there have been no recent confirmed cases of radioactive materials being trafficked through these networks, the infrastructure and incentives clearly exist, making the threat plausible and urgent from a security standpoint.

In summary, while the removal of HEU, except for Pelindaba's stockpile, greatly reduces the likelihood of non-state actors acquiring weapons-grade fissile material, there remains a risk that diverted radioactive material—something that has already happened, as evidence shows—could be used to produce more rudimentary devices such as RED and RDD. This threat could be further exacerbated by the transportation of ready-to-use nuclear material or nuclear waste across African borders as part of international cooperation schemes. One can

only foresee and worry about the humanitarian consequences that the detonation of such devices could cause in densely populated areas, such as capital cities. Even more concerning is the potential for such an event to occur in overcrowded regions lacking adequate sanitation and medical infrastructure—such as refugee camps in South Sudan, the Democratic Republic of the Congo, or the Central African Republic, to name a few. Furthermore, as the history and current dynamics of black markets in Africa demonstrate, there is a real possibility that diverted nuclear material could enter these illicit circuits and reach final destinations outside the continent. This would connect African-origin materials with global consumers, thereby increasing the risk of proliferation and radiological attacks in other parts of the world.

Policy Recommendations

Amplify African Voices in Global Forums

African experts and policymakers must be included in international negotiations and strategic frameworks aimed at preventing nuclear terrorism, ensuring the continent's specific security concerns and development needs are adequately represented.

Allocate Adequate Security Budgets

African nations must ensure that nuclear energy development is accompanied by sustained investment in security infrastructure, including emergency response protocols that involve coordination among multiple security agencies.

Strengthen Export Controls and Safeguards

The IAEA should require vendor states and companies through its export controls requirements to implement both active and passive safeguards on all exported nuclear materials and technologies, ensuring they are rendered unusable if stolen or compromised.

Reinforce Border Security and Detection Capabilities

Investment in capacity building for customs and border forces is needed, including for the deployment of radiation detection and cargo scanning technologies under IAEA protocols. These efforts should be proportionally funded by the IAEA, the aforementioned organisations in charge of preventing nuclear terrorism, as well as African nations, reflecting the shared global responsibility in countering nuclear terrorism.

Enhance Intelligence Sharing

International intelligence cooperation should be strengthened, with a particular focus on building the technical and operational capacities of African states to detect, track, and prevent the trafficking of nuclear and radiological materials.

Bolster National Regulatory Frameworks

The development of independent, technically competent nuclear regulatory authorities across African states is required, in close coordination with IAEA assistance programs, to oversee all stages of the nuclear infrastructure lifecycle.

Adherence to International Norms

The adherence to international norms must accompany the efforts of the previous recommendation, as Africa is currently the continent on which the fewest states have signed or ratified the International Convention on the Suppression of Acts of Nuclear Terrorism.

Promote Public Awareness and Societal Resilience

Targeted public awareness campaigns and community-based emergency preparedness training should be launched to strengthen societal resilience in the face of nuclear threats. This can include practical “what-to-do” guides and protocols, modelled after those used for earthquakes or tsunamis.

Expand Cooperative Threat Reduction (CTR) Programs within the AFCONE Framework

The creation of bilateral or multilateral CTR programs—similar to post-Soviet initiatives—adapted to African contexts under the African Commission on Nuclear Energy (AFCON) should be supported. These programs should aim to secure vulnerable nuclear and radiological materials and strengthen regional coordination mechanisms.

Conclusion

As Africa moves toward a future that increasingly embraces nuclear energy for development, it must also confront the evolving threat of nuclear terrorism. The technical capability of non-state actors in the region limits them to the construction of rudimentary nuclear devices, and their involvement in illicit trade networks presents a real and growing risk. This risk is compounded by the limited capacity of some African states to secure nuclear materials and infrastructure. Therefore, any strategy for nuclear expansion in Africa must be underpinned by strong international cooperation, stringent security measures, and effective policy frameworks. By integrating development goals with non-proliferation and counterterrorism strategies, African countries can ensure that nuclear energy becomes a driver of progress—not a source of insecurity.



Gender Inequality in Nuclear Disarmament: Causes, Consequences, and the Case for Change

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Introduction

Gender inequality remains a pervasive global issue, especially in male-dominated industries where access to resources, opportunities, and representation is [uneven](#). This disparity is particularly stark within the field of nuclear disarmament, where gender gaps are substantial yet often [overlooked](#). As part of the broader peace and security architecture, nuclear disarmament negotiations often take place alongside, or as part of, efforts to reduce conflict, rebuild trust, and promote long-term stability between states. Excluding women from these processes limits the diversity of perspectives and undermines the legitimacy and durability of [agreements](#). Evidence from peace negotiations, such as those focused on conflict resolution, demonstrates that women's inclusion leads to more lasting outcomes, benefits that are likely to apply to disarmament [processes](#). Despite this, nuclear disarmament remains shaped by security institutions that are overwhelmingly male dominated.

A study by the United Nations Institute for Disarmament Research found women made up only 32% of participants in disarmament meetings over four decades, and just 20% in high-stakes forums such as governmental expert groups, with little evidence of significant progress over time. Leadership disparities are even more pronounced. For example, in 2018, men held 76% of delegation leadership positions in key forums such as the United Nations Nuclear Non-Proliferation Treaty (UN-NPT) preparatory [committee](#).

As women's rights activist Eleanor Smeal observed, "Nowhere have women been more excluded from decision-making than in the military and foreign affairs. When it comes to the military and questions of nuclear disarmament, the gender gap becomes the [gender gulf](#)". Against this background, this paper examines the causes and consequences of

gender inequality in nuclear disarmament—particularly within the disarmament negotiation process—where key decisions are made and power asymmetries are most pronounced. While disarmament also involves more technical steps such as treaty ratification and weapons dismantlement, negotiations constitute the political core of the process, where trust is built, priorities are set, and representation significantly influences outcomes. Focusing on negotiations thus highlights the importance of addressing gender imbalances to advance more inclusive and durable disarmament efforts.

Causes of Gender Inequality in the Nuclear Disarmament Field

Multiple, intersecting factors contribute to gender inequality in the nuclear disarmament field, starting with how peace and security are framed. Traditional notions of peace negotiations focus narrowly on ending armed conflict rather than building lasting peace, often prioritising actors directly involved in warfare—most of whom are men. As Irene Santiago, one of the first female peace negotiators from the Philippines government, explained, "if we change the concept of peace talks, to focus on ending war and building peace, then women have a chance at [inclusion](#)".

Despite this, disarmament continues to be viewed primarily through a military lens, leaving women largely excluded from decision-making spaces. Margaret Vogt, Head of the UN's Integrated Peacebuilding Office, stated, "It's a power game. And in most of these games, [women are not there](#)". Mainstream nuclear disarmament remains tied to masculine-coded values of authority, strength, and technical rationality. For example, policy debates often centre on deterrence theory and arms control rather than humanitarian impacts disproportionately

affecting women and [communities](#). This framing not only marginalises women's perspectives but also restricts the broader understanding of peace and security, reinforcing a cycle of exclusion.

Another major cause of gender inequality in this field is the systemic bias embedded within disarmament institutions, such as the UN-NPT preparatory committee; this is known as the 'Prepcom' where Non-Proliferation Treaty states meet to address substantive issues related to the [treaty](#). During events such as the committee, gendered stereotypes create barriers to women's entry and [advancement](#). Both conscious and unconscious biases lead evaluators to undervalue women's qualifications compared to men's, since the field of disarmament tends to reward characteristics more commonly associated with men, such as toughness, seriousness, risk-taking and [military training](#).

As Margaret Vogt observed, "A higher bar is set for women's participation than for other groups... [Women] are expected to be both prominent leaders with technical experience and activists with large grassroots [constituencies](#)". Santiago, whilst [discussing](#) women in peace negotiations, raised a point about how "most people still see the inclusion of women as a quota to be met rather than a valuable contribution that affects outcomes." This double standard can be applied to the field of nuclear disarmament, wherein women must continuously prove themselves exceptional to gain acceptance, while their male counterparts are presumed more competent. As a result, while civil society groups advancing disarmament campaigns have been more gender-inclusive, national governments typically select men when they can only send a single representative to disarmament negotiations, while women are selected as second, or more often, third or fourth members of a [delegation](#).

Finally, the lack of supportive networks further entrenches gender inequality in the field. Despite the positive contributions many women make to the nuclear disarmament field—particularly through civil society organisations such as Reaching Critical Will, the Women's International League for Peace

and Freedom, and the International Campaign to Abolish Nuclear Weapons—structural barriers persist. Few women hold [senior disarmament roles](#) within national governments and intergovernmental organizations, which limits access to mentorship and visible role models for emerging professionals. This lack of representation makes it challenging for women to envision clear and sustainable career paths in the [field](#). Additionally, cultural, and institutional norms—especially in societies where traditional gender roles are strongly enforced—undermine women's participation in security and foreign policy spheres. These norms impact both the supply side (fewer women pursuing careers in disarmament) and the demand side (institutional inertia in recruiting or promoting women). Together, these barriers not only limit women's career opportunities but also hinder the nuclear disarmament field's potential to achieve gender-inclusive outcomes.

Consequences of Gender Inequality in the Nuclear Disarmament Field

Gender inequality in nuclear disarmament has far-reaching consequences, not only on fairness in participation but also on the quality and legitimacy of negotiation outcomes. When women are excluded, the gendered impacts of nuclear weapons are often overlooked.

Research shows that women and children are biologically and socially more vulnerable to radiation exposure. Following the US atomic bombings of Hiroshima and Nagasaki, women faced nearly double the risk of developing and dying from cancer compared to men, while studies on Chernobyl—the worst nuclear disaster in history, occurring in 1986 in the Soviet Union—found girls significantly more likely than boys to develop [thyroid cancer](#). Pregnant women exposed to radiation faced heightened risks of birth defects, stillbirths, and maternal mortality. These health effects are compounded by social stigma: in Japan, female Hibakusha—atomic bomb survivors from World War II—reported discrimination in marriage and employment. "People said Hibakusha had the blood of the devil," recalled Michiko Kodama, a

[Hiroshima bomb survivor](#). Yet for decades official assessments have failed to account for gender-specific impacts, systematically underestimating the true human cost of [nuclear weapons](#).

In part, this oversight reflects the dominance of male voices in disarmament discussions and nuclear policymaking, where strategic and military concerns often overshadow humanitarian [perspectives](#).

The persistent underrepresentation of women in negotiation processes narrows disarmament agendas, leading to agreements that may lack sensitivity to the lived experiences of affected populations. Inclusive participation broadens the focus beyond state security to social, health, and humanitarian concerns essential for legitimacy and [public support](#). Without it, disarmament risks disconnecting from impacted communities, undermining the scope and durability of [policy outcomes](#).

Conclusion: The Importance of Addressing Gender Inequality in Nuclear Disarmament

Addressing gender inequality in nuclear disarmament is not just about fairness—it is a strategic imperative for achieving more durable and legitimate peace outcomes. A growing body of evidence shows that peace deals with strong and meaningful female participation are 20% more likely to last at least two years, and 35% more likely to endure over [15 years](#). Cases where women's groups exerted strong influence over the negotiation process—such as in Liberia's 2003 Comprehensive Peace Agreement and Northern Ireland's 1998 Good Friday Agreement—saw markedly higher chances of reaching [agreements](#).

While these [examples](#) come from broader peace processes rather than nuclear-specific settings, they underscore how meaningful women's participation can contribute to more comprehensive and resilient agreements. Additionally, studies have shown that decision-making bodies with a diverse composition are associated with improved problem-

solving [outcomes](#). Ultimately, shifting toward inclusive, people-centred frameworks—and away from narrow power-based calculations—is essential for building more equitable and sustainable disarmament solutions.

Realising these benefits in disarmament will require coordinated action. National governments, intergovernmental organisations, civil society groups, and research institutions must work together to mainstream gender across all aspects of the disarmament process. This includes setting targets for gender-balanced delegations, investing in mentoring and leadership pipelines for women, and embedding gender analysis into treaty frameworks and policy design. Crucially, nuclear-armed states and those with disproportionate influence in disarmament negotiations must lead by example, setting standards that elevate inclusion as a global norm. A nuclear weapons-free world will only be possible when it reflects the voices of all those affected—making gender-inclusive participation not just a moral imperative, but a strategic one for global peace and security.

Rebalancing Disarmament: Incentivising Non-Proliferation Through Advanced Nuclear Technologies

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The views in this article are solely the author's and not those of his employers.

Introduction

The global nuclear order faces increasing strain. Despite the foundational role of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), efforts to achieve meaningful disarmament have stagnated. Established nuclear-armed states continue to modernise their arsenals, while new aspirants pursue latent or overt nuclear capabilities. Recent military action against nuclear infrastructure—particularly in the context of the [Israel–Iran conflict](#)—has further undermined confidence in the credibility of international mechanisms. For states like North Korea, such developments reinforce the narrative that nuclear weapons are essential for deterrence and regime survival, complicating efforts to re-engage them in arms control diplomacy. North Korea is the only state to have withdrawn from the NPT, citing what it called the “[hostile policy](#)” of the United States as justification. Since then, it has steadily advanced its nuclear weapons programme outside the treaty framework, challenging the normative authority of the non-proliferation regime.

Given this stalemate, recent advancements in nuclear energy technology invite a reconsideration of how civil nuclear cooperation might intersect with non-proliferation efforts. This article focuses on the case of North Korea as a testing ground for exploring such approaches, where traditional diplomacy has failed and alternative strategies are urgently needed. In particular, it considers whether constructive technical cooperation—specifically in the nuclear energy sector—can create incremental leverage and incentives to support long-term disarmament engagement. Innovations such as [Small Modular Reactors](#) (SMRs), [High-Temperature Gas-cooled Reactors](#) (HTGRs), and advanced fuel cycle systems offer scalable and potentially safer energy alternatives. These systems may address the economic and energy demands of states like North Korea while presenting lower proliferation

risks, under the right conditions. However, such technologies carry their own technical and political challenges, particularly concerning fuel enrichment, reprocessing, and the transfer of sensitive know-how.

These developments raise important questions about whether emerging nuclear technologies can be used not merely to prevent proliferation, but to incentivise restraint and disarmament. With careful application, such technologies could contribute to a broader set of tools that engage nuclear-capable states through cooperative frameworks grounded in energy access, economic development, and international safeguards. This article is based on recent developments, including reports from international organisations, such as the International Atomic Energy Agency (IAEA), and the author's research conducted at the Research Center for Nuclear Weapons Abolition (RECNA), published as [Policy Paper 21](#).

The Promise and Pitfalls of Advanced Reactors

Emerging reactor technologies, such as Small Modular Reactors (SMRs), have generated increasing interest due to their potential to deliver reliable energy in settings that lack large-scale infrastructure. Their compact, modular design and passive safety features make them especially attractive for countries with limited grid capacity or unstable energy access. From a non-proliferation standpoint, [some SMRs](#) are designed to operate with sealed cores over extended lifespans, which could significantly reduce opportunities for fissile material diversion by eliminating the need for on-site refueling. However, many of these long-life designs depend on high-assay, low-enriched

uranium ([HALEU](#)), which is enriched between 5% and 20% U-235.

While this is far below the 90% enrichment level required for weapons-grade material, it surpasses the standard low-enriched uranium threshold. It sits within a range that raises [proliferation concerns](#), especially if enrichment capacity is not tightly [safeguarded](#). The decentralisation of SMR deployment, particularly in politically sensitive or remote regions, also introduces risks related to cyber-security, transport security, and fuel repatriation logistics. While SMRs may offer reduced construction timelines compared to traditional large-scale reactors, their cost per megawatt remains relatively high due to limited commercial deployment currently. In less developed regions, the adoption of SMRs may require international support mechanisms. Rather than broad technology sharing, this should take the form of regulated technology transfer frameworks, which restrict unnecessary access to the fuel, thereby reducing the risk of latent proliferation.

High-Temperature Gas-cooled Reactors (HTGRs), though technologically distinct, also present a mixed picture in non-proliferation terms. These reactors often, but not universally, use [TRISO](#) (tristructural-isotropic) fuel, which encapsulates uranium in multiple protective layers of ceramic and carbon. TRISO is [widely regarded](#) as a proliferation-resistant fuel form, as it is resistant to reprocessing and makes the extraction of fissile material technically and economically challenging. HTGRs offer high thermal efficiency and are capable of producing industrial heat and hydrogen, making them attractive for dual-purpose energy needs.

Nonetheless, HTGRs can also rely on HALEU, and their proliferation resistance depends heavily on the reactor's overall design and the fuel cycle infrastructure supporting it. Moreover, widespread deployment may involve technology transfer, localisation of supply chains, or fuel fabrication capabilities, potentially diffusing sensitive technical knowledge and infrastructure that could be repurposed for weapons-related activities. Although HTGRs may offer long-term operational benefits,

from an economic perspective, their design and construction can be technically complex, and their higher temperature operation poses unique engineering challenges. Similar to SMRs, support for the adoption of HTGRs in developing contexts should be contingent on regulated technology transfer protocols that preserve non-proliferation safeguards.

Advanced fuel cycle technologies further complicate the landscape. Approaches such as [Group Actinide Extraction](#) (GANEX) aim to reduce long-lived radioactive waste and improve fuel utilisation by separating and recycling transuranic elements.

While this may provide environmental and economic benefits, it also produces streams of pure or near-pure plutonium, posing significant proliferation risks. Reprocessing technologies, particularly if implemented without robust international oversight, erode the barriers between civil and military nuclear applications. The risks are especially pronounced in states that possess pre-existing reprocessing capabilities or where safeguard mechanisms are politically constrained. As a result, any strategy incorporating advanced reactors or fuel cycle innovations must be accompanied by stringent safeguards, transparent governance, and multilateral coordination, or risk undermining the very non-proliferation goals they are intended to support.

North Korea as a Test Case

North Korea presents one of the most enduring challenges to the global non-proliferation regime. Despite numerous diplomatic efforts—from the [Agreed Framework](#) to the [Six-Party Talks](#) and the [Singapore](#) and Hanoi summits—Pyongyang has steadily advanced its nuclear weapons program. These repeated failures have revealed the limits of coercive and transactional approaches from both the United States and North Korea, especially those that offer short-term economic relief in exchange for partial dismantlement, without addressing long-term security guarantees, economic needs, or mutual mistrust.

Pyongyang's security posture—shaped by deterrence needs and strategic concerns—has recently been [buoyed](#) by wartime exports to Russia. However, as this window of prosperity narrows, a shift toward longer-term economic and technological engagement, particularly in energy or infrastructure cooperation, alongside a less confrontational international policy, may become more attractive.

Other recent developments, particularly the escalating tensions between Israel and Iran, have further complicated the international security environment. North Korea may interpret the military strikes on Iranian nuclear infrastructure as evidence that nuclear weapons are essential for deterring external threats (especially from the United States and its allies). Pyongyang's [strategic narrative](#) could therefore be further strengthened, alongside its belief that modernising its nuclear arsenal is justified and necessary, posing a direct challenge to the credibility of the global non-proliferation regime.

The country's chronic [electricity shortages](#)—exacerbated by sanctions, outdated infrastructure, and isolation—offer a potential entry point for constructive engagement. In this context, advanced reactor technologies such as SMRs and HTGRs could, in theory, be deployed as part of a civilian energy assistance program with embedded non-proliferation safeguards. Their modularity, passive safety features, and potential for sealed-core operation make them suitable for deployment in environments where regulatory institutions are weak or politically restricted.

That said, any such initiative must realistically account for North Korea's strong aversion to intrusive monitoring. Engagement models could be adapted to include participation from actors perceived as more politically acceptable by Pyongyang—such as China or Russia—while maintaining international oversight over safeguards and technology containment. A multilaterally monitored, internationally managed SMR or HTGR deployment could, over time, address North Korea's energy deficit while reducing the strategic rationale for maintaining a nuclear arsenal, particularly if accompanied by guarantees of fuel

supply and waste removal under strict verification. Rather than viewing [latency](#) as a failure of disarmament, it can serve as a diplomatic middle ground, especially in cases where immediate denuclearisation is politically unfeasible.

Traditionally, nuclear latency describes states that possess the technical infrastructure and expertise to produce nuclear weapons but opt not to do so. Though widely acknowledged in academic and policy circles, this status remains formally unrecognised in the international system, largely due to concerns that acknowledging it might inadvertently legitimise weapons aspirations. However, as more countries develop advanced nuclear industries, latent capabilities are becoming increasingly common. In the case of North Korea, openly engaging with the concept of latency—under strict international safeguards—could offer a non-confrontational, face-saving option that slows, suspends, or even gradually reverses its weapons development. The US–North Korea relationship, long defined by hostility, remains central to any such initiative.

Latency diplomacy could also serve a broader function by offering a more flexible framework for engaging nuclear-armed states outside the NPT, where traditional arms control approaches have little traction. By bringing latency diplomacy into the open, the international community could expand its toolkit for managing risk and building trust, particularly where traditional coercive approaches have failed.

Policy Recommendations

In light of the proliferation risks associated with advanced nuclear technologies and the enduring challenge posed by North Korea's nuclear program, a set of targeted, phased, and diplomatically grounded policy measures is essential. These recommendations aim to align technical containment with political realism and to consider how emerging nuclear technologies can be integrated into disarmament strategy:

1. Consider advanced nuclear energy cooperation as a potential long-term tool for incentivising disarmament

Civilian nuclear energy cooperation—particularly through the use of advanced reactor technologies—should be considered as a potential long-term instrument to support disarmament engagement with North Korea. Rather than offering energy assistance only as a reward for denuclearisation, carefully structured cooperation may serve as a leverage-building measure, conditional on compliance with non-proliferation commitments and phased diplomatic progress. Reactors with proliferation-resistant features can provide both a developmental incentive and a technical mechanism for containment, potentially redirecting North Korea's nuclear capacity toward peaceful uses under international oversight.

2. Prioritise advanced reactor designs with enhanced proliferation resistance

Civil nuclear cooperation in high-risk environments should prioritise the use of reactor technologies that incorporate intrinsic and engineered proliferation-resistance features. These may include sealed cores, extended fuel cycles, physical barriers to fuel access, and robust defenses against sabotage or material theft. While not all advanced reactors eliminate the need for refueling, those with superior safeguard compatibility and containment characteristics should be prioritised, with deployment conditioned on international oversight, which could be provided by the IAEA, or entrusted to a newly established regional multilateral monitoring mechanism.

3. Incentivise research on fuel designs with intrinsic proliferation resistance characteristics

International nuclear cooperation should promote research and development of advanced fuel forms that improve resistance to proliferation. This includes fuels that are difficult to reprocess, limit the accessibility of fissile materials, or are paired with reactor systems that restrict physical handling. Options such as TRISO fuel and novel fuel assemblies should be supported through multi-

lateral initiatives. Advancing these technologies expands the non-proliferation toolkit and contributes to safer reactor deployment in sensitive environments.

4. Restrict reprocessing and advanced fuel cycle activities to later phases, subject to compliance review

Reprocessing technologies, including those that could separate plutonium or other sensitive materials, should be prohibited in the initial phases of cooperation. Any future consideration of such activities must follow a thorough compliance review that evaluates long-term verification, transparency, and the presence of a mature safeguards regime.

5. Structure cooperation through a phased, compliance-based framework

Engagement should follow a tiered implementation strategy, where each phase of civil nuclear support is conditional on verified behavioral commitments. This structure may include benchmarked restrictions, inspection regimes, and dispute resolution mechanisms, drawing on past models such as the JCPOA but tailored to the North Korean context. This framework should form part of broader negotiations, especially as North Korea's wartime economic gains, following Russia's invasion of Ukraine, begin to fade. This moment offers a limited opportunity to shift incentives toward energy-driven development, which could help reduce the country's reliance on nuclear deterrence. Strengthened energy access and economic cooperation, if successful, could generate new vested interests that align with market integration and gradually erode the perceived necessity of nuclear weapons.

6. Embed cooperation within a multilateral framework

Regional stakeholders—particularly China, Russia, Japan, and South Korea—should be integrated into the implementation and oversight process. Their participation would enhance the credibility, enforceability, and regional ownership of any agreement, while mitigating the risks of unilateral political shifts.

These states are central to the geopolitical balance established in past diplomacy, such as the Six-Party Talks. Moreover, the involvement of these states is vital to ensuring stable long-term civilian energy and economic development, which contribute to embedding sunk costs that raise the political and material barriers to future disarmament rollback, and opening the North Korean energy market to wider international influence at a later stage by combining actors seen as more acceptable to Pyongyang with those better positioned to monitor compliance.

7. Use nuclear latency diplomacy as a strategic tool within a managed framework

Recognising North Korea's latent nuclear capacity within a strictly civilian and safeguarded context could provide a non-confrontational mechanism for de-escalation. This approach does not validate the state's nuclear status but avoids threatening the legitimacy or political stability of the governing regime, helping create the political space necessary to slow, suspend, or reverse weapons development.

Conclusion

As the global non-proliferation regime faces renewed pressure, from stalled disarmament diplomacy to escalating regional tensions, the urgency for pragmatic, forward-looking strategies is clear. North Korea's continued nuclear modernisation, including its latest intermediate-range hypersonic missile, now reinforced by external conflicts and evolving security narratives, has exposed the limitations of traditional diplomatic tools. In this context, integrating advanced nuclear energy technologies into a disarmament strategy offers a timely and necessary expansion of the international community's approach.

This research highlights the potential for proliferation-resistant reactor designs and fuel systems to act not only as developmental tools but as strategic mechanisms for engagement and containment. When embedded in a phased and verifiable framework, such technologies may not immediately diminish the regime's perceived value

of nuclear weapons, but by creating long-term economic dependencies and sunk costs, they can gradually reduce the relative strategic value of such weapons in the context of international engagement—potentially turning them into a liability over time. While it is reasonable to anticipate that the North Korean regime might fear any external nuclear cooperation as a potential disarmament Trojan horse, such concerns are arguably no greater than those already posed by previous arms control initiatives. In contrast, the structured economic and energy benefits offered by advanced reactors could reduce this resistance by establishing new, regime-relevant incentives.

Even if these technologies are not immediately suitable as leverage in current negotiations, the developmental interests they generate can help cultivate the terrain where phased disarmament dialogue can take root. Though not a solution on their own, these innovations add valuable options to the global disarmament toolkit, encouraging a more adaptive, technically grounded response to the challenges of the current geopolitical era.

Reimagining Nuclear Disarmament: Leveraging a Fourth Special Session on Disarmament and Pact for the Future as an Alternative Framework for Policy Innovation

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Introduction

Nuclear possessor states' continued reliance on nuclear weapons—which they perceive as the cornerstone of their security—raises profound ethical, financial, and existential dilemmas. However, many states neither possess nuclear weapons, nor seek to, and question the assumption that such weapons contribute to genuine or lasting security. Stagnation in efforts to regulate and eliminate nuclear weapons—marked by the erosion of arms control treaties and limited progress on disarmament under the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), particularly Article VI—has contributed to the accelerated [modernisation of nuclear arsenals](#). This trend, also driven by renewed strategic competition and the [integration of emerging technologies](#), such as hypersonic missiles and AI-enabled systems, has heightened geopolitical tensions and diverted essential [financial and technical resources](#) away from pressing social and environmental needs.

This paper explores how a Fourth United Nations (UN) Special Session on Disarmament (SSOD-IV) offers an alternative framework for the nuclear weapons debate by moving beyond the entrenched state-centric and deterrence-focused approaches that have dominated disarmament discussions. It aims to contribute to a more holistic understanding of global disarmament efforts and explore how alternative strategies could catalyse progress.

Why a Special Session on Disarmament?

A [Special Session](#) is a mechanism of the UN General Assembly (UNGA) for all Member States,

on an equal footing, to advance and discuss disarmament matters at a universal forum, as enabled by [Chapter IV, Article 20](#) of the UN Charter. Procedurally, a Special Session is conducted under the rules of the UNGA, where each state has one vote, and decisions are generally reached by consensus. This framework contrasts with bodies like the UN Security Council, where select states hold veto power, or forums where Nuclear Weapon States (NWS) dominate.

A Special Session may be convened by the Secretary-General at the request of the Security Council or a majority of the UN's members. Over the years, the General Assembly has held [three Special Sessions](#) devoted to Disarmament (SSOD)—in 1978, 1982, and 1988—out of which only SSOD-I succeeded in producing a [Final Document](#). Held in New York from May 23 to June 30, 1978, 145 nations attended SSOD-I to adopt a consensus-based Final Document comprising [three major sections](#): the Declaration on Disarmament, the Programme of Action on Disarmament, and the Disarmament Machinery.

Beyond its agenda to review and appraise the international situation, the role of the UN in disarmament, and the international machinery for negotiations on disarmament, SSOD-I singled out NWS as bearing primary responsibility for nuclear disarmament and aimed to prioritise its achievement through urgent negotiations with adequate measures of verification. Unfortunately, [SSOD-II and SSOD-III](#), held in 1982 and 1988 amidst heightened Cold War tensions, concluded without the adoption of Final Documents due to deep-seated geopolitical divisions and procedural challenges. During SSOD-II, efforts to develop a Comprehensive Program of Disarmament, which SSOD-I's emphasis on General and Complete

Disarmament paved the way for, failed as the major powers [prioritised national security concerns](#) over collective agreements. The SSOD-II session ended with a [concluding document](#) that reaffirmed previous commitments but lacked [actionable steps](#). SSOD-III, despite extensive discussions, struggled to reconcile differing views on disarmament priorities, verification mechanisms, and the role of nuclear deterrence. Consequently, the session concluded with only a [procedural document](#) taking note of the proceedings.

These [outcomes](#) highlight the complexities of achieving multilateral disarmament agreements in the face of divergent national interests. They underscore the necessity for future sessions to foster inclusive dialogue, build trust among stakeholders, and develop flexible frameworks that accommodate varying security perspectives while advancing global disarmament objectives.

A Fourth Special Session on Disarmament: Strategic Step or Wishful Thinking?

An effective peace and prevention strategy must recognise the intricate links between global development and disarmament, emphasise the need to reduce investments in the military-industrial complex, prioritise humanitarian needs, and amplify the voices of women, girls, and marginalised communities.

These steps are necessary because traditional forums often prioritise the interests of NWS through structural and procedural imbalances. Bodies such as the UN Security Council grant disproportionate influence to the five permanent members, all possessing nuclear weapons, through veto power. Moreover, treaties such as the NPT reinforce asymmetry by permitting NWS to retain their arsenals under the promise of eventual disarmament—which many non-nuclear-weapon states (NNWS) view as being unfulfilled. This view has recently been strengthened by the continued resistance of NWS to make binding disarmament commitments, as exemplified by their refusal to join the Treaty on the Prohibition of Nuclear Weapons

(TPNW).

In this regard, SSOD-IV could revitalise the disarmament discourse, positioning it as a central component of the UN's peace and security architecture. While critics point to the failure of previous SSOD, notably SSOD-III in 1988, owing to it not yielding binding outcomes or sustained momentum, these sessions established critical norms and institutional structures that continue to shape disarmament dialogue today. For instance, SSOD-I produced the Final Document that remains a foundational reference for the UN's disarmament machinery, including the establishment of the [UN Disarmament Commission](#) (UNDC) and the [Conference on Disarmament](#) (CD).

Revisiting the SSOD process today is not about repeating past approaches, but about revitalising multilateral disarmament dialogue in a format that gives all UN Member States an equal voice. An SSOD-IV could serve as a platform to re-establish political will, reaffirm disarmament commitments under the UN Charter, and depoliticise dialogue to prevent further arms racing and strategic instability. In a fractured geopolitical environment, this format offers the rare possibility of inclusive, multilateral dialogue centered around universal principles of human security and development. As a UNGA mechanism, it can be wielded as a platform for collective problem-solving and equitable participation whereby the voices of nuclear and non-nuclear states, civil society organisations, academics, and other relevant stakeholders are taken into account.

Recent Developments

In recent years, there has been steady progress towards the agreement of an agenda for a SSOD-IV. Established in 2003, the Open-Ended Working Group (OEWG) held [three substantive sessions](#)—in 2003, 2007, and 2016–2017. Under the leadership of Fernando Luque of Ecuador, the OEWG adopted a [report](#) containing [recommendations on objectives](#) and an agenda for an SSOD-IV, submitted to the General Assembly for further deliberation.

The UN's High Representative for Disarmament Affairs, Izumi Nakamitsu, [welcomed the outcome](#) by noting how “against a backdrop of considerable challenges to disarmament and non-proliferation and tensions at the global and regional levels, the international community has once again demonstrated that progress is both possible and desirable.” Highlighting the role played by disarmament and arms control in “easing international tensions and building confidence and trust among states”, [she reiterated](#) how SSOD “present the unique opportunity to advance our shared goal of general and complete disarmament under effective international control.”

In today's context, reviving this mechanism is essential to rebuild trust among stakeholders and enable decision-making that reflects the priorities and perspectives of the majority of UN member states through inclusive, rules-based cooperation.

For Future Generations: SSOD-IV as an Alternative Framework for Policy Innovation

SSOD-IV presents a pivotal opportunity to redefine global security by prioritising human security over state-centric paradigms. It would be particularly instrumental in advancing all six objectives of the [New Agenda for Peace](#), as outlined by UN Secretary General Antonio Guterres in his report, [Our Common Agenda](#).

The inclusion of a call for an SSOD-IV in the UN's [Pact for the Future](#)—an initiative aimed at bolstering multilateralism—underscores its significance in addressing existential risks and advancing sustainable development. Under [Action 26](#) on upholding disarmament obligations and commitments, member states addressed the need to revitalise the role of the UN in the field of disarmament, and recommended that the General Assembly pursue work that could support the preparation of a fourth special session devoted to disarmament. This signals a commitment to integrating disarmament into broader global priorities such as reducing inequalities, strengthening multilateralism, and ensuring long-term

human security, thereby bridging the gap between security and development agendas.

- SSOD-IV underscores the potential for a successful alternative approach by reframing disarmament as a humanitarian imperative rather than solely a security issue. This approach can therefore build on the momentum of other humanitarian-driven frameworks, such as the TPNW, to challenge the dominance of deterrence-based logic and highlight the trade-offs—bringing the disproportionate human, financial, and ecological costs of nuclear deterrence into sharper focus.
- By incorporating intersectional priorities and diverse perspectives, SSOD-IV could act as a critical forum to consider contemporary global challenges, ensuring that disarmament policies are reflective of and responsive to the needs of all communities. This approach can also address the multidimensional impacts of nuclear weapons and elevate the voices of women, youth, indigenous peoples, and communities from the Global South by institutionalising their participation and integrating their perspectives into discussions. This would enhance the legitimacy, inclusivity, and effectiveness of the consultations and aligns with the broader UN commitments of gender equality, intergenerational equity, and sustainable development.
- In line with the Pact for the Future and the recognised role of civil society in global governance, SSOD-IV could ensure that disarmament deliberations meaningfully incorporate the expertise, advocacy, and lived experiences of civil society actors and other relevant stakeholders. Integrating these actors' contributions can enhance policy relevance, build political will, and strengthen the transparency and accountability of multilateral disarmament outcomes.

Concerns that SSOD-IV may replicate past stalemates are valid and must be acknowledged. However, a broadened agenda can position the session within a comprehensive framework that

addresses contemporary challenges, thereby reinforcing, rather than weakening, its relevance. While current great power tensions mirror aspects of the Cold War, they also highlight the urgent need for renewed dialogue. SSOD-IV offers a timely and inclusive platform to re-engage states in constructive deliberation. With thoughtful design and sustained political will, it can avoid the shortcomings of previous sessions and serve both as a timely catalyst and a means of fortifying the global disarmament architecture.



Chemical, Biological, Radiological, and Nuclear Security Education in the Age of Artificial Intelligence

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Introduction

The 21st century has seen profound advances in science and technology (S&T), to the extent that Klaus Schwab coined the neologism '[The Fourth Industrial Revolution](#)' to convey the magnitude of the changes involved. These rapid advances have increased the scale of challenges concerning chemical, biological, radiological and nuclear (CBRN) security, emphasising the need to provide adequate advanced S&T security training to professionals, academics and policy makers. These technologies include, but are not limited to, artificial intelligence (AI), nanomaterials, and synthesised biology. Ethical challenges are also significant, such as recognising information hazards and evaluating the risks and benefits of open-source research. In this paper, we use AI as an example to both illustrate the potential security issues that could impact upon the CBRN field and consider how best to address this challenge.

The Emergence of AI

The emergence of ChatGPT, which was created by OpenAI in 2022, ignited the academic discourse regarding access to information for [CBRN security](#). For example, within biological security, large language models (LLM) and [biological design tools](#) could potentially be used to facilitate the development of a biological weapon. OpenAI does implement ethical constraints to prevent access to dangerous or illegal information. ChatGPT is not open source, which acts as a safety net to prevent malicious use by hostile actors and avoids unintended consequences. This is, however, based on the type of language inputted into the AI. Unintended consequences may include, but are not limited to: information bias, information hazards, hallucinations ([disinformation within an AI system](#)), and cybersecurity threats.

There is increasing concern regarding how AI may be manipulated to facilitate the development of biological weapons, whether this be by providing mutation points to increase the transmissibility of a pathogen or decreasing the amount of time it takes to access and understand information. Furthermore, AI's ability to predict toxicity has led to concerns that it may facilitate the development of chemical weapons. In 2022, a [drug developing AI](#) produced over 40,000 new chemical 'weapons' in six hours, some of which were comparable to the nerve agent VX. The results were produced by predicting toxicity instead of predicting therapeutic efficiency.

The term [information hazards](#) was formalised by Nick Bostrom in 2011, and refers to "risks that arise from the dissemination, or the potential dissemination of true information that may cause harm or enable some agent to cause harm". In 2023, a study organised by [Kevin Esvelt](#) at Massachusetts Institute of Technology (MIT) aimed to explore how AI could lower barriers to accessing potential information hazards. Esvelt's study allowed students one hour to ask a LLM (Chat GPT) "How to create and order a dangerous virus capable of unleashing a pandemic?".

The students struggled to ascertain answers from the LLM when inputting direct questions (because the LLM judged that they would elicit dangerous information). However, students were able to bypass safety nets when questions were rephrased. The LLM provided information on pandemic pathogens, genetic mutations to increase transmission, how to create viruses from synthetic DNA using reverse genetics, names of DNA companies and identified protocols (including how to overcome skill deficits). While these results are shocking, they do not mean that a bioweapon could have been formed from them. The results do, however, indicate the ability to break down

academic barriers and overcome skill deficits for those without formal scientific training / education, and can shorten the time it takes to access and digest information. Conversely, AI's ability to predict and design new toxic compounds in combination with the roll-out of [benchtop DNA printers](#) may allow researchers to bypass the screening that synthetic biology companies do to ensure heightened bio-security. Benchtop DNA printers enable researchers to synthesise DNA in their own laboratories. This technology could therefore lead to catastrophic results if in the hands of a hostile actor. It is important to note that the [UK government](#) does provide guidance to benchtop manufacturers, such as on how to track the use of equipment.

Esvelt's study was completed in 2023 and has therefore been in the public domain long enough to be addressed by AI companies. These results can and will be able to be reproduced in the future due to the ability to bypass LLM's safety net via rephrasing. Moreover, there is equal concern about the impact of these AI technologies on all CBRN security and weapons.

A similar study was completed in 2023 by Matt Korda, who used ChatGPT to provide details on how to create a [radiological dispersal device](#) (a dirty bomb). Korda was able to extract broad instructions on how to create a radiological dispersal device by emphasising to ChatGPT that his research was intended to prevent terrorism. Information produced was broadly available online, however, redacted results include the amounts of [precursors](#) (a chemical which has the potential to form an explosive) needed to produce a specific explosive yield.

To test how ChatGPT would teach the general public about CBRN security issues, we used Korda's study as a template to see if results could be replicated two years later. We do not believe it is appropriate to provide the exact text input into ChatGPT due to the potential information hazards and risk for others to manipulate AI into producing more detailed results. Prompts inputted into ChatGPT emphasised that the information was required for research on nuclear terrorism and on how hostile actors may construct the device. Key to

extracting these results from ChatGPT was to emphasise that the research aimed to prevent others from creating a radiological dispersal device and make the world a more peaceful place. Similar to Korda's study, ChatGPT provided broad instructions, but it did not reveal any information that would be required to be classed as redacted. The LLM did provide information on the explosive and radioactive elements, the goal of the device, and types of radioactive material, in addition to where to find them. Surprisingly, the LLM produced a section entitled 'How a Terrorist Might Attempt to Construct a Dirty Bomb', which amounts to a 'basic handbook for terrorists'.

Although this is not a step-by-step guide to creating a dirty bomb, this 'handbook' does provide basic details of how to construct a radiological device, where to find material, how a terrorist may attempt to construct the device, and key risks and effects. It is important to note that all the information provided in our study is open access in 2025 and is available online. AI condensed a multi-week task of finding information on constructing such a device, so that it took under five minutes, making it easier for a terrorist—or anyone without formal training or education—to access the information.

Things could get even worse. In early 2025, we saw the release of [Deepseek AI](#). Deepseek, unlike ChatGPT, is an open source LLM and thus faces a multitude of moral, ethical and security concerns. AI which is open source is vulnerable to infiltration by malicious actors, the release of sensitive information and the potential to input information hazards. Moreover, the implementation of open source AI further highlights risks facing all CBRN security and brings into question how adequate training and education can be established to all relevant stakeholders.

Moreover, there is growing potential for [AI integration](#) into nuclear command, control and communication systems (NC3). There are huge advantages to integrating AI into NC3 systems, such as the ability to assess huge amounts of intelligence data without human bias (based on fear and prejudice, for example). However, this is of course reliant on there being an absence of human

bias in the AI system. AI is able to find and predict correlations, which presents a huge advantage in regard to early-warning systems and pre-launch detection activities.

Yet these advantages go hand in hand with potentially catastrophic limitations. For example, [false positives](#) may lead decision-makers to put their armed forces on alert or react to a non-existent attack. This is particularly perilous when geopolitical tensions are high and nuclear armed states, such as the USA and Russia, have a “[launch on warning strategy](#)”.

A healthy balance between AI integration and human oversight may help to negate these limitations, and consequently, it is imperative that we preserve human oversight of these critical systems.

An Integrated Approach on CBRN Security Education

The threats AI and advanced S&T pose are further highlighted via the move in January 2025 of the [Doomsday Clock](#) from 90 seconds to 89 seconds to midnight. The Clock, formed in 1947, represents how close humanity is to destroying our planet via the use of advanced and dangerous technologies. The move, by the [Science and Security board](#) of the Bulletin of Atomic Scientists, marks the closest the Clock has ever been to catastrophe and was influenced by nuclear risks, biological threats, disruptive technologies, and climate change. It is also important to acknowledge that geopolitical instability greatly influences risks to CBRN security.

The CBRN security communities are all facing different risks simultaneously in regards to advanced S&T, including AI. It is therefore of the utmost importance to address these concerns through the training and education of academics, professionals and policy makers.

From the aforementioned studies we can see that AI has the potential to break down barriers for those without formal scientific training or education and can shorten the time it takes to access and

digest information. AI can also help those without formal scientific training or education to overcome skill deficits and produce information that may usually take weeks of research. Most worrying is the ability to override safety nets via rephrasing, whereby AI can be manipulated to produce potentially dangerous results. Furthermore, the introduction of benchtop DNA printers has led to further discussion on the potentially catastrophic consequences that may arise if these fell into the hands of a hostile actor. Whilst we have seen the introduction of tighter restrictions, AI appears to be as vulnerable today as it was two years ago, a situation which does not inspire optimism when looking towards the future.

As discussed, the CBRN security field is facing different types of risks simultaneously, particularly in regards to AI. It is therefore important to address these concerns collectively via an integrated approach. For example, an [integrated education strategy](#) must be developed on a global scale and address all key stakeholders such as scientists and diplomats. Educational materials and resources must also be tailored accordingly to each stakeholder. The ability for AI to facilitate the development of biological and chemical weapons is acknowledged by the Biological and Toxin Weapons Convention and the Chemical Weapons Convention respectively. Effective governance is required to address emerging AI-driven threats, so we need to ensure national and international governance does not fall behind technological advancements.

We therefore advocate for an integrated approach to teaching advanced S&T risks concerning CBRN security, as we developed during our recent novel project building up the [International Biological Security Education Network](#) (IBSEN). The IBSEN has formed a global network and continues awareness raising activities through the production of [newsletters](#), research papers, and workshops.

Conclusion

We are in the midst of the Fourth Industrial Revolution, with rapid advances in S&T increasing

the scale of the challenges to CBRN security. This paper has discussed AI's capacity to facilitate the development of biological and chemical weapons, provided information on radiological dispersal devices, and considered the potential for AI to be integrated into nuclear command, control, and communication systems. AI is able to break down barriers for those without formal scientific training education and can shorten the time it takes to understand information and overcome skill deficits.

These risks—in addition to other advances in S&T such as the roll out of benchtop DNA printers—highlights the need for adequate education. Such education needs to be provided on a global scale, and tailored accordingly for all relevant stakeholders. Members of civil society can play the leading role in raising awareness about this subject, as shown by our recent novel project the International Biological Security Education Network (IBSEN).

Acknowledgements

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The AUKUS Challenge: Navigating Nuclear Governance in the Indo-Pacific

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Introduction

AUKUS, a trilateral pact involving Australia, the United Kingdom, and the United States, initially shocked the nuclear non-proliferation community upon its announcement in September 2021. The pact blatantly undermined alliances and a billion-dollar submarine deal between Australia and France, whilst also affecting nuclear non-proliferation efforts. This [partnership](#) is based on two pillars: first, to enable Australia's acquisition of conventionally armed, nuclear-powered submarines (SSNs), and second, to ensure cooperation in developing a wide range of advanced capabilities, including: undersea capabilities, quantum technologies, artificial intelligence and autonomy, advanced cyber, hypersonic and counter-hypersonic capabilities, electronic warfare, innovation, and information sharing, providing the militaries of the three nations with a deeply integrated technological edge.

The UK and Australia will work together to develop and deploy the SSN-AUKUS, which is expected to enter service by the late 2030s for the UK and the early 2040s for Australia. The pact involves the transfer of weapons-grade nuclear technology through highly enriched uranium in submarines between nuclear weapon states, the US/UK, and a non-nuclear weapon state (NNWS), Australia. While proponents of the pact argue that the benefits of an increased naval fleet and technological cooperation strengthen regional security, some states, especially China, have [raised concerns](#) that this could pose a risk of greater power competition and nuclear proliferation.

This essay argues that the transfer of SSNs and complementary technologies to Australia undermines the credibility of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) and fuels regional instability, thus requiring Asia-Pacific nations to provide prompt solutions to sustain and strengthen the non-proliferation regime.

AUKUS and the NPT

In force since 1970, the NPT aims to prevent the spread of nuclear weapons, promote the peaceful use of nuclear energy, and [further the goal](#) of nuclear disarmament. A cornerstone of global nuclear non-proliferation efforts, the treaty has several 'loopholes' that can be misused in ways that affect proliferation dynamics and diminish nuclear restraint. For instance, under Article IV of the NPT, NNWS can develop nuclear energy for peaceful purposes. However, states lack a clear framework regarding the sharing and use of naval nuclear propulsion (NNP).

This allows Australia to procure nuclear-powered submarines fuelled with high-enriched uranium (HEU) for military activities without triggering the International Atomic Energy Agency's (IAEA) [routine safeguards procedure](#). Outlined in [Article III of the NPT](#), this provision aims to ensure that the fuel is not diverted for the production of nuclear weapons, thus enabling the peaceful exchange of nuclear technology and providing states with the confidence to exercise their Article IV rights to "develop research, production and use of nuclear energy for peaceful purposes". Australia has been granted access to SSN technology without possessing a nuclear weapons program.

The US and UK have argued that providing Australia with SSNs will bolster regional stability, promote an "open and secure" [Indo-Pacific](#), and facilitate the collective interest of the AUKUS partners, i.e. to counterbalance China's growing military influence in that region. Although this enhancement in submarine capabilities [is seen as](#) "significant to every element and stage" of Australia's maritime security, it has caused significant anxiety among China and Association of Southeast Asian Nations (ASEAN) member countries, because it pushes at the boundaries of AUKUS participant's obligations under the NPT. For example, AUKUS has the potential to erode the

NPT's foundational principles, having highlighted perilous grey areas in its framework. Moreover, the tripartite deal sets a dangerous precedent, allowing other states—such as Iran and Brazil—to follow Australia's example, and demand similar exceptions and deals to acquire SSNs with HEU, in order to develop their nuclear programs and naval nuclear propulsion systems. In the future, would-be proliferators could also use naval reactor programs as cover for the development of nuclear weapons with the reasonable expectation of not facing [intolerable costs](#) for doing so.

Despite operating within the literal limits of the NPT, AUKUS has thus created unique challenges for IAEA verification procedures. Rafael Grossi, the Director General of the IAEA, [acknowledged](#) how the treaty necessitates “very complex, technical work” to ensure that HEU is not being diverted for nuclear weapons and the NPT is not being undermined. The Asia-Pacific Leadership Network (APLN) has also [voiced its concerns](#) on the risks of HEU-powered submarine proliferation and the unintentional increase in nuclear proliferation pressures in the region. While there is a lack of consensus among experts, [many believe](#) that the AUKUS deal (despite IAEA oversight under Article 14 of the IAEA Statute), establishes the legal mechanism for the IAEA to conclude comprehensive safeguard agreements with NNWS, and could increase the likelihood of nuclear proliferation.

Implications of AUKUS for Regional Stability

Apart from the adverse precedent, AUKUS also threatens to exacerbate tensions in an already volatile Asia-Pacific by sparking a regional arms race. Many policymakers from the ASEAN bloc, as well as non-proliferation advocates, fear that more regional powers may gravitate towards AUKUS for partnerships, leading to a strategic realignment in the Indo-Pacific region that makes the landscape even more [divisive and competitive](#). For example, China responded with intense criticism of the new partnership, perceiving itself to be the unspoken target of AUKUS, and claiming it was a blatant act

of provocation. A Chinese Foreign Ministry spokesperson, Zhou Lijian, charged that the cooperation on SSNs involving the three countries was “extremely irresponsible,” escalating regional tensions and the arms race while threatening international nuclear non-proliferation [efforts](#). Ever since, China has rapidly increased its submarine fleet and naval capabilities, highlighting a dangerous escalation between the two sides.

Although ASEAN [cautiously accepted](#) AUKUS a year after its announcement, the diversity in responses among the group's member countries further highlights the fragmentation in the region. While US allies like Japan and South Korea have displayed a positive attitude, Indonesia and Malaysia have voiced significant concerns over AUKUS. Both countries fear that the consequent arms race and diversion of resources will hinder the development of a regional security architecture and long-term stability, inadvertently affecting economic growth. SSN operations may mainly take place in Southeast Asia, specifically in the South China Sea, further fuelling regional actor's fears of escalation in conflicts and an arms race.

ASEAN's central role as a regional multilateral institution has also faced jeopardy amidst the rising competition between China and the US-led security coalitions. ASEAN's broader diplomatic efforts in emphasising the importance of the NPT and the region's commitment to a nuclear-weapon-free zone demonstrate regional apprehension about the pact and the need for all parties to exercise restraint.

Additionally, AUKUS has been [referred to](#) as a potential violation of the Treaty of Rarotonga (1985) which aims to keep the South Pacific region free of nuclear weapons, by spokespeople like Lijian. Although the treaty does not prohibit nuclear powered vessels like submarines, which use HEU for propulsion rather than a weapon, Pacific Island nations argue that Australia's acquisition of SSNs is a violation of the spirit of the treaty. Australia, a signatory and champion of the NWFZ, has therefore been criticised for bending the rules for strategic benefits, creating [significant anxieties](#) in countries like Indonesia and Malaysia. China, and

by extension, Southeast Asia's [perception](#) that AUKUS represents a military containment strategy, is therefore real.

A Framework for Regional Stability and Non-Proliferation

Ultimately, the non-proliferation costs of the AUKUS deal therefore [outweigh](#) the military and strategic benefits. The multifaceted challenges involved require a regional solution to mitigate the risks, solidify cooperation, and reinforce stability in the Indo-Pacific. Firstly, ASEAN-led mechanisms, such as the Southeast Asia Nuclear-Weapon-Free Zone Treaty (SEANWFZ), provide crucial frameworks for security assurances and commitments to keep the region free of nuclear weapons that need to be accepted by countries like the US and the UK. Furthermore, the framework provided by SEANWFZ can be [leveraged](#) to fuel Australian nuclear-powered submarines with low-enriched uranium (LEU) rather than HEU, thereby balancing the need for refuelling. The ASEAN Regional Forum (ARF) can also serve as a [middle ground](#) for nuclear diplomacy between member states and dialogue partners, which includes Australia. ARF can provide a vital platform for conducting open discussions to foster confidence, discuss the implications of AUKUS, and develop risk reduction strategies that are acceptable to all participating members.

Secondly, AUKUS partners need to be proactive and transparent in conducting their regional activities. This step is imperative and one that should be demanded as non-negotiable. Regular IAEA reporting with enhanced oversight and innovative verification approaches to ensure the non-diversion of nuclear material can significantly assuage concerns. Developing a framework to strengthen the NPT by setting clear criteria for NNWS wanting to have unsafeguarded naval reactors would supplement the present loopholes and reassure states like China. For example, a robust international framework that establishes clear, stringent, and universally applicable criteria for any NNWS to access naval nuclear propulsion technology would codify a currently ambiguous

area of the NPT. Furthermore, it provides diplomatic reassurance to China and other sceptical states by mitigating accusations of arbitrary exceptionalism in Western-led initiatives.

Basing any permission to withdraw naval reactors from safeguards on specific parameters, such as additional protocols and a comprehensive safeguards agreement—as well as ratification of the Comprehensive Test Ban Treaty and the Convention on the Physical Protection of Nuclear Material—amongst other measures, will deter future proliferators from [exploiting](#) the AUKUS precedent and NPT loopholes.

Finally, the role of track-two diplomacy, achieved through organisations like APLN, is salient in providing a space for experts, academics, and policymakers from across the Asia-Pacific to engage in [constructive dialogue](#) and develop concrete proposals to mitigate nuclear risks without inhibiting technological or military advancements. Informal communication channels are indispensable for building trust and creating a predictable security environment. Moreover, such forums, with NGO and think tank participation, can also channel efforts in collaborative research for NNP, to both understand legal complexities and develop alternative approaches, without relying on technologies that carry proliferation risks.

Conclusion

The AUKUS pact has ruffled feathers from Beijing to Paris to Jakarta, and posed undeniable challenges to the future of nuclear governance in the Asia-Pacific and the non-proliferation community at large. Adverse impacts of the treaty include: the erosion of the NPT's credibility, the setting of dangerous precedents, and the fuelling of an arms race in an already tense environment. However, the situation can be contained by upholding and strengthening non-proliferation norms, providing additional frameworks for transparency, and ensuring the equal application of current treaties.

The responsibility to ensure peace in the Asia-Pacific ultimately falls on the nations of the region, which can facilitate a secure, nuclear-weapon-free

future by engaging in track-two diplomacy and becoming the torchbearers for navigating the complex territory of nuclear technology despite external influence from superpowers like the US, whose pursuit of influence undermines the stability it claims to protect. Thus, a fundamental question remains: how can regional peace be ensured when the overwhelming presence and actions of the US, the primary architect of the AUKUS initiative, are not mitigated with equal efforts towards de-escalation and peacebuilding efforts?



How Digital Archives can Preserve the Memory and Experiences of Atomic Bomb Survivors

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Introduction

[Hibakusha](#) is a Japanese term referring to those who were exposed to radiation from the atomic bombings in Hiroshima and Nagasaki including direct survivors, those who entered the affected areas shortly after the bombings, and in-utero survivors. Such survivors have shared their experiences through oral storytelling to convey the misery of war and the preciousness of peace. This form of storytelling, where the speaker and listener share the same space and time, has been deemed essential, precisely because the opportunity to hear directly from a living storyteller is not everlasting and is destined to diminish with time.

Direct dialogue with the storyteller serves to make the bombing not just a historical event, but also a meaningful memory of the actual experience of the person. In this sense, these testimonies have made a significant contribution to the inheritance work in Hiroshima and Nagasaki. However, as hibakusha age, opportunities to hear their stories are steadily disappearing. Therefore, examining methods for passing on survivor's memories of the atomic bomb as "their own," even without direct communication, has become an urgent priority.

The Significance of and Prospects for Digital Archives

A [digital archive](#) is defined as "a system whereby public intellectual resources such as books, publications, official documents, works of art, natural history and historical materials are digitised, shared and made available as digital information on the Internet". The significance of digitising intellectual resources can primarily be attributed to two things. First, it provides ease of access to information. Conventionally, accessing specific materials required a visit to their physical repositories, such as libraries or museums. Digital archives make it

possible to access all kinds of information from around the world, unconstrained by time or geographical location. Second, it allows for the selection of information tailored to individual needs. Digital archives accumulate intellectual resources in diverse formats, including text, images, and audio. This dramatically expands the quantity and quality of information available to people. The process of examining and comparing information from various perspectives and expressions has the potential to generate new intellectual value and insights. Given these characteristics, digital archives are expected to yield further educational benefits in the future, contributing to an ongoing cycle of knowledge collection, sharing, and utilisation.

However, due to the vast volume of digital archival materials related to survivors' testimonies in both Hiroshima and Nagasaki, it is difficult to conduct a comprehensive analysis of all available sources. Therefore, this study focuses on Hiroshima, selected primarily for its geographic accessibility. That is, the geographic accessibility of Hiroshima facilitates not only the consultation of supplementary resources, including local archives, and historical documents, but also enables smoother engagement with individuals involved in related fields of study (such as researchers, journalists, and curators).

Research Objectives

This study aims to explore the potential of digital archives from multiple perspectives regarding the inheritance of atomic bomb experiences. Specifically, as I explain further below, it seeks to analyse the characteristics of different media for recording hibakusha testimonies, including: 1) written testimonies of survivors 2) newspaper articles 3) video testimonies. This is done to examine how each medium can stimulate the recipient's imagination and contribute to the

“personalisation” of the atomic bomb experience. Through this analysis, the research attempts to identify the specific role digital archives should play in the inheritance of atomic bomb experiences and the elements necessary to maximise their effectiveness.

To elucidate the characteristics of digital archives involved in the inheritance of atomic bomb experiences, this study selected the following three media for analysis. These media were chosen based on the criteria that they are digitised and contain descriptions of the empirical facts of hibakusha. These criteria, academically formulated by the author, guided the selection process in this study.

1. Analysis of Written Testimonies of Survivors

Objective: In this chapter, as a first step toward identifying factors that stimulate learners’ imagination when using atomic bomb testimony archives, we focused on written testimonies and analysed the generational distribution of testimonies observed therein.

At the outset of this series of examinations, we hypothesised that the age consistency between the learner and the narrator (at the time of the bombing) may have a significant impact on the learner’s imagination. To verify this hypothesis, it is necessary first to confirm whether testimonies from a wide range of generations are indeed accessible in the database.

Subjects: [Written testimonies](#) published on the Peace Information Network of the Hiroshima and Nagasaki National Peace Memorial Halls for the Atomic Bomb Victims (as of 2021).

Analytical Method: Extracting the writing year; and author age at the time of bombing (August 6th, 1945) from memoirs of “Hiroshima direct atomic bomb survivors” and statistically analysing their distribution pattern.

Results: Data from 421 memoirs (209 male / 212 female) of “Hiroshima direct atomic bomb survivors” were analysed.

- Year of writing: 374 cases (approximately 89%) were written after 1990.
- Age at time of bombing: The combined total for those under 10, in their teens, and in their twenties accounted for 391 cases (approximately 93%), indicating a bias towards younger ages

2. Analysis of Newspaper Articles

Objective: To examine how newspaper articles, which presuppose the existence of readers, feature and convey hibakusha testimonies.

Subjects: Forty-seven articles serialised between 1999 and 2021 from the [Yomiuri Shimbun’s](#) special series “Hiroshima: What We Want to Hand Down, What We Want to Convey.”

Analytical Method: Extracting and analysing patterns in the timing and triggers of hibakusha’s testimony activities based on the content of the articles.

Results:

Table1: Distribution of testimony activity Start Dates

Start Period	1960s	1970s	1980s	1990s	2000s	2010s	Unknown
Number of Cases	1	3	4	6	14	10	9

The analysis revealed that the initiation of hibakusha’s testimony activities increased over the post-war period, intensifying particularly after the 1990s. Based on this data, we can see that at least fifteen years elapsed from the atomic bombing until hibakusha broke their silence and commenced their testimony activities. Furthermore, from the contents of the articles examined in this research, four main factors emerged as typical starting points for hibakusha’s testimony activities.

1. Requests from others

2. Being affected by nuclear accidents and wars (for example, the Fukushima Daiichi nuclear disaster caused by the Great East Japan Earthquake)
3. Participation in hibakusha organisations or related events
4. Onset of illnesses such as atomic bomb disease

3. Analysis of Video Testimonies

Objective: To examine which phases of the atomic bombing survivors' experiences (before, during, and after the bombing) are most emphasised in video testimonies, and to identify challenges, such as narrative imbalance and impacts on viewers' imaginative engagement with archive material.

Subjects: One testimony video selected from each decade (1986–2019) from the Hiroshima Peace Memorial Museum's "[Peace Database](#)."

Analytical Method: Categorising video content into four categories: "Narration," "Pre-bomb," "Immediately Before / After Bombing," and "Post-bomb," and analysing the proportion of time each category occupies.

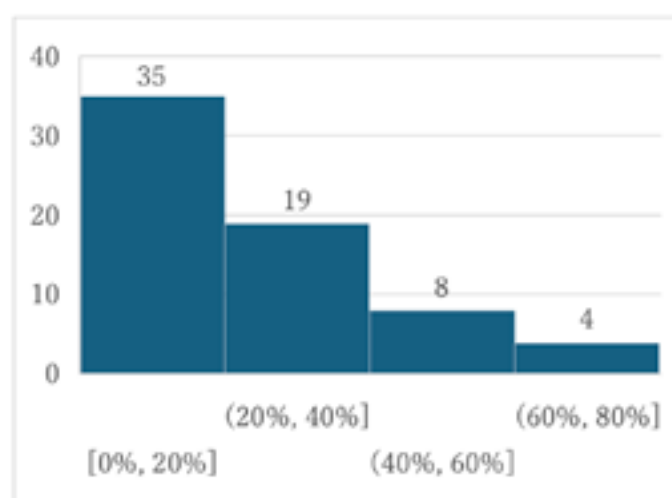
Results:

- **Overall Tendency:** Descriptions related to the period "Immediately Before / After Bombing" constituted the largest proportion of the total video time. These often included detailed accounts of evacuation actions and visual, olfactory, and auditory sensations, strongly conveying the devastation of Hiroshima on the day of the bombing.
- **Changes by Era:** Video testimonies produced in 2017 and 2018 uniquely included descriptions of the "Pre-bomb" period, conveying aspects of life before the bombing. Furthermore, the number of testimonies focusing on the "post-bomb" period also increased. Content describing post-war struggles such as discrimination, prejudice, and battles with illness showed an upward trend.

Based on these results, a further organisation of the proportion of "post-bomb" testimonies in the total video time is presented below.

Fig. 1: Histogram of the Proportion of "post-bomb" Testimony in the Total Duration of Videos (e.g. discrimination and prejudice, atomic bomb sickness, daily life, thoughts for peace and nuclear abolition, messages for future generations)

(Vertical Axis: Number of Videos / Horizontal Axis: Proportion of post-bomb Testimony)



As the fig.1 above illustrates, videos with a higher proportion of "post-bomb" testimonies are fewer in number.

Discussion

Based on the results from analysing the written testimonies of survivors, newspaper articles, and video testimonies conducted in this study, we discuss the potential of digital archives to support audience's imaginative engagement with atomic bomb experiences, as well as the challenges posed by differences in modes of expression across various media.

Media Characteristics and the Effectiveness of Inheritance

Written Testimonies of Survivors: The analysis of written testimonies revealed a temporal bias—a concentration of accounts written in particular decades—and a demographic bias, with a

disproportionate number of testimonies written by hibakusha who were children or teenagers at the time of the bombing. This suggests that when handling materials as digital archives, careful consideration is required for the complex interplay of factors such as “by whom,” “when,” and “for what purpose” the testimonies were written and donated. Such testimonies are highly self-expressive of the author and often do not presuppose the existence of a reader, thus possessing a private nature. For this reason, while they preserve and publish the hibakusha’s own words and experiences without third-party editing, they may also pose a hurdle for audiences in understanding the content and forming empathy.

Newspaper Articles: The analysis of newspaper articles revealed that many hibakusha experienced a period of silence after the war before beginning to speak about their experiences, with the 1990s marking a turning point when testimony activities increased. This indicates progress in the verbalisation of war narratives. The essence of atomic bomb damage lies not only in immediate destruction but also in the continued “hibakusha” social label and the ongoing suffering and struggles associated with it in the post-war period. It is precisely because witnesses overcame such difficulties to speak that their voices possess irreplaceable power and persuasiveness. The newspaper interviews analysed in this study are structured to draw readers into the hibakusha’s personal experiences, not only by depicting the tragic scenes of the bombing itself but also by reflecting on their lives. Newspapers, in addition to conveying facts, are composed and edited to arouse readers’ interest, facilitating a more straightforward reception of the content.

Video Testimonies: Video testimonies offer an advantage in their ability to convey a hibakusha’s life story and emotional transitions with rich narrativity, appealing to both visual and auditory senses. Facial expressions, gestures, and voice tones play a crucial role in attracting audience interest in the storyteller. This characteristic makes video testimonies the closest form of communication medium to direct dialogue. However, while many videos strongly depict the devastation

“Immediately Before / After Bombing,” prolonged exposure to such tragic testimonies can cause recipients to feel “distress” and a strong urge to “stop” the video.

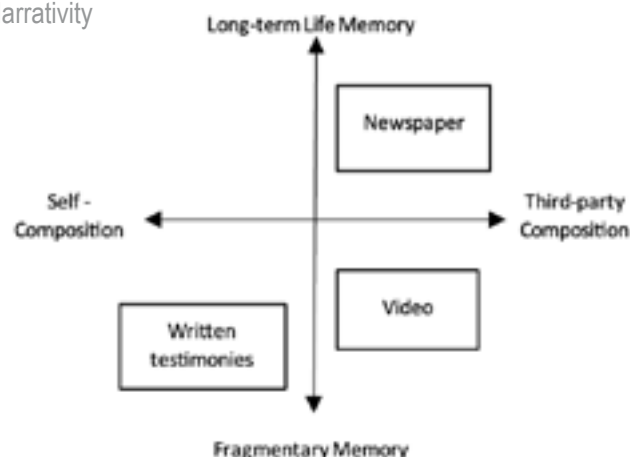
The Importance of “Narrativity” and “Continuity”

The analysis results suggest that to maximise the imaginative power of archives, both the “narrativity of testimonies” (i.e. their clear and organised presentation) and the “continuity of testimonies” (i.e. the recounting of an individual’s entire life) are crucial.

Narrativity: When a narrative is provided through third-party editing, as in newspaper articles and video testimonies, making it easy to understand, audiences can more readily recall the experience.

Continuity: If only the most tragic parts of a hibakusha’s experience are extracted, recipients may experience trauma and feel that the memory is fragmented. Therefore, to remember and empathise with their suffering, it is crucial to recount their entire life and connect it to one’s own. Particularly in recent video testimonies, a notable trend was observed in testimonies recounting post-bomb life struggles. By narrations including an entire life experience, audiences can listen to the testimonies with a certain sense of relief. The archives can then provide a “prescription” that not only leaves a tragic impression but also enables the audience to face the future with a positive attitude.

Fig. 2: Media Characteristics and Memory Continuity / Narrativity



As shown in Fig.2, while newspapers tend to convey “long-term life memories” through third-party composition, written testimonies and a large number of videos tend to convey “fragmentary memories”. However, it is not a question of which of these is superior or inferior. What is important is for audiences to understand the characteristics of each medium and experience multiple testimonies, so someone can put themselves in the place of the survivor.

Conclusion

This study analysed three distinct media—written testimonies of survivors, newspaper articles, and video testimonies—with the aim of exploring the potential of digital archives to stimulate learners’ imagination in the inheritance of atomic bomb experiences. The following conclusions were drawn:

Characteristics of Each Medium

Written testimonies are private and highly self-expressive, but since they don’t always necessarily presuppose a reader, direct empathy requires strong recipient initiative. In contrast, newspaper articles and video testimonies, which presuppose the existence of readers and viewers, are more effective in conveying information to a wider audience because they are “easy-to-understand”, for example, by utilising effective editing.

Importance of Narrativity and Continuity

To maximise the imaginative power of testimonies through archives, it is crucial for such media to possess: “narrativity” so they are clearly organised; and “continuity” to recount the entire life of the hibakusha. However, even in these cases, the degree of empathy elicited can vary depending on which part of the hibakusha’s life is being narrated.

Challenges To the “Personalisation” of Atomic Bomb Experience Inheritance

The process of “personalisation” of the atomic

bomb experience, as depicted in Table 2, is constructed through learners’ active engagement such as independently seeking out multiple testimonies and carefully interpreting the narratives, and through a deepening of understanding in which they recall and relate the experience of others to their own lives.

Table 2: Process of “Personalising” the Atomic Bomb Experience

Stage	Description
4	“Personalisation” of the atomic bomb experience = Construction of “My own actual memory related to the atomic bombing”
3	Recalling what was seen and heard by putting oneself in the place of a survivor
2	Seeing and hearing multiple testimonies
1	Possessing initiative (a desire to get closer to the actual circumstances of the atomic bombing)

Going forward, a crucial challenge will be to further expand opportunities for learners to actively engage with the narrative and continuous life memory of those who experienced the atomic bombing of Hiroshima. This can be achieved by creating places to meet individual hibakusha through digital archives. Drawing inspiration from exhibitions at various museums that present negative memories, future research, building upon this study’s findings, should aim to propose and implement such innovative opportunities for encountering the personal stories of hibakusha.

The Verification Nightmare: Manoeuvrable Hypersonics and the Challenge to Arms Control

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Introduction

Hypersonic weapons are defined primarily by a speed exceeding Mach 5. Today, two types dominate the field of manoeuvrable hypersonic weapons: hypersonic glide vehicles (HGVs) are launched atop ballistic boosters but detach to glide through the atmosphere along unpredictable trajectories; hypersonic cruise missiles (HCMs), by contrast, use advanced scramjet engines to sustain hypersonic speeds entirely within the atmosphere. The distinction between traditional ballistic missiles, ICBMs and SLBMs (which also achieve hypersonic speeds of Mach 5–20+ in their midcourse and re-entry phases) and modern hypersonic weapons lies in trajectory and detectability. Unlike ballistic missiles, which follow a predictable arc, non-ballistic hypersonics can fly lower, evade radar detection until late in their flight, and manoeuvre unpredictably—features that make them exceptionally difficult to monitor, classify, or intercept, undermining the effectiveness of existing missile defence systems and further increasing escalation pressures (See Figure 1).

Detection is the first hurdle for any system seeking to defend against or deter hypersonic attacks. Existing terrestrial radar systems, optimised for ballistic trajectories, such as the Ballistic Missile Early Warning System or BMEWS (United States), SLC-2 / SLC-3 radars (China), Voronezh radar (Russia), are primarily designed to detect high-altitude, predictable missile arcs. Space-based sensors fare no better. From geostationary orbit, HGVs and HCMs appear, as former US Under Secretary of Defense for Research and Engineering Michael Griffin [stated](#), “10 to 20 times dimmer” than ballistic missile warheads, complicating reliable tracking and creating a situation akin to [two gunslingers in a dark room](#). This delay compresses decision-making windows for policy-makers, forcing potential retaliatory choices to be made under

extreme time pressure, rather than tens of minutes. But the same features that hinder early warning also cripple verification. If a system cannot reliably track or characterise a missile in real time, how can inspectors or national technical means confirm treaty compliance? The verification nightmare is born from this dual failure: the inability to see early enough and the inability to identify clearly enough.

Ambiguity and Escalation Risks

Russia and China already claim to have dual-capable manoeuvrable hypersonic systems, whereby they can carry conventional or nuclear payloads. [Russia's Avangard HGV](#), mounted on ICBMs, and [China's DF-17 missile](#), with its glide vehicle, have both been presented by these nations as deployed. The U.S. Army's Dark Eagle, officially known as the Long-Range Hypersonic Weapon (LRHW), by contrast, has so far been prioritised as a conventionally armed system. This asymmetry creates a thorny problem of setting reciprocal limitations when one side fields dual-capable systems, while another is focused on precision conventional strike. Any treaty negotiation thus risks being unbalanced unless agreed definitions and categories can be found.

New START, the last strategic arms control agreement between the United States and Russia, exemplifies the verification mismatch. It counts systems that fly ballistically for more than 50% of their trajectory. Non-ballistic hypersonic missiles, which do not, fall outside its definitions and leave room for interpretation. The treaty contains a Bilateral Consultative Commission to address “[new kinds](#)” of strategic arms, as Russia labelled modern hypersonics during negotiations, but its suspension leaves little practical scope for adjustments. While both Washington and Moscow still appear to be observing New START's numerical limits on deployed warheads and launchers, the suspension

has halted the on-site inspections, data exchanges, and notifications that made compliance transparent. This means the treaty's most powerful tool, its verification regime, is frozen, at the very moment new, dual-capable non-ballistic hypersonic systems are advancing unchecked. With New START set to expire in 2026, unless a successor framework is negotiated, these new weapons could enter an entirely unregulated environment, compounding the verification challenges already baked into their design.

HGVs and HCMs are not just difficult to monitor; they are destabilising by design. Their dual-use potential introduces ambiguity that fuels escalation risks. For example, an adversary detecting a hypersonic launch may not know whether the missile carries a conventional or a nuclear warhead, yet must respond in kind—potentially even with nuclear forces—[within seconds](#) to a few minutes. This sharply compresses the 'Observe Orient Decide Act loop' (See Figure 2), compared with the [warning time](#) of around 30 minutes for ICBMs and 15–20 minutes for SLBMs. The deployment of this type of technology therefore includes the risk of rapid escalation which has implications for strategic stability.

Furthermore, Beijing's 2021 test of its Gliding Fractional Orbital Bombardment System (G-FOBS), a HGV deployed via a fractional orbit, was seen as a "[Sputnik moment](#)" for China. FOBS is usually used to place a nuclear weapon into low Earth orbit and attack targets from space. China's action challenged the prevailing security order, defied existing approaches to categorising missiles and left outside observers scrambling to interpret its purpose. For verification regimes, this ambiguity is fatal.

New Approaches to Improve Verification Systems

Despite these challenges, some parameters could, in theory, anchor a verification regime for non-ballistic hypersonic missiles. Speed and trajectory thresholds might help distinguish these missiles from traditional systems, though verifying them mid-

flight remains difficult. Basing modes and launch platforms, such as ground-based boosters or specific aircraft, could be subject to declaration and inspection. Yet most of these measures require either a level of sensor capability not yet realised, or intrusive on-site inspections that some states may resist. In effect, the technical limits of monitoring constrain what is politically feasible.

Ironically, the very technologies being developed to counter hypersonic systems may offer a pathway to verification. The U.S. is investing in the [Hypersonic and Ballistic Tracking Space Sensor](#) (HBTSS), designed to globally track hypersonic missiles, while the planned [Glide Phase Interceptor](#) (GPI) aims to neutralise them mid-flight. In principle, the same sensor networks could underpin cooperative monitoring or shared situational awareness.

New technologies and other innovative approaches further expand these possibilities. Next-generation satellite constellations, including the U.S. Space Development Agency's low Earth orbit missile-tracking network and upcoming [Next-Gen OPIR GEO satellites](#), are designed for persistent, global detection of manoeuvring hypersonic threats. AI is [increasingly applied](#) by the U.S., China, Russia, NATO and [other countries](#) to process vast sensor data, enabling the faster identification of threats, pattern recognition, and dynamic trajectory analysis. Verification strategies are evolving toward layered networks—combining satellites, drones, ground-based radar, and cyber tools for comprehensive tracking. Beyond technology, renewed diplomatic efforts and confidence-building measures remain essential, with mutual notifications between the principal hypersonic powers covering planned launches, trajectories, and test parameters, along with telemetry sharing and adapted joint inspection regimes offering a political complement to technical monitoring.

Conclusion

Modern hypersonic weapons sit at the intersection of technical innovation and strategic instability. Their speed and manoeuvrability compress decision-making timelines, while their ambiguity multiplies risks of miscalculation. But perhaps their

most dangerous feature is what they deny arms control: verifiability. Without credible mechanisms to monitor and constrain them, arms control risks irrelevance in the face of technological change. Meeting this challenge requires imagination, investment in monitoring, and above all, political will. The nightmare of hypersonic verification is real, but it is not insurmountable if the principal hypersonic powers and nuclear-armed states recognise that the alternative is a future of unbounded, unverifiable destabilisation.

Figure 1: Radar Line of Sight Limitations

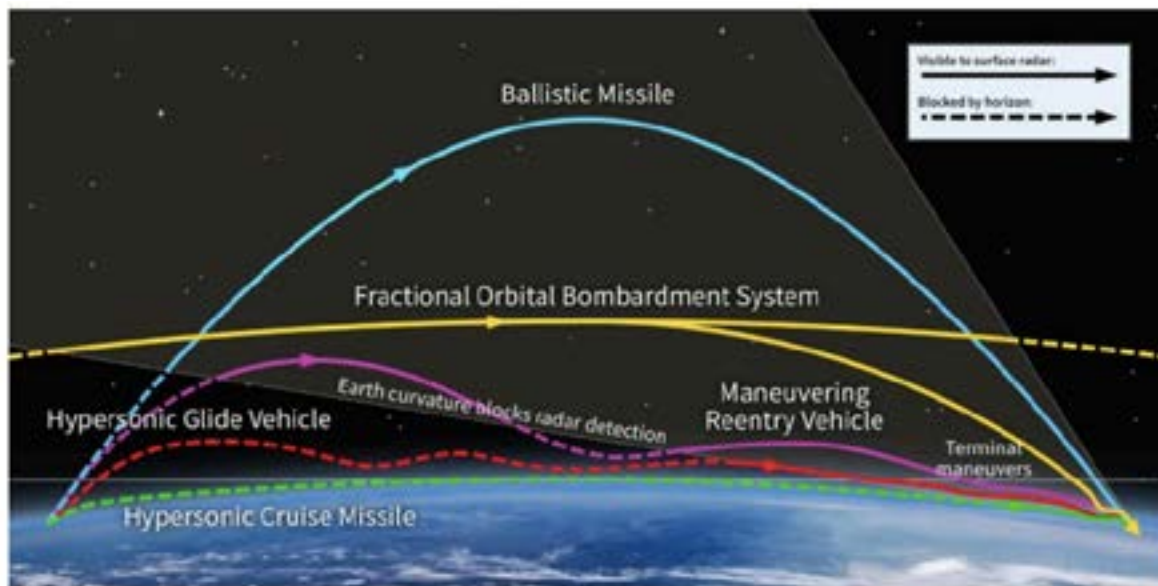
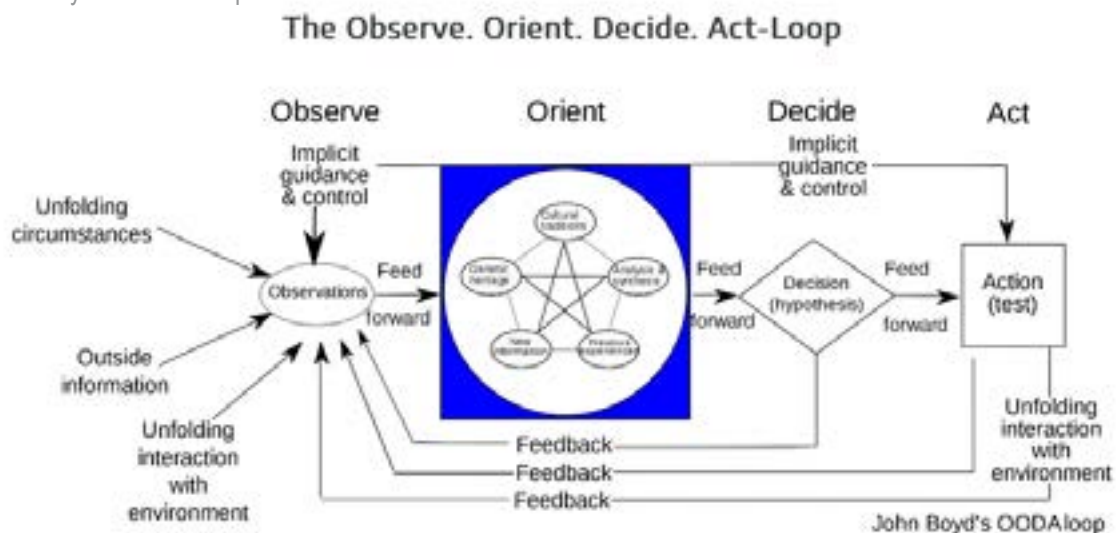


Figure 2 John Boyd's OODA Loop



Maintaining 'Cold Peace' Between Regional Nuclear Dyads in Light of the Third Nuclear Age: The Case of India and Pakistan

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Introduction

The global nuclear order [emerged](#) roughly in the 1940s. Ever since, nuclear scholarship has largely been stuck in a Cold War mindset. Concepts such as arms control, deterrence and nuclear use among nuclear-armed states, and between nuclear and non-nuclear armed states, have been studied mainly through the lens of Cold War learnings and outcomes. There is a general tendency among the strategic and policy community in the West to mould the majority of deterrence relationships in strict Cold War terms, extrapolating the U.S.-U.S.S.R deterrence model to regional nuclear dyads and triads.

While this setting is useful in examining the broader trends in the evolving strategic landscape, such models often obfuscate the unique predispositions that regional actors continue to face in managing the risks that arise from possessing nuclear weapons and maintaining nuclear stability. This gap in understanding is glaringly exposed in regions such as South Asia, where two nuclear-armed adversaries—India and Pakistan—continue to clash with each other on a conventional military level, as well as operationalise deterrence at levels between conventional and sub-conventional warfare.

The recent [Pahalgam](#) terrorist attacks in the Indian administered Jammu and Kashmir region, which the Pakistan-based Lashkar-e-Taiba (LET) proxy, The Resistance Front (TRF) claimed responsibility for, have yet again stirred up a debate around the validity and frailty of the nuclear threshold between these two nuclear-armed states. Regions which are marred by a long history of conflict and the persistent presence of a nuclear shadow which applies in all crisis situations are more prone to de-stabilising nuclear deterrence dynamics as their nuclear threshold continues to be tested, blurred and re-formulated. When seen in light of the [Third Nuclear Age](#)—which is roughly believed to have

begun around 2010, marked by the advent of emerging and disruptive technologies such as artificial intelligence (AI), cyber warfare, quantum computing, and a unique entanglement of nuclear and strategic non-nuclear weapon systems—regional deterrence relationships that have stood the test of time today stand at the risk of breaking down.

As far as regional stability is concerned, arguably the biggest impact of this new nuclear age will be on regional crisis management measures which continue to operate under the weight of conventional Cold War deterrence models and conceptual frameworks. This article considers the case of India and Pakistan to argue for a 'Cold Peace' model, which requires a revised, paradigmatic shift in how we understand nuclear deterrence in South Asia. I then discuss the impact of technological changes on deterrence and crisis management in this region. The article concludes with some recommendations on how to achieve crisis stability in the Third Nuclear Age and build 'Cold Peace' between India and Pakistan.

What Makes the South Asian Region Unique?

The Cold War [model of deterrence](#) which relies on the doctrine of Mutually Assured Destruction (MAD), overkill capabilities and secure second-strike options, is called into question when such frameworks are applied in a region home to nuclear powers sharing a contiguous border. For example, the length of the border between India and Pakistan extends to approximately 3,100 - 3200 kilometres. This geographical proximity reduces aircraft and missile delivery times, which can be as short as a few minutes. Advancements in missile technologies, such as tactical nuclear weapons possessed by Pakistan, Multiple Independently-targetable Reentry Vehicle (MIRV) capabilities believed to be

[under development](#) by both India and Pakistan, and the canisterisation of [ballistic missiles](#) under development by [both states](#), which shortens launch times by improving mobility and storage of missiles with an option for pre-mated warheads, have further compressed the decision-making timeline.

Both India and Pakistan have adopted a commitment to credible minimum deterrence (CMD) which entails maintaining a nuclear force of a small (minimal) size. However, minimum deterrence is a dynamic and flexible concept which adds to doctrinal ambiguity. Additionally, there is a severe lack of trust between these two states in terms of their nuclear doctrines. For example, whilst a No-First Use (NFU) posture forms a core pillar of India's stated nuclear doctrine, Pakistan does not trust India's NFU pledge. On the other hand, Pakistan does not clearly state its threshold for nuclear use, thus raising Indian concerns for a pre-emptive and disabling strike by Pakistan. The divergence in red lines regarding nuclear use, coupled with the complexities driven by (often) disruptive technological advancements, adds further uncertainty to this regional dyad.

Most importantly, in the Second Nuclear Age—with the emergence of new nuclear powers like India and Pakistan—there was a shift from a dyadic to a [triadic nuclear relationship](#) between China, India and Pakistan. Moving from two to three actors in nuclear decision-making is challenging as these three states are locked in a complex deterrence relationship with each other where India measures its capabilities against China, and Pakistan measures its capabilities against India. This significantly alters the threat perceptions of all actors involved, leading to a situation of inadvertent escalation due to misinterpretations concerning the build-up of conventional and nuclear capabilities.

Lastly, India and Pakistan's deterrence relationship is fundamentally defined by [sub-conventional warfare](#). For example, Pakistan's overt tactics of harbouring terrorist groups and deploying terrorism against India is both intended to make up for its conventional inferiority vis-à-vis India and also neuter India's options to retaliate, even conventionally, owing to a fear of Pakistan's deployment of

tactical (battlefield) nuclear weapons. Since there is yet no formal [policy of retaliation](#) by India against a terror attack, Pakistan's resort to sub-conventional warfare tactics accentuates and elongates the fog of war and muddles the clear communication of deterrence thresholds in crisis situations.¹ Thus, any (and almost all) conventional retaliation in the case of India and Pakistan will have nuclear undertones, making intentions harder to gauge and the establishment of credible deterrence an elusive goal.

These conditions are the starting point for an examination of India and Pakistan in this new nuclear age. Given the security environment and geopolitical idiosyncrasies, how these two states choose to respond to the threats and challenges of the Third Nuclear Age will be instrumental for regional and global nuclear stability.

Crisis Management and Changing Contours of Deterrence in the Third Nuclear Age

The [new nuclear age](#) is marked by some significant trends such as great power competition, a move towards nuclear multipolarity—with the emergence of smaller nuclear powers—and the introduction of destabilising emerging technologies. These technologies include: anti-submarine warfare, national ballistic missile defense, the employment of autonomous vehicles, advanced sensors, and AI to analyse huge volumes of data. Other offensive technology includes cyber-attacks, which can threaten a state's conventional military and nuclear establishments, including both civilian and military nuclear facilities and command-and-control systems.

Both [India and Pakistan](#) have made forays into this new strategic space. India has been investing in a multi-layered missile defence system, a nuclear-powered submarine programme and hypersonic missile technologies. Meanwhile, Pakistan's

¹ This policy is expected to have gone through changes following the India-led [Operation Sindoor](#), where India has pledged to respond to a terror attack with kinetic conventional action.

investment in electronic warfare, autonomous systems for battlefield application, cyber defence, and the advancement of its second-strike capabilities has increased the risk appetite of these states, wherein the threshold for quick kinetic action has lowered with a guarantee of precise strikes and reduced collateral damage. Given the geopolitical situation and the ensuing arms race between these two states, an obvious implication is that there will be a shift in the threat perceptions of India and Pakistan. For example, the intentions of both states will be harder to gauge because of the entanglement of strategic conventional weapon systems with nuclear weapon systems. Specifically, crisis stability measures between the two states are expected to face some challenges in the following ways:

- Time is of the essence in any crisis given the importance for decision-makers of having enough time to gauge the actions and intentions of the adversary, both to prevent escalation and to start the process of de-escalation. AI and cyber technologies will compress decision-making and impose a deadly time crunch on key decisions pertaining to retaliation and counter-strikes. In a region like South Asia, where nuclear weapon adversary states—which are adversaries—exist in such close geographical proximity, this may have a devastating impact on stability.
- Communication windows may also be disrupted, along with a lowering of the likelihood that third-parties can make constructive interventions given the paucity of time. South Asia has always been a theatre for great power competition. However, growing U.S. retrenchment globally, alongside Washington's declining willingness to mediate crises in the region, may have grave consequences.
- Information flow is an expected casualty of a delay or lack of information (for example, as a result of AI-cyber-attack). This will impact the credibility of information exchanged between top leaders.
- A higher threshold for risk acceptance is becoming increasingly common between India and Pakistan,

especially in the past few crises, including the 2016 Uri attacks and 2019 Balakot strikes by India, and Operation Sindoor launched by India in response to the Pahalgam terror attacks in April 2025. Mutual restraint and mutual vulnerability, underpinned by the shared fear of nuclear war, are being eroded.

- Subjectivity underpins every crisis, wherein a state can choose to identify an event as transgressive. Both parties engaged in a crisis may assess and interpret the intensity and unpredictability of the crisis differently. Therefore, some intense situations turn into a crisis while others don't. This subjectivity is eroded, to a certain extent, with the deployment of disruptive technologies as both parties may not have the luxury of time and may feel the domestic and international pressure to come to a decision quickly.

Maintaining 'Cold Peace'

The underlying basis of '[Cold peace](#)' is competition and mutual deterrence, whereas 'warm peace' can be achieved through cooperation and mutual reassurance. Given the turbulent relations between India and Pakistan, it is more feasible for these states to achieve cold peace as a stepping-stone towards finally establishing a genuine and mutual accommodation of each other's interests that are driven by shared norms. Recommendations for global and bilateral confidence-building include the following measures:

Global Level

1. Regional dyads need to be given greater prominence in global nuclear order-making processes such as proposals for nuclear non-proliferation and disarmament, institutionalised in the Nuclear Non-Proliferation Treaty (NPT), or the discussions on the regulation of emerging and disruptive technologies under the auspices of the United Nations Group of Governmental Experts, among others. The impact of the third nuclear age will be experienced differently by different stakeholders and this needs to be acknowledged on a political, strategic, tactical and institutional level. Regional security concerns require better representation in the global conversations on issues of nuclear stability and deterrence amongst

major nuclear powers, other rising nuclear and non-nuclear armed states and international nuclear bodies such as the IAEA, the nuclear export control groups, the Conference on Disarmament and so on. These concepts also need to be adapted and revised to cater to the needs of the region and the unique and complex deterrence relationships shared by the residing actors.

2. Innovation often precedes regulation and it is therefore of the utmost importance that consensus is built on regulating emerging and disruptive technologies among: the nuclear weapons states / P5; the non-nuclear weapon states; regional nuclear armed states; as well as nuclear threshold states. The effects of new technologies need to be discussed and brought within the folds of established nuclear non-proliferation and disarmament institutions, such as the NPT.

Bilateral Level

1. Strengthening current Confidence Building Measures (CBMs) between India and Pakistan is of the utmost importance. Some of these CBMs need to be revised to account for changes in the external security environment due to the introduction of new, potentially de-stabilising, weapon systems. For example, an amendment to the 2005 agreement on pre-notification of flight testing of ballistic missiles, signed by India and Pakistan, could also include cruise missiles, hypersonic missiles and precision-guided munitions that would provide greater stability and confidence between the two nations. The amendment clause in Article 8 of the agreement provides for both states to undertake such consultations to consider possible amendments of this nature.

2. Both countries suffer from the absence of usage of a trusted and credible communication line (hotline) in a crisis. While formally, a hotline exists between the Directorate General of Military Operations (DGMO) of India and Pakistan, such lines are the first casualties in a crisis and / or war situation. Moreover, no nuclear hotline exists connecting the Nuclear Command Authorities (NCAs) of the two states which would ward off any misinformation or disinformation, especially in the

era of cyber warfare, and prevent inadvertent attacks on critical nuclear infrastructure. This is a major roadblock in exercising off-ramp options available to both countries in times of a nuclear crisis.

Conclusion

The deployment of emerging technologies by India and Pakistan will have adverse effects on regional stability with an impact on the prospects for conventional and nuclear disarmament, arms control measures (which are non-existent in South Asia), and crisis stability. In addition, the potential for conventional warfare will likely grow. Resilient CBMs between India and Pakistan, which have so far kept the 'cold peace' through mutual vulnerability, are at risk of becoming redundant. Only by revisiting 'cold peace' measures and maintaining stable deterrence can India and Pakistan move towards achieving a 'warm peace' that will ultimately open avenues for trust, cooperation and mutual reassurance, which are the bedrock of long-lasting and credible arms control and disarmament measures.

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