NUCLEAR RISK REDUCTION

A FRAMEWORK FOR ANALYSIS

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LIST OF ACRONYMS AND ABBREVIATIONS

C3	command, control and communications
IAEA	International Atomic Energy Agency
NPT	Treaty on the Non-Proliferation of Nuclear Weapons
PAL	permissive action link
START	Strategic Arms Reduction Treaty
TPNW	Treaty on the Prohibition of Nuclear Weapons

EXECUTIVE SUMMARY

Addressing the risks that could lead to any use of nuclear weapons is in the security interests of all States. Yet there remains disagreement on the means through which this might be achieved. Such contestation over risk reduction measures exists because perspectives of risk concepts differ. For instance, decreasing the operational readiness of nuclear weapons for some would help lessen the likelihood for inadvertent launch, especially in crisis. For others, taking such action detracts from the predictability of force postures, while also upending the credibility of deterrence and increasing the risk of an adversarial first strike. Policy discussion of nuclear weapon risk reduction is often invoked from national perspectives, and focused on individual and isolated State ideas and proposals.

Is the pursuit of nuclear weapons risk reduction then a hopeless endeavour, built on empty rhetoric? No, it is not. Exploring the gamut of risk reduction-relevant possibilities in a full and systematic manner can facilitate the identification of areas of common interest among States and the development of practical, feasible, and contextually appropriate measures. To this end, this study presents an analytical framework that establishes initial parameters for exploring risk and risk reduction in particular contexts, including at the regional level. It identifies four pathways to potential nuclear use—doctrinal, escalatory, unauthorized, and accidental—and examines the sources and underlying conditions driving these scenarios. It then posits an approach to addressing each.

- To reduce **doctrinal risk**, States should narrow the situations in which they would consider nuclear use and lessen the ambiguity surrounding those situations. This involves:
  - stigmatizing overall use
  - circumscribing use conditions
  - clarifying doctrine
- To reduce **escalatory risk**, States should look to raise the threshold for nuclear use, especially in volatile situations. This involves:
  - increasing predictability of use conditions
  - strengthening nuclear restraint
  - preventing crisis
- To reduce **unauthorized risk**, States should bolster security to deny access—direct and indirect—to nuclear weapons and related materials. This involves:
  - enhancing physical and digital safeguarding operations
  - improving risk assessment and management

To reduce **accidental risk,** States should enact safeguards that can limit human and technical errors while restricting their impact. This involves:

- strengthening safety features
- enhancing operator control
- containing the consequences of error

This paper identifies some potential means to achieve these objectives. It presents an overview of pertinent risk reduction ideas, drawing on past mapping and scoping work. Enacting specific measures to address risk sources and underlying conditions narrows the possibility of particular pathways, lessening their number and reducing risk overall.

The framework presented in this paper is meant to serve as a foundation for contextual and regional analysis. Moving forward, examining the precise manner in which the four identified pathways—and their associated sources and conditions—might appear in a given context will allow a tailored identification of risk reduction measures to address those specific nuclear use scenarios. And by properly taking into consideration the nuclear characteristics, regional security environments, and broader geopolitical relations in a given region, future work can ensure those prescribed baskets of risk reduction measures are practical and feasible, creating a basis for joint action.

CONTEXT

In recent years there has emerged among the international community a renewed sense of urgency to address the range of risks that could lead to any use of nuclear weapons. This reflects concern with the current state of affairs, in which rising tension among nuclear-armed States has increased the possibility of conflict across a number of contexts. All of the nuclear-armed States are undertaking modernization programmes. Meanwhile, for some of these nuclear-armed States and their allies, extended nuclear deterrence remains central in strategic doctrine. The multipolar nature of today's international system, alongside changes in political leadership in some States, has further contributed to perceptions of increased uncertainty concerning the conditions under which nuclear weapons may be used. This is occurring against a backdrop in which the international arms control and disarmament architecture is under serious strain and progress in terms of nuclear reductions has faltered.

Risk reduction activity thus appears increasingly critical both in itself and in providing a foundation for engagement on divisive nuclear issues. Yet broad-based support for the idea of reducing to an absolute minimum nuclear risk has not—to date—translated into general agreement on the means by which this might be achieved.[1] What constitutes risk reduction measures for some may for others increase risk by upending the credibility of nuclear deterrence, threatening strategic stability, or creating new forms of unhelpful nuclear ambiguity. These differing interpretations of risk and risk reduction reflect varied constituencies, priorities, and strategic cultures. Still, such divergences should not be insuperable hinderances to nuclear risk reduction efforts. In fact, one priority of risk reduction should be to enhance mutual understanding of risk interpretations in order to reduce the possibility of use stemming from miscalculation or misperception. Overall, risk reduction efforts need to pinpoint areas of common interest in order to spark joint action.

[1] See W. Wan, *Nuclear Risk Reduction: The State of Ideas*, UNIDIR, 2019, http://unidir.org/files/publications/pdfs/nuclear-risk-reduction-the-state-of-ideas-en-767.pdf.

OUTLINE

A comprehensive and considered approach to nuclear weapon risk reduction must account for the dynamism of risk across situations. Nuclear risk is a global issue due to the interconnecting relations and security concerns of nuclear-armed States as well as the impacts of nuclear weapon use. But pathways to that use vary and are intertwined with the characteristics of a given context. These can include the doctrines and force postures of relevant nuclear-armed States, the nature of their alliances, and underlying sources of tension. Reducing risk of use in Europe, for instance, requires at a minimum consideration of the security perceptions of NATO States and the Russian Federation, which can then facilitate understanding of how proposed measures (for example, limiting the size and scope of military exercises in the Baltics) would address—or exacerbate—their particular concerns. This kind of contextual analysis can allow the reframing of a difficult topic, one often invoked from national perspectives. In the interim, a conceptual framework for risk reduction can help establish parameters for that analysis.

This paper proceeds as follows. The next section explores in the abstract risk scenarios involving the use of nuclear weapons. It discusses four pathways to use, identifying sources of risk and, where relevant, referring to historical 'close calls' that exemplify the scenario. Then, the paper considers the appropriate means of addressing the identified pathways to use. It outlines a broad approach and accompanying objectives for combating each. Drawing from scholars, analysts, and policymakers, it also previews baskets of risk reduction measures that fall into each approach (see the appendix for a summary of these ideas).[2] Following that, the paper considers how nuclear-armed States have hitherto engaged with nuclear risk reduction in bilateral and multilateral settings. A concluding section revisits contestation surrounding the concept of risk reduction. It offers a proposal for deploying the framework with a view to developing practical and feasible measures linked to particular contexts, which UNIDIR will explore in its research moving forward.

[2] As there are many such ideas and proposals, inevitably the selection is somewhat arbitrary.

NUCLEAR WEAPON USE SCENARIOS

Plausible scenarios in which nuclear weapons could be used vary widely due to factors such as the actors involved and their doctrines for employment of nuclear weapons, their nuclear and related capabilities (for instance, delivery systems), and the role of contingent factors (for instance, chance). Variation in use scenarios underlines the need to tailor risk reduction measures to the factors that define each context. But identifying the general pathways to nuclear use can set the initial parameters for contextual analysis. This section undertakes this exercise.

A framework that captures nuclear use scenarios in the abstract—as presented here—can build upon existing dialogue about nuclear weapons. The fundamental distinction often drawn is between intentional (or deliberate) and inadvertent use, with the latter category also encompassing accidental, mistaken, or unauthorized usage. Yet this binary distinction can be problematic, as a deliberate use of nuclear weapons based on a false assessment or in response to a false alarm blurs lines of intentionality. A catch-all third option—with use as intentional, accidental, or otherwise—does not address this issue either.[3] One recent study presented an altogether different range of categories: unauthorized use, unintended use, and intended use based on incorrect assumptions.[4] While this offers necessary nuance, the treatment conspicuously casts aside the possibility of deliberate use.

Building on existing categories, this paper presents four 'risk of use' scenarios. A detailed examination follows, but briefly:

- **doctrinal use** refers to use as outlined in declared policies, primarily based on retaliatory possibilities, with allowance for ambiguities in those policies;
- **escalatory use** refers to use linked to an ongoing tension or conflict, or to the introduction of nuclear weapons in times of crisis;
- **unauthorized use** refers to non-sanctioned use, including by rogue State actors, as well as use linked to non-State actors, including of lost, stolen, diverted, or crude nuclear devices; and
- **accidental use** refers to use linked to error, including technical malfunction and related human fallibility.

[3] Global Zero, *Global Zero Commission on Nuclear Risk Reduction: De-Alerting and Stabilizing the World's Nuclear Force Postures*, April 2015, https://www.globalzero.org/wp-content/uploads/2018/10/Global-Zero-Commission-on-Nuclear-Risk-Reduction-Full-Report.pdf.

[4] S. van der Meer, "Reducing Nuclear Weapons Risks: A Menu of 11 Policy Options", *Policy Brief*, Clingendael: Netherlands Institute of International Relations, June 2018, https://www.clingendael.org/sites/default/files/2018-06/PB_Reducing_nuclear_weapons_risks.pdf.

The categorization above is not 'hard and fast', and this section later considers interactive effects across pathways (for example, crisis conditions that contribute to accidental use). Examining US–Soviet relations three decades ago, Joseph Nye observed that "efforts to reduce the risk of nuclear war must start with an understanding of the likely paths by which a nuclear war might begin".[5] The same principle holds true when examining possible nuclear use today. The four scenarios above capture a range of possible detonation events (see table 1), comprising an organizing framework around which risk reduction can be discussed. Each is detailed below.

TABLE 1. NUCLEAR WEAPON USE SCENARIOS

PATHWAY	DEFINITION	EXAMPLES
Doctrinal Use	In accordance with declaratory policies and ambiguities thereof	• Following nuclear attack • Existential threat to the State
Escalatory Use	Linked to ongoing conflict or crisis, rising to nuclear use	• Pre-emptive strike • Battlefield situations
Unauthorized Use	Non-sanctioned use or use by non-State actors	• Rogue domestic actors • Nuclear terrorism
Accidental Use	Linked to error	• Technical malfunction • Driven by false alarm

Doctrinal Use

Most of the nine States that possess nuclear weapons have to some degree outlined the circumstances in which they would be prepared to use them.[6] Existing doctrines centre largely—but not exclusively—on notions of retaliation in response to both nuclear and non-nuclear attack. Two States—China and India—have expressly declared 'no first use' policies,[7]

[5] J.S. Nye Jr., "U.S.-Soviet Relations and Nuclear-Risk Reduction", *Political Science Quarterly*, vol. 99, no. 3, August 1984, p. 404.

[6] Even those who speak of a normative inhibition against nuclear use admit the so-called taboo is under fire, for example with "the restraints on nuclear use by a U.S. president [are] less robust than previously thought" and uncertainty regarding its overall robustness "in the face of strategic pressures". See N. Tannenwald, "How Strong Is the Nuclear Taboo Today?", *The Washington Quarterly*, vol. 41, no. 3, September 2018, p. 104.

[7] In a 2003 press release, India specified it also retained the nuclear option "in the event of a major attack against India, or Indian forces anywhere, by biological or chemical weapons". See Ministry of External Affairs, "The Cabinet Committee on Security Reviews Operationalization of India's Nuclear Doctrine", 4 January 2003, https://mea.gov.in/press-releases.htm?dtl/20131/The_Cabinet_Committee_on_Security_Reviews_perationalization_of_Indias_Nuclear_Doctrine.

cementing a retaliatory stance.[8] Meanwhile, the 2018 US Nuclear Posture Review sets forth that nuclear use is "contemplated only in the most extreme circumstances to protect our vital interests and those of our allies".[9] It establishes that nuclear capabilities are present to "respond effectively if deterrence were to fail", as means to re-establishing deterrence. The Russian Federation's 2014 Military Doctrine similarly notes that its right to use nuclear weapons is reserved "in response to the use of nuclear and other types of weapons of mass destruction against it/or its allies, as well as in the event of aggression against the Russian Federation with the use of conventional weapons when the very existence of the state is in jeopardy".[10]

Expansive notions of deterrence can increase the range of situations that fulfil established conditions for doctrinal use. For instance, the US Nuclear Posture Review specifies the deterrent role of nuclear weapons against "significant non-nuclear strategic attacks".[11] While it does not define these attacks, the document earlier identifies non-nuclear strategic *threats* as "including chemical, biological, cyber, and large-scale conventional aggression".[12] The Russian Federation's Military Doctrine extends the role of nuclear weapons beyond traditional deterrent situations, specifying its applicability for preventing outbreak of regional war.[13] Pakistan's National Command Authority has outlined its pursuit of full-spectrum deterrence.[14] Such language contains a degree of purposeful ambiguity, expanding the spectrum of circumstance for use. This is especially true as the self-restraints imposed on nuclear use remain modest.[15] Individual decision makers are the arbiters of what constitutes deterrence

[8] However, scholars have expressed some degree of scepticism both about the nature of their commitments and the continued viability of those policies under changing security circumstances; see K. Sundaram, "India and the Policy of No First Use of Nuclear Weapons", *Journal for Peace and Nuclear* Disarmament, vol. 1, no. 1, 2018; Z. Pan, "A Study of China's No-First-Use Policy on Nuclear Weapons", *Journal for Peace and Nuclear Disarmament*, vol. 1, no. 1, 2018.

[9] US Department of Defense, *Nuclear Posture Review 2018*, February 2018, p. II, https://media.defense.gov/2018/Feb/02/2001872886/- 1/-1/1/2018-NUCLEAR-POSTURE-REVIEW-FINAL-REPORT.PDF.

[10] The Military Doctrine of the Russian Federation, no. Pr.-2976, 25 December 2014, https://rusemb.org.uk/press/2029.

[11] US Department of Defense, *Nuclear Posture Review 2018*, February 2018, p. 58, https://media.defense.gov/2018/Feb/02/2001872886/- 1/-1/1/2018-NUCLEAR-POSTURE-REVIEW-FINAL-REPORT.PDF.

[12] Ibid, p. 38. This is in contrast to the 2010 US Nuclear Posture Review, which specified that the role of nuclear weapons "to deter and respond to non-nuclear attacks—conventional, biological, or chemical—has declined significantly". US Department of Defense, *Nuclear Posture Review Report,* April 2010, p. 15, https://dod.defense.gov/Portals/1/features/defenseReviews/NPR/2010_Nuclear_Posture_Review_Report.pdf.

[13] The Military Doctrine of the Russian Federation, no. Pr.-2976, 25 December 2014, https://rusemb.org.uk/press/2029.

[14] Inter-Services Public Relations, "Press Release: No PR-64/206-ISPR", 24 February 2016, https://www.ispr.gov.pk/press-release-detail.php?id=3211.

[15] The five nuclear-weapon States recognized by the Nuclear Non-Proliferation Treaty (NPT) do provide limited negative assurances against the use or threat of use against non-nuclear-weapon States, including in Security Council resolution 984 (11 April 1995) and in the context of nuclear-weapon-free zone (NWFZs) treaties. See "Mapping Negative Security Assurances: Background Paper for Subsidiary Group 4 of the Conference on Disarmament", UNIDIR, 12 June 2018, http://www.unidir.ch/files/medias/pdfs/background-paper-to-inform-cd-subsidiary-body-4-discussion-eng-0-780.pdf.

failure, or when nuclear weapons might be necessary "for our survival" in response to the crossing of national spatial, military, economic, and political thresholds.[16] These decision makers could perceive a non-nuclear attack as threatening their survival, invoking the "extreme circumstances of self-defence"—and engaging in retaliation.[17] Further, the anticipation of such attacks could suffice in fulfilling those conditions as well.[18] Consequently, how States perceive intentions, policies, plans, and actions can set in motion a pathway to doctrinal use. The role of subjective interpretation is concerning in a multipolar world marked by "increasingly competitive dynamics within the web of interlocking deterrence dyads", let alone triads and beyond.[19]

Escalatory Use

Escalatory risk refers to the introduction of nuclear weapons in an ongoing tension or conflict. The category is wide-ranging, and includes use in a strategic context, on the battlefield, in crisis, and in an offensive manner. Escalatory scenarios are often invoked in South Asia today, in light of the long history and simmering conflict between nuclear-armed neighbours India and Pakistan. For instance, a February 2019 attack by a Pakistani-based militant group in Kashmir escalated to an Indian incursion of Pakistani airspace and a tense standoff over a captured Indian air force pilot. Some have argued that such confrontations will persist due to asymmetries in conventional and nuclear capabilities, which has led Pakistan to "posturing bordering on brinksmanship".[20] Former Pakistani Director General of the Strategic Plans Division Khalid Kidwai once described the State's nuclear forces as "integrated as a backup force" and an extension of its conventional capabilities.[21]

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[16] Pakistan Defense Minister Khawaja Asif, as quoted in Z. Keck, "Pakistan Says It's Ready to Use Nuclear Weapons-Should India Worry?", *The National Interest*, 3 November 2017, https://nationalinterest.org/blog/the-buzz/pakistan-says-its-ready-use-nuclear-weapons%E2%80%94should-india-23034.

[17] "Self-defence" is specified by both France and the United Kingdom; see French Ministry of the Armed Forces, *Deterrence*, 1 November 2017, https://www.defense.gouv.fr/english/dgris/defence-policy/deterrence/deterrence; UK Government, *National Security Strategy and Strategic Defence and Security Review 2015: A Secure and Prosperous United Kingdom*, November 2015, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/555607/2015_Strategic_Defence_and_Security_Review.pdf.

[18] The Democratic People's Republic of Korea for instance claims its nuclear weapons serve the "purpose of deterring and repelling the aggression and attack of the enemy against the DPRK and dealing deadly retaliatory blows at the strongholds of aggression"; Korean Central News Agency, "Law on Consolidating Position of Nuclear Weapons States Adopted", 1 April 2013, http://www.kcna.co.jp/item/2013/201304/news01/20130401-25ee.html.

[19] J.M. Acton, "Technology, Doctrine, and the Risk of Nuclear War", in N. Tannenwald, J. Acton and J. Vaynman (eds), *Meeting the Challenges of the New Nuclear Age: Emerging Risks and Declining Norms in the Age of Technological Innovation and Changing Nuclear Doctrines*, American Academy of Arts and Sciences, 2018, p. 34, https://www.amacad.org/publication/emerging-risks-declining-norms.

[20] M. Sethi, "Pakistan's Nuclear Posturing and India's Nuclear Doctrine", *Scholar Warrior*, 2016, p. 69; see also E.B. Montgomery and E.S. Edelman, "Rethinking Stability in South Asia: India, Pakistan, and the Competition for Escalation Dominance", *Journal of Strategic Studies*, vol. 38, no. 1–2, 2015.

[21] "A Conversation with Gen. Khalid Kidwai" (transcript from the Carnegie Nuclear Policy Conference, 23 March 2015), Carnegie Endowment for International Peace, http://carnegieendowment.org/files/03-230315carnegieKIDWAI.pdf.

Yet evolving military strategies suggest that the possibility of nuclear weapons use in escalation-related purposes has not been definitively excluded elsewhere. In 2003, the Russian Federation's Ministry of Defence reportedly elaborated a concept of de-escalation through limited nuclear strikes.[22] Meanwhile, the 2018 US Nuclear Posture Review emphasizes the value of a flexible deterrent with low-yield options, and seeks "additional diversity in platforms, range, and survivability"—including against situations of "regional aggression" (though it was also clear to specify this will not enable "nuclear war-fighting").[23] In that vein, some observe that the Russian Federation and China are developing nuclear-capable forces that could be used in regional conflicts with the United States involving the Baltics or Taiwan respectively.[24] The general notion of conventional conflict rising to the level of nuclear use has taken new dimension as the line between conventional and nuclear weapons—and their delivery systems—blurs.[25] Indeed, there appears a "growing reliance on nuclear weapons in limited scenarios below the strategic level".[26] Modernization programmes that are enhancing the capabilities and effectiveness of nuclear weapons exacerbate the issue.

The potential for escalatory nuclear use in crisis, meanwhile, became abundantly clear during the 1962 Cuban Missile Crisis. The US Navy's tactic of signalling Soviet submarines to surface through its detonation of depth charges and hand grenades was not well understood and at times interpreted as hostile. In one instance, the manoeuvre prompted a Soviet submarine captain to direct an officer to assemble the nuclear torpedo onboard to battle readiness.[27] By some accounts, the captain was unable to establish contact with the General Staff, and made the decision not to launch the torpedo only following consultation with his officers—including the brigade chief of staff on board serving as second captain.[28] There is some dispute as to whether a decision to launch required an order from Moscow (if so, this use would have fallen into the 'unauthorized use' category). Still, as one study subsequently noted, the situation came "too close for comfort".[29] The potential for escalatory use here would have been a

[22] Discussed further in K. Zysk, "Nonstrategic Nuclear Weapons in Russia's Evolving Military Doctrine", *Bulletin of the Atomic Scientists*, vol. 73, no. 5, 2017.
[23] US Department of Defense, *Nuclear Posture Review 2018*, February 2018, pp. xii and 54, https://media.defense.gov/2018/Feb/02/2001872886/-1/-1/1/2018-NUCLEAR-POSTURE-REVIEW-FINAL-REPORT.PDF.
[24] E. Colby, "If You Want Peace, Prepare for Nuclear War", *Foreign Affairs*, November/December 2018, https://www.foreignaffairs.com/articles/china/2018-10-15/if-you-want-peace-prepare-nuclear-war.
[25] P. Podvig, "Blurring the Line between Nuclear and Nonnuclear Weapons: Increasing the Risk of Accidental Nuclear War?", *Bulletin of the Atomic Scientists*, vol. 72, no. 3, 2016, pp. 145–149.
[26] H.M. Kristensen, "The Quest for More Useable Nuclear Weapons", in J. Borrie, T. Caughley, and W. Wan (eds), *Understanding Nuclear Weapon Risks*, UNIDIR, 2017, p. 44, http://www.unidir.org/files/publications/pdfs/understanding-nuclear-weapon-risks-en-676.pdf.
[27] S.V. Savranskaya, "New Sources on the Role of Soviet Submarines in the Cuban Missile Crisis", *Journal of Strategic Studies*, vol. 28, no. 2, 2005.
[28] Ibid. See also B. Tertrais, "On the Brink—Really? Revisiting Nuclear Close Calls Since 1945", *The Washington Quarterly*, vol. 40, no. 2, 2017, pp. 51–66; W. Burr and T.S. Blanton, "The Submarines of October–U.S. and Soviet Naval Encounters During the Cuban Missile Crisis", National Security Archive Electronic Briefing Book, no. 75, 31 October 2002, https://nsarchive2.gwu.edu/NSAEBB/NSAEBB75/.
[29] P. Lewis, H. Williams, B. Pelopidas, and S. Aghlani, *Too Close for Comfort: Cases of Near Nuclear Use and Options for Policy*, Chatham House, 2014.

product of misunderstanding as well as miscalculation, as the Americans were unaware of nuclear torpedoes onboard those Soviet submarines.

Another pathway to escalatory use stems from attacks that undermine the deterrent capability of nuclear-armed States. For instance, space-based assets long critical to the functioning of nuclear operations (including reconnaissance and communication satellites and early-warning sensors) exist in an environment that is growing ever more busy and complex.[30] The development of anti-satellite capabilities and even the presence of space debris can render second-strike capabilities vulnerable; an incidental strike on these assets can drive escalation to nuclear use.[31] Meanwhile, reliance on space assets that serve dual-use purposes—nuclear and non-nuclear—can contribute to the possibility of escalation through entanglement, with attacks targeting non-nuclear capabilities potentially misinterpreted.[32] Advances in non-nuclear capabilities such as hypersonic weapons can have similarly destabilizing effects. In the case of a hypersonic glide vehicle "it may not be known until the very last moment whether it is targeting conventional forces and facilities or nuclear forces", or whether it may be carrying a conventional or nuclear warhead.[33] These systems and other nuclear-related capabilities present new escalatory chains to use.

Unauthorized Use

The risk of nuclear use not sanctioned by a State appears as a distinct possibility in times of crisis, when lines of authority "could blur and an aggressive junior commander could act precipitously"—a scenario raised above with the example cited of the Soviet submarine captain during the Cuban Missile Crisis.[34] The unauthorized use scenario emerged expressly in the Soviet Union during the August 1991 coup, in which eight members of the Soviet government declared a state of emergency and briefly seized control from Mikhail Gorbachev. This 72-hour period also included the loss of civilian control over the Soviet nuclear arsenal, as communication links were broken between the Soviet President (then also General Secretary) and the outside world—including members of his nuclear watch detail (the nuclear briefcase itself was allegedly disabled by loyal military officials).[35] Notably there were two other

[30] A. Atorino-Courtois, *Space and U.S. Deterrence: A Virtual ThinktTank (ViTTa) Report*, NSI Team, December 2017, http://nsiteam.com/social/wp-content/uploads/2018/01/NSI_Space_ViTTa_Q14_Space-and-US-Deterrence_FINAL.pdf

[31] J. Rodgers, *Space Security and Strategic Stability,* UNIDIR, 2018, http://unidir.ch/files/publications/pdfs/space-security-and-strategic-stability-en-697.pdf

[32] J.M. Acton, "Escalation through Entanglement: How the Vulnerability of Command-and-Control Systems Raises the Risks of an Inadvertent Nuclear War", *International Security*, vol. 43, no. 1, 2018.

[33] J. Borrie, A. Dowler, and P. Podvig, *Hypersonic Weapons: A Challenge and Opportunity for Strategic Arms Control*, UNODA/UNIDIR, 2019, p. 20, http://www.unidir.ch/files/publications/pdfs/hypersonic-weapons-a-challenge-and-opportunity-for-strategic-arms-control-en-744.pdf.

[34] P.D. Feaver, "Command and Control in Emerging Nuclear Nations", *International Security*, vol. 17, no. 3, 1992–1993, p. 167.

[35] M. Tsypkin, "Adventures of the 'Nuclear Briefcase': A Russian Document Analysis", *Strategic Insights*, vol. 3, no. 9, 2004.

briefcases—in the hands of the Minister of Defence and the Chief of General Staff—which were reportedly deactivated upon the disappearance of the first. While human judgment and technical safeguards helped to prevent seizure of the command and control of the Soviet Union's strategic nuclear weapons in this instance, it illustrates that even in the most carefully controlled decision-making environments, there are chains of events that could lead to access and control over nuclear weapons by non-State actors and groups. A retired colonel in the Soviet Strategic Rocket Forces later claimed that Soviet tactical or battlefield nuclear weapons had even fewer safeguards against misuse than strategic nuclear weapons.[36] And even outside the context of a coup, issues of personnel reliability—especially in the context of pre-delegated launch authority—raise the spectre of unauthorized use today.[37]

Discussions of unauthorized nuclear use in the twenty-first century to date have coalesced around non-State armed groups, primarily those with political or religious motivations.[38] The risk of non-State use, either of an existing warhead or a crude device constructed from weapons-usable materials, emerged in the public consciousness first following the events of 11 September 2001, when it was revealed that Al-Qaida had sought to acquire or develop nuclear weapons for nearly a decade; US officials voiced concerns internally as early as 1998.[39] Today, groups continue to harbour ambitions in the area of chemical, biological, radiological, and nuclear weapons. The Islamic State in Iraq and the Levant, for instance, in 2015 referred to the possibility of buying a nuclear weapon; that same year it also acquired approximately 40 kg of low-enriched uranium from scientific institutions in Iraq.[40] This is far from acquisition of warheads or highly enriched uranium or plutonium, and indeed experts identify a dirty bomb based on radiological materials as the more plausible scenario.[41] Still, the group's experience in the chemical field—with the development and use of sulfur mustard in Iraq and the Syrian Arab Republic—offers an ominous case study underlining its intent and likely

[36] R. Jeffrey Smith, "'Nuclear Suitcase' Disabled During Coup, Hill Told", The Washington Post, 25 September 1991, https://www.washingtonpost.com/archive/politics/1991/09/25/nuclear-suitcase-disabled-during-coup-hill-told/a5d5b155-ddec-41eb-bb2e-0f6d74821a74.

[37] The United Kingdom and the Russian Federation have known pre-delegation procedures, though under strict conditions; see J.G. Lewis and B. Tertrais, *The Finger on the Button: The Authority to Use Nuclear Weapons in Nuclear-Armed States*, CNS Occasional Paper no. 45, February 2019, https://www.nonproliferation.org/wp-content/uploads/2019/02/Finger-on-the-Nuclear-Button.pdf.

[38] C.D. Ferguson and W.C. Potter, *The Four Faces of Nuclear Terrorism*, 2005.

[39] National Commission on Terrorist Attacks Upon the United States, "The 9/11 Commission Report: Final Report of the National Commission on Terrorist Attacks upon the United States", 2004, p. 180, http://govinfo.library.unt.edu/911/report/911Report.pdf.

[40] H. Saul, "Isis Claims it Could Buy its First Nuclear Weapon from Pakistan within a Year", *The Independent*, 23 May 2015, https://www.independent.co.uk/news/world/middle-east/isis-claims-it-could-buy-its-first-nuclear-weapon-from-pakistan-within-12-months-10270525.html; W. Rudischhauser, "Could ISIL Go Nuclear?", *NATO Review Magazine*, 2015, https://www.nato.int/docu/review/2015/ISIL/ISIL-Nuclear-Chemical-Threat-Iraq-Syria/EN/index.htm.

[41] M. Bunn, M. Malin, N. Roth and W. Tobey, *Preventing Nuclear Terrorism: Continuous Improvement or Dangerous Decline?*, Project on Managing the Atom, Harvard Kennedy School and Belfer Center for Science and International Affairs, 2016, https://www.belfercenter.org/sites/default/files/legacy/files/PreventingNuclearTerrorism-Web.pdf.

willingness to use nuclear weapons if it acquired them.[42] And despite territorial setbacks, its financial capabilities mean that nuclear acquisition cannot be ruled out.[43]

Overall, while the non-State scenario likely entails a complex process of acquisition or development of weapons or weapons-usable materials, it cannot be discounted. Demand exists, and supply may too. Events in the early 2000s drew attention to the existence, reach, and complexity of the international nuclear black market.[44] While the consequences of this nuclear black market have so far been limited to incidents involving State clients, the illicit procurement of knowledge and technologies can provide an avenue of access for non-State actors as well.[45] Long after the 2004 arrest of Pakistani nuclear scientist Abdul Qadeer Khan, who admitted selling technology and equipment over decades to Libya, The Democratic People's Republic of Korea, and the Islamic Republic of Iran, "policymakers and intelligence agencies simply do not know the full extent of his ring" or how much nuclear weapons knowledge remains unaccounted for.[46] And despite multilateral initiatives to improve the control and security of nuclear arsenals and stocks, risk remains on that front. The Nuclear Threat Initiative continues to sound the alarm about the opacity of materials safety and security in the Islamic Republic of Iran, Israel, Pakistan, and especially the Democratic People's Republic of Korea. This is compounded by their security environments, with "political instability, ineffective governance, pervasiveness of corruption, and the presence and capabilities of terrorist groups" adding to the risk of theft or sabotage.[47] Such conditions even suggest the possibility of poorly guarded, or loose nuclear weapons—once discussed in the context of former Soviet satellites, now a "serious and growing risk … in India and Pakistan".[48]

Accidental Use

The known history of nuclear weapons programmes contains incidents of false alarms, accidents, and near misses attributed to technical malfunctions, human fallibility, and even natural events. None have yet resulted in a detonation event, although in a few documented instances the possibility of such was prevented only by individual judgment under high pressure and uncertainty. The need for such 'human safeguards'—while comforting on some

[42] See for example Third Report of the Organization for the Prohibition of Chemical Weapons–United Nations Joint Investigative Mechanism, UN document S/2016/738.
[43] S. Hummel, "The Islamic State and WMD: Assessing the Future Threat", *CTC Sentinel*, vol. 9, no. 1, 2016.
[44] Including the US interception of a 2002 Scud missile shipment from the Democratic People's Republic of Korea to Yemen.
[45] C. Braun and C.F. Chyba, "Proliferation Rings: New Challenges to the Nuclear Nonproliferation Regime", *International Security*, vol. 29, no. 2, 2004.
[46] C. Collins and D. Frantz, "The Long Shadow of A.Q. Khan: How One Scientist Helped the World Go Nuclear", *Foreign Affairs,* 31 January 2018, https://www.foreignaffairs.com/articles/north-korea/2018-01-31/long-shadow-aq-khan.
[47] E.D. Dumbacher and P. Southland, "NTI Nuclear Security Index: Building a Framework for Assurance, Accountability, and Action: Fourth Edition", *Nuclear Threat Initiative*, September 2018, https://ntiindex.org/wp-content/uploads/2018/08/NTI_2018-Index_FINAL.pdf.
[48] G. Allison, "Nuclear Terrorism: Did We Beat the Odds or Change Them?", *Prism*, vol. 7, no. 3, 2018, p. 19.

level—illustrates use scenarios linked to error. Perhaps the most prominent close call is the infamous 1983 incident in which the Soviet Union early-warning system generated 'high reliability' signals to its command system that a US intercontinental ballistic missile had been launched—and within seconds, identified four more as part of the attack.[49] Without the time to conduct a systems check, Lieutenant-Colonel Stanislav Petrov acted on gut instinct and reported the alert as a false alarm. It was discovered later that the false alarm had been caused by the sun's reflection off high-altitude clouds, which confused a Soviet early warning satellite's sensors. Petrov's decision prevented a situation in which Soviet leadership would have to decide in minutes on what they might have mistakenly perceived to be a second-strike response.

Erroneous warnings on the US side have also led to alert actions that, fortunately, fell shy of nuclear use.[50] In 1979, a simulation of a Soviet missile attack was transferred into the regular warning system at the North American Air Defense Command (NORAD). The 'launch' was reported to National Security Adviser Zbigniew Brezezinski but was revealed to be a false alarm before he called the President.[51] Beyond false alarms, declassified 'broken arrow' incidents involving nuclear weapons have included missile explosions, aircraft collisions, and even the release of nuclear weapons—without nuclear detonation. The fact that these types of occurrences—captured in works like Eric Schlosser's *Command and Control*—have taken place in the United States, whose nuclear weapons are "among the safest, most advanced, most secure against unauthorized use that have ever been built", strongly indicates they happen in other nuclear-armed States.[52] Fundamentally, this risk is a product of the complex interactions and tightly coupled systems that govern nuclear weapons systems and other advanced technologies. Response systems are of particular concern, as "missiles cannot be recalled; submarine commanders may be out of touch but able to act on their own; missiles may go off accidentally".[53]

The potential for accidental use of nuclear weapons has taken on new dimension in the contemporary landscape. Indeed, physical access to nuclear weapons or materials may no longer be necessary to cause a detonation event. The lack of knowledge regarding the vulnerability to cyberattack of existing nuclear weapons systems adds further cause for concern. It is possible, for instance, that cyberattack methods including "data manipulation, digital jamming and cyber spoofing could jeopardize the integrity of communication".[54]

[49] D.E. Hoffman, *The Dead Hand: The Untold Story of the Cold War Arms Race and Its Dangerous Legacy*, Doubleday, 2009.
[50] S.D. Sagan, *The Limits of Safety: Organizations, Accidents, and Nuclear Weapons*, 1993.
[51] "The 3 A.M. Phone Call", The National Security Archive Electronic Briefing Book, no. 371, George Washington University, 1 March 2012, https://nsarchive2.gwu.edu/nukevault/ebb371/.
[52] E. Schlosser, *Command and Control*, 2013, p. 481.
[53] C. Perrow, *Normal Accidents: Living with High-Risk Technologies*, 1999, p. 292.
[54] B. Unal and P. Lewis, *Cybersecurity of Nuclear Weapons Systems: Threats, Vulnerabilities and Consequences*, Chatham House, January 2018, p. 19,

Manipulation of the data provided by early-warning systems and command, control, and communications (C3), including space assets, can drive doctrinal and escalatory use scenarios based on false premises.[55] There also exists the possibility that rogue actors could manipulate the flow of information with an eye towards a nuclear attack by proxy; in fact a fake news story in 2016 contributed to online nuclear threats between Pakistan and Israel.[56] While there are no outward signs that this impacted on the decision-making of either State, the scenario puts a contemporary spin on the Cold War concept of 'catalytic nuclear war', in which third party actions induce a nuclear war between the two superpowers.

Interactive Effects

The categories identified above do not constitute mutually exclusive risk scenarios. Rather, the underlying conditions that can facilitate these scenarios could permit them to feed into one another. Ambiguities associated with doctrines can contribute to confusion that pushes decision makers to rationalize the escalatory use of nuclear weapons. For instance, the aforementioned Russian mention of limited nuclear strikes led many in the West to ascribe it a doctrine of "escalate to de-escalate".[57] Even as Moscow has steadily denied any interest in such a first-strike posture, perceptions of its lower nuclear threshold can have a psychological effect; for instance, its large-scale military exercises and strike simulations may appear more immediately threatening to others.[58] Meanwhile, just as the opacity surrounding nuclear safety and security raises concerns about non-State acquisition and unauthorized use, it could factor in accidental detonations as well. After all, the limited number of persons and institutions linked to domestic stockpile management can present a barrier to creating independent oversight; the known history of the US stockpile reflects the "difficulty of maintaining an adequate level of safety through exclusive reliance on internal command and control".[59]

Crisis conditions arguably may have the most consequential cross-cutting impact. Much can happen in a situation of heightened tension with a measure of unpredictability, and in which

https://www.chathamhouse.org/sites/default/files/publications/research/2018-01-11-cybersecurity-nuclear-weapons-unal-lewis-final.pdf.

[55] P. Hayes, "Non-State Terrorism and Inadvertent Nuclear War", Nautilus Institute for Security and Sustainability Special Reports, 18 January 2018, https://nautilus.org/napsnet/napsnet-special-reports/non-state-terrorism-and-inadvertent-nuclear-war/.

[56] R. Goldman, "Reading Fake News, Pakistani Minister Directs Nuclear Threat at Israel", *New York Times*, 24 December 2016, https://www.nytimes.com/2016/12/24/world/asia/pakistan-israel-khawaja-asif-fake-news-nuclear.html.

[57] For instance, see M.B. Schneider, "Escalate to De-escalate", *Proceedings*, US Naval Institute, vol. 143/2/1368, February 2017; M. Kroenig, "The Case for Tactical U.S. Nukes", *Wall Street Journal*, 24 January 2018.

[58] B. Tertrais, "Russia's Nuclear Policy: Worrying for the Wrong Reasons", *Survival*, vol. 60, no. 2, 2018.

[59] R. Lahidji, "The Safety of Nuclear Weapons and Materials: Lessons from the Assessment of Nuclear Power Plant Risks", in J. Borrie, T. Caughley, and W. Wan (eds), *Understanding Nuclear Weapon Risks,* UNIDIR, 2017, http://www.unidir.org/files/publications/pdfs/understanding-nuclear-weapon-risks-en-676.pdf.

the decision-making process is considerably shortened.[60] The 13 days of the Cuban Missile Crisis that followed the US discovery of deployed Soviet ballistic missiles in Cuba illustrates the long shadow cast by such circumstances. Decision makers can feel pressure to act forcefully, as US President John F. Kennedy did in pledging a "full retaliatory response" against the Soviet Union should Cuba launch a nuclear missile against any country in the Western hemisphere—expanding the possibility for doctrinal use.[61] The heightened alert status can increase the interactive complexity and tight coupling of relevant warning and response systems; indeed "numerous failure modes were not anticipated and never fixed" during this period—reflecting increased risk of accidental use.[62] The effects of technical and human errors can be compounded as well, as in the cited submarine encounter in which both sides acted under a cloud of uncertainty—nearly leading to escalatory use. Lingering questions as to whether a nuclear response by the submarine commander would have constituted unauthorized use further reflects the complexity of crisis, as "rules of engagement and delegations of authority can change in ways that may be inadequately understood by central authorities".[63]

Ultimately, it is not uncommon for the underlying risk conditions to have wide-ranging effects. At times, the line between the different use scenarios discussed can be quite blurry. Some doctrines refer—implicitly or explicitly—to escalatory scenarios, attaching a deliberative element to the latter (of course, intentional escalation unrelated to declaratory policy remains a distinct possibility). Meanwhile, accidental use can be thought of as inherently unauthorized. Again, this categorization is not hard and fast. In the abstract however, it provides a means to filter the risk reduction measures that can tangibly address each.

[60] "A crisis is a situation that threatens high-priority goals of the decision-making unit, restricts the amount of time available for response before the decision is transformed and surprises the members of the decision-making unit by its occurrence", C. F. Hermann (ed.), *International Crises: Insights from Behavioral Research*, 1972, p. 13.
[61] J.F. Kennedy, "Address during the Cuban Missile Crisis", 22 October 1962, https://www.jfklibrary.org/learn/about-jfk/historic-speeches/address-during-the-cuban-missile-crisis.
[62] S.D. Sagan, *The Limits of Safety: Organizations, Accidents, and Nuclear Weapons*, 1993, p. 153.
[63] S.D. Sagan, "Nuclear Alerts and Crisis Management", *International Security*, vol. 9, no. 4, 1985, p. 133.

ADDRESSING USE SCENARIOS

Debating the means by which to achieve nuclear disarmament lies beyond the scope of this paper, as does consideration of steps to try to address the consequences of nuclear weapon use.[64] Rather it considers pathways to nuclear use and measures that could narrow or obstruct these. This *does* include select proposals considered in arms control and disarmament contexts, as those targeting specific classes of weapons could impact those pathways. There also exist encompassing approaches to risk reduction that focus on awareness, dialogue, and general political commitments, including the 64-point Action Plan agreed upon at the 2010 Review Conference of the Nuclear Non-Proliferation Treaty (NPT) and more recently the dialogue on doctrine among the five NPT-recognized nuclear-weapon States (China, France, the Russian Federation, the United Kingdom, and the United States).[65] These too warrant further discussion.

This section primarily considers risk reduction in the context of the four pathways introduced earlier. It outlines for each an approach to address the conditions under which nuclear weapons may be used, identifying principles and objectives that should inform policy. It then catalogues for each a spectrum of ideas that reflect these principles and objectives, which include ideas and proposals drawn from disparate sources across the academic, research, and policymaking communities. Some have attracted more controversy than others, though all provide legitimate areas of discussion. Beyond briefly sketching them, this paper does not analyse the individual pros and cons of these ideas, nor does it discuss the complexities and unintended consequences linked to their implementation. Doing so requires systematic consideration of the contexts and regions in which such measures—and others—may be deployed.

Reducing Doctrinal Risk

As discussed, the risk of doctrinal nuclear use is linked to the declaratory policies of States as well as the purposeful ambiguity inherent in those policies. There are several means of approaching this pathway to use, beginning with a) stigmatizing overall use. Deterrence theory continues to underpin national security policies of many nuclear-armed and nuclear-allied States, with the implication that there exist "circumstances so extreme that they would remove

[64] For discussion of consequences, see J. Borrie and T. Caughley, *An Illusion of Safety: Challenges of Nuclear Weapon Detonations for United Nations Humanitarian Coordination and Response*, UNIDIR, 2014, http://www.unidir.org/files/publications/pdfs/an-illusion-of-safety-en-611.pdf.

[65] L.A. Dunn, "The Strategic Elimination of Nuclear Weapons: An Alternative Global Agenda for Nuclear Disarmament", *The Nonproliferation Review*, vol. 24, no. 5–6, 2017; R. Einhorn and W.P.S. Sidhu, "The Strategic Chain: Linking Pakistan, India, China, and the United States", *Arms Control and Non-Proliferation Series Paper 14*, Brookings, March 2017, https://www.brookings.edu/wp-content/uploads/2017/03/acnpi_201703_strategic_chain.pdf; Group of Eminent Persons for Substantive Advancement of Nuclear Disarmament, *Recommendations for the 2020 Review Process for the Treaty on the Non-Proliferation of Nuclear Weapons (NPT)*, March 2019, https://www.mofa.go.jp/files/000403715.pdf.

all inhibitions on nuclear use".[66] Strengthening the non-use taboo helps contain the spectrum of extreme circumstances. Relatedly, a second component of the approach entails b) circumscribing the conditions under which States contemplate nuclear retaliation. This effectively shrinks that universe of cases. A third centres on c) clarifying doctrine, or reducing ambiguity surrounding those conditions. Domestically, this diminishes the flexibility that individual decision makers have in deciding when using nuclear weapons might be 'appropriate'. Internationally, clearly defined thresholds for nuclear retaliation can create 'red lines' that reduce the possibility of brinksmanship (especially inadvertent brinksmanship) and in so doing help to prevent the crossing of those thresholds.

TABLE 2. REDUCING DOCTRINAL RISK: OBJECTIVES AND SAMPLE IDEAS

Stigmatize Use	Circumscribe Use Conditions	Clarify Doctrine
• Political statements to renounce use	• 'Sole purpose' or 'last resort' policies	• Exchange on nuclear policies
• Prohibition on use or threat of use	• Narrow 'extreme circumstances'	• Establish parameters on threshold for use
• 'No first use' policies	• Limit deterrence scope (e.g. not against cyberattack)	• Defence and military engagement

Stigmatize Use

A number of proposed measures seek to dissuade use even in the face of extreme circumstances. In 1985, US President Ronald Reagan and his Soviet counterpart Mikhail Gorbachev issued a joint statement that a "nuclear war cannot be won and must never be fought". [67] Some, including United Nations Secretary-General António Guterres, have suggested the value of the United States and the Russian Federation as well as other nuclear-armed States reaffirming the statement.[68] This—and other activities that strengthen the normative barriers against use—essentially seeks to remove doctrinal use as a legitimate

[66] L. Freedman, "Disarmament and Other Nuclear Norms", *The Washington Quarterly*, vol. 36, no. 2, 2013, p. 97.
[67] Joint Soviet–United States Statement on the Summit Meeting in Geneva, 21 November 1985, https://www.reaganlibrary.gov/research/speeches/112185a.
[68] *Securing our Common Future: An Agenda for Disarmament*, Office for Disarmament Affairs, 2018, https://s3.amazonaws.com/unoda-web/wp-content/uploads/2018/06/sg-disarmament-agenda-pubs-page.pdf; R. Berls Jr. and L. Ratz, "Rising Nuclear Dangers: Steps to Reduce Risks in the Euro-Atlantic Region", *NTI Paper*, Nuclear Threat Initiative, December 2016, https://media.nti.org/documents/NTI_Rising_Nuclear_Dangers_Paper_FINAL_12-5-16.pdf; J. Borrie, *Resuming Dialogue on Moving Nuclear Disarmament Forward: An Immediate Challenge*, UNIDIR, 2018, http://www.unidir.ch/files/publications/pdfs/resuming-dialogue-on-moving-nuclear-disarmament-forward-an-immediate-challenge-en-704.pdf.

option. Others espouse the need to tone down rhetoric on nuclear use in general. Other measures to disincentivize States from use could include an agreement or convention to prohibit use or threat of use. Among the provisions of the 2017 Treaty on the Prohibition of Nuclear Weapons is an explicit ban on States to "use or threaten to use" nuclear weapons or other nuclear explosive devices.[69] Proposals centring on first use seek to lessen the specific possibility that retaliation comes into play: these can take the form of universal policies (as declared by China and India), bilateral or multilateral agreements, and extended negative security assurances (for example, in the context of nuclear-weapon free zones, or by removing caveats regarding non-compliant NPT members).

Circumscribe Use Conditions

As mentioned, the 2018 Nuclear Posture Review specified the continuing deterrent role of nuclear weapons in responding to non-nuclear strategic attacks in US policy.[70] While that document lists example targets of such attacks, the lack of clear definition of 'strategic attacks' itself has led some to conclude that cyberattacks on those elements may suffice for a nuclear response—thus widening the scope for doctrinal use.[71] Limiting that scope would have the converse effect. For instance, NATO shrunk the role of nuclear weapons in its posture in 1990 when it identified its nuclear forces as "weapons of last resort" in the post-Cold War era.[72] In their national postures, States could exclude consideration of nuclear response to cyberattacks, specify as instigating events only WMD or nuclear attacks (for example, by affirming that the 'sole purpose' of nuclear forces is to deter nuclear attack), or more narrowly define what constitutes their extreme circumstances and vital interests. Such measures effectively take use off the table outside specified situations.

Clarify Doctrine

Clear declaratory policies such as the ones outlined above have the additional effect of reducing ambiguity. There may be general aversion to such actions. In some contexts, military planners in nuclear-armed and some nuclear-allied States see ambiguity as helpful if it contributes to the desired deterrent effect of nuclear weapons. For them, risk for an adversary stems from the outcome being determined by events and processes beyond the control and

[69] Treaty on the Prohibition of Nuclear Weapons, 2017, article I.
[70] "Significant non-nuclear strategic attacks include, but are not limited to, attacks on the U.S., allied, or partner civilian population or infrastructure, and attacks on U.S. or allied nuclear forces, their command and control, or warning and attack assessment capabilities"; see US Department of Defense, *Nuclear Posture Review 2018*, February 2018, p. 21, https://media.defense.gov/2018/Feb/02/2001872886/- 1/-1/1/2018-NUCLEAR-POSTURE-REVIEW-FINAL-REPORT.PDF.
[71] Ibid.; D.E. Sanger and W.J. Broad, "Pentagon Suggests Countering Devastating Cyberattacks with Nuclear Arms", *New York Times*, 16 January 2018, https://www.nytimes.com/2018/01/16/us/politics/pentagon-nuclear-review-cyberattack-trump.html.
[72] Declaration on a Transformed North Atlantic Alliance, issued by the Heads of State and Government participating in the meeting of the North Atlantic Council, 5–6 July 1990, https://www.nato.int/cps/en/natohq/official_texts_23693.htm.

even comprehension of both sides.[73] Indeed, "deterrence often depends on relinquishing the initiative to the other side", leaving the adversary to decide whether to act in a manner that pushes both sides to the brink.[74] This dependence on mutual restraint however can be problematic with a larger "number and diversity of players, for whom, in addition, deterrence could have different meanings".[75] Restraint is also not necessarily assured in crisis situations. Certainly, States will determine the level of transparency of doctrine and posture they are willing to accept. But even small movements in this manner—for example, defence and military engagement—can serve to reduce risk by enhancing mutual understanding of doctrines.[76] Greater clarity can also help prevent misperceptions regarding capabilities and posturing behaviours.[77] In the process, it contributes to a clearer distinction between situations involving conventional conflict and those involving nuclear conflict. This final aspect is especially pertinent in the context of escalation, which is explored next.

Reducing Escalatory Risk

There are several means to reducing the risk of escalation to nuclear weapon use, including a) increasing predictability around use conditions. This builds upon the notion of clarifying doctrine discussed above, while extending to other transparency- and engagement-driven measures that can reduce the likelihood of escalation through miscalculation or misperception. States can also move to b) strengthen nuclear restraint, raising the threshold for use (or at least not lowering it in response to crisis-related pressure). This restraint can have a secondary signalling effect that lowers risk of overall use.[78] Fundamentally, there is also a need for c) preventing crisis, thus minimizing situations in which use may be considered.

[73] T. Schelling, *The Strategy of Conflict*, 1960.
[74] T. Schelling, *Arms and Influence*, 1966, p. 45.
[75] T. Delpech, *Nuclear Deterrence in the 21st Century: Lessons from the Cold War for a New Era of Strategic Piracy*, RAND Corporation, 2012, p. 16.
[76] L.A. Dunn, *Reversing the Slide: Intensified Great Power Competition and the Breakdown of the Arms Control Endeavor,* UNIDIR, 2019, http://www.unidir.ch/files/publications/pdfs/reversing-the-slide-en-755.pdf.
[77] M. Downman and M. Messmer, *Re-emerging Nuclear Risks in Europe: Mistrust, Ambiguity, Escalation and Arms-racing between NATO and Russia*, BASIC, 2019.
[78] J.E. Doyle, "On Integrated Conventional and Nuclear Planning", *Arms Control Today*, vol. 47, no. 2, 2017.

TABLE 3. REDUCING ESCALATORY RISK: OBJECTIVES AND SAMPLE IDEAS

Increase Predictability	Strengthen Nuclear Restraint	Prevent Crisis
• Establishment of clearer declaratory policies	• Reinforce gap between conventional and nuclear	• Pre-notification and joint early warning centers
• Nuclear code of conduct, with common lexicon	• Lower operational readiness of systems	• Limit provocative behaviours
• Information exchange on weapons systems	• Crisis communication channels and hotlines	• Broader measures to assuage security concerns

Increase Predictability

In the post-Cold War era, the nature of relations among nuclear-armed States has been characterized by some as lacking general clarity. With the United States and the Russian Federation, "common understanding of the rules of mutual nuclear deterrence, the limited utility of nuclear weapons, and strategic stability has evaporated".[79] Others cite similar problems in US–Chinese relations.[80] This is even more so with the non-NPT nuclear-armed States, whose relations feature "deep distrust [and] lack of proper communication".[81] Accordingly, a host of risk reduction proposals target the lack of knowledge surrounding nuclear doctrines, postures, and intentions. Most direct is the establishment or further elaboration of declaratory policies. Some have proposed regularized bilateral or multilateral dialogue on the subject, pointing to the institutionalized discussion between the five NPT nuclear-weapon States over the past decade. Military-to-military engagement at multiple levels (from leadership to operations) could further contribute in providing "windows into military plans and programmes", lessening the possibility for misinterpretation.[82] Others propose the establishment of a nuclear code of conduct, with emphasis on a common lexicon on forces and deterrence concepts.[83] Clarifying concepts in bilateral or multilateral settings—

[79] A. Arbatov, "Challenges of the New Nuclear Era: The Russian Perspective", in L. Brooks, F. Gavin and Alexi Arbatov (eds), *Meeting the Challenges of the New Nuclear Age: U.S. and Russian Nuclear Concepts, Past and Present*, American Academy of Arts and Sciences, 2018, p. 45.
[80] L. Bin, "Differences Between Chinese and U.S. Nuclear Thinking and Their Origins", in L. Bin and T. Zhao (eds), *Understanding Chinese Nuclear Thinking,* Carnegie Endowment for International Peace, 2016, https://carnegieendowment.org/files/ChineseNuclearThinking_Final.pdf.
[81] T. Delpech, *Nuclear Deterrence in the 21st Century*, 2012, p. 16.
[82] L.A. Dunn, *Reversing the Slide: Intensified Great Power Competition and the Breakdown of the Arms Control Endeavor,* UNIDIR, 2019, p. 5, http://www.unidir.ch/files/publications/pdfs/reversing-the-slide-en-755.pdf.
[83] L.A. Dunn, "The Strategic Elimination of Nuclear Weapons: An Alternative Global Agenda for Nuclear Disarmament", *The Nonproliferation Review*, vol. 24, no. 5–6, 2017; J. Anderson, "Negotiating a Nuclear 'Code of

for example, an unelaborated mention by the Russian Federation of the potential use of precision-strike weapons "within the framework of strategic deterrence measures of a forceful nature", as highlighted by analysts—may restore some of that common understanding.[84]

A related set of ideas involves enhancing information exchange in and around nuclear weapons systems, for instance with select traits of systems and forces, numbers and types of warheads and delivery vehicles, and deployment or alert status. This would allow other parties to consider such disseminated data in light of stated doctrine, for instance to ensure that an arsenal serves a deterrent-only purpose. And even in the absence of clearer doctrines, a transparency regime on forces could set forth a de facto doctrine that clarifies use parameters. This in turn strengthens strategic analysis, increasing predictability and lessening the likelihood of misperception, including in the face of crisis—thus narrowing pathways to escalatory use.

Strengthen Nuclear Restraint

Other ideas to reduce escalatory risk involve voluntarily restricting capabilities. Reductions in, storage of, and the disassembly of particular types of nuclear weapons and delivery systems—those associated with battlefield use or those contributing to ambiguity—can limit their destabilizing effects.[85] Some have suggested arms control and disarmament measures for nuclear-capable cruise missiles and hypersonic missiles, as well as for short- and medium-range tactical missiles.[86] In their estimate, these delivery systems can contribute to confusion as to their nuclear or non-nuclear nature: eliminating or restricting them would lessen the possibility of escalation based on miscalculation or misinterpretation. This notion of reinforcing the barrier separating nuclear force-related systems from other systems underlies a series of proposals. They also include designating nuclear C3 as off-limits from cyber interference, excluding nuclear or nuclear-capable forces from military exercises, and

Conduct'", *Next Generation Nuclear Network*, 17 January 2018, https://nuclearnetwork.csis.org/negotiating-nuclear-code-conduct.

[84] The Military Doctrine of the Russian Federation, no. Pr.-2976, 25 December 2014, https://rusemb.org.uk/press/2029. For analysis on this particular issue, see A.L. Fink, "The Evolving Russian Concept of Strategic Deterrence: Risks and Response", *Arms Control Today*, July/August 2017, https://www.armscontrol.org/act/2017-07/features/evolving-russian-concept-strategic-deterrence-risks-responses

[85] For instance, P. Podvig and J. Serrat, *Lock Them Up: Zero Deployed Non-Strategic Nuclear Weapons in Europe*, UNIDIR, 2017, http://unidir.org/files/publications/pdfs/lockthem-up-zero-deployed-non-strategic-nuclear-weapons-in-europeen-675.pdf.

[86] A. Weber, "Nuclear-Armed Cruise Missiles Should be Banned", *Policy Brief No. 12*, Toda Peace Institute, May 2018, http://toda.org/files/policy_briefs/T-PB-12_Weber_Cruise-missiles.pdf; J. Borrie, A. Dowler, and P. Podvig, *Hypersonic Weapons: A Challenge and Opportunity for Strategic Arms Control*, UNODA/UNIDIR, 2019, http://www.unidir.ch/files/publications/pdfs/hypersonic-weapons-a-challenge-and-opportunity-for-strategic-arms-control-en-744.pdf; W.P.S. Sidhu, "To Reduce Missile Threats, Think Outside the Silo", *Bulletin of the Atomic Scientists,* 10 August 2016, https://thebulletin.org/roundtable_entry/to-reduce-missile-threats-think-outside-the-silo/.

prohibiting the targeting of nuclear installations or facilities (for example, expanding the 1988 India–Pakistan Non-Attack Agreement).[87]

Among the most prominent ideas under the risk reduction umbrella is the lowering the operational readiness of nuclear weapons systems. Whether these activities hinder the ability of nuclear-armed States to deter effectively, as some have argued, is the subject of analysis elsewhere and is not the subject of this paper. But one argument for the de-alerting approach, and related de-mating and de-targeting measures, is that these can help to extend the decision-making process in crisis. Proposals for such measures target everything from submarine-launched ballistic missiles to bombers to land-based armed missiles. They range in form from physical separation of warheads from delivery systems to removal of missile guidance systems to the use of silo barriers and safing switches.[88] Other proposals to extend the decision-making process involve enhancing communication in crisis. For instance, the establishment of dedicated channels and emergency hotlines—not only on a bilateral basis—draws from the precedent of the secure Moscow–Washington hotline created in response to the Cuban Missile Crisis.[89]

Prevent Crisis

A final group of proposed measures relates to crisis prevention. The reality is that nuclear-armed States are likely to rely first and foremost on their own national technical means for intelligence, surveillance, and early warning. Still, these can be supplemented by joint early warning centres (often discussed in the context of false alarms), which can provide pre-notification of changed alert statuses or missile tests, enhancing situational understanding. Relatedly, more exchange on mutual signalling in times of increased tension—concerning actions such as military mobilization, troop exercises, or weapon dispersion—can help prevent further escalation.[90] The Cuban Missile Crisis is again an instructive case, as US policymakers took into careful consideration how Soviet leadership might interpret their actions prior to

[87] R. Einhorn and W.P.S. Sidhu, "The Strategic Chain: Linking Pakistan, India, China, and the United States", *Arms Control and Non-Proliferation Series Paper 14*, Brookings, March 2017, https://www.brookings.edu/wp-content/uploads/2017/03/acnpi_201703_strategic_chain.pdf; R. Berls Jr. and L. Ratz, "Rising Nuclear Dangers: Steps to Reduce Risks in the Euro-Atlantic Region", *NTI Paper*, Nuclear Threat Initiative, December 2016, https://media.nti.org/documents/NTI_Rising_Nuclear_Dangers_Paper_FINAL_12-5-16.pdf; S. van der Meer, "Reducing Nuclear Weapons Risks: A Menu of 11 Policy Options", *Policy Brief*, Clingendael: Netherlands Institute of International Relations, June 2018, https://www.clingendael.org/sites/default/files/2018-06/PB_Reducing_nuclear_weapons_risks.pdf; P.O. Stoutland and S. Pitts-Kiefer, "Nuclear Weapons in the New Cyber Age: Report of the Cyber-Nuclear Weapons Study Group", Nuclear Threat Initiative, September 2018, https://media.nti.org/documents/Cyber_report_finalsmall.pdf.

[88] H.M. Kristensen and M. McKenzie, *Reducing Alert Rates of Nuclear Weapons*, UNIDIR, 2012, http://www.unidir.ch/files/publications/pdfs/reducing-alert-rates-of-nuclear-weapons-en-307.pdf.

[89] Global Zero, *Nuclear Crisis Group: Urgent Steps to De-Escalate Nuclear Flashpoints*, 2017, https://www.globalzero.org/wp-content/uploads/2018/10/NCG_Urgent-Steps_June-2017.pdf.

[90] See V. Narang, *Nuclear Strategy in the Modern Era: Regional Powers and International Conflict*, 2014; K. Ven Bruusgaard, "Russian Strategic Deterrence", *Survival,* vol. 58, no. 4, 2016.

deciding upon the naval blockade.[91] Other proposals relate to limiting or ending what might be construed as provocative behaviours, such as medium-altitude reconnaissance flights (including by uncrewed aerial vehicles), missile flight tests, and military exercises.[92] In recognition of entanglement scenarios, an interrelated set of ideas includes a code of conduct for space-based assets, or to establish guidelines on—or even prohibit—the testing and deployment of anti-satellite weapons.[93] Many of these measures play a dual role, seeking to prevent crises between nuclear-armed States from developing in the first place and managing them successfully without nuclear use if they do occur. Accordingly, broader measures to assuage security and geopolitical tensions fall in this category as well.

Reducing Unauthorized Risk

Although fortunately it has never occurred, a number of more-or-less plausible routes to unauthorized use of nuclear weapons are of global concern. For instance, experts have relayed fears that regime collapse or near-collapse would throw the control of nuclear arsenals in the Democratic People's Republic of Korea and Pakistan into question.[94] There are also broader concerns about the vulnerability of weapons-usable materials across all nuclear-armed States.[95] This reflects evidence of long-standing and continuing interest on the part of certain violent non-State armed groups in nuclear weapons and materials acquisition. Narrowing the unauthorized use pathway requires a supply-side approach that centres on denying access—direct and indirect—to nuclear weapons and materials.[96] This entails a) enhancing safeguarding procedures around nuclear weapons and materials, including their storage, maintenance, transfer, and control. In addition, the opacity concerning weapons and materials safety and security suggests a specific need for b) stronger assessment of the nature of unauthorized risk with a view to enhancing oversight.

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[91] G.T. Allison and P. Zelikow, *Essence of Decision: Explaining the Cuban Missile Crisis*, 1999.

[92] G. Woodhams and J. Borrie, *Armed UAVs in Conflict Escalation and Inter-State Crisis,* UNIDIR, 2018, http://www.unidir.org/files/publications/pdfs/armed-uavs-in-conflict-escalation-and-inter-state-crises-en-727.pdf

[93] R. Einhorn and W.P.S. Sidhu, "The Strategic Chain: Linking Pakistan, India, China, and the United States", *Arms Control and Non-Proliferation Series Paper 14*, Brookings, March 2017, https://www.brookings.edu/wp-content/uploads/2017/03/acnpi_201703_strategic_chain.pdf; J.M. Acton, "Escalation through Entanglement: How the Vulnerability of Command-and-Control Systems Raises the Risks of an Inadvertent Nuclear War", *International Security*, vol. 43, no. 1, 2018; D. Porras, *Toward ASAT Test Guidelines,* UNIDIR, 2018, http://www.unidir.ch/files/publications/pdfs/-en-703.pdf

[94] For instance, M.J. Mazarr, "The Korean Peninsula: Three Dangerous Scenarios", RAND Corporation, 2018, https://www.rand.org/pubs/perspectives/PE262.html; P.K. Kerr and M.B. Nikitin, *Pakistan's Nuclear Weapons,* Congressional Research Service, 1 August 2016, https://crsreports.congress.gov/product/pdf/RL/RL34248.

[95] E.D. Dumbacher and P. Southland, "NTI Nuclear Security Index: Building a Framework for Assurance, Accountability, and Action: Fourth Edition", *Nuclear Threat Initiative*, September 2018, https://ntiindex.org/wp-content/uploads/2018/08/NTI_2018-Index_FINAL.pdf. See also the discussion of insider threats, as in M. Bunn and S.D. Sagan, *A Worst Practices Guide to Insider Threats: Lessons from Past Mistakes*, American Academy of Arts and Sciences, 2014.

[96] A demand-side strategy (e.g. reinforcing nuclear stigmatization) should not be discounted in the longer term but is less pertinent to the risk of use scenarios described.

TABLE 4. REDUCING UNAUTHORIZED RISK: OBJECTIVES AND SAMPLE IDEAS

Enhance Safeguarding Procedures	Improve Risk Assessment
• Improve safety and security of weapons, materials, and facilities	• Increase independent oversight of nuclear weapons programmes at the domestic level
• Create global materials security system	• Intelligence exchange on unauthorized incidents
• Information exchange (e.g. accident notification or incident database)	• In-depth vulnerability assessments

Enhance Safeguarding Procedures

Ensuring the physical and cyber safety and security of nuclear weapons, materials, and facilities is ultimately a matter of national responsibility. For instance, in light of cyber vulnerabilities, further risk analysis could drive the strengthening of C3 defence and resilience.[97] Indeed, some proposals simply advise more efficient resource mobilization by States to this and other ends.[98] 'Gift basket' diplomacy has also been used as a means to add a level of diplomatic accountability to individual State measures, as in the Nuclear Security Summit series. The International Atomic Energy Agency (IAEA) could play a more formalized role—akin to its mandate in the area of safety—creating a stronger nuclear security culture in the process.[99] Still others call for multilateral collaboration, including through the development of a global materials security system to track, account for, manage and secure all weapons-usable materials, or through the expansion of the Cooperative Threat Reduction Program, which provided financial assistance and technical expertise in the area of warheads, delivery vehicles, and materials in the States of the former Soviet Union.[100] In that vein, the United States has reportedly assisted Pakistan in securing its stockpiles for over a decade, sharing best practices

[97] B. Unal and P. Lewis, *Cybersecurity of Nuclear Weapons Systems: Threats, Vulnerabilities and Consequences*, Chatham House, January 2018, https://www.chathamhouse.org/sites/default/files/publications/research/2018-01-11-cybersecurity-nuclear-weapons-unal-lewis-final.pdf.
[98] R. Mowatt-Larssen, "The Armageddon Test: Preventing Nuclear Terrorism", *Bulletin of the Atomic Scientists,* 1 September 2009, https://thebulletin.org/2009/09/the-armageddon-test-preventing-nuclear-terrorism/.
[99] M. Bunn, M. Malin, N. Roth and W. Tobey, *Preventing Nuclear Terrorism: Continuous Improvement or Dangerous Decline?*, Project on Managing the Atom, Harvard Kennedy School and Belfer Center for Science and International Affairs, 2016, https://www.belfercenter.org/sites/default/files/legacy/files/PreventingNuclearTerrorism-Web.pdf.
[100] G.P. Schultz, W. Perry, H.A. Kissinger and S. Nunn, "Next Steps in Reducing Nuclear Risks", *Wall Street Journal*, 5 March 2013, https://www.wsj.com/articles/SB10001424127887324338604578325912939001772; E. Regehr, "A Nuclear Risk Reduction Strategy for NATO", *The Ploughshares Monitor*, vol. 20, no. 1, March 1999.

and technical measures and providing equipment.[101] A different bilateral approach others have identified involves using civil nuclear cooperation agreements as conduits for strengthened strategic trade and export control measures that can prevent the flow of sensitive materials.[102]

Improve Assessment and Management

Much remains unknown in the public domain about the respective national safety and security procedures governing the global stockpile of nearly 14,000 nuclear weapons in nine States, or those governing the roughly 83 per cent of all highly enriched uranium and plutonium stocks that is in non-civilian custody. Existing information is piecemeal, focused on particular States and time periods such as those documented in *Command and Control*, or stem from the work of non-governmental organizations.[103] And even within domestic structures, knowledge regarding the "precise conditions of weapons stockpiles and safety procedures" as well as security aspects is generally limited to a select group of individuals and institutions.[104] While proper assessment is a prerequisite to addressing any risk, this appears to be a fundamental challenge in the context of the unauthorized use scenario—at both domestic and international levels.

Focused exchange, including intelligence sharing, among several or all nuclear-armed States can help improve efforts against the possibility of improper acquisition and unauthorized use, including by non-State armed groups. There exist model measures for such information exchange, from bilateral agreements on accident notification and radiation release, to the IAEA's Incident and Trafficking Database to which States voluntarily report unauthorized activities and events involving nuclear and other radioactive incidents. Certainly, there are legitimate security concerns that prevent nuclear-armed States from sharing information on their specific breaches and vulnerabilities; transparency is not a panacea.[105] Yet regularized exchange on such topics can refocus States on an objective that has enjoyed less political attention in the aftermath of the 2016 Nuclear Security Summit. Revitalizing the agenda at the international level can also inspire domestic action, for instance the strengthening of

[101] P.K. Kerr and M.B. Nikitin, *Pakistan's Nuclear Weapons,* Congressional Research Service, 1 August 2016, https://crsreports.congress.gov/product/pdf/RL/RL34248.
[102] T. Ogilvie-White, "Strengthening Australia's Security: Proposals for Reducing Nuclear Dangers", Australian Institute of International Affairs, 21 November 2014, https://www.internationalaffairs.org.au/australianoutlook/strengthening-australias-security-proposals-for-reducing-nuclear-dangers/.
[103] E. Schlosser, *Command and Control: Nuclear Weapons, the Damascus Incident, and the Illusion of Safety*, 2013; R. Edwards, *Nukes of Hazard: The Nuclear Bomb Convoys on Our Roads*, ICAN UK, 2016, http://www.acronym.org.uk/new-website/wp-content/uploads/2017/03/Nukes-of-Hazard-report-FINAL-7.pdf.
[104] R. Lahidji, "The Safety of Nuclear Weapons and Materials: Lessons from the Assessment of Nuclear Power Plant Risks", in J. Borrie, T. Caughley, and W. Wan (eds), *Understanding Nuclear Weapon Risks,* UNIDIR, 2017, p. 79, http://www.unidir.org/files/publications/pdfs/understanding-nuclear-weapon-risks-en-676.pdf.
[105] E. Sokova, "Non-state Actors and Nuclear Weapons", in J. Borrie, T. Caughley, and W. Wan (eds), *Understanding Nuclear Weapon Risks,* UNIDIR, 2017, http://www.unidir.org/files/publications/pdfs/understanding-nuclear-weapon-risks-en-676.pdf.

independent oversight and wider nuclear security culture, or the expansion of practices such as vulnerability assessments and stress testing by regulators and operators.[106]

Reducing Accidental Risk

The nature of complex interactions and tightly coupled systems may make accidents inevitable.[107] Yet there are means to lessen the possibility of accidental nuclear detonation. Some of the measures discussed in relation to the previous scenarios potentially have an impact here as well. For instance, clearer understandings of postures can help prevent overreaction to incongruous events involving nuclear force-related systems that may be the result of faults or accidents rather than being intentional. Measures to extend the decision-making process can allow clarification of radar readings that turn out to be erroneous—a scenario that calls to mind the mistaken interpretation by the Russian military of Norway's Black Brant scientific rocket as a potential incoming missile in 1995. But an approach that seeks specifically to address the accidental use scenario should focus on minimizing errors, both human and technical, by a) strengthening safety features (including in the cyber realm) in nuclear weapons and related systems, and b) enhancing operator control of those systems; while also c) containing the consequences of errors when they occur.

TABLE 5. REDUCING ACCIDENTAL RISK: OBJECTIVES AND SAMPLE IDEAS

Strengthen Safety Features	Enhance Operator Control	Contain Consequences of Errors
• Incorporate safeguards into weapons and delivery systems	• Clearly defined procedures for action related to use	• Bilateral / mutlilateral data exchange on accidents
• Permissive action links	• Incorporate backups in operations and data collection	• Joint monitoring of select events
• Enhance cyber systems		• Human training

[106] M. Bunn, N. Roth, W.H. Tobey, *Revitalizing Nuclear Security in an Era of Uncertainty*, Project on Managing the Atom, 2019.

[107] J. Borrie, *A Limit to Safety: Risk, 'Normal Accidents', and Nuclear Weapons*, ILPI–UNIDIR, December 2014, https://www.files.ethz.ch/isn/186094/a-limit-to-safety-en-618.pdf.; P. Podvig, "Risks of Nuclear Command and Control Accidents", in J. Borrie, T. Caughley, and W. Wan (eds), *Understanding Nuclear Weapon Risks,* UNIDIR, 2017, http://www.unidir.org/files/publications/pdfs/understanding-nuclear-weapon-risks-en-676.pdf.

Strengthen Safety Features

Safety features incorporated into nuclear weapons and their systems have long served as a defence against accidental nuclear use. The US stockpile, for instance, contains warheads and bombs with insensitive high explosives and fire-resistant pits.[108] In addition, it has developed permissive action links (PAL) devices to prevent arming or launching of nuclear weapons without prescribed codes. Evidence suggests that the United States in the 1970s also provided assistance on the development of PAL technologies to the Soviet Union, France, and the United Kingdom.[109] Yet cost concerns, design modifications, and even bureaucratic resistance have hindered the timely installation of these and other safety components in the past.[110] While limited information is available on the safeguard technologies deployed by all nuclear-armed States, developing and incorporating such measures—including as part of national nuclear modernization programmes, or in cooperative fashion—presents an avenue to reducing risk of accidental use. This is true of cyber safety as well. Indeed, the cyber challenge as it pertains to nuclear risk is not entirely external, as a number of "accidents, mistakes, and near misses … occurred because of computer errors or problems".[111]

Enhance Operator Control

Safeguard measures such as PALs can have the added effect of enhancing operator control over nuclear use. A more direct means to this end involves tightening the procedures around nuclear weapons management, such as the two-person rule adhered to by some nuclear-armed States requiring the presence of two authorized individuals in all critical operations. The inclusion of redundant or dependent systems is in fact a recurring theme in accident prevention. For instance, the presence of analogue and digital components in command and control or the establishment of multiple survivable communications links can help maintain operations in either system even if individual components fail.[112] Multiplicity in data collection meanwhile can help to reduce the possibility of decision-making fallibility; the United States for instance employs a 'dual phenomenology', with information on events that could drive a nuclear response confirmed by two independent sensors of different types (for example, infrared satellite detection and land-based radars).[113] Others suggest that the further incorporation of machine learning and autonomous systems can lessen the data searching,

[108] A.P. Donnell Jr., "A Robust Approach to Nuclear Weapon Safety", document SAND2011-4123C, Sandia National Laboratories, 2011, https://www.osti.gov/servlets/purl/1120301.
[109] D. Caldwell, "Permissive Action Links: A Description and Proposal", *Survival,* vol. 20, no. 3, 1987, pp. 224–238.
[110] E. Schlosser, *Command and Control*, 2013.
[111] A. Futter, *Hacking the Bomb: Cyber Threats and Nuclear Weapons*, 2018, p. 10.
[112] B. Unal and P. Lewis, *Cybersecurity of Nuclear Weapons Systems: Threats, Vulnerabilities and Consequences*, Chatham House, January 2018, https://www.chathamhouse.org/sites/default/files/publications/research/2018-01-11-cybersecurity-nuclear-weapons-unal-lewis-final.pdf.
[113] R. Halloran, "Nuclear Missiles: Warning System and the Question of When to Fire", *New York Times*, 29 May 1983, https://www.nytimes.com/1983/05/29/us/nuclear-missiles-warning-system-and-the-question-of-when-to-fire.html.

processing, and analysis burden, offering human command better situational awareness.[114] Notably however, the inclusion of technical elements can create a new source of errors, as they contribute to system complexity and can contain vulnerabilities hidden from operators.[115]

Contain Consequences of Errors

Stronger operational control (or human safeguards) can limit the severity of technical error. Similarly, bilateral or multilateral data exchange about accidents can build a repository of knowledge that could help to prevent future accidents from increasing in magnitude to the level of nuclear use. Through early warning centres, States could engage in joint monitoring of security events that could be mistakenly interpreted, including missile launches and military exercises.[116] The Vienna Document of the Organization for Security and Cooperation in Europe presents a model for such data exchange and notification; this would address escalatory use scenarios as well.[117] In 1998, the United States and the Russian Federation reached agreement on a Joint Data Exchange Center to monitor global ballistic missile launches and space launch vehicles; they have reaffirmed support for the idea several times since, with a 2000 memorandum detailing the nature of its operations, but without further steps towards implementation.[118]

Other proposals aim both to reduce the occurrence of error and contain its consequences. Expanded training of relevant staff in simulated crisis situations could enhance their readiness in abnormal situations. Should cyberattacks occur, the ability of States to efficiently pinpoint their source can lessen the possibility of mistaken retaliation. While there are inherent challenges to attribution, some have identified best practices to mitigate human fallibility.[119] Proposals mentioned previously to lengthen the decision-making process, to enhance communication in crisis, or to designate nuclear C3 as off-limits from cyber interference can have utility here too. Some, noting the increasing role of artificial intelligence and autonomy in nuclear forces, call for commitments to retain the human element in decision-making linked

[114] For more on automation and nuclear weapons systems, see J. Borrie, "Cold War Lessons for Automation in Nuclear Weapon Systems" and V. Boulanin, "The Future of Machine Learning and Autonomy in Nuclear Weapon Systems", in V. Boulanin (ed.), *The Impact of Artificial Intelligence on Strategic Stability and Nuclear Risk – Volume I: Euro-Atlantic Perspectives*, SIPRI, 2019.
[115] C. Perrow, *Normal Accidents: Living with High-Risk Technologies*, 1999.
[116] P. Maurer, *Nuclear Weapons: Averting a Global Catastrophe,* ICRC Statement, 23 April 2018, https://www.icrc.org/en/document/nuclear-weapons-averting-global-catastrophe.
[117] H. Miall, "Exploring New Approaches to Arms Control in the 21st Century: Building Lessons from the INF Treaty and Presidential Nuclear Initiatives (PNIs)", *Policy Brief No. 30*, Toda Peace Institute, November 2018, http://www.toda.org/files/policy_briefs/T-PB%2030_Hugh%20Miall_INF%20Workshop%20Report.pdf.
[118] Memorandum of Agreement Between the United States of America and The Russian Federation on the Establishment of a Joint Center for the Exchange of Data from Early Warning Systems and Notifications of Missile Launches, 4 June 2000, https://www.state.gov/t/isn/4799.htm.
[119] Office of the Director of National Intelligence, *A Guide to Cyber Attribution*, 14 September 2018, https://www.dni.gov/files/CTIIC/documents/ODNI_A_Guide_to_Cyber_Attribution.pdf.

to early warning and C3.[120] And even following an accidental launch, fail-safes built into delivery systems may be able to destroy missiles prior to catastrophe.[121] Still, no range or combination of measures can altogether eliminate the possibility of operator error. And again, given the nature of complex interactions, technical solutions can bring about their own issues and uncertainties.[122]

[120] S. van der Meer, "Reducing Nuclear Weapons Risks: A Menu of 11 Policy Options", *Policy Brief*, Clingendael: Netherlands Institute of International Relations, June 2018, https://www.clingendael.org/sites/default/files/2018-06/PB_Reducing_nuclear_weapons_risks.pdf; H. Miall, "Exploring New Approaches to Arms Control in the 21st Century: Building Lessons from the INF Treaty and Presidential Nuclear Initiatives (PNIs)", *Policy Brief No. 30*, Toda Peace Institute, November 2018, http://www.toda.org/files/policy_briefs/T-PB%2030_Hugh%20Miall_INF%20Workshop%20Report.pdf.

[121] See Range Commanders Council Range Safety Group Flight, *Termination Systems Commonality Standard*, document 319-14, September 2014, https://apps.dtic.mil/docs/citations/ADA620923.

[122] P. Podvig, "Risks of Nuclear Command and Control Accidents", in J. Borrie, T. Caughley, and W. Wan (eds), *Understanding Nuclear Weapon Risks*, UNIDIR, 2017, http://www.unidir.org/files/publications/pdfs/understanding-nuclear-weapon-risks-en-676.pdf.

RISK REDUCTION IN PRACTICE

As indicated in the discussion above, there exists a foundation for risk reduction activities beyond the national level. In fact, nuclear risk reduction was a "central preoccupation" of Cold War-era leaders in the United States and the Soviet Union.[123] The resolution of the Cuban Missile Crisis included a private agreement for the removal of ballistic missiles from Cuba and Turkey. Alongside the Moscow–Washington hotline, this suggested an active desire to avoid the brinksmanship that precipitated the crisis and near escalatory use.[124] These concerns contributed also to the 1971 Agreement on Measures to Reduce the Risk of Outbreak of Nuclear War—which included pledges to notify one another of possible detonation incidents, planned missile launches, and detection of unidentified objects by missile warning systems. A year later, the sides concluded the first round of the Strategic Arms Limitation Talks—the basis for an arms control structure that later came to include the Strategic Arms Reduction Treaty and its successors, with accompanying Nuclear Risk Reduction Centers.

The two superpowers sought to address potential drivers of nuclear crisis in other ways as well. A 1972 agreement on the Prevention of Incidents On and Over the High Seas (the IncSea accord), detailed naval restraint, use of informative signals, and notification exchange between the sides. A 1989 Prevention of Dangerous Military Activities Agreement echoed similar principles across other areas. While neither agreement referred specifically to nuclear use, they aimed to "reduce the possibility of conflict by accident, miscalculation, or the failure of communication; and to increase stability in times of both calm and crisis" between two nuclear-armed States.[125] Unauthorized use, meanwhile, has become a post-Cold War point of emphasis, with the United States and the Russian Federation addressing stockpile and material safety through the Trilateral Initiative, the Cooperative Threat Reduction programme, and the Plutonium Management and Disposition Agreement—though these activities have halted in recent years.

The nature of tension and conflict has similarly driven bilateral measures between India and Pakistan. Some of these predate the development of nuclear weapons in South Asia but have become pertinent to that context, including the installation of hotlines between Prime Ministers and Directors General of Military Operations. The 1988 Agreement on the Prohibition of Attack against Nuclear Installations and Facilities is an early example of restraint in the

[123] M. Krepon, "Nuclear Risk Reduction: Is Cold War Experience Applicable to Southern Asia?", in M. Krepon (ed.), *Nuclear Risk Reduction in South Asia*, 2004, p. 8.
[124] J.M. Lindsay, "TWE Remembers: Secret Soviet Tactical Nuclear Weapons in Cuba (Cuban Missile Crisis, a Coda)", Council on Foreign Relations blog, 29 October 2012, https://www.cfr.org/blog/twe-remembers-secret-soviet-tactical-nuclear-weapons-cuba-cuban-missile-crisis-coda.
[125] US Department of State Bureau of International Security and Nonproliferation, *"Narrative" on the Agreement Between the Government of the United States of America and the Government of the Union of Soviet Socialist Republics on the Prevention of Incidents on and over the High Seas*, 25 May 1972.

civilian nuclear sphere.[126] Following their weapons tests, the 1999 Lahore Declaration pushed both sides to "take immediate steps for reducing the risk of accidental or unauthorized use of nuclear weapons and discuss concepts and doctrines with a view to elaborating measures for confidence building in the nuclear and conventional fields, aimed at prevention of conflict".[127] This has led to ministerial and expert level dialogue that resulted in the 2005 Agreement on Pre-Notification of Flight Testing of Ballistic Missiles, and in 2006, consultations specifically on nuclear doctrines.[128] In 2007 the States signed an agreement specifically on nuclear risk reduction, which included national measures to guard against accidents as well as for bilateral accident notification.

Outside the US–Soviet (now Russian) and the India–Pakistan nuclear dyads (in which China also features), nuclear risk reduction activity remains elusive, with multilateral engagement uneven. The 64-point action plan outlined in the final document of the 2010 NPT Review Conference did call for the five nuclear-weapon States to pursue "a diminishing role for nuclear weapons in security policies to minimize the risk that these weapons ever be used", to "discuss policies that could prevent the use of nuclear weapons" with a view to reducing risk of accidental use.[129] Since 2009 the five NPT nuclear-weapon States have held sporadic conferences among themselves on issues of strategy and security. In January 2019, following a two-year break, they affirmed the need to "strengthen exchanges on nuclear policies and strategies, enhance strategic mutual trust and maintain common security, in a bid to spare no effort to prevent nuclear risks that may be caused by misunderstandings and misjudgments".[130] Risk reduction has emerged as a key issue in the 2020 NPT review cycle, with the chair of the 2019 Preparatory Committee recommending the "elaboration of measures that can contribute to building confidence and reduce the risk of the use of nuclear weapons".[131]

The continued P5 dialogue constitutes a significant step in enhancing mutual understanding, increasing the predictability of potential nuclear engagement, and reducing risk of use across all scenarios—at least those involving the five NPT nuclear-weapon States. Along similar lines,

[126] It defines those installations and facilities based on the presence of "fresh or irradiated nuclear fuel and materials". See Agreement on the Prohibition of Attack Against Nuclear Installations and Facilities, 31 December 1988, https://fas.org/nuke/guide/india/doctrine/nucl.htm.
[127] The Lahore Declaration and Memorandum of Understanding, 21 February 1999, https://peacemaker.un.org/indiapakistan-lahoredeclaration99.
[128] Joint Statement, 4th Round of Pakistan–India Expert Level Dialogue on Nuclear CBMs held in Islamabad on 25–26 April, https://mea.gov.in/bilateral-documents.htm?dtl/6110/Joint+Statement+4th+Round+of+PakistanIndia+Expert+Level+Dialogue+on+Nuclear+CBMs+held+in+Islamabad+on+2526+April.
[129] *2010 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons: Final Document*, volume I, parts I and II, document NPT/CONF.2010/50, 28 May 2010, pp. 15 and 21, http://undocs.org/NPT/CONF.2010/50%20(VOL.I).
[130] "Five Nuclear-weapon States Hold a Formal Conference in Beijing", 30 January 2019, Ministry of Foreign Affairs of the People's Republic of China, https://www.fmprc.gov.cn/mfa_eng/wjbxw/t1634793.shtml.
[131] Chair's factual summary (working paper), Preparatory Committee for the 2020 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons, 10 May 2019, document NPT/CONF.2020/PC.III/WP.49, p. 3, http://undocs.org/NPT/CONF.2020/PC.III/WP.49.

the Group of Seven in April 2019 cited specifically the need for "efforts towards strategic risk reduction" to "help avoid misunderstanding and miscalculation".[132] The value of these exchanges on fundamental concepts—and of expressed recognition of and commitment to risk reduction activities—cannot be overstated. Yet against the backdrop of these high-level multilateral campaigns there remains a need for a practical approach that allows for bespoke actions to address contextual specificities. Past bilateral experiences can serve as invaluable points of reference, but the complexities of the current geopolitical environment suggest the value of a wider perspective. For instance, for those for whom nuclear weapons remain essential, maximizing regional security and stability is "nuclear risk reduction in the highest sense".[133] As unfolding regional nuclear dynamics may define the security landscape for decades to come, engagement with the topic of risk reduction at that level indeed could prove invaluable.[134]

[132] Efforts would include "transparency and dialogue on nuclear doctrines and postures, military-to-military dialogues, hotline agreements among nuclear weapon possessors, 'accident measure' agreements, transparency, and notification exercises, as well as missile launch notification and other data exchange agreements", *2019 G7 Statement on Non-Proliferation and Disarmament*, 6 April 2019, para. 22, https://www.diplomatie.gouv.fr/IMG/pdf/2019_g7_statement_on_non-proliferation_and_disarmament_cle881416.pdf.

[133] C.A. Ford, *Stability Engagement with Nuclear "Third Parties": Regional Risk Reduction Diplomacy,* 8 March 2019, https://www.state.gov/stability-engagement-with-nuclear-third-parties-regional-risk-reduction-diplomacy/.

[134] The Arms Control and Regional Security (ACRS) process in the Middle East serves as a historical example of an overarching regional framework. It was not nuclear-focused but negotiated confidence-building measures that included a communications network, military information exchange, and other transparency measures. Formal activities ceased in 1995. See M.D. Yaffe, "Promoting Arms Control and Regional Security in the Middle East", *Disarmament Forum*, no. 2, 2001, pp. 9–25.

MOVING FORWARD

Widespread concern about nuclear risk has not forged consensus among States on how to move forward. Risk reduction has become a contested space. Some may argue that risk reduction is a status quo endeavour that impedes progress towards the larger goal of nuclear disarmament. Indeed nuclear-armed States often cite improvements to the safety, security, and reliability of their nuclear weapons in describing their extensive modernization programmes. Others criticize the sensationalism around the subject and the "myth of an inherently and permanently high risk of nuclear use": after all, nuclear weapons have not been used since 1945.[135] Still others may cite the futility of developing risk reduction measures against a difficult security and geopolitical environment: the deterioration of arms control and disarmament structures appears indicative of the fundamental lack of political will on such issues.

Yet risk of nuclear use takes many forms. Modernization programmes may lessen the possibility of accidents but they also improve nuclear weapon capabilities and effectiveness, in the eyes of some rendering them more usable in conflict situations.[136] Responsible management rather than luck may be the reason for the lack of detonation events over seven decades but changes to that management will be necessary to respond to technological developments across nuclear weapons systems and other systems impinging on the nuclear balance. Underlying tension and security concerns may provide rationalization for States aggressive nuclear doctrines but adversaries can still clarify those postures and find common ground on measures to prevent accidents or unauthorized use, as they did during the Cold War. Ultimately, nuclear risk reduction stands on its own. It should not be seen as an impediment to disarmament progress but as a distinct means to create a more propitious environment for constructive engagement on all nuclear issues, including disarmament. Indeed, risk reduction takes on added meaning in current circumstances.

In order to advance the conversation, nuclear risk reduction must be recast in a more systematic manner. This paper has advanced a framework identifying four risk of use scenarios: doctrinal, escalatory, unauthorized, and accidental. It sets out approaches to reduce the risk of each, establishing general objectives and offering illustrative measures. What is required next is an understanding of how these scenarios may manifest in particular contexts, including regional ones. There is no shortage of analysis of NATO and Russian doctrines, postures, and activities, but considering these in the context of specific escalatory use scenarios—for

[135] B. Tertrais, "On the Brink—Really? Revisiting Nuclear Close Calls Since 1945", *The Washington Quarterly*, vol. 40, no. 2, 2017, p. 51. Others see this as an inductive fallacy; see J. Borrie, *A Limit to Safety: Risk, 'Normal Accidents', and Nuclear Weapons*, ILPI–UNIDIR, December 2014, https://www.files.ethz.ch/isn/186094/a-limit-to-safety-en-618.pdf.

[136] H.M. Kristensen, "The Quest for More Useable Nuclear Weapons", in J. Borrie, T. Caughley, and W. Wan (eds), *Understanding Nuclear Weapon Risks*, UNIDIR, 2017, http://www.unidir.org/files/publications/pdfs/understanding-nuclear-weapon-risks-en-676.pdf.

instance, in the Baltic sub-region—will shed light on the necessary approach and appropriate measures to combat the possibility. Similarly, examining the Korean Peninsula for potential trigger events across different use pathways is a prerequisite to identifying relevant measures to assuage risk there. In this manner, the international community can move to identify practical and feasible risk reduction baskets pertinent to the situation, tackling pathways that may be present, lessening their number and thus reducing risk of use overall.

APPENDIX

Expanded Summary of Compiled Ideas, Proposals, and Recommendations to Reduce the Risk of Nuclear Weapon Use

CATEGORY	RISK REDUCTION ACTIVITIES	SAMPLE MEASURES AND PROPOSALS
Political–Doctrinal Commitments	Commitment to non-use or no threat of use	▪ Reaffirm Reagan–Gorbachev statement: "A nuclear war cannot be won and must never be fought." ▪ Agreement on prohibition of use or threat of use (e.g. Article 1(d) in TPNW) ▪ Address use rhetoric from political and military leaders
	Lessened role of nuclear weapons in security policies	▪ Scaling back of modernization programmes ▪ Dialogue and research on deterrence alternatives ▪ 'Denuclearization' of war plans and military exercises
	Declaratory policies on avoiding nuclear use	▪ 'No first use' pledges, or bilateral or multilateral agreements ▪ Declarations of 'sole purpose (is to deter/defend)' or '(weapon of) last resort' ▪ Pledges to limit scope of nuclear use even in 'extreme circumstances'
	Ban on classes of nuclear weapons or delivery systems	▪ Targeting lower-yield warheads, dual-capable systems ▪ Dialogues on intermediate-range ballistic missiles, nuclear-armed cruise missiles and drones, hypersonic weapons, and other relevant systems
	Extension of negative security assurances	▪ Binding legal treaty or resolution ▪ Eliminate caveats, e.g. against non-compliant NPT States or other WMD use ▪ Sign and ratify nuclear-weapon free zone treaties and remove exemptions
	Develop understandings or statements of principles	▪ Develop common lexicon on deterrence and capabilities ▪ Establish code of conduct or code on nuclear responsibility ▪ Expand Global Initiative to Combat Nuclear Terrorism principles
Strategic Considerations	Protection of nuclear-related technological systems	▪ Agreement on cyber non-interference with C3 or critical infrastructure ▪ Protection of space-based assets linked to early warning or communications ▪ Guidelines on testing or deployment of anti-satellite weapons
	Agreement not to attack nuclear-related facilities	▪ Expansion of 1988 India–Pakistan Non-Attack Agreement to cover military and civilian facilities, or adoption to other geographic areas ▪ Includes regular list exchange of relevant facilities
	Reductions in numbers of deployed weapons	▪ Withdrawal, to be put into central/national storage or be disassembled ▪ Targeting non-strategic nuclear weapons and other weapons or delivery systems perceived as destabilizing (see examples presented in 'ban on classes' above)
	Restrictions on the nature of deployment	▪ Limit number of storage locations, especially in volatile areas ▪ Establish geographic boundaries, e.g. proximity of submarines to coasts ▪ Limits on particular systems, e.g. New START and deployed mobile launchers
	Changes to deployment patterns and alert status (increasing decision time)	▪ Removal from prompt-launch status, or de-alert ▪ Adjustments to timeframe of readiness plans from minutes to days or weeks ▪ 'Partial' de-alerting, including reducing warhead loading
	Crisis avoidance and management cooperation	▪ Agreements (e.g. 1973 US–Soviet Agreement on the Prevention of Nuclear War) ▪ Restraint in deployments and mobilization in times of crisis ▪ Military/defence personnel engagement

CATEGORY	RISK REDUCTION ACTIVITIES	SAMPLE MEASURES AND PROPOSALS
Operational Procedures	Strengthen data assessment and decision-making	▪ 'Dual phenomenology' to verify or refute early warning data ▪ Two-person rule requiring multiple authorized individuals for critical operations ▪ Inclusion of redundancies in C3
	Physical separation of nuclear weapons	▪ De-mating nuclear weapons from delivery vehicles ▪ Isolate fissile core or trigger from warhead package ▪ Maintain separate sites for storage of nuclear and conventional weapons
	Mechanisms to delay, disrupt, or deactivate launch	▪ De-targeting (e.g. default on open ocean areas rather than territories) ▪ Use of ready-safe switches; or removal or altering of firing switches ▪ Place visible barriers on missile silo lids
	Enhance safety and security of weapons and materials	▪ Strengthen nuclear security systems, including human training ▪ Expand Cooperative Threat Reduction-type assistance activities ▪ Deploy resources for interdiction of illicit ship-to-ship transfers
	Address provocative military practices	▪ Airspace incidents: e.g. reconnaissance flights, missile flight tests, buzzing practices ▪ Large-scale military exercises, including with nuclear forces ▪ Increased mutual signalling, especially in times of crisis
	Pre-notification of actions susceptible to misinterpretation	▪ Changes in deployment, alert status, etc., as well as practices listed above
Bolstering Engagement and Transparency	High-level dialogues on pertinent issues	▪ Topics include strategic stability, deterrence, nuclear risk/threats ▪ Regularized discussion in context of NPT or other multilateral forums ▪ e.g. P5 on national nuclear doctrines and postures; Nuclear Security Summit series
	Information exchange on pertinent issues	▪ Includes doctrines, capabilities, hosted weapons, military exercises ▪ e.g. 2011 Vienna Document of OSCE: with exchange of information, follow-up reporting, site visits, consultative mechanisms
	Communication in crisis situations	▪ Implement or expand hotlines or direct communication links for national and military leadership, e.g. Washington–Moscow or New Delhi–Islamabad ▪ Early warning centres and systems, joint notifications
	Notification of nuclear-related incidents	▪ Expand 1986 Convention on Early Notification of a Nuclear Accident ▪ Intelligence sharing, building on IAEA Incident and Trafficking Database ▪ Enhance detection and attribution of cyberattacks linked to nuclear weapons systems
	Systematized risk assessment and analysis	▪ Database of past nuclear weapons-related incidents; share best practices ▪ Strengthen resilience and diversity of C3 in context of risk linked to emerging technologies ▪ Conduct simulated crisis scenarios and stress testing

This paper — part of UNIDIR's ongoing work on reducing the risk of nuclear weapon use — presents an analytical framework for considering the risks associated with nuclear weapon use. It highlights four potential pathways to nuclear use: doctrinal, escalatory, unauthorized, and accidental. It examines the conditions driving each scenario and posits an approach to addressing them, identifying key objectives and presenting pertinent ideas. Following on from UNIDIR's recent publication "Nuclear Risk Reduction: The State of Ideas", this framework is intended to serve as a basis for further contextual and regional analysis, enabling a more tailored approach to nuclear risk reduction and providing grounds for joint action.

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