

Third Meeting of States Parties to the Treaty on the Prohibition of Nuclear Weapons

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Update to the 2023 report of the Scientific Advisory Group on the status and developments regarding nuclear weapons, nuclear weapon risks, the humanitarian consequences of nuclear weapons, nuclear disarmament and related issues

Working paper submitted by the Scientific Advisory Group

I. Introduction

1. At the first Meeting of States Parties to the Treaty on the Prohibition of Nuclear Weapons, the Scientific Advisory Group was established on the basis of the mandate set out in working paper [TPNW/MSP/2022/WP.6](#). Among other roles and responsibilities, the Group was tasked with reporting to the second Meeting of States Parties on the status and developments regarding nuclear weapons, nuclear weapon risks, the humanitarian consequences of nuclear weapons, nuclear disarmament and related issues. This report was published first as document [TPNW/MSP/2023/8](#) and later as an enhanced version with figures.¹

2. In the present working paper for the third Meeting of States Parties, the Scientific Advisory Group provides an update on developments relating to key issues covered since that report was first issued in October 2023.

3. The Scientific Advisory Group acknowledges with gratitude the assistance of the States parties to the Treaty on the Prohibition of Nuclear Weapons, the President of the second and third Meetings of States Parties, the secretariat of the United Nations Office for Disarmament Affairs and experts who were consulted during the period between the second and third Meetings of States Parties. The list of members of the Scientific Advisory Group is included in the annex to the present working paper.

¹ Available at <https://disarmament.unoda.org/report-of-the-scientific-advisory-group-on-the-status-and-developments-regarding-nuclear-weapons-nuclear-weapon-risks-the-humanitarian-consequences-of-nuclear-weapons-nuclear-disarmament-and-relate>.



II. Status of nuclear weapons

4. In the present section, significant information about the status of nuclear weapons in the nine nuclear-armed States is briefly noted, with a focus on changes since the report of October 2023 was submitted by the Scientific Advisory Group to the second Meeting of States Parties.

5. The present section includes updates on the nuclear weapons stockpiles, capabilities and modernization efforts of nuclear-armed States, developments regarding nuclear weapon host States and others, and the status of the holdings and production of plutonium and highly enriched uranium, the key ingredients for nuclear weapons. The section is based on published independent analysis and estimates, as well as the limited official data available.

Weapons stockpiles

6. As at the beginning of 2025, the nine nuclear-armed States are estimated to have a combined total of about 12,300 nuclear warheads, of which about 9,600 are in military inventories, with roughly another 2,700 weapons awaiting dismantlement in the Russian Federation and the United States of America.² This is an increase over the estimated global stockpile of 12,120 nuclear warheads in early 2024.

7. In July 2024, the United States declared the size of its stockpile as at September 2023, the changes in its stockpile size since 1945 and the numbers of weapons dismantled from 1994 to the end of 2023 (the previous release of data was in 2021).³ It has provided such declarations, including historical data, at irregular periods, making it relatively more transparent about its nuclear warhead stockpile than other nuclear-armed States. No other nuclear-armed State has provided any significant update on its arsenal size in the past year.

8. In 2024, neither the Russian Federation nor the United States provided aggregate data for their deployed strategic nuclear weapons under the data exchange rules of the Treaty between the United States of America and the Russian Federation on Measures for the Further Reduction and Limitation of Strategic Offensive Arms (New START Treaty). This is the first time that no data have been published since the Treaty entered into force in 2011.

9. The Russian Federation suspended its participation in the New START Treaty in February 2023. The last declaration of aggregate numbers of strategic weapons based on a data exchange was for 1 September 2022.⁴ In May 2023, the United States unilaterally issued its aggregate data as at March 2023, but it has provided no aggregate data since.⁵ The New START Treaty is set to expire in February 2026.

10. China is believed to be continuing to increase its nuclear weapon arsenal. According to independent estimates, China held about 600 nuclear warheads (including deployed, operational and reserve warheads) as at the beginning of 2025.⁶ The United States Department of Defense has reported that, according to its estimates,

² Data obtained from the Nuclear Information Project of the Federation of American Scientists, February 2025. See also Hans Kristensen and others, “Status of world nuclear forces”, Federation of American Scientists, 29 March 2024.

³ United States of America, Department of State, “Transparency in the U.S. nuclear weapons stockpile”, fact sheet, 19 July 2024.

⁴ United States, Department of State, “Report to Congress on implementation of the New START Treaty”, January 2023.

⁵ United States, Department of State, “New START Treaty aggregate numbers of strategic offensive arms”, fact sheet, 12 May 2023.

⁶ Data obtained from the Nuclear Information Project of the Federation of American Scientists, February 2025. See also Kristensen and others, “Status of world nuclear forces”.

China held over 600 nuclear warheads as at mid-2024, which was about 100 warheads more than its estimate for 2023.⁷

11. In 2024, the United States declared that “absent a change in the trajectory of adversary arsenals, we may reach a point in the coming years where an increase from currently deployed numbers is required”.⁸ Released in 2024, the Fiscal Year 2025 Stockpile Stewardship and Management Plan for the United States nuclear weapon arsenal includes the goal of possibly expanding the arsenal and new and future capabilities.⁹

12. India, Pakistan and the Democratic People’s Republic of Korea are believed to have continued increasing their nuclear weapons stockpiles since 2023.¹⁰ There is no public indication that the United Kingdom of Great Britain and Northern Ireland, France or Israel have been increasing their arsenals over the past year.

Modernization

13. Nuclear arsenal modernization efforts continued in all nuclear-armed States throughout 2024, in some cases with delays and setbacks.

14. In the United States, the modernization of all three legs of the nuclear triad, consisting of submarines (and submarine-launched ballistic missiles), bombers and intercontinental ballistic missiles, is under way. The development of a new nuclear-armed cruise missile, nuclear gravity bombs and new missile warheads also continued. In late 2023, the United States announced a new aircraft-delivered nuclear bomb, the B61-13, with a 360 kiloton yield.¹¹ In 2024, the country announced that work had started on a new sea-launched nuclear-armed cruise missile, which may not be completed until the 2030s.¹² The United States had retired its previous sea-launched nuclear-armed cruise missile in 2013, deeming it unnecessary.¹³

15. According to the 2025 Stockpile Stewardship and Management Plan, the United States intends to “define the appropriate warheads to support anticipated future threats”, and these warheads “currently include the Future Strategic Land-Based Warhead, the Future Strategic Sea-Based Warhead, the Future Air-Delivered Warhead, and a Submarine-Launched Warhead”. As part of its nuclear weapon capability planning, work is under way on a “concept assessment” on “non-ballistic re-entry vehicles” (hypersonic boost-glide weapons) and means for “hard and deeply buried target defeat” (bunker busters).¹⁴

16. The Russian Federation is concluding its updates of Soviet-era weapons and currently has plans to develop a new long-range bomber, a new intermediate-range

⁷ Hans Kristensen, “The 2024 DOD China military power report”, Federation of American Scientists, 18 December 2024.

⁸ Pranay Vaddi, Special Assistant to the President and Senior Director for Arms Control, Disarmament and Non-Proliferation at the National Security Council of the United States, remarks during the annual meeting of the Arms Control Association, Washington, D.C., 7 June 2024.

⁹ United States, Department of Energy, National Nuclear Security Administration, *Fiscal Year 2025 Stockpile Stewardship and Management Plan: Biennial Plan Summary* (Washington, D.C., 2024).

¹⁰ Kristensen and others, “Status of world nuclear forces”.

¹¹ Hans Kristensen and Matt Korda, “Biden administration decides to build a new nuclear bomb to get rid of an old bomb”, Federation of American Scientists, 27 October 2023.

¹² Xiaodon Liang, “U.S. starts work on nuclear-capable missile”, *Arms Control Today*, vol. 54 (July/August 2024).

¹³ Hans Kristensen, “US Navy instruction confirms retirement of nuclear Tomahawk cruise missile”, 18 March 2013.

¹⁴ United States, Department of Energy, National Nuclear Security Administration, *Fiscal Year 2025 Stockpile Stewardship and Management Plan*.

fighter aircraft, two new submarines and possibly three new intercontinental ballistic missiles (after the Sarmat intercontinental ballistic missile becomes operational).¹⁵

17. The replacement by the United Kingdom of its nuclear-armed submarine fleet is under way, with the new submarines expected to be in service in the early 2030s unless there are delays.¹⁶ The submarine-launched ballistic missiles used by the United Kingdom are leased from the United States and are being modernized as part of the United States submarine-launched ballistic missile programme. The United Kingdom is developing a new nuclear warhead, Astraea, in partnership with the United States W93 warhead programme. There are indications that the Royal Air Force Lakenheath base is being prepared to host United States nuclear weapons; a similar arrangement ended in 2008. The base currently hosts the first European squadron of F-35A fighter aircraft, which were certified in March 2024 for use with the United States B61-12 nuclear bomb.

18. The development by France of a third generation nuclear-armed submarine is under way, although production has not yet started. France is upgrading its submarine-launched ballistic missile fleet and its nuclear-armed air-launched cruise missile.¹⁷

19. China is continuing to modernize its nuclear weapon arsenal. It is building three new fields of launch silos for intercontinental ballistic missiles and is expanding its older silo fields. Only some silos presently appear to be loaded with missiles.¹⁸ China is developing new intercontinental ballistic missile types, a new long-range bomber and a nuclear-capable air-launched ballistic missile.

20. India is continuing work on at least three land-based and two sea-based ballistic missiles, planned to be operational within a few years.¹⁹ India is also expanding its submarine fleet. Four nuclear-powered ballistic missile submarines have been built, of which two were in service as at 2024.²⁰ A new submarine is under development.²¹

21. Pakistan operates medium-range nuclear ballistic missiles of various ranges and is developing additional systems.²² A medium-range missile with the capability for multiple independently targetable re-entry vehicles was tested for a second time in late 2023. Pakistan is developing a nuclear-capable air-launched cruise missile and a submarine-launched nuclear-capable cruise missile. A nuclear-capable ground-launched cruise missile may be operational, and work is under way on a longer-range version. In December 2024, the United States Deputy National Security Adviser claimed that Pakistan was developing rocket engines that could give it a potential intercontinental ballistic missile capability with a range of over 10,000 km.²³

22. The Democratic People's Republic of Korea continues to develop and test intercontinental ballistic missiles, as well as submarine-launched ballistic missiles and intermediate- and short-range missile types. It tested the Hwasong-18 twice in

¹⁵ Hans M. Kristensen and others, "Russian nuclear weapons, 2024", *Bulletin of the Atomic Scientists*, vol. 80, No. 2 (2024).

¹⁶ Hans M. Kristensen and others, "United Kingdom nuclear weapons, 2024," *Bulletin of the Atomic Scientists*, vol. 80, No. 6 (2024).

¹⁷ Hans Kristensen and Matt Korda. "World nuclear forces", in *SIPRI Yearbook 2024: Armaments Disarmaments and International Security* (Oxford University Press, 2024).

¹⁸ Ibid.

¹⁹ Hans M. Kristensen and others, "Indian nuclear weapons, 2024", *Bulletin of the Atomic Scientists*, vol. 80, No. 5 (2024).

²⁰ "India launches its latest nuclear submarine with 75% indigenous tech: here's what the new S4 means for regional security", *The Economic Times*, 24 October 2024.

²¹ Kristensen and others, "Indian nuclear weapons, 2024".

²² Kristensen and Korda, "World nuclear forces".

²³ Daryl G. Kimball, "Pakistan and the nuclear danger in Asia", *Arms Control Today*, vol. 55 (January/February 2025).

2023 and the Hwasong-19 in 2024; both are intercontinental ballistic missiles.²⁴ In January 2025, it tested a 1,500 km-range cruise missile and a 1,500 km-range hypersonic ballistic missile.²⁵ It is continuing its work on fielding a ballistic missile submarine and other naval nuclear weapon delivery systems, including a sea-based cruise missile and a torpedo.²⁶

23. Information on the arsenal of Israel remains scarce and uncertain, and no official information is released. In Israel, public discussion of the country's national nuclear weapons policy is subject to censorship.²⁷ Available information suggests that the main nuclear weapon delivery systems of Israel are ground-launched ballistic missiles, which are currently being upgraded to systems with a range of over 4,000 km.²⁸ Israel also has nuclear-capable fighter aircraft supplied by the United States and may have nuclear-armed submarine-launchable cruise missiles.

24. The nature and implications of nuclear-armed States increasing their respective nuclear weapons stockpiles, and of their arsenal modernization activities and plans, need to be understood in more detail. The States parties to the Treaty on the Prohibition of Nuclear Weapons should support and seek to develop independent capabilities to analyse current developments in nuclear forces and delivery systems, while also encouraging more transparency from the nuclear-armed States.

25. Action in this regard could also be taken collectively at the regional level and through the commissioning of studies by the General Assembly. The last United Nations study to review relevant developments in the field of nuclear weapons was published in 1991.²⁹ This followed the comprehensive study on nuclear weapons of 1980 (A/35/392).

Nuclear weapon host States and others

26. In addition to the nine nuclear-armed States, there are currently six States that host nuclear weapons.³⁰

27. As at the beginning of 2025, of the 32 States of the North Atlantic Treaty Organization (NATO), 5 – Belgium, Germany, Italy, Netherlands (Kingdom of the) and Türkiye – were hosting nuclear weapons owned by the United States. The United Kingdom may resume hosting nuclear weapons owned by the United States.³¹

28. In 2024, NATO member Poland declared its interest in hosting United States nuclear weapons.³² Finland joined NATO in 2023, and the President of Finland stated, when the country was applying to join NATO in 2022, that Finland has no intention

²⁴ Soo-Hyang Choi and Josh Smith, “North Korea says test launch was latest Hwasong-18 ICBM”, Reuters, 13 July 2023; Soo-Hyang Choi and Kantoro Komiya, “North Korea fires ICBM after condemning US ‘war’ moves”, Reuters, 18 December 2023; and Hyunsu Yim, Josh Smith and Hyun Young Yi, “North Korea says record test was new Hwasong-19 intercontinental ballistic missile”, Reuters, 1 November 2024.

²⁵ Hyunsu Yim, “North Korea fires strategic cruise missiles, vows tough stance on U.S.”, Reuters, 25 January 2025; and Hyonhee Shin, “North Korea successfully tests new intermediate-range missile, state media says”, Reuters, 7 January 2025.

²⁶ Hans M. Kristensen and others, “North Korean nuclear weapons, 2024”, *Bulletin of the Atomic Scientists*, vol. 80, No. 4 (2024).

²⁷ Alan Dowty, “The enigma of opacity: Israel’s nuclear weapons program as a field of study”, *Israel Studies Forum*, vol. 20, No. 2 (Winter 2005).

²⁸ Kristensen and Korda, “World nuclear forces”.

²⁹ *Nuclear Weapons: A Comprehensive Study* (United Nations publication, 1991).

³⁰ Hans M. Kristensen and others, “Nuclear weapons sharing, 2023”, *Bulletin of the Atomic Scientists*, vol. 79, No. 6 (2023).

³¹ Matt Precy, “Ministers urged to clarify nuclear deployment”, BBC, 24 January 2025.

³² Associated Press, “Poland’s leader says his country is ready to host NATO members’ nuclear weapons to counter Russia”, 22 April 2024.

of bringing nuclear weapons onto its territory.³³ Sweden joined NATO in 2024, and the Government of Sweden announced that “there is no reason to have nuclear weapons or permanent bases on Swedish territory in peacetime”, leaving open the option to have such weapons based there in wartime.³⁴

29. Beyond NATO, the United States also provides assurances against the threat and use of nuclear weapons in support of Japan, the Republic of Korea and Australia. In 2023, a United States nuclear-armed submarine made a port visit to the Republic of Korea for the first time in 40 years.³⁵

30. Belarus has hosted Russian nuclear weapons since June 2023 according to officials from both countries.³⁶ Independent experts also report evidence that storage facilities have been built in Belarus for nuclear weapons.³⁷ In 2024, the Russian Federation and Belarus conducted joint training exercises involving preparation for the use of nuclear weapons.³⁸

31. This is the first time that the Russian Federation has based nuclear weapons abroad. The Soviet Union deployed nuclear weapons abroad in Soviet republics, including Belarus, and in Eastern Europe. At the end of the cold war, these weapons were withdrawn to the Russian Federation as the successor State to the Soviet Union.

Fissile material stockpiles

32. In nuclear fission weapons and in the fission component of two-stage thermonuclear weapons, the fissile material used is either plutonium or highly enriched uranium, or both in combination. Since the 2023 report of the Scientific Advisory Group, the independent International Panel on Fissile Materials estimates that fissile material stockpiles in nuclear-armed States have mostly stayed the same, with the production of fissile materials for weapons continuing in India, Pakistan and the Democratic People’s Republic of Korea.³⁹

III. Nuclear weapon risks

33. In 2024, the perceived probabilities – and therefore the risks – of nuclear weapons use increased, mainly due to conflicts in which nuclear-armed States are active as combatants or allied to warring parties. In 2024, it was revealed that the perceived risks of the use by the Russian Federation of nuclear weapons in the context of the Ukraine war had become acute in late 2022, with reports that the United States intelligence community had assessed the possibility of use at that time as 50 per cent or higher.⁴⁰

³³ Yle, “President Niinistö: Finland has no intention of siting nuclear arms on its territory”, 7 November 2022.

³⁴ Tobias Billström, Minister for Foreign Affairs of Sweden, statement of Government policy following the accession of Sweden to NATO, 20 March 2024.

³⁵ Heather Mongilio, “USS Kentucky make port call in South Korea, first SSBN visit in 40 years”, USNI News, 18 July 2023.

³⁶ President of Russia, “Plenary session of the St. Petersburg International Economic Forum”, 16 June 2023.

³⁷ Hans Kristensen and Matt Korda, “Depot in Belarus shows new upgrades possibly for Russian nuclear warhead storage”, Federation of American Scientists, 14 March 2024.

³⁸ Guy Faulconbridge, “Russia begins second stage of tactical nuclear weapon drills with Belarus”, Reuters, 11 June 2024.

³⁹ International Panel on Fissile Materials, “Fissile material stocks”, 13 April 2024.

⁴⁰ David Sanger, “Biden’s Armageddon moment: when nuclear detonation seemed possible in Ukraine”, *The New York Times*, 9 March 2024; and Bob Woodward, *War* (Simon and Schuster, 2024).

34. Throughout 2024, perceived nuclear weapon risks were also affected by worsening geopolitical tensions, particularly those involving the United States, the Russian Federation and China – the countries holding the largest nuclear arsenals. Risk assessments were affected by recurring threats to use nuclear weapons, the breakdown of arms control agreements and evidence of nuclear arms racing. Risk perceptions were also affected by policies, actions and interactions involving the other six nuclear-armed States, States that host nuclear weapons and countries that are allies and partners of nuclear-armed States.

35. In its report to the second Meeting of States Parties, the Scientific Advisory Group discussed the challenges of conceptualizing risk and the many ways to think about and estimate risk. It emphasized that the risks posed by nuclear weapons are in a special category and that risks change over time and cannot be seen as static. For example, together with conflict and crises, the leadership in nuclear-armed States, new military doctrines, changing demographics and new technologies all influence risk. The perception of risk also changes when new information that was previously unknown is revealed and when priorities change, new situations emerge and new capabilities are pursued and developed. In particular, the Group noted that available data are insufficient to provide meaningful estimates for the risks of the use of nuclear weapons in an actual conflict.

36. Historical evidence indicates that, especially during times of conflict and crisis, military exercises involving nuclear weapons preparedness can increase the risks of misinterpretation and inadvertent action, potentially leading to escalatory responses that include nuclear weapons use.⁴¹

37. Throughout 2024, several nuclear-armed States held military exercises involving preparedness for nuclear weapons use. Such exercises are conducted on a regular basis. In 2024, the annual NATO exercise “Steadfast Noon” included nuclear-capable aircraft of the United States and nuclear host nations Belgium, Germany, Italy and Netherlands (Kingdom of the), as well as conventional forces from other NATO countries.⁴²

38. The Russian Federation conducted its annual strategic forces exercise in October 2024, with a scenario involving a nuclear counterstrike.⁴³ China and the Russian Federation conducted a joint exercise in 2024 involving nuclear-capable long-range bombers.⁴⁴ France also holds regular nuclear war exercises; during its “Poker” exercise in 2024, nuclear attacks by Rafale aircraft armed with air-launched cruise missiles were practised.⁴⁵ The Democratic People’s Republic of Korea conducted a number of nuclear exercises in 2024, including a “combined tactical drill simulating nuclear counter-attack” with the simultaneous launching of four KN25 missiles “tipped with simulated nuclear warheads”.⁴⁶ This list is illustrative rather than exhaustive, as not all exercises are publicly announced.

39. The States parties to the Treaty on the Prohibition of Nuclear Weapons have been working on the issue of threat and risk perceptions as part of a consultative

⁴¹ Patricia Lewis and others, *Too Close for Comfort: Cases of Near Nuclear Use and Options for Policy* (London, Chatham House, 2014).

⁴² Hans Kristensen, “NATO tactical nuclear weapons exercise and base upgrades”, Federation of American Scientists, 14 October 2023.

⁴³ Ibid.; and Pavel Podvig, “Strategic forces exercise includes a launch of Bulava”, Russian Strategic Nuclear Forces, blog, 29 October 2024.

⁴⁴ North American Aerospace Defense Command Public Affairs, “NORAD detects, tracks and intercepts Russian and PRC aircraft operating in the Alaskan ADIZ”, 24 July 2024.

⁴⁵ Hans Kristensen (@nukestrat), “Apparently the French Air Force nuclear strike exercise is underway: POKER. The third of four such exercises this year. Check out @FrenchTrackers for more”, 25 September 2024. Available at <https://x.com/nukestrat/status/1838876972882993651>.

⁴⁶ Kristensen and others, “North Korean nuclear weapons, 2024”.

process established at the second Meeting of States Parties. The States parties could consider commissioning research into the risks of inadvertent nuclear use and its relationship to nuclear war preparedness exercises and how to mitigate such risks. The States parties could also consider proposals for greater transparency and notification requirements in respect of military nuclear exercises, possible limits on such exercises and a call for a moratorium on nuclear weapon-related military exercises in times and regions of crisis involving nuclear-armed States.

40. In November 2024, the Russian Federation announced a revised nuclear weapon policy that reduced the threshold for nuclear weapons use.⁴⁷ Under the previous policy, issued in 2020, the nuclear weapons would be used “in response to the use of nuclear and other types of weapons of mass destruction, 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”.⁴⁸ The revised policy refers to a threshold for nuclear weapons use in the case of “aggression against the Russian Federation and (or) the Republic of Belarus, as the members of the Union State, with the use of conventional weapons that creates a critical threat to their sovereignty and (or) territorial integrity”. The nuclear weapons use criteria include the “mass launch (take-off) of air and space attack means (strategic and tactical aircraft, cruise missiles and uncrewed, hypersonic and other aerial vehicles) and their crossing of the State border of the Russian Federation”.⁴⁹

41. The perception of nuclear risks is shaped by immediate events and expectations about longer-term processes, making nuclear risks hard to understand. The impacts of undermining arms control treaties through non-compliance, decreased engagement or withdrawal take years to be fully understood.

42. Evidence continued to emerge in 2024 of the consequences of the collapse of the Intermediate-Range Nuclear Forces Treaty, from which the United States withdrew in 2019. The United States and Germany announced their intention to deploy conventional intermediate-range missiles in Germany starting in 2026.⁵⁰ A few days before this announcement, the Russian Federation announced its plan to develop and deploy nuclear-armed intermediate-range missiles.⁵¹ Later, the Russian Federation used the Oreshnik conventionally armed intermediate-range missile in combat for the first time.⁵²

43. Late 2024 saw a development that could prevent some new nuclear risks. The Presidents of China and the United States agreed on the need to maintain human control over the decision to use nuclear weapons rather than allowing or enabling artificial intelligence to have control.⁵³

⁴⁷ Russian Federation, “On approval of the fundamentals of the State policy of the Russian Federation in the field of nuclear deterrence”, Decree of the President of the Russian Federation No. 991, 19 November 2024. Available at <http://publication.pravo.gov.ru/document/0001202411190001?index=2,19>.

⁴⁸ Russian Federation, “On the fundamentals of the State policy of the Russian Federation in the field of nuclear deterrence”, Decree of the President of the Russian Federation, No. 355, 2 June 2020. Available at <http://kremlin.ru/acts/bank/45562>.

⁴⁹ Russian Federation, “On approval of the fundamentals of the State policy of the Russian Federation in the field of nuclear deterrence”, Decree of the President of the Russian Federation No. 991.

⁵⁰ Xiaodon Liang, “U.S. to deploy intermediate-range missiles in Germany”, *Arms Control Today*, vol. 54 (September 2024).

⁵¹ David Sanger and Anton Troianovski, “Putin vows to make new nuclear missiles and to weigh placing them near NATO nations”, *The New York Times*, 28 June 2024.

⁵² Associated Press, “Russia has used its hypersonic Oreshnik missile for the first time. What are its capabilities?”, 9 December 2024.

⁵³ Jarrett Renshaw and Trevor Hunnicutt, “Biden, Xi agree that humans, not AI, should control nuclear arms”, Reuters, 16 November 2024.

Nuclear weapons risk analysis

44. In 2023 and 2024, the United States National Academies of Sciences, Engineering, and Medicine published a two-part report on risk analysis methods for nuclear war and nuclear terrorism,⁵⁴ which was commissioned by the United States Congress. In the report, the authoring committee of experts of the National Academies explored the risk assessment literature, highlighted the strengths and weaknesses of risk assessment approaches and discussed publicly available assumptions that underpin United States strategies on nuclear war and nuclear terrorism. For the second part of the report, the committee was given “access to classified briefings and reports up to the Secret level”.⁵⁵

45. In the second part of the report, the committee noted that “consequence is one part of a traditional risk equation”. It highlighted the use by the United States Defense Threat Reduction Agency of “probabilistic models for targeting and damage estimates, including blast, cratering, and ground shock” and noted that “some estimates of collateral damage to humans are included – prompt, thermal, and air blast effects” but that “political, military, economic, social, information, and infrastructure impacts are not currently included”. It also noted that there are no government requirements for such analysis to be included in the nuclear weapon consequence models. The committee concluded that United States modelling of the consequences of the use of nuclear weapons is only “partial”, resulting in planning and decision-making based on a “limited understanding of the breadth of the outcomes”.

46. Overall, the committee judged that “there is a need to improve the understanding of the physical effects of nuclear weapons (e.g., fires, damage in modern urban environments, electromagnetic pulse effects, and climatic effects, such as nuclear winter), as well as the assessment and estimation of psychological, societal, and political consequences of nuclear weapons use”.⁵⁶

47. The States parties to the Treaty on the Prohibition of Nuclear Weapons should develop, both within their national scientific communities and collectively, the capability to conduct peer reviews and national, regional and global consequence modelling of all aspects of the effects of nuclear weapons for the purpose of improving national and global nuclear weapons risk analysis.

IV. Humanitarian consequences of nuclear weapons use and testing

Humanitarian consequences of nuclear weapons use

48. In June 2024, the science academies of the Group of Seven countries released a joint statement on nuclear arms control to inform discussions during the Group’s summit in Italy and to offer guidance for ongoing policymaking.⁵⁷ This was the first statement on the subject of nuclear weapons by the Group of Seven science academies since they began collaborating in 2005.

⁵⁴ National Academies of Sciences, Engineering, and Medicine, *Risk Analysis Methods for Nuclear War and Nuclear Terrorism*, Phase I report (Washington, D.C., 2023).

⁵⁵ National Academies of Sciences, Engineering, and Medicine, *Risk Analysis Methods for Nuclear War and Nuclear Terrorism: Phase II (Expanded Abbreviated Report of the CUI Version)* (Washington, D.C., 2024).

⁵⁶ This conclusion is included in both the first and second parts of the *Risk Analysis Methods for Nuclear War and Nuclear Terrorism* report.

⁵⁷ Group of Seven, “Nuclear arms control”, joint statement by the national science academies of the Group of Seven countries, 12 April 2024.

49. In their statement, the science academies of the Group of Seven countries drew attention to the rise in international tensions and the new wars involving countries possessing nuclear weapons. They highlighted the catastrophic effects of nuclear weapons, noting that “a full-scale nuclear war between the nations with the largest arsenals would result in devastation to those nations and would cause harm worldwide”. They observed that: “Depending on the scale of use of nuclear weapons, there is the potential for the destruction of entire ecosystems and extinction of species, due to the direct impact of explosions and fires and altered climatic conditions. In the worst cases this could be on the scale of a mass extinction.”

50. The science academies of the Group of Seven countries concluded by stating that they, “in light of the rise in international tensions and wars, call on the G7 leaders to once again reaffirm their commitment to achieving a world without nuclear weapons and to take the necessary steps to help the world realise this goal safely and securely”. They noted that the scientific community can contribute to this goal by developing and communicating scientific evidence that shows the catastrophic effects of nuclear warfare on human populations and other species, and by developing means to monitor, detect and verify agreements.

51. In 2024, the General Assembly adopted resolution [79/238](#), in which it mandated a study on the effects of nuclear war. This was a key recommendation made by the Scientific Advisory Group in its 2023 report. The Assembly last mandated a study on nuclear war in its resolution [40/152](#) G of 1985. That study ([A/43/351](#)) was completed and released in 1988.

52. Resolution [79/238](#) was introduced by Ireland and New Zealand and was sponsored by 48 countries.⁵⁸ In the resolution, the General Assembly calls for the establishment of an international Scientific Panel on the Effects of Nuclear War, consisting of 21 members to be appointed by the Secretary-General. The Panel is tasked with examining the physical effects and societal consequences of a nuclear war on a local, regional and planetary scale, including, inter alia, the climatic, environmental and radiological effects, and their impacts on public health, global socioeconomic systems, agriculture and ecosystems, in the days, weeks and decades following a nuclear war. The Panel is also tasked with making key conclusions and identifying areas requiring future research.

53. In the resolution, the Assembly encourages Member States, relevant international and regional organizations and others to support the work of the Panel, including by providing relevant information, scientific data and analyses; facilitating and hosting Panel meetings, including regional meetings; and making voluntary budgetary contributions, or in-kind contributions.

54. The Assembly also calls for the Panel to consult with the widest range of scientists and experts and for the United Nations system and relevant agencies to support the work of the Panel, including by contributing expertise, commissioned studies, data and papers. The Panel will report to the Assembly in 2027.

55. The States parties to the Treaty on the Prohibition of Nuclear Weapons could support the work of the Panel individually and jointly, including by facilitating and hosting Panel meetings and, where feasible, by making voluntary budgetary contributions or in-kind contributions.

⁵⁸ Algeria, Andorra, Austria, Bosnia and Herzegovina, Brazil, Chile, Costa Rica, Cyprus, Djibouti, the Dominican Republic, Ecuador, Egypt, Fiji, Indonesia, Iraq, Ireland, Jamaica, Jordan, Kazakhstan, Kiribati, Liechtenstein, Malaysia, Malta, Marshall Islands, Mexico, Namibia, New Zealand, Nigeria, Norway, Palau, Papua New Guinea, Paraguay, the Philippines, Samoa, San Marino, Senegal, Sierra Leone, Solomon Islands, South Africa, Suriname, Switzerland, Thailand, Tonga, Trinidad and Tobago, Tuvalu, Uruguay, Viet Nam and Zimbabwe.

56. New information surfaced in 2024 about the possible economic effects of the use of one or more nuclear weapons. In September 2024, the United States declassified a memo prepared by its National Intelligence Council entitled “Potential global economic consequences of a use by Russia of nuclear weapons in Ukraine”.⁵⁹ This followed a request by the United States National Security Council for “an examination of the possible global economic impact of use by Russia of one or more nuclear weapons in Ukraine”.

57. In the memo, the National Intelligence Council reported that: “Use by Russia of a nuclear weapon in Ukraine would further disrupt the global economy, leading to additional volatility in financial and commodity markets – including energy markets – higher inflation, increased food insecurity, and declining economic growth. This volatility would further strain countries’ ability to maintain financial and political stability.”

58. It assessed that “many countries would have trouble maintaining financial stability”, with some emerging countries going into “default” and “many countries falling into recession”, and that “the banking sector could be destabilized in many countries”. At the same time, “global food prices probably would increase”, leading to “sharp increases in global food insecurity”, “oil and natural gas prices probably would face sharp upward pressure”, and there could be “price spikes and increased volatility in a range of strategic materials”. The assessment of anticipated crises following the use of even one nuclear weapon did not include the inevitable social and humanitarian consequences.

59. In the memo, the National Intelligence Council noted that: “We have low confidence in our ability to predict the duration and severity of economic disruptions because they are subject to a range of key uncertainties, and we have no precedent against which to benchmark.”

Humanitarian consequences of nuclear weapons testing

60. In 2023 and 2024, the General Assembly adopted resolutions [78/240](#) and [79/60](#), entitled “Addressing the legacy of nuclear weapons: providing victim assistance and environmental remediation to Member States affected by the use or testing of nuclear weapons”. In these resolutions, the Assembly encouraged further international cooperation and discussions to assist victims and assess and remediate environments contaminated by the use and testing of nuclear weapons and other nuclear explosive devices, including through bilateral, regional and multilateral frameworks, such as relevant treaties, while acknowledging the significant work in some jurisdictions.

61. Currently, Kazakhstan and Kiribati are the only States parties to the Treaty on the Prohibition of Nuclear Weapons that have had nuclear weapon tests conducted on their national territories (Algeria has signed but not ratified the treaty). Both Kazakhstan and Kiribati have faced the challenges of victim assistance and environmental remediation due to this legacy and are eligible for international cooperation and assistance in addressing these challenges, as laid out in article 7 of the Treaty.

62. Kazakhstan has in its territory former test sites that were utilized over a 40-year period for nuclear weapons testing, causing damage to human health and the environment. The Semipalatinsk nuclear test site, the largest of the sites, was closed in 1991. The National Nuclear Centre of Kazakhstan has been responsible for the radiological investigation of these sites and their adjacent territories. Through studies, contamination has been found in parts of the Semipalatinsk site due to nuclear

⁵⁹ United States, National Intelligence Council, “Potential global economic consequences of a use by Russia of nuclear weapons in Ukraine”, declassified memorandum, 28 November 2022.

weapons tests, and the boundaries of such contamination and areas that might be contaminated by radiological migration processes have been identified. These studies have allowed Kazakhstan to identify areas posing an immediate hazard to inhabitants, areas that need to be monitored and areas where remediation measures are required under existing national laws.⁶⁰

63. Remediation requires long-term and costly programmes aimed at land reclamation and ecosystem restoration. The total area in Kazakhstan requiring remediation under current laws is estimated at about 8,400 km², half the current area of the Semipalatinsk site. The National Nuclear Centre is engaged in establishing a radiation monitoring system at the site, drawing up an inventory of hazardous facilities and maintaining access restriction systems at the high-risk areas of the site. A Semipalatinsk nuclear safety zone without any public access has been demarcated under a special regulatory regime.⁶¹ Kazakhstan plans to continue monitoring the radiological status of the site and the adjacent territory as part of an environmental monitoring programme covering the currently defined hazardous territories and their boundaries. The monitoring system will require further modernization with equipment at fixed sites to gather real-time radiation data.

64. Kiribati has yet to understand fully the enduring effects of the 33 nuclear weapon test explosions by the United Kingdom and the United States on Kiritimati and Malden Islands.⁶² Analysis is needed of the extent of the health impacts of the testing on the Indigenous population of Kiritimati Island and the potential needs for victim assistance. No comprehensive epidemiological, public health or medical studies have been conducted to evaluate the long-term health consequences of these nuclear tests.

65. More than 20 years have passed since the last environmental survey of the radiological contamination of the former test sites on Kiritimati and Malden Islands.⁶³ The United Kingdom, which performed nine nuclear tests there between 1952 and 1958, reported that it had conducted environmental radioactivity studies at the time of the tests and follow-on studies in 1964, 1975, 1978, 1981 and 1998.⁶⁴ In November 2023, the United Kingdom declared that it “has reviewed residual contamination relating to British nuclear tests on Kiribati and concluded that any required remediation had been undertaken”.⁶⁵ No significant primary measurement data have been released.

66. Recent work coordinated by the International Atomic Energy Agency (IAEA) to assess the long-term environmental behaviour and potential impacts of radioactive particles for plants, animals and people has raised significant questions about prior and existing radioactivity monitoring methods based on local sampling and averaging

⁶⁰ Republic of Kazakhstan, Law No. 1787-XII of 18 December 1992, on the social protection of citizens who suffered from nuclear tests at the Semipalatinsk nuclear test site, and Land Code No. 442.

⁶¹ Republic of Kazakhstan, Law No. 16-VIII of 5 July 2023, on the Semipalatinsk nuclear safety zone.

⁶² Becky Alexis-Martin and others, “Addressing the humanitarian and environmental consequences of atmospheric nuclear weapon tests: a case study of UK and US test programmes at Kiritimati (Christmas) and Malden Islands, Republic of Kiribati”, *Global Policy*, vol. 12, No. 1 (February 2021). See also the supporting information on the nuclear tests and radiation exposure and contamination surveys.

⁶³ *Ibid.*, see supporting information, table 6: studies of radiological conditions at Kiritimati and Malden Islands.

⁶⁴ United Kingdom of Great Britain and Northern Ireland, Ministry of Defence, “UK atmospheric nuclear weapons tests”, fact sheet, No. 1, 2008.

⁶⁵ Leo Docherty, answer of 27 November 2023 to question for the Foreign, Commonwealth and Development Office on the topic “Christmas Island and Kazakhstan: nuclear weapons”, UIN 2726, tabled on 20 November 2023.

approaches. Through this work, which aims to improve dose assessments for humans and other organisms in radiologically contaminated environments, IAEA has found that:

The existing system for assessing the impact of environmental radiation on people, animals and plants is essentially based on assumptions of continuous and uniform radioactive sources. Contrary to these assumptions, real life often demonstrates greater diversity of existing forms of radioactive contaminants, which range from continuous substances, like gases and fluids, to highly heterogeneous solid refractory particles. ... objective information on properties of radioactive particles released to the environment due to past practices or events and on associated radiological threats is needed. In areas affected by particle contamination, a substantial amount of radioactivity can be present in particulate form, so the radioactive contamination can be unevenly distributed, and the inventories can be underestimated. Correspondingly, estimates of radiological impacts to human health and to the environment may become biased with unacceptably large uncertainties if the radioactive particles are ignored and continuity assumptions are utilised.⁶⁶

67. Further research is needed to understand the full extent of the long-term contamination and resulting public health and environmental impacts of radioactive fallout from nuclear weapons testing. The States parties to the Treaty on the Prohibition of Nuclear Weapons should encourage their respective scientific communities to collaborate and work together on this set of issues as a part of their obligations under article 7 of the Treaty. In particular, the States parties should support medical needs assessments and assistance for long-term radiation exposure, and environmental monitoring and sampling of food systems, biota, soil, water and ocean sediments in Kiribati. IAEA has done similar environmental studies at other test sites, making it a potential candidate to conduct a study of radiological conditions on Kiribati and design a monitoring programme.

V. Nuclear disarmament and related issues

68. In the present section, developments since 2023 relevant to the disarmament provisions of the Treaty on the Prohibition of Nuclear Weapons (article 4) and the recognition in article 8 of possible “further measures for nuclear disarmament” are discussed.

Disarmament measures

69. In late 2023, the Russian Federation revoked its ratification of the Comprehensive Nuclear-Test-Ban Treaty as a response to the United States showing “no sign of intent to ratify [that Treaty] in the foreseeable future”.⁶⁷ The Russian Federation remains a signatory to the Treaty and an active participant in the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization and continues to operate its share of the International Monitoring System.⁶⁸ Evidence emerged in 2024 that the United States, the Russian Federation

⁶⁶ Alexander Ulanowski and Manfred Groening, “Completed CRP: environmental behaviour and potential biological impact of radioactive particles (K41013)”, International Atomic Energy Agency, 19 April 2021.

⁶⁷ President of Russia, “Law revoking the ratification of the Comprehensive Nuclear-Test-Ban Treaty”, 2 November 2023.

⁶⁸ Comprehensive Nuclear-Test-Ban Treaty Organization, “Russia’s last global monitoring system station is installed, sending data”, 14 December 2023.

and China – all signatories to the Treaty – actively expanded facilities at their nuclear weapon test sites.⁶⁹

70. In 2024, at the Preparatory Committee for the 2026 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons, China submitted a proposal on no-first-use of nuclear weapons ([NPT/CONF.2026/PC.II/WP.33](#)). In its proposal, China encouraged the nuclear-armed States parties to the Non-Proliferation Treaty to “actively explore the conclusion of a treaty on no-first-use of nuclear weapons or to issue a political statement to that effect” (ibid. para. 7). It suggested specific elements of such a treaty or statement for discussion, including that “States parties undertake not to be the first to use nuclear weapons against other States parties at any time or under any circumstances and also undertake to support the early negotiation of a convention on the non-use or threat of use of nuclear weapons against non-nuclear-weapon States and nuclear-weapon-free zones”. This proposal comes 30 years after China submitted a draft treaty on no-first use of nuclear weapons to the nuclear-weapon States parties to the Non-Proliferation Treaty.

71. The proposed obligation “not to be the first to use nuclear weapons against other States parties at any time or under any circumstances” parallels, in a limited way, part of the obligation under article 1 of the Treaty on the Prohibition of Nuclear Weapons “never under any circumstances to ... use or threaten to use nuclear weapons”. The States parties to the Treaty on the Prohibition of Nuclear Weapons could deliberate on how the goals and provisions of the Treaty might benefit from progress towards and the achievement of a no-first-use treaty.

72. In 2024, Japan announced the establishment of the friends of the proposed treaty banning the production of fissile material for nuclear weapons or other nuclear explosive devices, a cross-regional group that aims to maintain and enhance political attention on the need for such a treaty.⁷⁰ The group comprises Australia, Brazil, Canada, France, Germany, Italy, Japan, Netherlands (Kingdom of the), Nigeria, the Philippines, the United Kingdom and the United States.⁷¹

Verification

73. In December 2024, the General Assembly adopted resolution [79/240](#), in which it requested the Secretary-General to seek the views of Member States on the possible establishment of a Group of Scientific and Technical Experts on Nuclear Disarmament Verification. Such a group could potentially generate results supporting the verification of the comprehensive, transparent and irreversible elimination of nuclear weapon programmes, as required by the Treaty on the Prohibition of Nuclear Weapons. The States parties to the Treaty could consider and develop statements on the need for such a group and the possible tasks relevant to the Treaty that such a group could be assigned.

74. In 2024, the International Partnership for Nuclear Disarmament Verification, an initiative of the United States Department of State in which more than 25 countries have participated, including some States parties to the Treaty, published a report summarizing its work over the past decade.⁷² The focus of this work is a potential 14-step conceptual model for a process of nuclear warhead dismantlement.

⁶⁹ Kathleen Kingsbury, “Where the world plans to test nuclear weapons next”, *The New York Times*, 20 June 2024.

⁷⁰ Kamikawa Yoko, Minister for Foreign Affairs of Japan, statement at the Security Council ministerial briefing on nuclear disarmament and non-proliferation, 18 March 2024.

⁷¹ Shizuka Kuramitsu, “New group seeks progress on fissile material treaty”, *Arms Control Today*, vol. 54 (November 2024).

⁷² Nuclear Threat Initiative, *Verification of Nuclear Disarmament: Insights from a Decade of the International Partnership for Nuclear Disarmament Verification* (Washington, D.C., 2024).

75. In September 2024, the Quad Nuclear Verification Partnership, an initiative of Norway, Sweden, the United Kingdom and United States, held an exercise aimed at exploring a multilateral approach to nuclear disarmament verification through “continuous monitoring of nuclear facilities ... to ensure that nuclear weapons are not being produced or maintained in secret” rather than verification by a regime of discrete inspections.⁷³

76. To meet the need for a more globally representative community of experts on nuclear disarmament verification, a trilateral conference was held in Brazil in 2024. This was part of a process launched in 2018 to facilitate capacity-building and knowledge transfer to create a new generation of experts through the establishment of three regional research and innovation hubs in Africa, Central Asia and Latin America. The hubs are intended to provide a platform for research into conceptual, political and practical nuclear disarmament verification measures and for the development of regional perspectives on the challenges of nuclear disarmament verification.⁷⁴

77. Under the Treaty on the Prohibition of Nuclear Weapons, irreversibility is a key part of the nuclear disarmament process. In the biennium 2023–2024, the *Journal for Peace and Nuclear Disarmament* published three special issues containing 20 articles on the broad theme of irreversibility and global nuclear politics.⁷⁵ More technically focused work is needed to determine how irreversibility concerns will apply to the implementation of the Treaty.

78. In particular, work is needed to clarify the end point of the elimination or conversion of weapons programmes and the requirement under article 4 of the Treaty for any nuclear-armed State joining the Treaty to conclude a safeguards agreement with IAEA to provide credible assurance of the non-diversion of declared nuclear material from peaceful nuclear activities and of the absence of undeclared nuclear material or activities in the State as a whole.

79. As at the beginning of 2025, 182 States had comprehensive safeguards agreements with IAEA. A total of 142 States and the European Atomic Energy Community have concluded additional protocols with IAEA that are now in force.⁷⁶ Another 12 States have signed additional protocols but have yet to bring them into force. Additional protocols increase the ability of IAEA to verify the peaceful use of all nuclear material in States with comprehensive safeguards agreements. China, France, the Russian Federation, the United Kingdom and the United States have voluntarily offer safeguards agreements with IAEA to allow for safeguards on material in select facilities and have also concluded limited additional protocols.

⁷³ Norwegian Radiation and Nuclear Safety Authority, “DSA participates in unique nuclear disarmament collaboration”, 4 October 2024.

⁷⁴ This effort is led by the Verification Research, Training and Information Centre in London, the Non-proliferation for Global Security Foundation in Argentina, the Radiation and Health Physics Unit at the University of Witwatersrand in South Africa and the International Science and Technology Centre in Kazakhstan. See www.vertic.org/2024/10/vertic-hosts-trilateral-conference-in-brazil-in-support-of-nuclear-disarmament-verification-expertise.

⁷⁵ See *Journal for Peace and Nuclear Disarmament*, vol. 6, No. 2 (2023), Special Issue: Irreversibility in Global Nuclear Politics Part I; *Journal for Peace and Nuclear Disarmament* vol. 7, No. 1 (2024), Special Issue: Irreversibility in Global Nuclear Politics Part II: Empirical Insights; and *Journal for Peace and Nuclear Disarmament*, vol. 7, No. 2 (2024), Special Issue: Irreversibility in Global Nuclear Politics Part III: Applications.

⁷⁶ International Atomic Energy Agency, “Status list: conclusion of safeguards agreements, additional protocols and small quantities protocols status”, 31 December 2024. Available at www.iaea.org/sites/default/files/20/01/sg-agreements-comprehensive-status.pdf.

VI. Conclusion

80. The present working paper is an update of the report on the status and developments regarding nuclear weapons, nuclear weapon risks, the humanitarian consequences of nuclear weapons, nuclear disarmament and related issues ([TPNW/MSP/2023/8](#)), submitted by the Scientific Advisory Group to the second Meeting of States Parties.

81. In the present working paper, the Group addressed, among other issues, nuclear weapons stockpile increases and modernization programmes, the effects of nuclear weapon threats and nuclear war exercises on global risk perception, shortcomings in the current understanding of the humanitarian consequences of nuclear weapons use and testing, and nuclear disarmament and verification matters. It made relevant recommendations on these issues for the States parties to the Treaty on the Prohibition of Nuclear Weapons to consider.

82. The Group plans to produce a report on these issues for the first Review Conference of the Treaty in 2026.

Annex

The members of the Scientific Advisory Group are as follows:

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 - Erlan Batyrbekov
 - André Johann Buys
 - Jans Fromow-Guerra
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