6. World nuclear forces

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I. Introduction

The nine nuclear-armed states—the United States, the Russian Federation, the United Kingdom, France, China, India, Pakistan, the Democratic People's Republic of Korea (DPRK or North Korea) and Israel—continued to modernize their nuclear arsenals in 2024 and some deployed new nuclear-armed or nuclear-capable weapon systems during the year.

Of the total global inventory of an estimated 12 241 warheads in January 2025, about 9614 were in military stockpiles and available for potential use—roughly 29 more than the previous year (see table 6A.1 in appendix 6A). An estimated 3912 of those warheads were deployed with missiles and aircraft—around the same number as in January 2024—and the rest were in central storage. Approximately 2100 of the deployed warheads were kept in a state of high operational alert on ballistic missiles. Nearly all of these warheads belonged to Russia or the USA. France, the UK and possibly China are thought to have small numbers of warheads on high operational alert.

Overall, the number of nuclear warheads in the world continues to decline; however, this is only due to Russia and the USA dismantling retired warheads. In addition to their military stockpiles, Russia and the USA each hold more than 1000 warheads previously retired from military service, which they are gradually dismantling. Notably, the number of warheads being dismantled annually appears to be decreasing and it seems likely that the rate at which retired warheads are dismantled may soon be outpaced by the rate at which new warheads enter global stockpiles each year.

Section II of this chapter outlines the major trend: the ongoing modernization of all nuclear-armed states' nuclear arsenals. Section III explores two other key developments: the changing nuclear doctrines of several nuclear-armed states because of armed conflict, regional tensions or their modernization programmes (with a focus on Russia, the USA and China); and the growing saliency of nuclear-sharing arrangements. Section IV concludes that these trends raise concerns about the future potential use of nuclear weapons. An appendix to the chapter provides simplified tables of the

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deployed nuclear forces, delivery systems and warhead stockpiles of each of the nine nuclear-armed states (appendix 6A).[1]

The availability of reliable information on the status of the nuclear arsenals and capabilities of the nuclear-armed states varies considerably as some states have a higher level of transparency in this area than others. Estimates are primarily based on observations of each state's force structure as well as the amount of fissile material—plutonium and highly enriched uranium—that the state is believed to have produced (see chapter 8). In previous years, official data on US and Russian deployments of nuclear weapons could be obtained through treaty-based declarations. However, the collapse of the 2010 Treaty on Measures for the Further Reduction and Limitation of Strategic Offensive Arms (New START) during 2023 and 2024 has eliminated that source of data from the public debate. The figures presented here are estimates based on public information and contain some uncertainties.

II. Nuclear weapon modernization trends

All the nine nuclear-armed states continued to strengthen their nuclear arsenals in 2024 and some deployed new nuclear-armed or nuclear-capable weapon systems during the year. Although most nuclear-armed states typically refer to their ongoing development and production efforts as nuclear 'modernization', their actions go well beyond simple maintenance and sustainment operations. This section first provides a brief general overview of developments in nuclear weapon modernization among the nuclear-armed states. It then explores noteworthy developmental trends in vertical proliferation in 2024 relating to specific nuclear capabilities: dual-capable missiles; multiple independently targetable re-entry vehicles (MIRVs); hypersonic missiles; and sea- and air-based systems.

Nuclear arsenals being strengthened around the world

The United States and Russia

The USA and Russia together possess almost 90 per cent of all nuclear warheads. They both have extensive programmes under way to modernize and

[1] These tables summarize the more detailed findings published by the authors in the *Bulletin of the Atomic Scientists*, 'Nuclear notebook' series. The estimates presented here may differ from those published in the most recent nuclear notebooks as a result of reassessments based on new information. See also Kristensen, H. M. and Korda, M., 'Estimating world nuclear forces: An overview and assessment of sources', SIPRI Commentary, 14 June 2021.

replace their nuclear warheads and to upgrade their aircraft and missile and submarine delivery systems and their nuclear weapon production facilities.[2] The size of the USA's military stockpile (i.e. its usable warheads) remained relatively stable in 2024, while a year-on-year decrease in SIPRI's estimate of Russia's stockpile was largely due to a reassessment by SIPRI of the number of warheads assigned to non-strategic (tactical) nuclear forces (see tables 6A.1, 6A.2 and 6A.3).

The USA's modernization programme covers both its strategic and non-strategic nuclear forces. In terms of strategic forces, it includes the LGM-35A Sentinel intercontinental ballistic missile (ICBM) to replace the LGM-30G Minuteman III ICBM; the Columbia-class nuclear-powered ballistic missile submarine (SSBN) to replace the Ohio-class SSBN; and the B-21 Raider heavy bomber aircraft to replace the B-2A. The USA is also modernizing each of these delivery system's associated nuclear warheads and the overarching nuclear command, control and communication infrastructure. In February 2024 the US National Nuclear Security Administration (NNSA) reported that it had delivered 'more than 200 modernized nuclear weapons' to the US Department of Defense (DOD) during the 'past year' (presumably referring to US fiscal year 2023)—the most in one year since the end of the cold war.[3]

Russia is close to concluding a modernization of its strategic nuclear forces that has focused, in particular, on the replacement of Russia's Soviet-era ICBMs with newer versions, including the Sarmat heavy ICBM (which is designated as the SS-29 by the USA), the fixed and mobile versions of the Yars (SS-27 Mod 2) ICBM, and the Avangard hypersonic glide weapon system (SS-19 Mod 4). In addition, Russia is developing follow-on ICBM systems, including the Osina, Kedr and Yars-M, although it remains unclear which of these will ultimately be deployed and which are intended as technology demonstrators. Russia is also modernizing its air- and sea-based nuclear delivery systems as well as its non-strategic nuclear forces. However, the significant increase in Russia's non-strategic nuclear warheads projected by the US Strategic Command in 2020 has yet to materialize.[4]

China

China is in the middle of a significant modernization and expansion of its nuclear arsenal.[5] SIPRI's estimate of the size of China's nuclear arsenal

[2] Kristensen, H. M. et al., 'United states nuclear weapons, 2025', Nuclear notebook, *Bulletin of the Atomic Scientists*, vol. 81, no. 1 (Jan. 2025); and Kristensen, H. M. et al., 'Russian nuclear weapons, 2025', Nuclear notebook, *Bulletin of the Atomic Scientists*, vol. 81, no. 3 (May 2025).

[3] Hruby, J., Administrator, US National Nuclear Security Administration, Remarks at the 2024 Nuclear Deterrence Summit, Washington, DC, 1 Feb. 2024.

[4] Richard, C. A., Commander, US Strategic Command, Statement before the US Senate, Armed Services Committee, 13 Feb. 2020, p. 5.

[5] Kristensen, H. M. et al., 'Chinese nuclear weapons, 2025', Nuclear notebook, *Bulletin of the Atomic Scientists*, vol. 81, no. 2 (Mar. 2025).

increased from 500 warheads in January 2024 to up to 600 in January 2025 (see tables 6A.1 and 6A.6), and it is expected to keep growing over the coming decade. An estimated 132 of these warheads are thought to be assigned to launchers that are still being loaded.

The vast majority of China's warheads are thought to be stored separate from their launchers. However, in its assessment of Chinese nuclear forces published in 2024, the US DOD indicated that China may now be deploying a small number of its warheads on missiles during peacetime, marking a change in China's long-standing policy of keeping warheads and missiles de-mated.[6] Depending on how it decides to structure its forces, China could potentially have at least as many ICBMs as either Russia or the USA by the turn of the decade, although its stockpile of nuclear warheads is still expected to remain much smaller than the stockpiles of either of those two countries.

China is building new silos for its ICBMs in three large silo fields in northern China and in three mountainous areas in east-central China.[7] By January 2025, China had completed or was close to completing a total of approximately 350 new silos.[8] The location of the fields in the north of China potentially reduces their vulnerability to long-range conventional strikes. The US DOD assessed in 2024 that China had 'loaded at least some ICBMs into these silos'; however, it remained unclear as of January 2025 whether any ICBM units at these fields had begun combat duty.[9]

As well as building new missile silos, China is refitting its Type 094 SSBNs with longer-range missiles. It is also developing a new class of SSBN and a new type of strategic bomber aircraft.

The United Kingdom and France

The UK is not thought to have increased its nuclear weapon arsenal in 2024 (see tables 6A.1 and 6A.4); however, it is likely that its warhead stockpile will grow in the future based on the British government's announcement in 2021, and reaffirmation in 2023, that it was raising the stockpile's upper limit from 225 to 260 warheads. In addition, the government said it would no longer publicly disclose its quantities of nuclear weapons, deployed warheads or deployed missiles, making any confirmation of an increase in the stockpile

[6] US Department of Defense (US DOD), *Military and Security Developments Involving the People's Republic of China 2024*, Annual Report to Congress (Office of the Secretary of Defense: Washington, DC, 18 Dec. 2024), p. 110.

[7] Authors' assessment based on analysis of satellite imagery; and US Department of Defense (note 6), pp. 103–104.

[8] Authors' assessment based on analysis of satellite imagery; and US Department of Defense (note 6), p. 63.

[9] Authors' assessment based on analysis of satellite imagery; and US Department of Defense (note 6), p. 63.

highly challenging.[10] As of January 2025, the Labour government elected in July 2024 had not publicly announced any changes to these policies.

The UK's nuclear weapon modernization programme comprises several initiatives. These include replacing the Vanguard-class SSBN with the new Dreadnought class; participating in the US Trident II D5 missile programme to extend the service life of that missile; and replacing the Mk4A nuclear warhead with the A21/Mk7 (also known as Astraea). The UK's warhead programme is being carried out in parallel with the USA's W93/Mk7 warhead programme, with each country developing its own sovereign but similar design.

Although France's nuclear arsenal is also thought to have remained stable, at around 290 warheads as of January 2025 (see tables 6A.1 and 6A.5), its nuclear modernization programme progressed during 2024. France continued to develop a third-generation SSBN and a new air-launched cruise missile (ALCM)—the ASN4G—as well as to refurbish and upgrade existing systems.[11]

India and Pakistan

India and Pakistan continued to develop new types of nuclear weapon delivery system in 2024, and both are pursuing the capability to deploy multiple warheads on ballistic missiles (see below). India was estimated to have a growing stockpile of about 180 nuclear weapons as of January 2025—a small increase from the previous year (see tables 6A.1 and 6A.7).[12] These weapons were assigned to a maturing nuclear triad of aircraft, land-based missiles and SSBNs. It has long been assumed that India stores its nuclear warheads separate from its deployed launchers during peacetime; however, the country's recent moves towards placing missiles in canisters and conducting sea-based deterrence patrols suggest that India could be shifting in the direction of mating some of its warheads with their launchers in peacetime.[13] Although Pakistan remains the focus of India's nuclear deterrent, India appears to be placing growing emphasis on longer-range weapons capable of reaching targets throughout China.

[10] British Government, *Global Britain in a Competitive Age: The Integrated Review of Security, Defence, Development and Foreign Policy*, CP 403 (Her Majesty's Stationery Office: London, Mar. 2021), pp. 76–77; and British Government, *Integrated Review Refresh 2023: Responding to a More Contested and Volatile World*, CP 811 (His Majesty's Stationery Office: London, Mar. 2023). See also Kristensen, H. M. et al., 'United Kingdom nuclear weapons, 2024', Nuclear notebook, *Bulletin of the Atomic Scientists*, vol. 80, no. 6 (Nov. 2024).

[11] Kristensen, H. M., Korda, M. and Johns, E., 'French nuclear weapons, 2023', Nuclear notebook, *Bulletin of the Atomic Scientists*, vol. 79, no. 4 (July 2023).

[12] Kristensen, H. M. et al., 'Indian nuclear weapons, 2024', Nuclear notebook, *Bulletin of the Atomic Scientists*, vol. 80, no. 5 (Sep. 2024).

[13] For further detail see Kristensen, H. M. and Korda, M., 'Indian nuclear forces', *SIPRI Yearbook 2021*.

While Pakistan's nuclear warhead stockpile is thought to have remained stable at around 170 warheads as of January 2025 (see tables 6A.1 and 6A.8), it continued to develop its nascent triad of aircraft, ground-launched ballistic and cruise missiles and sea-launched cruise missiles (SLCMs) during 2024. Pakistan's development of several new delivery systems and accumulation of fissile material suggest that its nuclear weapon arsenal and fissile material stockpile are likely to continue to expand over the next decade, although projections vary considerably due to limited official publicly available data.[14]

North Korea

North Korea's military nuclear programme remains central to its national security strategy. SIPRI estimates that, as of January 2025, North Korea had assembled around 50 warheads and possessed enough fissile material to reach a total of up to 90 warheads (see tables 6A.1 and 6A.9).[15] While North Korea conducted no nuclear test explosions in 2024, officials from the Republic of Korea (South Korea) warned in July that the development of North Korea's 'tactical nuclear weapon' was in the 'final stages'.[16] In addition, the United Nations panel of experts assessed in its annual report released in 2024 that North Korea's ballistic missile programme had made advancements during the reporting period, including improved manoeuvrability, precision, survivability and preparedness of the weapon systems.[17]

In November 2024 North Korea's ambassador to the UN, Kim Song, said that North Korea was accelerating its nuclear and missile programmes to 'counter any threat presented by hostile nuclear weapons states'.[18] Later that month, the North Korean leader, Kim Jong Un, called for a 'limitless' expansion of the nuclear programme.[19] Based on such statements and the likely continued acceleration in the country's fissile material production rates, North Korea's nuclear weapon stockpile is expected to grow in the coming years.

[14] Kristensen, H. M., Korda, M. and Johns, E., 'Pakistan nuclear weapons, 2023', Nuclear notebook, *Bulletin of the Atomic Scientists*, vol. 79, no. 5 (Sep. 2023).

[15] SIPRI's estimate of North Korea's operational nuclear weapon arsenal is within the 20–60 range noted in the latest publicly available intelligence assessments issued by South Korea (in 2018) and the USA (in 2020). See Kim, H., 'Seoul: North Korea estimated to have 20–60 nuclear weapons', AP, 2 Oct. 2018; and US Army, *North Korean Tactics*, Army Techniques Publication no. 7-100.2 (Headquarters, US Department of the Army: Washington, DC, July 2020), p. 1-11. See also Kristensen, H. M. et al., 'North Korean nuclear weapons, 2024', Nuclear notebook, *Bulletin of the Atomic Scientists*, vol. 80, no. 4 (July 2024).

[16] Chan, R., 'North Korean tactical nuclear weapon in "final stages": South', *Newsweek*, 25 July 2024.

[17] United Nations, Security Council, Final report of the panel of experts established pursuant to resolution 1874 (2009), S/2024/215, 7 Mar. 2024. In Mar. 2024 Russia used its UN Security Council veto to end the work of the panel of experts charged with monitoring the UN arms embargo on North Korea. For further detail see chapter 15, section III, in this volume.

[18] Roth, A., 'North Korea tells UN it is speeding up nuclear weapons programme', *The Guardian*, 5 Nov. 2024.

[19] Tong-Hyung, K., 'North Korean leader calls for expanding his nuclear forces in the face of alleged US threat', AP, 18 Nov. 2024.

Israel

Israel continues to maintain its long-standing policy of nuclear ambiguity, leaving significant uncertainty about the number and characteristics of its nuclear weapons.[20] SIPRI estimates that Israel's stockpile probably remained stable at around 90 warheads as of January 2025 (see tables 6A.1 and 6A.10). Israel is believed to be modernizing its nuclear arsenal and in 2024 conducted a test of a missile propulsion system, possibly related to its Jericho family of missiles.[21] It is also upgrading its plutonium production reactor facility at the Negev Nuclear Research Center (NNRC) near Dimona.[22]

Vertical proliferation of key capabilities

Nuclear modernization is typically prompted by several interlocking factors. These include the long timeline for the development of weapons, the influence of corporate lobbyists on nuclear policy decisions, the lack of arms control treaties keeping arsenals in check, and—perhaps most importantly—the prioritization on the part of all nuclear-armed states of the need to maintain a secure second-strike capability. This section provides an overview of how these trends manifest themselves across nuclear-armed states with regard to the development of certain types of nuclear weapon capability.

Dual-capable missiles

Dual-capable missiles can deliver either nuclear or conventional warheads. This capability may be appealing to certain states depending on their doctrines and modernization constraints because dual-capable missiles introduce potential targeting and threat assessment challenges for adversaries (see below). In some cases, it can also be more cost-effective to produce dual-use systems rather than to produce separate delivery systems for nuclear and conventional warheads. Russia, China, India, Pakistan and North Korea deploy dual-capable missiles and all five are believed to be modernizing these capabilities. There is no evidence that any of the missiles possessed by the USA, the UK, France or Israel are dual-capable.

Russian dual-capable missiles are thought to include the ground-launched Iskander short-range ballistic missile (which is designated as the SS-26 by the USA) and the intermediate-range 9M729 (SSC-8) ground-launched cruise

[20] On Israel's 'strategic ambiguity' policy see also Cohen, A., 'Israel', eds H. Born, B. Gill and H. Hänggi, SIPRI, *Governing the Bomb: Civilian Control and Democratic Accountability of Nuclear Weapons* (Oxford University Press: Oxford, 2010).

[21] Lappin, Y., 'Israel's missile propulsion test—part of arms race with Iran', JNS, 1 July 2024.

[22] Commercial satellite imagery has revealed progress on significant construction inside and near to the NNRC site since 2021, although the purpose of this work is unknown. See also Kristensen, H. M. and Korda, M., 'Israeli nuclear weapons, 2021', Nuclear notebook, *Bulletin of the Atomic Scientists*, vol. 78, no. 1 (Jan. 2022).

missile (GLCM). In addition, the Russian Navy operates the dual-capable Kalibr SLCM and the potentially dual-capable P-800 Oniks (SS-N-26) on ships and submarines. The dual-capable 9-A-7760 Kinzhal air-launched ballistic missile (ALBM) is deployed on MiG-31K combat aircraft (designated as Foxhound by the USA).[23] Significant numbers of conventional Kinzhals and Iskanders have been used during Russia's war against Ukraine.[24]

China's primary dual-capable missile is the DF-26 intermediate-range ballistic missile (IRBM), which notably has the capability for ground crews to swap between nuclear and conventional warheads on the battlefield.[25] China also deploys a dual-capable ALBM (designated as CH-AS-X-13 by the USA) with its H-6N bomber aircraft.

India's short-range Prithvi ballistic missile is thought to be dual-capable and there have been unconfirmed reports that some of India's other nuclear-capable missiles may also be capable of carrying conventional warheads.[26]

All of Pakistan's missiles, including its Nasr land-based ballistic missile (which has the Hatf-9 designation), are thought to be dual-capable. It is unclear, however, whether all or only some of Pakistan's missile bases have a nuclear role. In addition, Pakistan is developing two versions of the Ra'ad (Hatf-8) ALCM to supplement its small stockpile of nuclear gravity bombs, but neither version is believed to be operational. Within the Pakistan Air Force, the Mirage III and possibly the Mirage V are the most likely aircraft to have a nuclear-delivery role. There is increasing evidence to suggest that when these aircraft are eventually phased out, the JF-17 will most likely take over their nuclear role and the Ra'ad ALCM will then be integrated on to the JF-17.[27]

Given North Korea's small number of nuclear warheads relative to the much larger number of delivery systems it possesses, it is likely that the majority of its missiles are dual-capable. North Korea's longer-range missiles are almost certainly assigned exclusively nuclear missions based on the missiles' relative inaccuracy and target sets. It was previously believed that North Korea's shorter-range missiles had mostly conventional missions

[23] President of Russia, 'Expanded meeting of the Defence Ministry Board', 21 Dec. 2021; 'Russia's upgraded MiG-31 fighters to provide security for Northern Sea Route', TASS, 26 Nov. 2021; and Kretsul, R. and Cherepanova, A., 'Прибавить гиперзвук: еще один военный округ вооружат «Кинжалами»' [Hypersonic boost: Another military district to be armed with 'daggers'], *Izvestia*, 7 June 2021.

[24] See e.g. 'Shoigu reveals Kinzhal hypersonic missile was used three times during special operation', TASS, 21 Aug. 2022; and Court, E., 'All Russian Kinzhal missiles downed over Kyiv since arrival of Patriot systems, Ukrainian Air Force says', Kyiv Independent, 4 July 2024. On missile use during the Russia–Ukraine war see chapter 7, section II, in this volume.

[25] Singer, P. W. and Xiu, M., 'China's ambiguous missile strategy is risky', *Popular Science*, 11 May 2020; and Pollack, J. H. and LaFoy, S., 'China's DF-26: A hot-swappable missile?', Arms Control Wonk, 17 May 2020.

[26] Kristensen et al. (note 12).

[27] 'Pakistani Thunder', Scramble, 21 Mar. 2023; and Johns, E., 'Photo depicts potential nuclear mission for Pakistan's JF-17 aircraft', FAS Strategic Security Blog, Federation of American Scientists, 1 July 2024.

owing to North Korea's lack of sufficiently miniaturized nuclear warheads for those missiles. In recent years, however, North Korea has placed significant emphasis on developing 'tactical' warheads and has claimed that several of its newer delivery systems—including short-range ballistic missiles, land-attack cruise missiles and underwater weapon systems—are nuclear-capable.[28]

Dual-capable systems introduce complications for both targeting and threat assessment: how can a state target another state's dual-capable systems during a conventional conflict without risking triggering a nuclear escalation, given that those systems may have been assigned a nuclear payload? Conversely, if a state is being attacked by a dual-capable system, how can that state assess whether the incoming attack is nuclear or conventional? These challenges (often referred to as 'entanglement' of nuclear and conventional systems) increase the risk that conventional conflicts could unexpectedly and inadvertently move into the nuclear realm.

Multiple independently targetable re-entry vehicles

Up until the mid 2000s, only France, Russia, the UK and the USA deployed missiles with multiple warheads. In 2006 China modified its DF-5 ICBMs to carry multiple warheads and, over the past five years, has deployed a second type of missile, the DF-41, with this capability. India, Pakistan and North Korea are all currently pursuing the capability to deploy multiple warheads on ballistic missiles.

The rise in the number of states with multiple-warhead programmes could potentially lead to a rapid increase in deployed warheads and allow nuclear-armed states to threaten the destruction of significantly more targets, especially in the case of China, which has the fastest-growing nuclear arsenal in the world. If China eventually fills each of its new silos under construction with a single-warhead missile, it will have the capacity to deploy approximately 650 warheads on its ICBMs within another decade. The US DOD concluded in 2024 that China probably plans to arm the silos with the DF-31 ICBM, a type that so far has only been able to carry a single warhead.[29] But if each silo were filled with a missile equipped with three MIRVs, this number could rise to more than 1200 warheads.

India has an intermediate-range missile under development with MIRV capability—the Agni-V IRBM. In March 2024 India conducted 'Mission Divyastra', its first flight test of the MIRV-capable Agni-V.[30]

Pakistan is developing a medium-range missile, the Ababeel, that can reportedly deliver MIRVs but that had probably not been operationally

[28] Korean Central News Agency, 'On report made by Supreme Leader Kim Jong Un at 8th Congress of WPK', KCNA Watch, 9 Jan. 2021.

[29] US Department of Defense (note 6), pp. 63, 103.

[30] Narendra Modi (@narendramodi), X, 11 Mar. 2024, <https://x.com/narendramodi/status/1767159762108465538?lang=en>.

deployed as of January 2025.[31] Pakistan's pursuit of MIRV technology is most likely a countermeasure to India's procurement of advanced ballistic missile defences, including the S-400 system acquired from Russia.[32]

In June 2024 North Korea claimed to have successfully tested a part of a developing MIRV system; however, South Korean officials subsequently claimed that the test was a failure.[33] In November 2024 North Korea tested a new solid-fuelled Hwasong-19 ICBM, possibly with a post-boost vehicle, calling it a 'final edition' ICBM. The missile's size and throw-weight (i.e. the weight of the payload that the missile is capable of placing on a ballistic trajectory), as well as the high level of North Korean media attention around the test, suggest that this missile—probably alongside the liquid-fuelled Hwasong-17—is being developed with a MIRV capability in mind.[34]

Although Russia has long deployed MIRVs, in November 2024 it used a new type of dual-capable experimental IRBM, known as Oreshnik, in combat in Ukraine. The Oreshnik is capable of carrying at least six multiple re-entry vehicles; in the conventional configuration each re-entry vehicle can carry multiple submunitions.[35]

Hypersonic missiles

Hypersonic missiles are highly manoeuvrable delivery systems that travel at speeds of at least Mach 5. They fall into two main categories: unpowered hypersonic glide vehicles (HGVs), which are launched from rockets at the edge of space and glide to target from high altitudes, and hypersonic cruise missiles (HCMs), which are powered by high-speed, air-breathing engines after initial launch from a rocket. Re-entry vehicles delivered by long-range ballistic missiles already reach hypersonic speed during re-entry, but HGVs and HCMs are designed to be much more manoeuvrable at high speeds and able to change course in mid flight.

Given the complexity of the technology and the substantial research and development costs involved, the USA, Russia and China are the clear front-runners in this area of missile design. India, France and, more recently, North Korea (along with several non-nuclear-armed states, such as Australia, Germany and Japan) have more limited hypersonic missile development

[31] Jamal, S., 'Pakistan tests nuclear-capable Shaheen-III ballistic missile', *Gulf News*, 20 Jan. 2021; 'Pakistan conducts successful flight test of Ababeel weapon system', Radio Pakistan, 18 Oct. 2023; and Pakistani Inter Services Public Relations (ISPR), Press release no. PR-34/2017-ISPR, 24 Jan. 2017.

[32] SIPRI Arms Transfers Database, Mar. 2024.

[33] Choe, S. H., 'North Korea says it tested multiple-warhead missile technology', *New York Times*, 26 June 2024.

[34] Zwirko, C., 'North Korea says it tested new "Hwasong-19" ICBM, largest solid-fuel missile yet', NK News, 1 Nov. 2024; and Van Diepen, V. H., 'North Korea tests new solid ICBM probably intended for MIRVs', 38 North, 5 Nov. 2024.

[35] Kullab, S. and Morton, E., 'Ukraine shows AP the wreckage of a new experimental Russian missile', AP, 24 Nov. 2024.

programmes. India, for example, is developing dual-use hypersonic cruise missiles, while France is developing HCM technology as part of its nuclear arsenal modernization.[36]

Russia claimed to have completed the rearmament of two regiments with nuclear-armed Avangard HGV systems in 2023, although significant construction at the second regiment was still visible using commercial satellite imagery in late 2024.[37] Russia is also in the early stages of developing a range of new HGVs that could be fitted on to modified ICBMs.[38]

Sea-based systems

The USA, Russia, France and the UK were early adopters of sea-based nuclear weapons, arguing that they provide stability because of their relative invulnerability to surprise attack. This is meant to provide a secure second-strike capability, ensuring that nuclear deterrence is credible. In recent years, sea-based nuclear-weapon delivery systems have been proliferating, especially in the four nuclear-armed states in the Indo-Pacific.

The United States. The USA is modernizing its SSBNs and submarine-launched ballistic missiles (SLBMs) as well as some of the associated nuclear warheads. A new class of at least 12 SSBNs (the Columbia class) is under construction to replace the Ohio class. The lead boat of the incoming Columbia class was 50 per cent complete as of August 2024, while the second boat was around 14 per cent complete as of September 2024.[39] The construction of the new SSBNs has been subject to delays owing to challenges related to design, materials, work quality and complications related to the Covid-19 pandemic. By September 2024, work on the lead boat had fallen

[36] Sayler, K. M., *Hypersonic Weapons: Background and Issues for Congress*, Congressional Research Service (CRS) Report for Congress R45811 (US Congress, CRS: Washington, DC, 10 Apr. 2025), p. 22. See also e.g. French National Assembly, Rapport d'information par la Commission de la Défense Nationale et des Forces Armées portant recueil d'auditions de la Commission sur la Dissuasion Nucléaire [Information report by the Committee on National Defence and the Armed Forces compiling the hearings of the Committee on Nuclear Deterrence], no. 1112, 24 Apr. 2023.

[37] Karakaev, S. V., interviewed in *Krasnaya Zvezda*, 'Стратегическая мощь России крепнет' [Russia's strategic power is growing], Dzen News, 16 Dec. 2023; and authors' assessment based on analysis of satellite imagery.

[38] Karakaev (note 37); MilitaryRussia.Ru (@militaryrussia.ru), Telegram, 15 May 2023, <https://t.me/militaryrussiaru/5673> and <https://t.me/militaryrussiaru/5674>; Ryabkov, K., '«Ярс-М» и «Осина-РВ». Направления развития стратегического ракетного комплекса' ['Yars-M' and 'Osina-RV'. Directions of strategic missile complex], TopWar, 18 May 2023; M51.4ever (@M51_4ever), X, 20 Nov. 2023, <https://twitter.com/M51_4ever/status/1725181990062719000>; and Richard, C. A., Commander, US Strategic Command, Statement before the US House of Representatives, Armed Services Committee on Strategic Forces, 1 Mar. 2022.

[39] Parrella, M. C., Columbia-class SSBN Program Manager, Remarks at the Task Force 21 Nuclear Triad Symposium, Washington, DC, 20 Sep. 2024.

12–16 months behind schedule, delaying the first expected deterrence patrol of the Columbia-class SSBN until 2031.[40]

Since 2017, the US Navy has been replacing its Trident II D5 SLBMs with an enhanced version, known as the D5LE (LE for 'life extension'), a process that is scheduled for completion in 2025.[41] The new version will arm Ohio-class SSBNs for the remainder of their service lives (up to 2042) and will also be deployed on the UK's Trident submarines. Each Columbia-class SSBN will carry 16 missiles, initially the D5LE—although these will later be replaced with an upgraded SLBM, the D5LE2, which will include several substantially redesigned components. The D5LE2 is scheduled to enter service on the ninth Columbia-class SSBN in 2039, after which it will be retrofitted on to the eight other Columbia-class SSBNs over the following decade as each boat returns to port for routine maintenance. The final D5LE SLBM is scheduled to be retired in 2049, at which point all of the Columbia-class SSBNs currently planned for the US fleet should have been fitted with D5LE2 SLBMs.[42]

The D5LE2 will be armed with a new nuclear warhead, the W93. This will be the first new warhead design fielded by the USA since the end of the cold war. The completion of the first production unit of the W93 is tentatively scheduled for 2034–36.[43]

The USA is also developing a nuclear sea-launched cruise missile (SLCM-N). Originally conceived in the 2018 US Nuclear Posture Review (NPR), the SLCM-N was seemingly rejected in the 2022 NPR.[44] However, following intervention by the US Congress, in 2024 the SLCM-N became a formal 'programme of record', with the aim of reaching operational capability in 2034.[45] Development of the SLCM-N would violate the US pledge from 1992 not to develop such a weapon.[46] It could potentially also result in the first significant increase in the size of the US nuclear weapon stockpile since

[40] Parrella (note 39); US Government Accountability Office (GAO), *Columbia Class Submarine: Overcoming Persistent Challenges Requires yet Undemonstrated Performance and Better-informed Supplier Investments*, Report no. GAO-24-107732 (GAO: Washington, DC, Sep. 2024), p. 1; and US Navy, 'Secretary of the Navy's 45-Day Shipbuilding Review', Inside Defense, 2 Apr. 2024.

[41] Wolfe, J., Director of US Strategic Systems Programs, 'FY 2025 budget request for nuclear forces and atomic energy defense activities', Statement before the US Senate, Armed Services Committee, Subcommittee on Strategic Forces, 22 May 2024.

[42] US Navy, 'Development of strategic weapons systems capabilities', Strategic Systems Programs, [n.d.].

[43] US Department of Energy (DOE), National Nuclear Security Administration (NNSA), *Fiscal Year 2023 Stockpile Stewardship and Management Plan*, Report to Congress (DOE: Washington, DC, Apr. 2023), p. 2-10.

[44] US DOD, *Nuclear Posture Review 2018* (DOD: Washington, DC, Feb. 2018); and US DOD, *2022 National Defense Strategy of the United States of America* (DOD: Washington, DC, Oct. 2022), *2022 Nuclear Posture Review*.

[45] Executive Office of the President, Office of Management and Budget, 'Statement of administration policy: HR 2670—National Defense Authorization Act for Fiscal Year 2024', 10 July 2023; and US Public Law 118-31, signed into law on 22 Dec. 2023, HR 2670, pp. 460–62.

[46] Bush, G. W., US President, 'Address before a joint session of the Congress on the state of the union', 28 Jan. 1992.

1996, although this will ultimately depend on which warhead is selected to arm the missile—a decision that is expected to be taken in 2025.[47]

Russia. Modernization of Russia's sea-based missile systems includes replacing the five remaining Delfin-class SSBNs with Borei-A (or Project 955A) SSBNs—an upgraded variant of the original Borei design. In 2024 the *Knyaz Pokharsky*, Russia's eighth Borei-class SSBN and fifth of the improved Borei-A type, began sea trials, preparing it for delivery to the Russian Navy scheduled for June 2025.[48] It seems that Russia aims to have a total of 12 Borei-class SSBNs, 9 of which will be of the Borei-A type. A follow-on SSBN, known as Arktur or Arcturus, may begin replacing the Borei-class SSBNs in the late 2030s.[49]

In 2024 the Russian Navy continued to develop the Poseidon or Status-6 (Kanyon), a long-range, strategic nuclear-powered torpedo intended for deployment on two new types of special-purpose submarine: the K-329 *Belgorod* and the *Khabarovsk*. One additional special-purpose submarine is scheduled for delivery by 2027, for a total of at least three submarines, each capable of carrying up to six Poseidon torpedoes.[50] However, since the development of the submarines and of the infrastructure associated with the Poseidon has been delayed significantly, it is unlikely that Russia will meet its target of deploying the weapon by the conclusion of its state armament programme in 2027.[51]

Russia is also upgrading many of its naval non-strategic forces. For example, five new Project 855/855M Yasen/Yasen-M (Severodvinsk) nuclear-powered guided-missile submarines (SSGNs) are currently operational after the latest—named *Arkhangelsk*—was commissioned in December 2024.[52] Four more are under construction. Russia is reportedly considering building three additional Project 855M SSGNs, although this had not been officially confirmed as of January 2025.[53]

[47] Former US official, Private communication with the authors, July 2024.

[48] 'Атомный ракетоносец "Князь Пожарский" передадут ВМФ в июне' [Nuclear missile carrier 'Knyaz Pokharsky' will be transferred to the navy in June], TASS, 4 Dec. 2024.

[49] 'Атомную подлодку "Арктур" оснастят новым оружием, сообщило КБ "Рубин"' [The nuclear submarine 'Arktur' will be equipped with new weapons, said CB 'Rubin'], RIA Novosti, 16 Aug. 2022; and Safranov, S., 'В конструкторском бюро назвали сроки появления в ВМФ новых атомных подлодок' [The design bureau announced the timing of the appearance of new nuclear submarines in the navy], RIA Novosti, 21 June 2023.

[50] 'First batch of nuclear-armed drones Poseidon manufactured for special-purpose sub Belgorod', TASS, 16 Jan. 2023.

[51] 'Russian Navy to get Poseidon nuclear underwater drones by 2027—source', TASS, 12 May 2018.

[52] 'Arkhangelsk nuclear submarine ready to join Russian Navy—Sevmash Shipyard CEO', TASS, 21 Dec. 2024.

[53] Kornev, D., 'Спрос с «Ясеня»: что даст флоту строительство новых атомных подлодок' [Demand from 'Yasen': What the construction of new nuclear submarines will give the fleet], *Izvestia*, 26 Nov. 2023; and 'Источник сообщил, что число АПЛ семейства "Ясень" доведут до 12' [According to a source, the number of nuclear submarines of the 'Yasen' family will be increased to 12], TASS, 18 Nov. 2023.

China. In 2024 China continued to pursue its strategic goal from the early 1980s of developing and deploying sea-based nuclear weapons. The People's Liberation Army (PLA) Navy (PLAN) currently fields six Type 094 (Jin class) SSBNs, two of which are Type 094As—upgraded variants of the original design.[54] The US DOD's 2024 report on Chinese nuclear forces assessed that these six operational SSBNs constitute China's 'first credible, sea-based nuclear deterrent', and that throughout the year China continued to construct additional Type 094A SSBNs.[55] Development of China's next-generation Type 096-class SSBN appears to be subject to delays and it remains unclear how many SSBNs the PLAN ultimately intends to operate.[56]

The United Kingdom. The UK is replacing its four Vanguard-class SSBNs with four new Dreadnought-class SSBNs.[57] The Labour government elected in July 2024 declared a 'triple lock' commitment to nuclear weapons, committing to (*a*) building the four new SSBNs, (*b*) maintaining the UK's continuous at-sea nuclear deterrence, and (*c*) delivering all future upgrades needed.[58] The new submarines were originally expected to begin entering service by 2028, but this has been delayed until the start of the 2030s at the earliest. Due to the delays affecting the development of the Dreadnought-class SSBNs, the service life of the existing Vanguard-class SSBNs has been commensurately extended to an overall lifespan of about 37–38 years; however, the work to upgrade each Vanguard-class SSBN in turn has also been subject to significant delays and budget overruns.[59] As a result, the UK's operational Vanguard-class SSBNs have had to extend their deterrence patrols. The length of time at sea for British nuclear submarines has reportedly increased from about 60–70 days in the 1970s to 150–200 days in recent years—potentially contributing to several operating errors, accidents and personnel issues within the UK's nuclear forces.[60]

The UK also plans to upgrade the missiles and warheads carried on its SSBNs. Given that the UK draws its SLBMs from a common pool shared with the USA, the UK is benefiting from the US Navy's programme to extend the

[54] Chan, M., 'China's new nuclear submarine missiles expand range in US: Analysts', *South China Morning Post*, 2 May 2021.

[55] US Department of Defense (note 6), p. 54.

[56] US Department of Defense (note 6), p. 104.

[57] British Government, *National Security Strategy and Strategic Defence and Security Review 2015: A Secure and Prosperous United Kingdom*, Cm 9161 (Her Majesty's Stationery Office: London, 2015), para. 4.73.

[58] Jolly, J., 'Reality check: Is Keir Starmer's triple lock on nuclear weapons anything new?', *The Guardian*, 3 June 2024.

[59] Nuclear Information Service, 'HMS Vanguard leaves Devonport after 7 years of maintenance', 7 July 2023; British Ministry of Defence, 'British jobs secured through upgrade to nuclear deterrent', 4 Dec. 2015; and 'HMS Vanguard finally sails from Devonport after more than 7 years', Navy Lookout, 10 May 2023.

[60] For further detail see Kristensen, H. M. and Korda, M., 'British nuclear forces', *SIPRI Yearbook 2023*, p. 277.

service life of the Trident II D5 missile. The warhead carried on the UK's Trident II D5 missiles is called the Holbrook and is produced by the UK but thought to be based closely on the USA's W76 warhead design. In 2023 the UK completed the refurbishment of its warheads for incorporation on to the US-supplied Mk4A aeroshell as part of its Nuclear Warhead Capability Sustainment Programme.[61] In 2020 the British government announced its intention to replace the Holbrook with a new warhead that will use the A21/Mk7 aeroshell being developed in parallel with the Mk7 aeroshell for the USA's new W93 warhead (see above).[62] The UK's new warhead, named Astraea, is unlikely to enter into service until sometime in the late 2030s or early 2040s.[63]

Notably, the UK's past two consecutive Trident SLBM test launches, in 2024 and in 2016, both failed. After the most recent test failure, the British Ministry of Defence noted that an 'anomaly' occurred that caused the first-stage booster to not ignite following its ejection from the missile's canister.[64] British officials subsequently stated that the anomaly was not related to the missile, but rather to the specific conditions on the day of the test.[65]

France. The French SLBM, the M51, is continuously being upgraded. The missile is equipped with MIRVs and the first version, the M51.1, could carry up to six 100-kiloton TN 75 warheads. The second version, the M51.2, is armed with an updated warhead, the *tête nucléaire océanique* (TNO, sea-based nuclear warhead), which is assumed to have a yield of 100 kt.[66] France's next iteration of the missile, the M51.3, is scheduled for commissioning by the end of 2025 and will be accompanied by a new warhead, the TNO-2.[67] The last French SSBN believed to be carrying M51.1 SLBMs with accompanying

[61] British Government, Defence Nuclear Enterprise, *Delivering the UK's Nuclear Deterrent as a National Endeavour*, CP 1058 (His Majesty's Stationery Office: London, Mar. 2024); and Cullen, D., *Extreme Circumstances: The UK's New Nuclear Warhead in Context* (Nuclear Information Service: Reading, Aug. 2022).

[62] Wallace, B., British Secretary of State for Defence, 'Nuclear deterrent', Written statement HCWS125, British House of Commons, 25 Feb. 2020; and Wolfe, J., Director of US Strategic Systems Programs, 'FY 2022 budget request for nuclear forces and atomic energy defense activities', Statement before the US Senate, Armed Services Committee, Subcommittee on Strategic Forces, 12 May 2021.

[63] Mills, C., 'Replacing the UK's Nuclear Deterrent: The Warhead Programme', House of Commons Library Briefing Paper no. 9777, 1 Aug. 2024.

[64] Shapps, G., British Secretary of State for Defence, 'Nuclear deterrent', Statement before the British House of Commons, UIN HCWS272, 21 Feb. 2024.

[65] British officials, Private communication with the authors, Sep. 2024.

[66] Groizeleau, V., 'Dissuasion : 25 milliards en cinq ans pour le renouvellement des deux composantes' [Deterrence: 25 billion in five years for the renewal of the two components], Mer et Marine, 2 Oct. 2019; and Groizeleau, V., 'Dissuasion : F. Hollande détaille sa vision et l'arsenal français' [Deterrence: F. Hollande outlines his vision and the French arsenal], Mer et Marine, 20 Feb. 2015.

[67] Cormier-Bouligeon, F., 'Avis fait au nom de la Commission de la Défense Nationale et des Forces Armées sur le projet de loi de finances pour 2025, Tome VII, Défense: Équipement des forces—Dissuasion', [Opinion on behalf of the Committee on National Defence and the Armed Forces on the Draft Finance Bill for 2025, vol. VII, Defence: Equipment of the forces—Deterrence], no. 324, French National Assembly, 30 Oct. 2024.

TN 75 warheads, *Le Vigilant*, began a period of long-term maintenance in late 2023 and moved to dry dock in early 2024. *Le Vigilant* is scheduled to rejoin the French fleet in 2026 and will probably be the first SSBN equipped with the new M51.3 SLBM and TNO-2 warhead.[68] Work on a follow-on missile, the M51.4, is scheduled to begin in 2025 and be completed by the mid 2030s.[69]

A production programme for a third-generation SSBN, designated the SNLE 3G, was officially launched in early 2021. Production of the first of these new SSBNs began in March 2024.[70] The first submarine is expected to be completed by 2035 and thereafter three other submarines will be delivered on a planned schedule of one boat every five years.[71]

India. India is building a fleet of four to six SSBNs as it continues to develop the naval component of its nascent nuclear triad. The first of these SSBNs, INS *Arihant*, completed what the Indian government described as its first 'deterrence patrol' in 2018. India's second SSBN, INS *Arighaat*, was commissioned into the Indian Navy in August 2024 after several years of delays.[72] Satellite imagery indicates that each submarine has been equipped with a four-tube vertical-launch system and each could carry up to 12 two-stage, short-range K-15 SLBMs. SIPRI estimates that 12 nuclear warheads have been delivered for potential deployment by INS *Arihant* and another 12 have been produced for INS *Arighaat*. Satellite imagery indicates that India's third SSBN, provisionally known as S4, is approximately 16 to 18 metres longer than the first two SSBNs and equipped with eight missile tubes—twice the number present on the *Arihant* and *Arighaat*.[73] A next generation of SSBNs, known as S5, is reportedly in the design stage.[74]

Pakistan. As part of its efforts to achieve a secure second-strike capability, Pakistan has sought to create a nuclear triad by developing a sea-based nuclear force. The Babur-3 SLCM, which was most recently test-launched in

[68] Cormier-Bouligeon (note 67); and authors' assessment.
[69] Cormier-Bouligeon (note 67).
[70] Naval Group, 'Naval Group starts the construction of the first third generation French nuclear-powered ballistic missile submarine (SNLE 3G)', Press release, 20 Mar. 2024.
[71] Groizeleau, 'Dissuasion : 25 milliards en cinq ans' (note 66); and Mackenzie, C., 'France to begin building new ballistic missile subs', Defense News, 22 Feb. 2021.
[72] Indian Ministry of Defence, Press Information Bureau, 'Second Arihant-class Submarine "INS Arighaat" commissioned into Indian Navy in the presence of Raksha Mantri in Visakhapatnam', Release no. 2049870, 29 Aug. 2024.
[73] Authors' assessment based on analysis of satellite imagery. For further detail see Kristensen et al. (note 12).
[74] See e.g. Sterk, R., 'India levels up in nuclear submarines', Defense and Security Monitor, 1 May 2023.

2017 and 2018, is intended to establish a nuclear capability for the Pakistan Navy's three Agosta-90B diesel–electric submarines.[75]

North Korea. To add to its one Sinpo-class (or Gorae-class) experimental ballistic missile submarine, which can hold and launch only one SLBM, North Korea has developed a new submarine, named No. 841 *Hero Kim Kun Ok*. This 'tactical nuclear submarine' appears to be a heavily modified Project-633 (Romeo) diesel–electric submarine fitted with 10 vertical missile-launch tubes: four for large-diameter Pukguksong ('Polaris') SLBMs and six for smaller-diameter missiles.[76] In 2024 the submarine was moved to the dry dock at the South Sinpo Shipyard to prepare it for upcoming sea trials.[77] In 2023 Kim Jong Un announced a 'plan to convert all existing medium-sized submarines into attack submarines equipped with tactical nuclear weapons'; activities at the shipyard during 2024, visible using commercial satellite imagery, were probably related to this plan.[78]

In addition to modernizing its submarines, North Korea has continued to develop its family of Pukguksong solid-fuelled SLBMs. North Korea has displayed or tested at least six increasingly larger Pukguksong iterations over the years.

North Korea is also developing a new SLCM, known as Pulhwasal-3-31. The system has been described as a 'strategic cruise missile', implying a nuclear-capable status, and state media noted that a 2024 test of the missile took place in the context of the 'nuclear weaponization of our navy'.[79] In addition, a new 'underwater nuclear attack drone', known as Haeil, is under development. North Korean media stated that the system's mission is 'to stealthily infiltrate into operational waters and make a super-scale radioactive tsunami through underwater explosion to destroy naval striker groups and major operational ports of the enemy'.[80] North Korea claims to have tested various iterations of the Haeil system dozens of times, some of which included test durations of

[75] Panda, A. and Narang, V., 'Pakistan tests new sub-launched nuclear-capable cruise missile. What now?', The Diplomat, 10 Jan. 2017; and Pakistani Inter Services Public Relations (ISPR), 'Pakistan conducted another successful test fire of indigenously developed submarine launched cruise missile Babur having a range of 450 kms', Press release no. PR-125/2018-ISPR, 29 Mar. 2018. Reports of a ship-launched cruise missile test in 2019 might have been for a different missile. Gady, F.-S., 'Pakistan's Navy test fires indigenous anti-ship/land-attack cruise missile', The Diplomat, 24 Apr. 2019.

[76] Bermudez, J. S., Cha, V. and Jun, J., 'North Korea launches new ballistic missile submarine', Beyond Parallel, Center for Strategic and International Studies, 11 Sep. 2023.

[77] Makowsky, P. and Liu, J., 'Sinpho South Shipyard: Construction and modernization efforts continue', 38 North, 6 Sep. 2024.

[78] *Rodong Sinmun*, 'Respected comrade Kim Jong Un makes congratulatory speech at ceremony for launching newly-built submarine', KCNA Watch, 9 Sep. 2023; and Liu, J., Makowsky, P. and Ragnone, I., 'Sinpho South Shipyard: Indications of new submarine construction', 38 North, 8 May 2024.

[79] *Minju Choson*, 'Respected comrade Kim Jong Un guides test-fire of submarine-launched strategic cruise missile', KCNA Watch, 29 Jan. 2024.

[80] Korean Central News Agency, 'Important weapon test and firing drill conducted in DPRK', KCNA Watch, 24 Mar. 2023.

between 40 and 70 hours, but it is unlikely that the system had been deployed as of January 2025.[81]

Israel. Israel operates five potentially nuclear-capable Dolphin-class diesel–electric submarines. SIPRI estimates that these submarines could carry a maximum total of 20 missiles that could potentially be nuclear-armed. The submarines have six standard 533-millimetre torpedo tubes, but are reportedly equipped with four other specially designed 650-mm tubes that could be used to launch larger nuclear-armed SLCMs. Israel's sixth submarine, the INS *Drakon*, appears to be equipped with a vertical-launch system for launching additional missiles, although it remains unclear what those missiles would be and whether they would be nuclear-armed.[82]

Air-based systems

The USA and Russia maintain large fleets of nuclear strategic bomber aircraft as well as non-strategic dual-capable air-based systems. Both had extensive modernization programmes under way in 2024.

The USA had 65 nuclear-capable bombers as of January 2025. The USA's 46 B-52H bombers carry nuclear cruise missiles while its 19 B-2As carry gravity bombs. The USA plans to produce at least 100 new B-21 bombers that will gradually replace the B-2As and result in an increase in the number of US nuclear bomber bases.

The USA completed the planned production run of the B61-12 guided nuclear bomb in December 2024. The B61-12 bombs for strategic forces are deployed at Whiteman Air Force Base in Missouri for delivery by B-2A bombers. The B61-12 will also arm non-strategic dual-capable aircraft deployed in and outside the USA. The NNSA announced at the start of 2025 that the B61-12 is 'fully forward deployed' and SIPRI estimates that a total of around 100 B61-12s were deployed across six bases in five North Atlantic Treaty Organization (NATO) member states (Belgium, Germany, Italy, the Netherlands and Türkiye) as of January 2025.[83] These bombs replaced the earlier versions of the B61 deployed at the bases (see below).

SIPRI estimates that, as of January 2025, Russia had a fleet of around 67 legacy strategic bombers capable of delivering nuclear cruise missiles. Russia continued to modernize this fleet during 2024, although some of its newer bomber development programmes are suffering from significant delays. Russia is also modernizing its non-strategic dual-capable aircraft.

[81] Korean Central News Agency (note 80); and Naenara, 'An underwater strategic weapon system test conducted', KCNA Watch, 8 Apr. 2023.

[82] Kristensen and Korda (note 22).

[83] Hruby, J., Administrator, US National Nuclear Security Administration, Remarks at the Hudson Institute, Washington, DC, 16 Jan. 2025.

III. Changing nuclear doctrines and developments in nuclear sharing

A state's nuclear doctrine encompasses the goals and missions that guide the deployment and use of nuclear weapons, and determines the state's nuclear force structure, declaratory policy and diplomacy. With the global strategic context undergoing major changes in recent years, the nuclear doctrines of the nuclear-armed states may also be changing to reflect this new environment.

Debates around nuclear-sharing arrangements increased in saliency in 2024. Notably, both Russia and Belarus continued to make claims that Russia had deployed nuclear weapons on Belarusian territory, although as of the end of 2024 there was no conclusive publicly available visual evidence that the actual deployment of warheads had taken place. Extended nuclear deterrence has been a key component of collective security through NATO since the alliance's inception. The first US nuclear weapons arrived in Europe in 1954, although it took several years of political and military deliberation to put in place the current nuclear-sharing arrangements.[84] Discussions about these arrangements, largely triggered by Russia's full-scale invasion of Ukraine in 2022, continued in 2024.

This section first examines the latest updates to Russia's nuclear doctrine and the claims that nuclear weapons have been deployed in Belarus. It then briefly looks at the USA's doctrine and potential changes in nuclear-sharing arrangements among NATO member states. Finally, the section explores how China's modernization of its nuclear forces suggests that its doctrine is also evolving.

Russian nuclear doctrine and nuclear sharing

In November 2024 Russia updated its official nuclear weapons doctrine, which lays out explicit conditions under which it could launch nuclear weapons. While much of the doctrine remained the same as its 2020 iteration, the 2024 update appeared to expand the range of contingencies under which Russia could use nuclear weapons. Most notably, the update indicated that Russia could use nuclear weapons in the event of 'aggression against the Russian Federation and (or) the Republic of Belarus as participants in the Union State with the employment of conventional weapons, which creates a critical threat to their sovereignty and (or) territorial integrity', or upon 'receipt of reliable data on the massive launch (take-off) of air and space

[84] On the history of nuclear sharing in NATO see NATO, 'NATO's nuclear sharing arrangements', Fact sheet, Feb. 2022; and Center for Arms Control and Non-Proliferation, 'Fact sheet: US nuclear weapons in Europe', 18 Aug. 2021.

attack means (strategic and tactical aircraft, cruise missiles, unmanned, hypersonic and other aerial vehicles) and their crossing of the state border of the Russian Federation'.[85] By contrast, the 2020 iteration of the doctrine emphasized that Russia could use nuclear weapons in response to 'the use of conventional weapons when the very existence of the state is in jeopardy'.[86]

The revised wording in the 2024 update is probably a result of the evolving nuclear dynamics around the Russia–Ukraine war, and could be interpreted to mean that Russia has lowered the threshold for the use of its nuclear weapons. The mixed performance of Russia's conventional weapons in its war against Ukraine could reaffirm, and potentially even deepen, Russia's reliance on nuclear weapons in its national security strategy.[87]

The war has also had an impact on Russian nuclear basing. Russia has historically housed all its strategic bombers at two strategic bomber bases—Engels (Saratov oblast) and Ukrainka (Amur oblast)—but commercial satellite imagery has revealed that Russia dispersed large numbers of bombers to its Belaya (Irkutsk oblast) and Olenya (Murmansk oblast) airbases during 2023 and 2024 after Ukraine attacked the Engels airbase in several strikes with uncrewed aerial vehicles.[88]

In addition, the war appears to have resulted in delays in Russia's nuclear modernization schedule during 2024. In their end-of-year interviews, Russian military leaders indicated that progress in many areas—particularly the rearmament of Russian strategic missile forces—was stalled at the same level as the previous year.[89] This was partly confirmed by the authors' analysis of commercial satellite imagery showing that work at ICBM bases had made only limited progress in 2024. Moreover, many milestone events that were scheduled to take place during the year, including the delivery of a new ballistic missile submarine and upgraded strategic bombers, did not occur.

Russian nuclear weapon sharing with Belarus

Since the full-scale Russian invasion of Ukraine in 2022, Russia and Belarus have made numerous claims about the deployment of non-strategic nuclear weapons to Belarus. In December 2024 Belarusian President Alexander Lukashenko claimed that 'dozens' of Russian nuclear weapons were forward-

[85] Russian Ministry of Foreign Affairs, 'Fundamentals of state policy of the Russian Federation on nuclear deterrence', Approved by Russian Presidential Executive Order no. 991, 19 Nov. 2024.

[86] Russian Ministry of Foreign Affairs, 'Basic principles of state policy of the Russian Federation on nuclear deterrence', Approved by Russian Presidential Executive Order no. 355, 2 June 2020.

[87] Watling, J. and Reynolds, N., 'Tactical developments during the third year of the Russo–Ukrainian War', Royal United Services Institute (RUSI), 14 Feb. 2025.

[88] Tiwari, S., 'After Tu-95 bomber, Russia's Tu-22 M3 Backfire destroyed in Ukraine drone attack—reports', Eurasian Times, 21 Aug. 2023; MT Anderson (@MT_Anderson), X, 16 May 2024, <https://x.com/MT_Anderson/status/1791270930796167583>; and authors' assessment based on analysis of satellite imagery.

[89] Starchak, M., 'Why Russia's nuclear forces are no longer being updated', Carnegie Politika, Carnegie Endowment for International Peace, 23 Jan. 2025.

deployed to Belarus; however, these claims cannot be independently verified.[90] In 2024 commercial satellite imagery indicated that a military depot near Asipovichy in central Belarus had recently been upgraded with at least three security perimeters and an access point, suggesting that it could be intended for housing Russian nuclear warheads for Belarus's Russian-supplied Iskander missile launchers.[91] These elements would be consistent with other aspects of physical protection associated with Russian nuclear weapons storage. Nevertheless, there was no conclusive publicly available visual evidence as of January 2025 that Russian nuclear warheads and related personnel were deployed in Belarus.

At the end of 2024, Russian President Vladimir Putin indicated that Russia's new dual- and MIRV-capable Oreshnik IRBM could be deployed to Belarus in the second half of 2025.[92]

US nuclear doctrine and NATO nuclear sharing

The administration of US President Joe Biden came under increasing pressure in 2023–24 to modify US posture to counterbalance Russian and Chinese nuclear developments. For example, a report by the bipartisan US Congressional Commission on Strategic Posture, published in October 2023, recommended a wide range of modifications to US strategic and regional nuclear forces, including making urgent preparations to 'upload some or all' of the USA's reserve warheads.[93]

Despite this increasing pressure, the Biden administration's updated nuclear employment guidance, published in April 2024, did not significantly change the USA's nuclear posture. Press reports erroneously claimed that the new guidance shifted focus to China, but an unclassified version of the guidance, released in November, noted that Russia remained the 'acute threat'. The guidance directed 'that the United States be able to deter Russia, the PRC [People's Republic of China], and the DPRK simultaneously in peacetime, crisis, and conflict'.[94] However, the USA has clearly aimed to deter those states simultaneously for many years, and the guidance does not require achieving all war objectives against Russia and China at the

[90] 'Belarus has dozens of Russian nuclear weapons and is ready for its newest missile, its leader says', AP, 10 Dec. 2024.

[91] Kristensen, H. and Korda, M., 'Depot in Belarus shows new upgrades possibly for Russian nuclear warhead storage', FAS Strategic Security Blog, Federation of American Scientists, 14 Mar. 2024.

[92] Light, F., 'Putin says Oreshnik missiles could be deployed in Belarus in late 2025', Reuters, 6 Dec. 2024.

[93] Congressional Commission on the Strategic Posture of the United States, *America's Strategic Posture: Final Report of the Congressional Commission on the Strategic Posture of the United States* (Institute for Defense Analyses, IDA: Alexandria, VA, 2023), p. 48.

[94] US Department of Defense, 'Report on the Nuclear Employment Strategy of the United States', 7 Nov. 2024.

same time.[95] Given the result of the 2024 US presidential election, it is possible that the new administration of Donald J. Trump will reassess some of these conclusions.

Developments in NATO nuclear sharing

There was growing evidence between 2022 and 2024 to suggest that the USA is upgrading the nuclear storage vaults and related infrastructure at the British Royal Air Force (RAF) Lakenheath airbase in the UK, in order to facilitate the potential contingency storage of nuclear weapons at the base.[96] These upgrades are taking place in the broader context of a plan to modernize up to 180 nuclear storage vaults across Europe, which probably include all active vaults as well as dozens of vaults in caretaker status at other bases.[97]

In January 2025 the NNSA stated that the new B61-12 gravity bombs were 'fully forward deployed', indicating that the B61-3 and B61-4 bombs previously deployed at NATO bases outside the USA have been returned to the USA and replaced with the B61-12.[98] Unlike the older versions, the B61-12 is equipped with a guided tail-kit that enables the bomb to hit targets more accurately, meaning that it can use lower yields and thus generate less radioactive fallout.[99] The NNSA's Stockpile Stewardship and Management Plan for US fiscal year 2025 indicated that the B61-12 had been formally assigned to the F-15, F-16, F-35, B-2 and 'certified NATO aircraft'—especially the F-35A—suggesting that the B61-12 had received certifications of compatibility with all of these aircraft.[100] The F-35A will eventually replace all Belgian, Dutch and US F-16s and German and Italian Tornado aircraft in the nuclear strike role.

In recent years, including in 2024, there have been discussions in several NATO member states about nuclear-sharing arrangements. For example, Finland, which formally joined NATO in April 2023, and Sweden, which joined in March 2024, agreed bilateral defence agreements with the USA in

[95] Mount, A. and Kristensen, H., 'Biden nuclear weapons employment guidance leaves nuclear decision to Trump', FAS Strategic Security Blog, Federation of American Scientists, 5 Dec. 2024.

[96] Kristensen, H. M., 'Lakenheath air base added to nuclear weapons storage site upgrades', FAS Strategic Security Blog, Federation of American Scientists, 11 Apr. 2022; Korda, M. and Kristensen, H. M., 'Increasing evidence that the US Air Force's nuclear mission may be returning to UK soil', FAS Strategic Security Blog, Federation of American Scientists, 28 Aug. 2023; and Diver, T., 'US to station nuclear weapons in UK to counter threat from Russia', *Daily Telegraph*, 26 Jan. 2024.

[97] 'Request for information: Vault modernization program', System for Award Management (SAM.gov), Notice ID FA9422_VMP, 29 Aug. 2023.

[98] Hruby (note 83).

[99] Kristensen, H. M. and McKinzie, M., 'Video shows earth-penetrating capability of B61-12 nuclear bomb', FAS Strategic Security Blog, Federation of American Scientists, 14 Jan. 2016.

[100] Marrow, M., 'Exclusive: F-35A officially certified to carry nuclear bomb', Breaking Defense, 8 Mar. 2024; and US Department of Energy (DOE), National Nuclear Security Administration (NNSA), *Fiscal Year 2025 Stockpile Stewardship and Management Plan—Biennial Plan Summary*, Report to Congress (DOE: Washington, DC, Sep. 2024), pp. 1-4, 2-10.

2023 that entered into force in 2024.[101] These agreements grant the USA the right to station troops and weapons in those two states and do not contain any limitations regarding nuclear weapons. Moreover, both Finland and Sweden have signalled that they would potentially be open to stationing US nuclear weapons on their soil during wartime.[102] In 2024 Polish President Andrzej Duda announced that Poland was 'ready' to accept a deployment of NATO nuclear weapons on its territory.[103] French President Emmanuel Macron has also repeatedly suggested, including in 2024, that there should be a European dimension to France's nuclear deterrence.[104] It remains unclear, however, how such a mission would interact with NATO nuclear-sharing practices. An advisor to Macron clarified in 2022 that the proposal for European strategic dialogue remained on the table but was about connecting 'nuclear deterrence and European interests' and not about 'sharing the deterrent'.[105]

Chinese nuclear doctrine and nuclear modernization

The Chinese government's declared aim is to maintain China's nuclear capabilities at the minimum level required to safeguard national security, with the goal of 'deterring other countries from using or threatening to use nuclear weapons against China'.[106] China has long maintained a policy of not using or threatening to use nuclear weapons against non-nuclear-armed states or nuclear weapon-free zones.[107] However, the dramatic changes in China's nuclear posture in recent years, especially its deployment of quick-launch solid-fuelled missiles in silos and the possible development of a launch-on-warning (LOW) capability, have triggered widespread discussions about long-standing elements of Chinese nuclear doctrine, including its stated

[101] Agreement on Defense Cooperation between the Government of the Kingdom of Sweden and the Government of the United States of America, signed 5 Dec. 2023, entered into force 15 Aug. 2024; and Agreement on Defense Cooperation between the Government of the Republic of Finland and the Government of the United States of America, signed 18 Dec. 2023, entered into force 1 Sep. 2024.

[102] DR, NRK, SVT and YLE, 'Unik nordisk sändning om svaret på Putins krig' [Unique Nordic broadcast on the answer to Putin's war], SVT, 12 Sep. 2024; and Allik, H.-L., 'Sweden approves controversial US defense deal', DW, 19 June 2024.

[103] 'Poland's leader says his country is ready to host NATO members' nuclear weapons to counter Russia', AP, 22 Apr. 2024.

[104] See e.g. Macron, E., French President, Speech on defence and deterrence strategy, École de Guerre, Paris, 7 Feb. 2020 (in French, with English translation); and Rosemain, M., 'France's nuclear weapons should be part of European defence debate, Macron says', Reuters, 28 Apr. 2024.

[105] Schuller, K., 'Nukleare Abschreckung: Frankreich erneuert das Angebot, mit der EU über Atomwaffen zu reden' [France renews offer to talk to EU about nuclear weapons], *Frankfurter Allgemeine*, 14 Jan. 2022.

[106] Chinese State Council, *China's National Defense in the New Era* (Information Office of the State Council: Beijing, July 2019), chapter 2.

[107] 'China reiterates non-first-use principle of nuclear weapons', Xinhua, 18 Feb. 2018; and US Department of Defense, *Military and Security Developments Involving the People's Republic of China 2023*, Annual Report to Congress (Office of the Secretary of Defense: Washington, DC, 19 Oct. 2023), p. 105.

nuclear 'no-first-use' (NFU) policy.[108] Since 2022, the US DOD has assessed that China is implementing an 'early warning counterstrike' strategy—akin to a LOW posture—using ground- and space-based sensors to enable rapid launch of missiles before an adversary can destroy them. According to the US DOD, China has deployed at least three early-warning satellites to facilitate this posture.[109] However, there is no official publicly available evidence that the Chinese government has deviated from its long-standing core nuclear policies, including its NFU policy. In its 2024 report on Chinese nuclear forces, the US DOD stated that China 'seems to believe a LOW posture is consistent with its no first use policy'.[110]

China's standard posture since it developed nuclear weapons has been to keep warheads, missiles and launchers separate during peacetime, with procedures in place for loading warheads on to launchers in a crisis.[111] However, there has been considerable speculation in recent years, which continued in 2024, about whether this remains the case. For example, the US DOD claims that China's SSBNs 'likely began near-continuous at-sea deterrence patrols' in 2021 and noted in its 2024 report that China 'probably continued' such patrols throughout 2023.[112] This wording implies that China may have begun intermittent SSBN patrols with nuclear weapons onboard, which would constitute a significant change to its long-standing doctrine. The US DOD's 2024 report also claimed that a small number of land-based missile units conduct 'combat readiness duty' and 'high alert duty' drills, which allow the PLA Rocket Force (PLARF) 'to maintain a portion of its units on a heightened state of readiness while leaving the other portion in peacetime status with separated launchers, missiles, and warheads'.[113] This wording suggests that some of China's warheads may be deployed on launchers. In addition, the report noted that China test-launched two 'CSS-10 Mod 3 ICBMs in quick succession from training silos', most likely in an effort to validate its ability to launch multiple missiles.[114] This is consistent with PLARF training exercises

[108] See e.g. Havrén, S. A., 'China's no first use of nuclear weapons policy: Change or false alarm?', Royal United Services Institute (RUSI), 13 Oct. 2023; and Kulacki, G., 'Would China use nuclear weapons first in a war with the United States?', The Diplomat, 27 Apr. 2020.

[109] US Department of Defense (note 6), p. 110.

[110] US Department of Defense (note 6), p. 110

[111] Stokes, M. A., *China's Nuclear Warhead Storage and Handling System* (Project 2049 Institute: Arlington, VA, 12 Mar. 2010), p. 8; Li, B., 'China's potential to contribute to multilateral nuclear disarmament', *Arms Control Today*, vol. 41, no. 2 (Mar. 2011); and US Department of Defense, *Military and Security Developments Involving the People's Republic of China 2022*, Annual Report to Congress (Office of the Secretary of Defense: Washington, DC, 29 Nov. 2022), p. 95.

[112] US Department of Defense (note 6), p. 104.

[113] US Department of Defense (note 6), p. 106.

[114] US Department of Defense (note 6), p. 107.

that emphasize conducting fast launches of ballistic missiles before enemy missiles can hit their position.[115]

IV. Conclusions

While the global total inventory of nuclear warheads continues to fall as retired weapons are gradually dismantled, year-on-year increases can be seen in the number of operational (stockpiled) nuclear warheads. This trend seems likely to continue and will probably accelerate in the coming years.

These developments are made all the more concerning by the fact that states are becoming increasingly secretive about their nuclear weapons. While this is partly due to a general reduction in transparency in several nuclear-armed states, it is also due to the degradation of arms control agreements like New START that included transparency measures forcing states to exchange data about their arsenals.

[115] Lu, Z. and Liu, X., 'The missile was successfully launched, but all the personnel were "killed". Is it a victory?', PLA Daily, 7 Dec. 2021 (in Chinese); and Baughman, J., 'An assessment of People's Liberation Army Rocket Force survivability training', China Aerospace Studies Institute, 15 Aug. 2022.

Appendix 6A. Nuclear forces, by state, January 2025

HANS M. KRISTENSEN AND MATT KORDA

Table 6A.1. World nuclear forces, January 2025

All figures are approximate and are estimates based on public information or assessments by the authors.

	Year of first nuclear test	Deployed warheads, 2025[a]	Stored warheads, 2025[b]	Military stockpile[c]		Retired warheads[d]		Total inventory[e]	
				2024	2025	2024	2025	2024	2025
USA	1945	1 770[f]	1 930[g]	3 708	3 700	1 620	1 477	5 328	5 177
Russia	1949	1 718[h]	2 591[i]	4 380	4 309[j]	1 200	1 150	5 580	5 459
UK	1952	120	105	225	225	–	–	225	225
France	1960	280	10	290	290	. .	. .	290	290
China	1964	24	576	500	600	–	–	500	600
India	1974	–	180	172	180	. .	. .	172	180
Pakistan	1998	–	170	170	170	. .	. .	170	170
North Korea	2006	–	50	50	50	. .	. .	50	50[k]
Israel	. .	–	90	90	90	. .	. .	90	90
Total		**3 912**	**5 702**	**9 585**	**9 614**	**2 820**	**2 627**	**12 405**[l]	**12 241**

. . = not applicable or not available; – = nil or a negligible value.

Notes: SIPRI revises its world nuclear forces data each year based on new information and updates to earlier assessments. The data for Jan. 2025 replaces all previously published SIPRI data on world nuclear forces.

[a] These are warheads placed on missiles or located on bases with operational forces.

[b] These are warheads in central storage that would require some preparation (e.g. the installation of certain components, transport and loading on to launchers) before they could be deployed.

[c] This refers to all deployed warheads as well as warheads in central storage that could potentially be deployed after some preparation.

[d] These warheads have been retired from the military stockpile but have not yet been dismantled.

[e] This refers to both stockpiled and retired warheads.

[f] This figure includes *c.* 1370 warheads deployed on ballistic missiles and *c.* 300 stored at bomber bases in the USA, as well as *c.* 100 non-strategic (tactical) nuclear bombs thought to be deployed across 6 airbases in 5 North Atlantic Treaty Organization member states (Belgium, Germany, Italy, the Netherlands and Türkiye). These bombs remain in the custody of the USA.

[g] This figure includes *c.* 100 non-strategic nuclear bombs stored in the USA. The remainder are strategic nuclear warheads.

[h] This figure includes *c.* 1518 strategic warheads deployed on ballistic missiles and *c.* 200 deployed at heavy bomber bases.

[i] This figure includes *c.* 1114 strategic and *c.* 1477 non-strategic warheads in central storage.

[j] The year-on-year decrease in SIPRI's estimate of Russia's stockpile was largely due to a reassessment by SIPRI of the number of warheads assigned to non-strategic nuclear forces.

[k] North Korea might have produced enough fissile material to build up to 90 nuclear warheads; however, it is likely that it has assembled fewer warheads, perhaps *c.* 50.

[l] Based on new assessments, SIPRI estimates that the overall global inventory stood at 12 405 in Jan. 2024 rather than 12 121 as published in *SIPRI Yearbook 2024*.

Table 6A.2. United States nuclear forces, January 2025

All figures are approximate and some are based on assessments by the authors.

Type	Designation	No. of launchers	Year first deployed	Range (km)	No. of warheads x warhead type x yield	Total no. of warheads
Strategic nuclear forces		**745**				**3 500**
Aircraft (bombers)		*65*				*780*
B-52H	Stratofortress	76/46	1961	16 000	8–20 x AGM-86B ALCMs x 5–150 kt	500
B-2A	Spirit	19/19	1994	11 000	Up to 16 x B61-11 x 400 kt, -12 x 0.3–50 kt	280
Land-based ICBMs		*400*				*800*
LGM-30G Minuteman III						
	Mk12A	200	1979	13 000	1–3 x W78 x 335 kt	600
	Mk21 SERV	200	2006	13 000	1 x W87-0 x 300 kt	200
SLBMs		*280*				*1 920*
UGM-133A Trident II D5LE						
	Mk4A	. .	2008	>12 000	1–8 x W76-1 x 90 kt	1 511
	Mk4A	. .	2019	>12 000	1 x W76-2 x 8 kt	25
	Mk5	. .	1990	>12 000	1–8 x W88 x 455 kt	384
Non-strategic nuclear forces						**200**
F-15E	Strike Eagle	. .	1988	3 840	5 x B61-12 x 0.3–50 kt	80
F-16C/D/ MLU	Falcon	. .	1985/1996	3 200	2 x B61-12 x 0.3–50 kt	75
PA-200	Tornado	. .	1983	2 400	2 x B61-12 x 0.3–50 kt	30
F-35A	Lightning II	. .	2024	2 200	2 x B61-12 x 0.3–50 kt	15
Total stockpile						**3 700**
Deployed warheads						1 770
Reserve warheads						1 930
Retired warheads awaiting dismantlement						**1 477**
Total inventory						**5 177**

. . = not available or not applicable; ALCM = air-launched cruise missile; ICBM = intercontinental ballistic missile; kt = kiloton; SERV = security-enhanced re-entry vehicle; SLBM = submarine-launched ballistic missile.

Notes: **Strategic nuclear forces**: Of the *c.* 3500 strategic warheads, *c.* 1670 were deployed on land- and sea-based ballistic missiles and at airbases (see below for the estimated deployed warhead numbers for each category). The remaining warheads were in central storage. The USA and Russia no longer publish aggregate numbers for strategic forces limited by the 2010 Russian–US Treaty on Measures for the Further Reduction and Limitation of Strategic Offensive Arms (New START).

The USA has 95 bombers in its inventory (76 B-52Hs and 19 B-2As), but only 65 are counted as nuclear-capable under New START (46 B-52Hs and 19 B-2As). The USA has declared that it will deploy no more than 60 nuclear bombers at any given time but normally only *c.* 50 are deployed, with the remaining aircraft in overhaul. Of the *c.* 780 bomber weapons, *c.* 300 (200 ALCMs and 100 gravity bombs) were deployed at the bomber bases; all the rest were in central storage. Many

of the gravity bombs are no longer fully active and are slated for retirement after the forward deployment of the B61-12 was completed in 2024.

Of the 800 ICBM warheads, only 400 were deployed on the missiles. The remaining warheads were in central storage. Only 200 of the 600 W78 warheads were deployed, as each ICBM has had its warhead load reduced to carry a single warhead; all of the remaining warheads were in central storage. Although only 200 W87 warheads are listed, SIPRI estimates that another 340 W87 warheads might be in long-term storage outside the stockpile for use in the W87-1 warhead programme to replace the W78.

There are 14 nuclear-powered ballistic missile submarines (SSBNs) in the US fleet that can carry a maximum of 280 missiles. However, 2 vessels are normally undergoing refuelling overhaul at any given time and are not assigned missiles. The remaining 12 SSBNs can carry up to 240 missiles, but 1–2 of these vessels are usually undergoing maintenance at any given time and may not be carrying missiles.

Of the 1920 SLBM warheads, *c.* 970 were deployed on submarines as of Jan. 2025; all the rest were in central storage. Although each D5 missile was counted under the 1991 Strategic Arms Reduction Treaty (START I) as carrying 8 warheads and the missile was initially flight-tested with 14, the US Navy has reduced the warhead load of each missile to an average of 4–5 warheads. D5 missiles equipped with the new low-yield W76-2 (to be deployed on at least 2 of the SSBNs on patrol in the Atlantic and Pacific oceans) are estimated to carry only 1 warhead each.

Non-Strategic nuclear forces: Of the 200 non-strategic bombs, *c.* 100 are thought to be deployed across 6 airbases in 5 North Atlantic Treaty Organization (NATO) member states (Belgium, Germany, Italy, the Netherlands and Türkiye), although the weapons remain in the custody of the US Air Force. The other *c.* 100 bombs were in central storage in the USA.

Other issues: Up until 2018, the US government published the number of warheads dismantled each year, but the first administration of President Donald J. Trump ended this practice. The administration of President Joe Biden restored transparency and released stockpile data in 2021 and 2024; however, publication of the data showed that far fewer warheads had been dismantled than assumed (e.g. only 69 in 2023—the lowest number ever released). Nonetheless, dismantlement of the warheads has continued, leaving an estimated 1477 warheads in the dismantlement queue as of Jan. 2025.

In addition to the estimated 5177 intact warheads, nearly 20 000 plutonium pits were stored at the Pantex Plant, Texas, and perhaps 4000 uranium secondaries were stored at the Y-12 facility at Oak Ridge, Tennessee.

Table 6A.3. Russian nuclear forces, January 2025

All figures are approximate and some are based on assessments by the authors.

Type/Russian designation (NATO designation)	No. of launchers	Year first deployed	Range (km)	Warheads x yield	Total no. of warheads
Strategic nuclear forces	**592**				**2 832**
Aircraft (bombers)	*67*				*586*
Tu-95MS/M (Bear-H)	52	1984/2015	6 500–10 500	6–16 x 200 kt ALCMs, bombs	430
Tu-160M1/M2 (Blackjack)	15	1987/2021	10 500–13 200	12 x 200 kt ALCMs, bombs	156
Land-based ICBMs	*333*				*1 254*
RS-20V Voevoda (SS-18 Mod 5 Satan)	34	1988	11 000–15 000	10 x 500–800 kt	340
Avangard (SS-19 Mod 4)	12	2019	10 000	1 x HGV	12
RS-12M1/2 Topol-M (SS-27 Mod 1/mobile/silo)	78	1997/2006	10 500	1 x [800 kt]	78
RS-24 Yars (SS-27 Mod 2/ mobile/silo)	206	2010/2014	10 500	[4 x 250 kt]	824
Sirena-M	3	2022	–	Command and control module	–
SLBMs	*192*				*992*
RSM-54 Sineva/Layner (SS-N-23 M2/3)	80	2007/2014	9 000	4 x 100 kt	320
RSM-56 Bulava (SS-N-32)	112	2012	>8 050	[6 x 100 kt]	672
Non-strategic nuclear forces					**1 477**
Navy weapons	*. .*				*704*
Air force weapons	*289*				*333*
Air, coastal and missile defence	*882*				*345*
Army weapons	*170*				*95*
Total stockpile					**4 309**
Deployed strategic warheads					1 718
Reserve warheads					2 591
Strategic					1 114
Non-strategic					1 477
Retired warheads awaiting dismantlement					**1 150**
Total inventory					**5 459**

. . = not available or not applicable; – = nil or a negligible value; [ ] = uncertain SIPRI estimate; ALCM = air-launched cruise missile; HGV = hypersonic glide vehicle; kt = kiloton; ICBM = intercontinental ballistic missile; NATO = North Atlantic Treaty Organization; SLBM = submarine-launched ballistic missile.

Notes: **Strategic nuclear forces**: Of the *c.* 2832 warheads estimated to be assigned to nuclear-capable delivery systems, only *c.* 1718 are estimated to have been deployed on land- and sea-based ballistic missiles and at airbases (see below for the estimated deployed warhead numbers

for each category), with *c.* 1114 estimated to be held in reserve in central storage. Russia and the USA no longer publish aggregate numbers for strategic forces limited by the 2010 Russian–US Treaty on Measures for the Further Reduction and Limitation of Strategic Offensive Arms (New START).

Because of ongoing bomber modernization and maintenance, there is considerable uncertainty about how many bombers are operational. The maximum possible payload on the bombers is estimated to be *c.* 650 nuclear weapons but, given that only some of the bombers are fully operational, SIPRI estimates that only *c.* 586 weapons have been assigned to the long-range bomber force. Of these, *c.* 200 might be deployed and stored at the 2 strategic bomber bases. The remaining weapons are thought to be in central storage facilities.

Russia's land-based ICBMs can carry a total of *c.* 1254 warheads, but SIPRI estimates that they have had their warhead load reduced to *c.* 878 warheads, with the remaining warheads in storage.

Russia operates 12 nuclear-powered ballistic missile submarines (SSBNs) that can carry a maximum of 192 missiles. Of Russia's 12 operational SSBNs, 1–2 are in overhaul at any given time and do not carry their assigned nuclear missiles and warheads. The warhead load on SLBMs is also thought to have been reduced for Russia to stay below the New START warhead limit. Therefore, it is estimated here that only *c.* 640 of the 992 SLBM warheads have been deployed.

Non-strategic nuclear forces: Most Russian delivery systems for non-strategic nuclear weapons are dual-capable, meaning that they can also deliver conventional warheads. They are intended for use by ships and submarines, aircraft, air- and missile-defence systems, and in army missiles. According to the Russian government, non-strategic nuclear warheads are not deployed with their delivery systems but are kept in storage facilities. Some storage facilities are near operational bases. It is possible that there are more unreported nuclear-capable non-strategic systems.

Table 6A.4. British nuclear forces, January 2025

All figures are approximate and some are based on assessments by the authors.

Type/designation	No. of launchers	Year first deployed	Range (km)	Warheads x yield	Total no. of warheads
SLBMs	*64*				*120*
Trident II D5	48	1994	>10 000	1–8 x 100 kt	120
Total operationally available warheads					**120**
Other stored warheads					*105*
Total stockpile					**225**

kt = kiloton; SLBM = submarine-launched ballistic missile.

Notes: The United Kingdom operates 4 nuclear-powered ballistic missile submarines (SSBNs) that can carry a maximum of 64 missiles. However, the total number of missiles carried is lower (48) because 1 of the 4 SSBNs is in overhaul at any given time. The UK has purchased the right to 58 missiles from a pool shared with the United States Navy.

The Trident II D5 missiles on British SSBNs are identical to the Trident II D5 missiles on US Navy SSBNs, which have demonstrated a range of more than 10 000 kilometres in test flights.

The British warhead is called the Holbrook, a modified version of the USA's W76 warhead, with a potential lower-yield option.

Of the 120 operationally available warheads, *c*. 40 are deployed on the single SSBN that is at sea at any given time, with the remaining warheads assigned to the 2 other deployable SSBNs.

The 'other stored warheads' figure includes retired warheads that have not yet been dismantled. It seems likely that they will be reconstituted to become part of the UK's total stockpile over the coming years.

The British government declared in 2010 that its inventory would not exceed 225 warheads, and that the UK would reduce the number of warheads in its overall nuclear stockpile to no more than 180. Despite these stated intentions, the UK's nuclear stockpile appears to have remained at *c*. 225 warheads. The UK's Integrated Review of Security, Defence, Development and Foreign Policy, published in 2021, introduced a new ceiling of 260 warheads.

Table 6A.5. French nuclear forces, January 2025

All figures are approximate and some are based on assessments by the authors.

Type/designation	No. of launchers	Year first deployed	Range (km)	Warheads x yield	Total no. of warheads
Land-based aircraft					
Rafale BF3/4	40	2010–11	2 000	1 x [<300 kt] TNA	40
Carrier-based aircraft					
Rafale MF3/4	10	2010–11	2 000	1 x [<300 kt] TNA	10
SLBMs	*64*				*240*
M51.1	–	2010	>6 000	4–6 x 100 kt TN 75	–
M51.2	32	2016	>9 000	4–6 x 100 kt TNO	160
M51.3	16	[2026]	>9 500	4–6 x 100 kt TNO-2	80
Total stockpile					**290**

– = nil or a negligible value; [ ] = uncertain SIPRI estimate; kt = kiloton; SLBM = submarine-launched ballistic missile; TNA = *tête nucléaire aéroportée* (air-launched nuclear warhead); TNO = *tête nucléaire océanique* (sea-based nuclear warhead).

Notes: The Rafale B and M aircraft both carry the ASMPA (*air–sol moyenne portée–améliorée*) air-launched cruise missile (ALCM). Most sources report that the ASMPA has a range of 500–600 kilometres, although some suggest that it might be over 600 km. In 2023 France began to upgrade its Rafale BF3 and MF3 aircraft to the new F4 standard; the full upgrade was scheduled to be completed by 2025. The 10 warheads assigned to France's carrier-based aircraft are thought to be kept in central storage and are not normally deployed.

There is uncertainty as to the yield of the new TNA warhead. Some non-official sources continue to attribute a yield of 300 kt to the TNA, the same yield as the previous TN 81 warhead carried by the original ASMP missile. However, MBDA, the manufacturer of the ASMPA missile that carries the TNA, has stated that the warhead has a 'medium energy' yield, which is thought to imply less than 300 kt. The TNA also appears to be based on the same design as the TNO, which is believed to have a yield of 100 kt.

France operates 4 nuclear-powered ballistic missile submarines (SSBNs) that can carry a maximum of 64 missiles. However, the total number of missiles carried is lower (48) because 1 of the 4 SSBNs is in overhaul at any given time. The last SSBN believed to be carrying M51.1 SLBMs with accompanying TN 75 warheads, *Le Vigilant*, began a period of long-term maintenance in late 2023 and moved to dry dock in early 2024. This would indicate that its missiles and warheads have been removed. *Le Vigilant* is scheduled to rejoin the French fleet in 2026 and will probably be the first SSBN equipped with the new M51.3 SLBM—which is scheduled for commissioning by the end of 2025—and the new TNO-2 warhead.

In Feb. 2020 President Emmanuel Macron reaffirmed that the arsenal 'is currently under 300 nuclear weapons'. A few of the warheads are thought to be undergoing maintenance and inspection at any given time.

Table 6A.6. Chinese nuclear forces, January 2025

All figures are approximate and some are based on assessments by the authors.

Type/Chinese designation (US designation)	No. of launchers	Year first deployed	Range (km)	Total no. of warheads
Aircraft	*20*			*20*
H-6N (B-6N)	20	2020	3 100	20
Land-based missiles	*712*			*376*
DF-5A (CSS-4 Mod 2)	6	1981	12 000	6
DF-5B (CSS-4 Mod 3)	12	2015	13 000	60
DF-5C (. .)	. .	[2025]	13 000	. .
DF-26 (CSS-18)	250	2016	>3 000	100
DF-31A/AG (CSS-10 Mod 2)	96	2007/2018	11 200	96
DF-31-class (silo)	320	[2024]	11 200	30
DF-41 (mobile version) (CSS-20)	28	2020	12 000	84
DF-41 (silo version) (CSS-20)	. .	[2025]	12 000	. .
SLBMs	*72*			*72*
JL-3 (CSS-N-20)	72	2022	>10 000	72
Other stored warheads				[*132*]
Total stockpile	**804**			**600**

. . = not available or not applicable; [ ] = uncertain SIPRI estimate; SLBM = submarine-launched ballistic missile.

Notes: The yields of China's nuclear warheads are not known, except that older and less accurate missiles were equipped with megaton-yield warheads. Newer long-range missile warheads probably have yields of a few hundred kilotons, and it is possible that some warheads have even lower yield options. The vast majority of China's warheads are not thought to be deployed on launchers under normal circumstances but kept in storage facilities, although this is likely to change as missiles continue to be loaded into silos.

Figures are based on estimates of 1 warhead per nuclear-capable launcher, except for those that have multiple independently targetable re-entry vehicles (MIRVs). The MIRV-capable DF-5B is estimated to carry up to 5 warheads while the DF-41 is estimated to carry up to 3. The number of bombers only counts those estimated to be assigned a nuclear role.

Around half of the DF-26 dual-capable launchers are estimated to carry conventional warheads. A new intercontinental range missile (DF-27 (CSS-X-24)) is under development but may serve in an exclusively conventional strike role.

China operates 6 nuclear-powered ballistic missile submarines (SSBNs) that can carry a total of 72 SLBMs. China is probably replacing its deployed JL-2 SLBMs with JL-3 SLBMs on a rotational basis as each submarine returns to port for routine maintenance and overhaul. It is thought that the system is also intended to arm future Type 094 SSBNs as well as the future Type 096 SSBN, which will not be ready for several years.

SIPRI's estimate of China's total stockpile includes *c.* 132 'other stored warheads' that might have been produced for missiles nearing operational status.

Table 6A.7. Indian nuclear forces, January 2025

All figures are approximate and some are based on assessments by the authors.

Type/designation	No. of launchers	Year first deployed	Range (km)	Total no. of warheads
Aircraft	*48*			*48*
Mirage 2000H	32	1985	1 850	32
Jaguar IS	16	1981	1 600	16
Land-based missiles	*80*			*80*
Prithvi-II	24	2003	250–350	24
Agni-I	16	2007	>700	16
Agni-II	16	2011	>2 000	16
Agni-III	16	2018	>3 200	16
Agni-IV	8	2022	>3 500	8
SLBMs	*24*			*24*
K-15 (B-05)	24	2018	700	24
Other stored warheads				[*28*]
Total stockpile	**152**			**180**

. . = not available or not applicable; [ ] = uncertain SIPRI estimate; SLBM = submarine-launched ballistic missile.

Notes: The yields of India's nuclear warheads are not known. The 1998 nuclear tests demonstrated yields of up to 12 kt. Since then, it is possible that boosted warheads have been introduced with a higher yield, perhaps up to 40 kt. There is no open-source evidence that India has developed 2-stage thermonuclear warheads. India does not deploy its warheads on launchers but keeps them in separate storage facilities.

Aircraft and several missile types are thought to be dual-capable—that is, they can be armed with either conventional or nuclear warheads. This estimate counts an average of 1 nuclear warhead per launcher.

Three additional land-based missiles are under development: 2 intermediate-range ballistic missiles (Agni-V and Agni-VI) and 1 intercontinental ballistic missile (Agni-P).

India operates 2 nuclear-powered ballistic missile submarines (SSBNs). Each of these SSBNs has 4 missile tubes, each of which can carry 3 K-15 SLBMs, for a total of 12 missiles per SSBN. India is developing a new SLBM—the K-4.

SIPRI's estimate of India's total stockpile includes *c.* 28 'other stored warheads' that might have been produced for missiles nearing operational status, including the Agni-V and Agni-P land-based missiles and the K-4 SLBM.

Table 6A.8. Pakistani nuclear forces, January 2025

All figures are approximate and some are based on assessments by the authors.

Type/designation	No. of launchers	Year first deployed	Range (km)	Total no. of warheads
Aircraft	*36*			*36*
Mirage III/V	36	1998	2 100	36
Land-based missiles	*126*			*126*
Abdali (Hatf-2)	10	2002	200	10
Ghaznavi (Hatf-3)	16	2004	300	16
Shaheen-I/IA (Hatf-4)	16	2003/2022	750/900	16
Shaheen-II (Hatf-6)	24	2014	2 000	24
Shaheen-III (. .)	–	[2024]	2 750	–
Ghauri (Hatf-5)	24	2003	1 250	24
Nasr (Hatf-9)	24	2013	70	24
Ababeel	–	. .	2 200	–
Babur/-1A GLCM (Hatf-7)	12	2014/[early 2020s]	350/450	12
Babur-2/-1B GLCM	–	. .	900	–
Sea-based missiles				
Babur-3 SLCM	–	[2025]	450	–
Other stored warheads				[*8*]
Total stockpile	**162**			**170**

. . = not available or not applicable; – = nil or a negligible value; [ ] = uncertain SIPRI estimate; GLCM = ground-launched cruise missile; SLCM = sea-launched cruise missile.

Notes: The yields of Pakistan's nuclear warheads are not known. The 1998 nuclear tests demonstrated a yield of up to 12 kt. Since then, it is possible that boosted warheads have been introduced with a higher yield. There is no open-source evidence that Pakistan has developed 2-stage thermonuclear warheads. Pakistan does not deploy its warheads on launchers but keeps them in separate storage facilities.

Aircraft and several missile types are thought to be dual-capable—that is, they can be armed with either conventional or nuclear warheads. Cruise missile launchers can carry more than 1 missile. This estimate counts an average of 1 nuclear warhead per launcher. Some land-based launchers might have 1 or more missile reloads.

Pakistan is thought to be close to completing the development of an SLCM (the Babur-3) that is intended to establish a nuclear capability for 3 of its diesel–electric submarines.

SIPRI's estimate of Pakistan's total stockpile includes *c.* 8 'other stored warheads' that might have been produced to arm future Shaheen-III missiles.

Table 6A.9. Operational North Korean forces with potential nuclear capability, January 2025

All figures are approximate and some are based on assessments by the authors.

Type/North Korean designation (US designation)	Year first displayed	Estimated no. of launchers	Description
Short-range ballistic missiles (land based)			
Hwasong-5/-6 (Scud-B/-C)	1984/1990	>100	Single-stage, liquid-fuelled
Hwasong-11A/B/D (KN23/ KN24), (KN25)	2018/2019/ 2022	. .	Solid-fuelled
Medium-range ballistic missiles (land based)			
Hwasong-7 (Nodong/Rodong)	1993	>100	Single-stage, liquid-fuelled
Hwasong-9 (KN04/Scud-ER)	2016	. .	Single-stage, liquid-fuelled Scud extended-range variant
Pukguksong-2 (KN15)	2017	. .	Two-stage, solid-fuelled
Hwasal-1/-2	2021	. .	Land-attack cruise missiles
Intermediate-range ballistic missiles (land based)			
Hwasong-12 (KN17)	2017/2022	. .	Single-stage, liquid-fuelled
Intercontinental ballistic missiles (land based)			
Hwasong-15 (KN22)	2017	. .	Two-stage, liquid-fuelled
Hwasong-17 (KN28)	2020	. .	Two-stage, liquid-fuelled
Hwasong-18	2023	. .	Three-stage, solid-fuelled
Hwasong-19	2024	. .	Three-stage, possibly with post-boost vehicle, solid-fuelled
Submarine-launched ballistic missiles			
None thought to be operational, but Pukguksong-1 (KN11) and Pukguksong-3 (KN26) have been flight-tested and other variants are under development			
Total warheads			**50**

. . = not available or not applicable.

Notes: Information about the status and capability of North Korea's missiles comes with significant uncertainty. There is no publicly available evidence that North Korea has produced an operational nuclear warhead for delivery by an intercontinental ballistic missile. SIPRI estimates that North Korea might have produced enough fissile material to build 70–90 nuclear warheads; however, it is likely that it has assembled fewer warheads, perhaps *c*. 50. Of these, it is likely that nearly all would be lower-yield single-stage fission warheads and only a few would be thermonuclear warheads.

Table 6A.10. Israeli nuclear forces, January 2025

All figures are approximate and some are based on assessments by the authors.

Type/designation	No. of launchers	Year first deployed	Range (km)	Total no. of warheads
Aircraft	*50*			*30*
F-16I	100/25	1980	1 600	30
F-15	25/25	1998	4 450	. .
Land-based missiles	*50*			*50*
Jericho II	25	1990	>1 500	25
Jericho III	25	[2011]	[>4 000]	25
Sea-based missiles	*20*			*10*
Popeye Turbo SLCM	20	[2002]	[<1 500]	10
Total stockpile	**120**			**90**

. . = not available or not applicable; [ ] = uncertain SIPRI estimate; SLCM = sea-launched cruise missile.

Notes: Israel continues to maintain its long-standing policy of nuclear ambiguity. Given the unique lack of publicly available information about Israel's nuclear arsenal, the estimates presented here come with a considerable degree of uncertainty.

It is assumed that Israel does not deploy its warheads on launchers but keeps them in separate storage facilities.

Israel has *c.* 125 combat aircraft in its inventory that are potentially nuclear-capable (100 F-16Is and 25 F-15s), but SIPRI estimates that only *c.* 50 aircraft (25 F-16Is and all 25 F-15s) might serve a nuclear strike role. It is not known whether the Israeli Air Force has added nuclear capability to the F-15 aircraft as the United States has done; however, one US official has privately described Israel's F-15s as its 'nuclear squadron'.

The Jericho III is gradually replacing the older Jericho II and it is possible that this process might already have been completed. A longer-range version of the Jericho missile with a new solid rocket motor may be under development.

Israel operates 5 Dolphin-class diesel–electric submarines that are estimated to carry a maximum total of 20 missiles that could potentially be nuclear-armed.