7. World nuclear forces

Overview

At the start of 2024, nine 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—together possessed approximately 12 121 nuclear weapons, of which 9585 were considered to be potentially operationally available. An estimated 3904 of these warheads were deployed with operational forces (see table 7.1), including about 2100 that were kept in a state of high operational alert—about 100 more than the previous year.

Overall, the number of nuclear warheads in the world continues to decline. However, this is only due to the USA and Russia dismantling retired warheads. Global reductions of operational warheads appear to have stalled, and their numbers are rising again. The USA and Russia, which together possess almost 90 per cent of all nuclear weapons, have extensive programmes under way to replace and modernize their nuclear warheads, their missile, aircraft and submarine delivery systems, and their nuclear weapon production facilities (see sections I and II).

China is in the middle of a significant modernization and expansion of its nuclear arsenal (see section V). Its nuclear stockpile is expected to continue growing over the coming decade and some projections suggest that China could potentially deploy at least as many intercontinental ballistic missiles as either Russia or the USA in that period. Even so, China's overall nuclear warhead stockpile is expected to remain smaller than that of either of those states.

The nuclear arsenals of the other nuclear-armed states are even smaller (see sections III–IV, VI–IX), but all are either developing or deploying new weapon systems or have announced their intention to do so. India and Pakistan also appear to be increasing the size of their nuclear weapon inventories, and the UK plans to increase its stockpile. North Korea's military nuclear programme remains central to its national security strategy and it may have assembled up to 50 nuclear weapons and could produce more. Israel continues to maintain its long-standing policy of nuclear ambiguity, leaving significant uncertainty about the number and characteristics of its nuclear weapons.

The availability of reliable information on the status of the nuclear arsenals and capabilities of the nuclear-armed states varies considerably. In some cases, estimates can be based on the amount of fissile material—plutonium and highly enriched uranium—that a country is believed to have produced (see section X) and on observations of missile forces.

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Table 7.1. World nuclear forces, January 2024

All figures are approximate and are estimates based on assessments by the authors. The estimates presented here are based on public information and contain some uncertainties, as reflected in the notes to tables 7.1–7.10.

Country	Year of first nuclear test	Military stockpile[a]			Retired warheads	Total inventory
		Deployed[b]	Stored[c]	Total		
United States	1945	1 770[d]	1 938[e]	3 708	1 336[f]	5 044
Russia	1949	1 710[g]	2 670[h]	4 380[i]	1 200[f]	5 580
United Kingdom	1952	120	105	225	–	225
France	1960	280	10	290	. .	290
China	1964	24[j]	476	500	–	500
India	1974	–	172	172	. .	172
Pakistan	1998	–	170	170	. .	170
North Korea	2006	–	50	50	. .	50[k]
Israel	. .	–	90	90	. .	90
Total		**3 904**	**5 681**	**9 585**	**2 536**	**12 121**

. . = 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. 2024 replaces all previously published SIPRI data on world nuclear forces.

[a] Some states, such as the USA, use the official term ‘stockpile’ to refer to this subset of warheads, while others, such as the UK, often use ‘stockpile’ to describe the entire nuclear inventory. SIPRI uses the term ‘stockpile’ to refer to all deployed warheads as well as warheads in central storage that could potentially be deployed after some preparation.

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

[c] These are warheads in central storage that would require some preparation (e.g. transport and loading on to launchers) before they could be deployed.

[d] 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 non-strategic bombs remain in the custody of the USA.

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

[f] This figure refers to retired warheads that have not yet been dismantled.

[g] This figure includes *c.* 1510 strategic warheads deployed on ballistic missiles and *c.* 200 deployed at heavy bomber bases.

[h] This figure includes *c.* 1112 strategic and *c.* 1558 non-strategic warheads in central storage.

[i] SIPRI estimates that Russia had more strategic warheads in Jan. 2024 than in Jan. 2023 but has revised the estimated number of non-strategic warheads downwards based on new assessments, resulting in a net overall decrease in the Russian military stockpile of *c.* 109 warheads compared with the estimate for the previous year.

[j] SIPRI assesses that, as of Jan. 2024, China might have started to deploy a small number of its warheads (*c.* 24) on their launchers.

[k] Information about the status and capability of North Korea’s nuclear arsenal comes with significant uncertainty. 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.

I. United States nuclear forces

HANS M. KRISTENSEN AND MATT KORDA*

As of January 2024 the United States maintained a military stockpile of approximately 3708 nuclear warheads, the same number as the previous year. Approximately 1770 of these—consisting of about 1670 strategic and roughly 100 non-strategic (tactical) warheads—were deployed on ballistic missiles and at bomber bases. In addition, about 1938 warheads were held in reserve and around 1336 retired warheads were awaiting dismantlement (200 fewer than the previous year's estimate), giving a total inventory of approximately 5044 nuclear warheads (see table 7.2, end of section).

The estimates presented here are based on publicly available information regarding the US nuclear arsenal and assessments by the authors.[1] While in 2021 the USA briefly restored a policy of declassifying the size of its nuclear stockpile and the annual number of dismantled warheads, the information was not released in 2022 or 2023.[2]

The US stockpile is expected to continue to decline slightly over the next decade as nuclear modernization programmes consolidate some nuclear weapon types. The US Department of Energy (DOE) reported in April 2023 that it had been 'on pace to complete the dismantlement of all warheads retired before FY [fiscal year] 2009 by the end of FY 2022' but that the Covid-19 pandemic had 'delayed the dismantlement of a small number of these retired warheads until after FY 2022'.[3] As for warheads retired during and after FY 2009, the DOE reported in November 2023 that 'Warheads awaiting dismantlement constitute a significant fraction of the total warhead population', and that the DOE planned to 'remove additional retired weapons from . . . [US Department of Defense (DOD)] facilities' and 'dismantle several [retired] weapons systems'.[4]

This section details the USA's holdings of nuclear weapons, both strategic (including those delivered by air, land and sea) and non-strategic. Before doing so, it first considers the USA's compliance with its bilateral arms control obligations, outlines the role played by nuclear weapons in the USA's military doctrine and describes the country's warhead-production capacity.

[1] Kristensen, H. M. and Korda, M., 'Estimating world nuclear forces: An overview and assessment of sources', SIPRI Commentary, 14 June 2021.

[2] US Department of State, 'Transparency in the US nuclear weapons stockpile', Fact sheet, 5 Oct. 2021; and Kristensen, H. M., 'While advocating nuclear transparency abroad, Biden administration limits it at home', FAS Strategic Security Blog, Federation of American Scientists, 31 July 2023.

[3] 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. 2-12. US fiscal years end on 30 Sep. of the named year.

[4] US Department of Energy (DOE), National Nuclear Security Administration (NNSA), *Fiscal Year 2024 Stockpile Stewardship and Management Plan*, Report to Congress (DOE: Washington, DC, Nov. 2023, pp. 2-12, G-6.

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US compliance with New START

During 2023 the USA appeared to continue to be in compliance with the limits on deployed strategic nuclear forces prescribed by the 2010 Russian–US Treaty on Measures for the Further Reduction and Limitation of Strategic Offensive Arms (New START).[5] Under the treaty, the Russian Federation and the USA are obligated to exchange data on their nuclear forces twice a year. Although Russia stopped publishing and sharing treaty data in early 2023 (see section II of this chapter), the USA initially disclosed its numbers in May 2023 by publicly declaring that it had 1419 warheads attributed to 662 deployed ballistic missiles and heavy bombers as of 1 March 2023.[6] The USA stated that it had voluntarily released the numbers 'In the interest of transparency and the US commitment to responsible nuclear conduct'.[7] However, the USA did not disclose its aggregate numbers for September 2023; in January 2024 it instead republished the numbers for March 2023.[8]

In addition to no longer publicly volunteering its New START aggregate data, the USA announced four countermeasures in June 2023 in response to Russia's violation of the treaty. The USA (*a*) will not provide biannual force data; (*b*) will not provide notifications (e.g. on the location and status of deployed missiles and launchers); (*c*) will not facilitate Russian inspections on US territory; and (*d*) will not provide telemetry information on test launches of US intercontinental ballistic missiles (ICBMs) and submarine-launched ballistic missiles (SLBMs). The US Department of State said the countermeasures were in line with international law as they aimed to induce Russia to return to compliance.[9]

Just as with Russia, many of the USA's strategic delivery systems carry fewer warheads than their maximum capacity in order to meet the limits of New START. While New START has so far constrained US nuclear warhead loadings, the National Defense Authorization Act (NDAA) for FY 2024 directed the US Air Force (USAF) to 'develop a plan to decrease the amount of time required to upload additional warheads to the intercontinental ballistic missile force in the event Presidential direction is given to exercise such a plan'.[10] In addition, a report by the bipartisan US Congressional Commission on Strategic Posture published in October 2023, while not part of official US

[5] For a summary and other details of New START see annex A, section III, in this volume. On related developments in 2023 see chapter 8, section I, in this volume.

[6] US Department of State, Bureau of Arms Control, Verification and Compliance, 'US New START Treaty aggregate numbers of strategic offensive arms', Fact sheet, 12 May 2023, p. 2.

[7] US Department of State (note 6).

[8] US Department of State, Bureau of Arms Control, Deterrence, and Stability, '2023 report to Congress on implementation of the New START treaty', 31 Jan. 2024, p. 4.

[9] US Department of State, Bureau of Arms Control, Deterrence, and Stability, 'US countermeasures in response to Russia's violation of the New START treaty', Fact sheet, 1 June 2023.

[10] National Defense Authorization Act for Fiscal Year 2024, US Public Law 118-31, signed into law on 22 Dec. 2023, HR 2670, pp. 466–67.

policy, recommended that the USA should urgently prepare to 'upload some or all' of the country's reserve warheads.[11]

The role of nuclear weapons in US military doctrine

The 2022 Nuclear Posture Review (NPR) released by the administration of President Joe Biden affirmed three overall roles for US nuclear weapons: 'Deter strategic attacks; Assure Allies and partners; and Achieve US objectives if deterrence fails.'[12] It noted that 'The United States would only consider the use of nuclear weapons in extreme circumstances to defend the vital interests of the United States or its Allies and partners'; however, it did not elaborate on what specifically constitutes 'vital interests', nor did it define the phrase 'Allies and partners'.[13] The 2022 NPR also appeared to scale back somewhat the language about the role that nuclear weapons could play against non-nuclear strategic attacks, a role the 2018 NPR issued by the administration of President Donald J. Trump had sought to broaden.[14]

The overall roles of US nuclear weapons outlined in the 2022 NPR are in line with long-held policies, but the force structure required to serve those roles appears to be changing. The administration of President Barack Obama (2009–17) initiated a general nuclear weapon modernization programme, which the Trump administration (2017–21) sought to expand by adding new low-yield and tactical nuclear weapons (see below).[15] While the 2022 NPR rejected some of this expansion, the Biden administration came under increasing pressure in 2023 to modify US posture to counterbalance Russian and Chinese nuclear developments. For example, in October 2023 the Congressional Strategic Posture Commission recommended a wide range of urgent modifications to US strategic and regional nuclear forces.[16]

[11] 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.

[12] US Department of Defense (DOD), *2022 National Defense Strategy of the United States of America* (DOD: Washington, DC, Oct. 2022), *2022 Nuclear Posture Review*, p. 7.

[13] US Department of Defense (note 12), p. 9.

[14] US Department of Defense (note 12), p. 7; and US Department of Defense (DOD), *Nuclear Posture Review 2018* (DOD: Washington, DC, Feb. 2018). On the 2018 NPR see Kristensen, H. M., 'US nuclear forces', *SIPRI Yearbook 2019*. Note that the NPRs are public documents but the detailed requirements for the role of nuclear weapons are described in a number of White House and US DOD documents that remain classified.

[15] For further detail see Kristensen, H. M. and Korda, M., 'United States nuclear forces', *SIPRI Yearbook 2023*, pp. 252–53.

[16] Congressional Commission on the Strategic Posture of the United States (note 11), p. 48.

Warhead production

Since the end of the cold war, the USA has relied on refurbishment of existing warhead types to maintain the nuclear arsenal. The National Nuclear Security Administration (NNSA) delivered more than 200 refurbished nuclear weapons to the US military in 2023.[17] In more recent years, the USA has moved towards a more ambitious plan focused on producing new or significantly modified warheads. Because the plan depends heavily on the ability to produce new pits—the plutonium core of a nuclear weapon—the NNSA aimed to increase pit production capacity from around 10 per year to up to 30 pits in 2026 and at least 80 pits per year by 2030.[18] However, the NNSA acknowledged in 2022 that this timeline was unrealistic.[19] As a result, some of the nuclear weapon programmes described below will probably face delays or new delivery systems could be initially deployed with existing warheads.[20]

Strategic nuclear forces

US offensive strategic nuclear forces include heavy bombers, land-based ICBMs and nuclear-powered ballistic missile submarines (SSBNs). These forces, together known as the triad, changed little during 2023. SIPRI estimates that a total of 3508 nuclear warheads were assigned to the strategic triad, of which an estimated 1670 warheads were deployed on ballistic missiles and at heavy bomber bases.

Aircraft and air-delivered weapons

As of January 2024 the USAF heavy bomber fleet included B-1Bs, B-2As and B-52Hs. Of these, 66 (20 B-2As and 46 B-52Hs) were nuclear-capable, but not all are operationally deployed at any given time. The B-2A can deliver gravity bombs (B61-7, B61-11, B61-12 and B83-1) and the B-52H can deliver the AGM-86B/W80-1 nuclear air-launched cruise missile (ALCM). SIPRI estimates that approximately 788 warheads were assigned to strategic bombers, of which about 300 are deployed at bomber bases and ready for delivery on relatively short notice. The USA is modernizing its nuclear bomber force by upgrading nuclear command-and-control capabilities on existing bombers, developing improved nuclear weapons (the B61-12 gravity bomb and the new

[17] US National Nuclear Security Administration (NNSA), '2023: Year in review: Making our vision a reality', Feb. 2024.

[18] US National Nuclear Security Administration (NNSA), 'Plutonium pit production', Fact sheet, Apr. 2019; and US Government Accountability Office (GAO), *Nuclear Weapons: NNSA Should Further Develop Cost, Schedule, and Risk Information for the W87-1 Warhead Program*, Report no. GAO-20-73 (GAO: Washington, DC, Sep. 2020), pp. 7–8, 14–15.

[19] For further detail see Kristensen and Korda (note 15), pp. 253–54.

[20] US Air Force (USAF), *Report on Development of Ground-Based Strategic Deterrent Weapon*, Report to eight congressional committees (USAF: [Washington, DC,] May 2020), p. 4.

AGM-181 Long-Range Standoff, LRSO, cruise missile), and building a new heavy bomber (the B-21 Raider).

The first six B-21s are expected to enter service in 2027; the aircraft will gradually replace the B-1B and B-2 bombers.[21] The B-21 made its first flight in November 2023.[22] It is expected that the USAF will procure at least 100 (possibly as many as 145) of the new bombers, with the latest service costs estimated at approximately $203 billion for the entire 30-year operational programme, at an estimated production cost of $550 million per aircraft; however, several critical cost details remain classified.[23] To accommodate the incoming B-21s, the number of US bomber bases with nuclear capability is expected to increase from two as of January 2024 to five by the early 2030s.[24] Commercial satellite imagery indicates that a new weapons generation facility is under construction at Barksdale Air Force Base in Louisiana, which will reinstate its former nuclear storage capability upon completion.[25]

The B-21 appears to have a slightly smaller weapon load than the B-2. It will be capable of delivering four types of nuclear weapon: the B61-12 and B61-13 guided nuclear gravity bombs; the B61-11 nuclear earth-penetrator; and the AGM-181 LRSO ALCM, which is in development. The AGM-181 LRSO will replace the AGM-86B ALCM in the early 2030s and will carry the W80-4 nuclear warhead, a modified version of the W80-1 warhead that is used on the AGM-86B. In March 2023 the NNSA authorized the production engineering phase for the W80-4, with the first production unit scheduled to be ready by FY 2027 (September 2027), instead of FY 2025 as originally planned.[26] Production is scheduled to be completed in FY 2031.[27]

The B61-12 was previously viewed as a replacement for all other gravity bombs in the stockpile, including the B61-7, B61-11 and B83-1 used for strategic bombers. However, in October 2023 the Biden administration announced plans to develop a new modification of the B61 gravity bomb, the B61-13, possibly as part of an effort to gain Congressional approval to retire the

[21] Tirpak, J. A., 'B-21 Raider first flight now postponed to 2023', *Air and Space Forces Magazine*, 20 May 2022; and US Air Force, 'B-21 bomber to be unveiled Dec. 2', 20 Oct. 2022.

[22] Stone, M. and Swanson, D., 'US Air Force's new B-21 Raider "flying wing" bomber takes first flight', Reuters, 11 Nov. 2023.

[23] Capaccio, A., 'Under-wraps B-21 bomber is seen costing $203 billion into 2050s', Bloomberg, 17 Nov. 2021; Tirpak, J. A., 'A new bomber vision', *Air Force Magazine*, 1 June 2020; and Stone and Swanson (note 22).

[24] Dawkins, J. C., Commander, 8th Air Force and Joint-Global Strike Operations Center, Barksdale Air Force Base, 'B21 General Dawkins intro', YouTube, 19 Mar. 2020, 01:35; and Kristensen, H. M., 'USAF plans to expand nuclear bomber bases', FAS Strategic Security Blog, Federation of American Scientists, 17 Nov. 2020.

[25] Knight, M., 'Construction of new nuclear weapons facility at Barksdale AFB', FAS Strategic Security Blog, Federation of American Scientists, 20 Feb. 2024.

[26] US National Nuclear Security Administration (NNSA), 'W80-4 life extension program enters phase 6.4, production engineering', 1 May 2023.

[27] Leone, D., 'Two-year delay for first LRSO warhead, but NNSA says will still deliver on-time to Air Force', Defense Daily, 4 Aug. 2022.

B83-1.[28] The B61-13 will reportedly use the warhead from the outgoing B61-7s—and will thus have the same maximum yield of 360 kilotons—but will be modified with new safety and control features as well as a guided tail-kit for improved accuracy and to facilitate broad area targeting.[29] According to the US DOD, the B61-13 will not increase the size of the US stockpile because the number of B61-12s to be produced (approximately 480) 'will be lowered by the same amount as the number of B61-13s produced'.[30]

Land-based missiles

As of January 2024 the USA deployed 400 LGM-30G Minuteman III ICBMs in 400 silos across three missile wings.[31] Another 50 empty silos are kept in a state of readiness for reloading with stored missiles if necessary. SIPRI estimates that 800 warheads were assigned to the ICBM force, of which 400 were deployed on the missiles. Each Minuteman III ICBM is armed with either a 335-kt W78/Mk12A or a 300-kt W87-0/Mk21 warhead. ICBMs carrying the W87-0 can only be loaded with one warhead, while those carrying the W78 can be uploaded with up to two more warheads for a maximum of three multiple independently targetable re-entry vehicles (MIRVs).[32] In recent years, there has been growing internal pressure on the US government—which intensified in 2023—to re-MIRV some of the USA's deployed ICBMs.[33]

The USAF has scheduled its next-generation ICBM to begin replacing the Minuteman III in 2028, with full replacement by 2036, although delays to this schedule are expected.[34] The first flight test of this new ICBM—the LGM-35A Sentinel—was initially planned for 2023; however, technological and staffing issues have caused delays, pushing the first flight test and first full functional test back to FY 2024 and FY 2025, respectively.[35] In 2023 commercial satellite imagery revealed ongoing construction at an ICBM test launch silo at Vandenberg Air Force Base in California, one of more than 600 facilities that

[28] Kristensen, H. and Korda, M., 'Biden administration decides to build a new nuclear bomb to get rid of an old bomb', FAS Strategic Security Blog, Federation of American Scientists, 27 Oct. 2023.

[29] US Department of Defense, 'Department of Defense announces pursuit of B61 gravity bomb variant', Press release, 27 Oct. 2023.

[30] US Department of Defense, 'Fact sheet on B61 variant development', Fact sheet, 27 Oct. 2023.

[31] US Air Force, 'LGM-30G Minuteman III', Fact sheet, accessed 15 Mar. 2024.

[32] On the warheads and yields see also Kristensen, H. M. and Korda, M., 'United States nuclear forces', *SIPRI Yearbook 2021*, p. 341.

[33] Kristensen, H. M. et al., 'Strategic Posture Commission report calls for broad nuclear buildup', FAS Strategic Security Blog, Federation of American Scientists, 12 Oct. 2023.

[34] Richard, C. A., Commander, US Strategic Command, Statement before the US Senate, Armed Services Committee, 13 Feb. 2020, p. 9. On the Sentinel see also Kristensen and Korda (note 32), p. 341.

[35] 'LGM-35A Sentinel intercontinental ballistic missile, USA', Airforce Technology, 29 July 2022; and US Government Accountability Office (GAO), *Weapon Systems Annual Assessment*, Report no. GAO-23-106059 (GAO: Washington, DC, June 2023).

will require an upgrade as part of the Sentinel programme.[36] Complications related to these infrastructure upgrades have contributed to the delays and cost overruns faced by the programme: the USAF announced in January 2024 that the Sentinel deployment will be delayed by up to two years and cost an estimated 37 per cent more than originally expected.[37] The scale of the cost overrun triggered legislation (the 1982 Nunn–McCurdy Act) that potentially could result in the termination of the programme. To avoid this, the US Secretary of Defense must investigate the cause of the overrun, put in place mitigating measures and re-certify the programme as essential to national security.[38]

Each Sentinel will be able to carry up to two warheads, with the USAF planning to produce a significantly modified warhead based on the same design as the W87-0, known as the W87-1. The cost of the W87-1 warhead-modernization programme has been estimated at between $11.9 billion and $15.9 billion in 'then-year' dollars (i.e. the values account for inflation), but this excludes the considerable costs of producing the plutonium pits for the warhead.[39] The programme formally entered the development engineering phase in May 2023, with completion of the first production unit expected sometime in FY 2031 or FY 2032 (although the original plan was for FY 2030).[40] However, production of the W87-1 in time to meet the Sentinel's planned deployment schedule depended on the NNSA's projected production rate of at least 80 plutonium pits per year by 2030 (see above). The NNSA's acknowledgement that this objective was unrealistic means that the Sentinel will initially be deployed with the existing W87-0 warheads.[41]

The Sentinel is also expected to carry a new type of re-entry vehicle (known as the Next Generation Re-entry Vehicle, NGRV). The USAF's budget for FY 2024 includes funding for 'early acquisition activities' for the NGRV. To accommodate the delays affecting production of the W87-1 warhead, the NGRV will be capable of carrying both current and future warheads.[42]

Sea-based missiles

The US Navy operates a fleet of 14 Ohio-class SSBNs, of which 12 are normally considered to be operational with the remaining 2 typically undergoing

[36] US Government Accountability Office (note 35); and authors' assessment based on analysis of satellite imagery.

[37] Tirpak, J. A., 'New ICBM has "critical" cost and schedule overruns, needs SecDef certification to continue', *Air and Space Forces Magazine*, 18 Jan. 2024.

[38] Knight, M., '"Critical" overrun of Sentinel ICBM program demands government transparency', FAS Strategic Security Blog, Federation of American Scientists, 2 Feb. 2024.

[39] US Department of Energy (note 4), pp. 8-27, 8-32.

[40] US Department of Energy (note 4), pp. 1-6, 2-10, 2-11, 8-6.

[41] For further detail see Kristensen and Korda (note 15), pp. 253–54.

[42] US Department of Defense (DOD), *Department of Defense Fiscal Year (FY) 2024 Budget Estimates*, Justification Book, vol. 3 of 4, Research, Development, Test and Evaluation, Air Force (DOD: Washington, DC, Mar. 2023).

maintenance at any given time. Eight of the SSBNs are based at Naval Base Kitsap in Washington state, on the Pacific Ocean, and six at Naval Submarine Base Kings Bay in Georgia, on the Atlantic. The last mid-life refuelling was completed in March 2022, meaning that all 14 boats are now potentially deployable until 2027, when the first Ohio-class submarine is expected to retire.[43]

Each Ohio-class SSBN was built to carry up to 24 Trident II SLBMs, but to meet the New START limit on deployed launchers, 4 of the 24 initial missile tubes on each submarine were deactivated so that the 12 SSBNs that are usually operational can carry no more than 240 missiles.[44] At any given time 8–10 SSBNs are normally at sea, of which 4–5 are on alert in their designated patrol areas and ready to fire their missiles within 15 minutes of receiving the launch order. The US SSBN fleet conducts about 30 deterrence patrols per year.[45]

The Trident II D5 SLBMs carry two basic warhead types: the 455-kt W88 and the W76. The latter exists in two versions: the 90-kt W76-1 and the low-yield W76-2.[46] The NNSA has begun modernizing the ageing W88 warhead. The first production unit of the W88 Alt 370 was completed on 1 July 2021 and the warhead was formally accepted into the stockpile in 2023.[47] Each SLBM can carry up to eight warheads but normally carries an average of four or five. SIPRI estimates that around 1920 warheads were assigned to the SSBN fleet as of January 2024, of which approximately 970 were deployed on SLBMs.[48]

The low-yield W76-2, which was first deployed in late 2019 and is operational on SSBNs in both the Atlantic and the Pacific, is a modification of the W76-1 and is estimated to have an explosive yield of 8 kt.[49] The 2022 NPR left open the possibility that the W76-2 warhead might be retired as the B61-12 and the LRSO's low-yield capabilities are fielded over the coming decade.[50]

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'), which is equipped with the new Mk6 guidance system. The upgrade is scheduled for

[43] Puget Sound Naval Shipyard and Intermediate Maintenance Facility, 'Louisiana back underway: Project team completes the final engineering refueling overhaul for an Ohio-class ballistic missile submarine', US Navy, Naval Sea Systems Command, 8 Mar. 2023.

[44] US Navy Office of Information, 'Fleet ballistic missile submarines—SSBN', Fact file, 25 May 2021.

[45] See e.g. Kristensen, H., 'US SSBN patrols steady, but mysterious reduction in Pacific in 2017', FAS Strategic Security Blog, Federation of American Scientists, 24 May 2018.

[46] The older W76-0 version has been, or remains in the process of being, retired. On these warheads see Kristensen and Korda (note 32), p. 341.

[47] US National Nuclear Security Administration (NNSA), 'NNSA completes first production unit of W88 Alteration 370', 13 July 2021; and US Department of Energy (note 4), p. 2-1.

[48] US Department of State (note 6).

[49] Arkin, W. M. and Kristensen, H. M., 'US deploys new low-yield nuclear submarine warhead', FAS Strategic Security Blog, Federation of American Scientists, 29 Jan. 2020; US Department of Defense, 'Statement on the fielding of the W76-2 low-yield submarine launched ballistic missile warhead', Press release, 4 Feb. 2020; and US military officials, Private communication with authors, 2019–20.

[50] US Department of Defense (note 12), p. 20.

completion in 2025.[51] It will arm Ohio-class SSBNs for the remainder of their service lives (up to 2042) and will also be deployed on the United Kingdom's Trident submarines (see section III).

A new class of at least 12 SSBNs (the Columbia class) is under construction to replace the Ohio class. The lead boat in the new class, the USS *District of Columbia*, is scheduled to start patrols in 2031.[52] Each Columbia-class SSBN will carry 16 missiles, initially the D5LE, but from 2039 these will be replaced with an upgraded SLBM, the D5LE2.[53]

To arm the D5LE2, the NNSA has begun early design development of a new nuclear warhead, known as the W93. This will be the first new warhead design fielded by the USA since the end of the cold war. The W93 warhead will be housed in a new Mk7 re-entry body (aeroshell) that will also be deployed on the UK's new Dreadnought-class submarines (see section III). The W93 appears intended to initially supplement, rather than replace, the W76-1 and the W88. Another new warhead is planned to replace those warheads. The completion of the first production unit of the W93 is tentatively scheduled for 2034–36.[54]

Non-strategic nuclear forces

As of January 2024 the USA had one basic type of non-strategic weapon in its nuclear arsenal—the B61 gravity bomb, with three versions assigned to non-strategic forces: the B61-3, the B61-4 and the new B61-12, which is scheduled to replace the two older versions by 2026.[55]

SIPRI estimates that there were 200 B61 bombs in the stockpile, of which approximately 100 (all B61-3/-4 versions) were deployed in Europe for potential use by US and allied combat aircraft. The bombs, which are controlled by the US Air Force, are deployed at six airbases in five North Atlantic Treaty Organization (NATO) member states: Kleine Brogel in Belgium; Büchel in Germany; Aviano and Ghedi in Italy; Volkel in the Netherlands; and İncirlik in Türkiye.[56] The remaining (*c.* 100) B61 bombs are thought

[51] Wolfe, J., Director of US Strategic Systems Programs, 'US nuclear weapons policy, programs, and strategy in review of the defense authorization request for fiscal year 2020 and the Future Years Defense Program', Statement before the US Senate, Armed Services Committee, Subcommittee on Strategic Forces, 1 May 2019, p. 4.

[52] Wolfe (note 51), p. 8.

[53] Wolfe, J., Director of US Strategic Systems Programs, 'FY2021 budget request for nuclear forces and atomic energy defense activities', Statement before the US House of Representatives, Armed Services Committee, Subcommittee on Strategic Forces, 3 Mar. 2020, p. 5.

[54] US Department of Energy (note 3), p. 2-10.

[55] Another version of the B61, the B61-10, was retired in Sep. 2016. US Department of Energy (DOE), National Nuclear Security Administration (NNSA), *Fiscal Year 2018 Stockpile Stewardship and Management Plan*, Report to Congress (DOE: Washington, DC, Nov. 2017), figures 1.1–1.7, p. 1-13.

[56] For detailed overviews of the dual-capable aircraft programmes of the USA and its NATO allies see Kristensen (note 14), pp. 299–300; and Andreasen, S. et al., *Building a Safe, Secure, and Credible NATO Nuclear Posture* (Nuclear Threat Initiative: Washington, DC, Jan. 2018).

to be stored at Kirtland Air Force Base in New Mexico for potential use by US aircraft, possibly including in East Asia.[57] USA-based combat aircraft assigned this mission include F-15Es of the 366th Fighter Wing at Mountain Home Air Force Base in Idaho.[58]

There was growing evidence in 2022 and 2023 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.[59] 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.[60]

Full-scale production of the B61-12 began in late 2022 and the first bombs were formally accepted into the US military stockpile in 2023, with the entire replacement process scheduled to be completed by 2026.[61] Once deployment to the bases in Europe begins, the B61-3 and B61-4 bombs currently deployed at those bases will gradually be returned to the USA and dismantled. Unlike the older versions, the B61-12 is equipped with a guided tail-kit that enables the B61-12 to hit targets more accurately, meaning that it can use lower yields and thus generate less radioactive fallout.[62]

Operations continued in 2023 to integrate the incoming B61-12 on seven types of aircraft operated by the USA or its NATO allies: the B-2A, the new B-21, the F-15E, the F-16C/D, the F-16MLU, the F-35A and the PA-200 (Tornado).[63] In October 2023 the F-35A achieved technical certification to carry the B61-12, clearing the way for USAF units in Europe to complete their nuclear surety certifications before later receiving the new bombs.[64] The F-35A will replace all Belgian, Dutch and US F-16s and German and Italian Tornado aircraft in the nuclear strike role.

[57] US Department of Defense, *Nuclear Posture Review 2018* (note 14), p. 48.

[58] Heflin, L., '53rd Wing WSEP incorporates NucWSEP, enhances readiness for real world operations', Press release, Air Combat Command, 9 Sep. 2021.

[59] 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.

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

[61] Meub, K., 'B61-12 production begins', *Sandia LabNews*, Sandia National Laboratories, 11 Feb. 2022; and US Department of Energy (note 4), p. 2-1.

[62] 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.

[63] US Air Force (USAF), *Acquisition Annual Report Fiscal Year 2018: Cost-effective Modernization* (USAF: Washington, DC, [n.d.]), p. 24.

[64] Marrow, M., 'EXCLUSIVE: F-35A officially certified to carry nuclear bomb', Breaking Defense, 8 Mar. 2024.

The 2018 NPR implemented by the Trump administration included plans to develop a new nuclear sea-launched cruise missile (SLCM-N) that would form part of the USA's non-strategic nuclear arsenal. The 2022 NPR released by the Biden administration seemingly rejected this plan. However, in 2023 the US Congress challenged the Biden administration's decision by authorizing funding for further research and reinstating the SLCM-N as part of the nuclear modernization programme. Despite strong initial opposition from the Biden administration, the NDAA for FY 2024 authorized $190 million for the missile and associated warhead, with the aim of reaching operational capability in 2034.[65] Development of the SLCM-N would violate the US pledge from 1992 not to develop such a weapon and could potentially result in the first significant increase in the size of the US nuclear weapon stockpile since 1996.[66]

[65] 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 National Defense Authorization Act for Fiscal Year 2024 (note 10), pp. 460–62.

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

Table 7.2. United States nuclear forces, January 2024

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

Type	Designation	No. of launchers	Year first deployed	Range (km)[a]	Warheads x yield	No. of warheads[b]
Strategic nuclear forces		**746**				**3 508**[c]
Aircraft (bombers)		*96/66*[d]				*788*[e]
B-52H	Stratofortress	76/46	1961	16 000	20 x AGM-86B ALCMs 5–150 kt[f]	500[g]
B-2A	Spirit	20/20	1994	11 000	16 x B61-7, -11, -12, B83-1 bombs[h]	288
Land-based missiles (ICBMs)		*400*				*800*[i]
LGM-30G Minuteman III						
	Mk12A	200	1979	13 000	1–3 x W78 335 kt	600[j]
	Mk21 SERV	200	2006	13 000	1 x W87-0 300 kt	200[k]
Sea-based missiles (SLBMs)		*14/280*[l]				*1 920*[m]
UGM-133A Trident II D5LE						
	Mk4	..	1992	>12 000	1–8 x W76-0 100 kt	–[n]
	Mk4A	..	2008	>12 000	1–8 x W76-1 90 kt	1 511
	Mk4A	..	2019	>12 000	1 x W76-2[o] 8 kt	25
	Mk5	..	1990	>12 000	1–8 x W88 455 kt	384
Non-strategic nuclear forces						**200**[p]
F-15E	Strike Eagle	..	1988	3 840	5 x B61-3, -4	80
F-35A	Lightning II	..	2023	>2 200	2 x B61-12	..
F-16C/D	Falcon	..	1987	3 200[q]	2 x B61-3, -4	60
F-16MLU	Falcon[r]	..	1985	3 200	2 x B61-3, -4	30
PA-200	Tornado[r]	..	1983	2 400	2 x B61-3, -4	30
Total stockpile						**3 708**
Deployed warheads						1 770
Reserve warheads						1 938
Retired warheads awaiting dismantlement						**1 336**[s]
Total inventory						**5 044**[t]

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

[a] For aircraft, the listed range is for illustrative purposes only; actual mission range will vary according to flight profile, weapon payload and in-flight refuelling.

[b] These figures show the total number of warheads estimated to be assigned to nuclear-capable delivery systems. Only some of these warheads have been deployed on missiles and at airbases, as described in the notes below.

[c] Of these strategic warheads, *c.* 1670 were deployed on land- and sea-based ballistic missiles and at bomber bases. The remaining warheads were in central storage. This number differs from the number of deployed strategic warheads counted by the 2010 Russian–US Treaty on Measures for the Further Reduction and Limitation of Strategic Offensive Arms (New START) because the treaty attributes 1 weapon to each deployed bomber, even though bombers do not carry weapons under normal circumstances. Additionally, the treaty does not count weapons stored at bomber bases and, at any given time, some nuclear-powered ballistic missile submarines (SSBNs) are not fully loaded with warheads and are thus not counted under the treaty. The USA no longer publishes aggregate figures for strategic nuclear forces limited by New START.

[d] The first figure is the total number of bombers in the inventory; the second is the number of bombers that are counted as nuclear-capable under New START. 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.

[e] Of the *c.* 788 bomber weapons, *c.* 300 (200 ALCMs and 100 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 deployment of the B61-12 is completed in the mid 2020s.

[f] The B-52H is no longer configured to carry nuclear gravity bombs.

[g] In 2006 the US Department of Defense decided to reduce the number of ALCMs to 528 missiles. Burg, R., Director of Strategic Security in the Air, Space and Information Operations, 'ICBMs, helicopters, cruise missiles, bombers and warheads', Statement before the US Senate, Armed Services Committee, Subcommittee on Strategic Forces, 28. Mar. 2007, p. 7. Since then, the number has probably decreased gradually to *c.* 500 as some missiles and warheads have probably been expended in destructive tests.

[h] Strategic gravity bombs are assigned to B-2A bombers only. The maximum yield of strategic bombs is 360 kt for the B61-7, 400 kt for the B61-11 and 1200 kt for the B83-1. However, all these bombs, except the B61-11, have lower-yield options. Most B83-1s have been moved to the inactive stockpile and B-2As rarely exercise with the bomb. The B61-12 was formally accepted into the stockpile in 2023 and assigned for use by B-2A bombers.

[i] Of the 800 ICBM warheads, only 400 were deployed on the missiles. The remaining warheads were in central storage.

[j] Only 200 of these 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.

[k] 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.

[l] The first figure is the total number of SSBNs in the US fleet; the second is the maximum number of missiles that they can carry. However, although the 14 SSBNs can carry up to 280 missiles, 2 vessels are normally undergoing refuelling overhaul or long-term maintenance 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.

[m] Of the 1920 SLBM warheads, *c.* 970 were deployed on submarines as of Jan. 2024; 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 are estimated to carry only 1 warhead each.

[n] It is assumed here that all W76-0 warheads have been replaced by the W76-1.

[o] According to US military officials, the new low-yield W76-2 warhead will normally be deployed on at least 2 of the SSBNs on patrol in the Atlantic and Pacific oceans.

[p] 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. Older B61 versions will be dismantled once the B61-12 is deployed. The maximum yields of non-strategic bombs are 170 kt for the B61-3 and 50 kt for the B61-4. All have selective lower yields. The B61-10 was retired in 2016.

[q] Most sources list an unrefuelled ferry range of 2400 kilometres, but Lockheed Martin, which produces the F-16, lists 3200 km.

[r] These dual-capable aircraft are operated at airbases outside the USA by other members of NATO.

[s] Up until 2018, the US government published the number of warheads dismantled each year, but the administration of President Donald J. Trump ended this practice. The administration of President Joe Biden temporarily restored transparency, but publication of the 2018, 2019 and 2020 data showed that far fewer warheads had been dismantled than assumed (e.g. only

184 in 2020). Nonetheless, dismantlement of the warheads has continued, leaving an estimated 1336 warheads in the dismantlement queue as of Jan. 2024.

[t] In addition to these intact warheads, more than 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.

Sources: US Department of Defense, various budget reports and plans, press releases and documents obtained under the Freedom of Information Act; US Department of Energy, various budget reports and plans; US Air Force, US Navy and US Department of Energy, personal communication with officials; *Bulletin of the Atomic Scientists*, 'Nuclear notebook', various issues; and authors' estimates.

II. Russian nuclear forces

HANS M. KRISTENSEN AND MATT KORDA*

As of January 2024 the Russian Federation maintained a military stockpile of approximately 4380 nuclear warheads. About 2822 of these were strategic warheads, of which roughly 1710 were deployed on land- and sea-based ballistic missiles and at bomber bases. Russia also possessed approximately 1558 non-strategic (tactical) nuclear warheads, all of which are assessed to be at central storage sites. Although the authors estimate that Russia had a higher number of strategic warheads in January 2024 than in January 2023, the estimated number of non-strategic warheads has been revised downwards based on new assessments, resulting in a net overall decrease in the Russian military stockpile of around 109 warheads compared with the estimate for the previous year. As of January 2024 an additional 1200 retired warheads were awaiting dismantlement (200 fewer than the previous year's estimate, based on assumptions of the current rate of dismantlement), giving Russia a total estimated inventory of approximately 5580 nuclear warheads (see table 7.3, end of section).

These estimates are based on publicly available information about the Russian nuclear arsenal and assessments by the authors. Because of a lack of transparency, estimates and analysis of Russia's nuclear weapon developments come with considerable uncertainty, particularly regarding the country's sizable stockpile of non-strategic nuclear weapons. However, it is possible to formulate a reasonable assessment of the progress of Russia's nuclear modernization by reviewing satellite imagery and other forms of open-source intelligence, official statements, industry publications and state media interviews with Russian government officials.[1]

This section details Russia's holdings of strategic and non-strategic air-delivered, land-based and sea-based nuclear weapons. Before doing so, it first considers Russia's compliance with its bilateral arms control obligations and describes the role played by nuclear weapons in Russian military doctrine.

Russian compliance with New START

In February 2023 President Vladimir Putin announced Russia's intention to 'suspend' its participation in the last remaining bilateral strategic arms control treaty between Russia and the United States, the 2010 Treaty on Measures for the Further Reduction and Limitation of Strategic Offensive

[1] Kristensen, H. M. and Korda, M., 'Estimating world nuclear forces: An overview and assessment of sources', SIPRI Commentary, 14 June 2021.

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Arms (New START).[2] This treaty places a cap on the numbers of Russian and US deployed strategic nuclear forces and allows for on-site inspections to verify compliance.[3]

Although Putin stated in 2023 that Russia planned to remain within the central limits set by New START, the decision to suspend treaty inspections indefinitely meant that the USA could not verify that Russia remained in compliance with its obligation to deploy no more than 1550 strategic warheads.[4] Nonetheless, the US assessed that Russia 'likely did not exceed the New START Treaty's deployed warhead limit in 2023'.[5]

The last bilateral data exchanges under the treaty are from September 2022. Russia declared that it had 1549 deployed warheads attributed to 540 strategic launchers, thus remaining under the final warhead limits of New START.[6] Just as with the USA, many of Russia's strategic delivery systems carry fewer warheads than their maximum capacity in order to meet the New START limits. If Russia chose to no longer comply with the treaty limits, or if the treaty were to expire without a follow-on agreement, Russia (like the USA) could add reserve warheads to missiles and bombers and potentially double its number of deployed strategic nuclear weapons.[7]

The role of nuclear weapons in Russian military doctrine

Russia's official deterrence policy, which was last updated in a decree in 2020, lays out explicit conditions under which it could launch nuclear weapons: (*a*) the receipt of reliable data on a launch of ballistic missiles attacking the territory of Russia or its allies; (*b*) the use of nuclear weapons or other types of weapon of mass destruction against Russia or its allies; (*c*) an attack against Russia's critical governmental or military sites, disruption of which would undermine the nuclear forces; and (*d*) aggression against Russia with the use of conventional weapons when the very existence of the state is in jeopardy.[8] This formulation is largely consistent with previous public iterations of

[2] President of Russia, 'Presidential address to Federal Assembly', 21 Feb. 2023.

[3] For a summary and other details of New START see annex A, section III, in this volume. On related developments in 2023 see chapter 8, section I, in this volume.

[4] 'Russia suspends START arms inspections over US travel curbs', Reuters, 8 Aug. 2022; Atwood, K. and Hansler, J., 'Russia postpones nuclear arms control talks with US, State Department says', CNN, 28 Nov. 2022; and US Department of State, 'Report to Congress on implementation of the New START Treaty', Jan. 2024.

[5] US Department of State (note 4), p. 6.

[6] US Department of State, Bureau of Arms Control, Verification and Compliance, 'New START Treaty aggregate numbers of strategic offensive arms', Fact sheet, 1 Sep. 2022.

[7] Korda, M. and Kristensen, H., 'If arms control collapses, US and Russian strategic nuclear arsenals could double in size', FAS Strategic Security Blog, Federation of American Scientists, 7 Feb. 2023. On the negotiation of the renewal of New START see chapter 8, section I, in this volume.

[8] 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.

Russian nuclear policy under President Putin, which also shied away from no-first-use policies and negative security assurances.

The Russia–Ukraine war has raised questions about Russia's nuclear doctrine, and about where, when, how and under what conditions Russia might use nuclear weapons. Several speeches made by President Putin and senior Russian officials and commentators alluding to the potential use of nuclear weapons in the conflict have added to the uncertainty.[9] For example, in January 2023 Dmitry Medvedev, the former Russian president and current deputy chairman of the Russian Security Council, stated in an interview that 'defeat of a nuclear power in a conventional war may trigger a nuclear war'. However, use of nuclear weapons in Ukraine would appear to exceed the conditions in the 2020 decree because losing the war in Ukraine would not threaten the existence of the Russian state.[10]

Strategic nuclear forces

As of January 2024 Russia had an estimated 2822 warheads assigned for potential use by strategic launchers: heavy bombers, land-based intercontinental ballistic missiles (ICBMs) and submarine-launched ballistic missiles (SLBMs). This is an increase of approximately 149 warheads compared with January 2023 due to fluctuations in the arsenal caused by the deployment of newer ICBMs with multiple independently targetable re-entry vehicles (MIRVs) as well as the introduction of a new nuclear-powered ballistic missile submarine (SSBN).

Aircraft and air-delivered weapons

As of January 2024 the Long-Range Aviation command of the Russian Air Force operated a fleet of approximately 67 operational heavy bombers, comprising 15 Tu-160 (Blackjack) and 52 Tu-95MS (Bear) bombers.[11] SIPRI estimates that perhaps only 58 of these are counted as deployed under New START. The maximum possible payload on the bombers is approximately 650 nuclear weapons; however, since some of the bombers were not fully operational, it is assumed here that Russia has not produced this many warheads for its bomber force. SIPRI estimates that weapons exist only for the deployed bomber force, giving a total of approximately 586 warheads. Around 200 of these weapons are probably stored at the two strategic bomber bases:

[9] See e.g. President of Russia, 'Address by the president of the Russian Federation', 24 Feb. 2022; President of Russia, 'Address by the president of the Russian Federation', 21 Sep. 2022; and 'Russia can defend new regions with nuclear weapons: Medvedev', Al Jazeera, 22 Sep. 2022.

[10] Faulconbridge, G. and Light, F., 'Putin ally warns NATO of nuclear war if Russia is defeated in Ukraine', Reuters, 19 Jan. 2023.

[11] For the missiles, aircraft and submarines discussed in this section, a designation in parentheses (e.g. Blackjack) following the Russian designation (e.g. Tu-160) is that assigned by the North Atlantic Treaty Organization (NATO).

Engels in Saratov oblast and Ukrainka in Amur oblast. Russia has historically housed all its strategic bombers at these two bases, but commercial satellite imagery revealed that Russia dispersed large numbers of bombers to its Belaya (Irkutsk oblast) and Olenya (Murmansk oblast) airbases during 2023 after Ukraine attacked the Engels airbase in several drone strikes.[12]

Modernization of the bombers—which includes upgrades to their avionics suites, engines and long-range nuclear and conventional cruise missiles—continued throughout 2023 but remained subject to delays.[13] Both the Tu-160 and the Tu-95 strategic bombers currently carry the Kh-55 (AS-15) air-launched cruise missile (ALCM), but this is being replaced on the upgraded bombers by the new Kh-102 (AS-23B) ALCM. It seems likely that all of the Tu-160s (including at least 10 brand-new Tu-160M2 bombers) and most of the Tu-95s will eventually be upgraded to maintain a bomber force of perhaps 50–60 operational aircraft. These modernized bombers are intended to be a temporary bridge to Russia's next-generation bomber: the PAK-DA, serial production of which is planned to begin in 2028–29.[14] The PAK-DA will also eventually replace all Tu-22M3M (Backfire-C) bombers deployed with non-strategic forces (see below).[15]

During a visit by North Korean leader Kim Jong Un to Russia's Knevichi airfield (near the city of Vladivostok) in September 2023, Russia revealed a Tu-160 aircraft equipped with 'novel' Kh-BD cruise missiles, which could be based upon the existing Kh-102. It is unclear, however, whether the new missile had been deployed or whether it was still under development at the end of 2023.[16]

Land-based missiles

As of January 2024 the Strategic Rocket Forces (SRF)—the branch of the Russian armed forces that controls land-based ICBMs—consisted of 12 missile divisions grouped into 3 armies, deploying an estimated 329 ICBMs

[12] Tiwari, S., 'After Tu-95 bomber, Russia's Tu-22 M3 Backfire destroyed in Ukraine drone attack—reports', Eurasian Times, 21 Aug. 2023.

[13] President of Russia, 'Meeting with workers of Gorbunov Kazan aviation factory and Tu-160M pilots', 25 Jan. 2018; Ignatyeva, L., 'New Kazan strategic bombardier hits the sky', Realnoe Vremya, 11 Jan. 2023; and President of Russia, 'Заседание коллегии Министерства обороны' [Ministry of Defence Board meeting], 21 Dec. 2022.

[14] 'PAK DA demonstrational model to be ready by 2023—Source', TASS, 2 Aug. 2021; 'Russia begins construction of the first PAK DA strategic bomber—Sources', TASS, 26 May 2020; Lavrov, A., Kretsul, R. and Ramm, A., 'ПАКетное соглашение: новейшему бомбардировщику назначили сроки выхода в серию' [PAKage agreement: The latest bomber assigned a deadline for production], *Izvestia*, 14 Jan. 2020; and 'Russia tests engine for next-generation strategic missile-carrying bomber', TASS, 31 Oct. 2022.

[15] 'Russia to test next-generation stealth strategic bomber', TASS, 2 Aug. 2019.

[16] Cook, E., 'What is Kh-BD? Russian Tu-160 bombers armed with new long range missiles', *Newsweek*, 19 Sep. 2023.

of different types and variations (see table 7.3).[17] These ICBMs can carry a maximum of about 1244 warheads, but SIPRI estimates that they have had their warhead load reduced to around 872 warheads to keep Russia below the New START limit for deployed strategic warheads. These ICBMs carry approximately half of Russia's estimated 1710 deployed strategic warheads.

Russia is close to completing the replacement of Soviet-era ICBMs with new types, although this process has taken much longer than expected. By December 2023 around 88 per cent of the ICBM force had reportedly been modernized.[18] The bulk of the modernization programme has focused on the RS-24 Yars (SS-27 Mod 2), a MIRVed version of the RS-12M1/2 Topol-M (SS-27 Mod 1). SIPRI estimates that, as of January 2024, the number of deployed RS-24s had risen to approximately 204 mobile- and silo-based RS-24 missiles, including all six completed mobile divisions (at Barnaul, Irkutsk, Nizhniy Tagil, Novosibirsk, Vypolzovo and Yoshkar-Ola).[19] The rearmament of all of these divisions means that, by the end of 2023, Russia's entire strategic mobile ICBM force had rearmed with post-Soviet era missiles.[20]

Deployment of silo-based RS-24s continues at Kozelsk, Kaluga oblast, with one regiment of 10 silos completed in 2018 and the second completed in 2020.[21] The third regiment began combat duty in December 2021 and SIPRI estimates that four of its silos were loaded with missiles by the end of 2023.[22] The 60 RS-12M2 Topol-M (SS-27 Mod 1) silos at Tatishchevo, Saratov oblast, will also probably be upgraded to the RS-24.

Russia is in the final stages of rearming its first two regiments of the Soviet-era RS-20V (SS-18 Mod 5 Satan) ICBM at Dombarovsky, Orenburg oblast, with RS-18 (SS-19 Mod 4) missiles equipped with the Avangard hypersonic glide vehicle (HGV) system. The first regiment completed its rearmament in December 2021, while the second reportedly completed its rearmament in December 2023, although satellite imagery indicated that construction had not concluded by the end of the year.[23]

[17] One of these ICBM divisions, the 8th Missile Division at Yurya, Kirov oblast, was being modernized alongside the rest of the ICBM force; however, the division's Sirena-M ICBMs are believed to serve as back-up launch code transmitters and therefore have not been armed with nuclear weapons.

[18] Karakaev, S. V. , interviewed in *Krasnaya Zvezda*, 'Стратегическая мощь России крепнет' [Russia's strategic power is growing], Dzen News, 16 Dec. 2023.

[19] Karakaev (note 18); and authors' estimates.

[20] Karakaev (note 18); and authors' estimates.

[21] 'Два полка РВСН в 2021 году будут перевооружены на ракетные комплексы "Ярс"' [Two regiments of the Strategic Rocket Forces will be re-equipped with 'Yars' missile systems in 2021], TASS, 21 Dec. 2020; Karakaev, S. V., interviewed in Biryulin, R., Andreev, D. and Reznik, A., 'Ядерный щит России по-прежнему надёжен' [Russia's nuclear shield is still reliable], *Krasnaya Zvezda*, 16 Dec. 2022; and authors' assessment based on analysis of satellite imagery.

[22] Karakaev, S. V., interviewed in Biryulin, R. and Andreev, D., 'Бесспорный аргумент России' [Russia's indisputable argument], *Krasnaya Zvezda*, 17 Dec. 2021; and authors' estimates.

[23] President of Russia, 'Expanded meeting of the Defence Ministry Board', 21 Dec. 2021; Karakaev (note 18); and authors' estimates.

Russia has also been developing a new ‘heavy’ liquid-fuelled, silo-based ICBM, known as the RS-28 Sarmat (SS-29), as an additional replacement for the RS-20V. Russia is believed to have flight-tested the RS-28 only twice: in April 2022 and in February 2023, with the latter probably being a failed test.[24] Nevertheless, satellite imagery and official statements from 2023 suggest that the RS-28 is rapidly approaching deployment.[25] The first division to receive RS-28 ICBMs will be the ICBM division at Uzhur, Krasnoyarsk krai.[26] Satellite imagery indicates that one regiment’s older RS-20Vs have already been removed to prepare for the incoming RS-28 ICBMs and that construction for at least four silos had been completed by the end of 2023, although it was unclear whether any RS-28 ICBMs had been loaded into those silos.

Several new ICBM programmes, as well as various HGVs that could be fitted on modified ICBMs, appear to be in the early stages of development. These follow-on programmes reportedly include the ‘Yars-M’ (a MIRV-capable ICBM that uses a parallel-staging rocket booster configuration), the ‘Osina-RV’ (a modernized version of the RS-24) and the ‘Kedr’ (a next-generation system intended to replace the RS-24).[27]

In December 2023 Russia announced plans to conduct seven ICBM flight tests in 2024. However, given that in recent years Russia has launched significantly fewer ICBMs than planned, it may not meet this target.[28]

Sea-based missiles

As of January 2024 the Russian Navy had a fleet of 12 nuclear-armed SSBNs, made up of 5 Soviet-era Delfin-class or Project 667BDRM (Delta IV) SSBNs and 7 Borei-class or Project 955/955A (Dolgorukiy) SSBNs. A few of these are in overhaul at any given time and not considered fully operational.

Russia plans to replace the 5 remaining Delfin-class SSBNs with new Borei-A (or Project 955A) SSBNs. It probably aims to have a total of 12 Borei-class SSBNs. Half will be assigned to the Northern Fleet (in the Arctic Ocean)

[24] President of Russia, ‘Test launch of Sarmat ICBM’, 20 Apr. 2022; and Liebermann, O. and Bertrand., N., ‘US believes Russia had failed intercontinental ballistic missile test around when Biden was in Ukraine’, CNN, 22 Feb. 2023.

[25] Korda, M. and Kristensen, H., ‘Upgrade underway for Russian silos to receive new Sarmat ICBM’, FAS Strategic Security Blog, Federation of American Scientists, 19 Oct. 2023; Минобороны России (@mod_russia), Telegram, 7 Oct. 2023, <https://t.me/mod_russia/31220>; and ‘First Sarmat ICBMs regiment to go on combat duty in December 2023–Source’, TASS, 19 Nov. 2023.

[26] Karakaev (note 21).

[27] Karakaev (note 18); 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.

[28] Karakaev (note 18).

and the other half to the Pacific Fleet.[29] After years of delays due to technical issues, over the past four years Russia has delivered new Borei-A SSBNs to the navy at an average rate of one per year. One new Borei-A SSBN—*Imperator Alexandr III* (also known as *Emperor Alexander III*)—was delivered to the navy in 2023, with the remainder scheduled for delivery in the late 2020s or early 2030s.[30] A new design concept for a follow-on SSBN, known as 'Arktur' or 'Arcturus', was unveiled in 2022. The new SSBN would be smaller than the current Borei class, have a reduced number of ballistic missiles and, if the design is approved, begin replacing the Borei SSBNs in the late 2030s.[31]

Each of the 12 operational SSBNs can be equipped with 16 ballistic missiles and the Russian SSBN fleet can carry up to 992 warheads.[32] However, one or two SSBNs are normally undergoing repairs and maintenance at any given time and are not armed. It is also possible that the warhead load on some missiles has been reduced to meet the total warhead limit under New START. As a result, SIPRI estimates that about 640 of the 992 warheads are deployed. The Delfin SSBNs are thought to carry RSM-54 SLBMs, either the Sineva (SS-N-23 M2) or a modified version, known as Layner (SS-N-23 M3), while the Borei and Borei-A SSBNs carry newer RSM-56 Bulava (SS-N-32) SLBMs.

In 2023 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* or Project 09852, which is a converted Antei-class or Project 949A (Oscar II) nuclear-powered guided-missile submarine (SSGN); and the *Khabarovsk* or Project 09851.[33] The Poseidon system was reportedly tested twice in 2023.[34]

[29] 'Sevmash shipyard ready to continue construction of Borei-A nuclear subs—CEO', TASS, 16 Mar. 2023.

[30] Russian Federation, 'Ceremony for raising naval flags on nuclear-powered submarines Emperor Alexander III and Krasnoyarsk', 11 Dec. 2023; and Sevmash, 'На Севмаше заложили атомные подводные крейсеры «Дмитрий Донской» и «Князь Потемкин»' [Nuclear-powered submarine cruisers 'Dmitry Donskoy' and 'Prince Potemkin' laid down at Sevmash], 23 Aug. 2021.

[31] '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.

[32] The Delfin-class SSBNs carry RSM-54 Sineva/Layner (SS-N-23 M2/3) SLBMs, while the Borei and Borei-A SSBNs carry RSM-56 Bulava (SS-N-32) SLBMs. Each RSM-54 can carry up to 4 warheads, while each RSM-56 can carry up to 6 warheads. It is assumed that each RSM-56 has had its warhead load reduced to 4 warheads, to meet New START limits.

[33] Sutton, H. I., 'Khabarovsk-class-submarine', Covert Shores, 20 Nov. 2020; and Sutton, H. I., 'Poseidon torpedo', Covert Shores, 22 Feb. 2019.

[34] 'АПЛ "Белгород" завершила бросковые испытания макета торпеды "Посейдон"' [The design bureau announced the timing of the appearance of the navy's new nuclear submarines], TASS, 9 Jan. 2023; and Cook, E., 'Russia successfully tests secret nuclear-powered "Poseidon" torpedo', *Newsweek*, 10 June 2023.

The official handover of the *Belgorod* to the Russian fleet took place in July 2022.[35] The *Khabarovsk* appeared to be in the final stages of construction at the Sevmash shipyard at the end of 2023.[36] 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.[37] However, the weapon system is unlikely to be operational for several years.[38] Russia is upgrading warhead storage facilities at the Pacific Fleet submarine base in Kamchatka krai, which will house at least two of the special-purpose submarines and their Poseidon weapon systems.[39]

Non-strategic nuclear forces

Russia's non-strategic nuclear weapons chiefly serve to compensate for perceived conventional inferiority relative to North Atlantic Treaty Organization (NATO) forces; to provide regional (as opposed to intercontinental) deterrence options; and to maintain overall parity with the total US nuclear force level.[40] There has been considerable debate among Western officials and experts about the role that non-strategic nuclear weapons have in Russian nuclear strategy, including potential first use.[41]

The US Defense Intelligence Agency estimated in 2021 that Russia had 1000–2000 non-strategic warheads; this estimate was repeated in a US State Department report to the US Congress in May 2023.[42] SIPRI estimates that,

[35] 'Shipbuilders deliver special-purpose sub with nuclear-powered drones to Russian Navy', TASS, 8 July 2022.

[36] 'Submarine force armed with Poseidon torpedoes to come into operation in Kamchatka in 2025', TASS, 3 Apr. 2023.

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

[38] 'Вторую подлодку-носитель "Посейдонов" планируют спустить на воду весной–летом 2021 года' [Second 'Poseidon' carrier submarine to be launched in spring–summer 2021], TASS, 6 Nov. 2020.

[39] 'Base for Poseidon nuclear super-torpedoes to go on stream in Kamchatka next year—Source', TASS, 27 Mar. 2023; and authors' assessment based on analysis of satellite imagery.

[40] There is no universally accepted definition of 'tactical', 'non-strategic' or 'theatre' nuclear weapons. These terms generally refer to shorter-range weapons that are not covered by arms control agreements regulating long-range strategic forces.

[41] On this debate see e.g. US Department of Defense, *Nuclear Posture Review 2018* (DOD: Washington, DC, Feb. 2018), p. 30; Kofman, M. and Fink, A. L., 'Escalation management and nuclear employment in Russian military strategy', War on the Rocks, 23 June 2020; Oliker, O., 'Moscow's nuclear enigma: What is Russia's arsenal really for?', *Foreign Affairs*, Nov./Dec. 2018; Stowe-Thurston, A., Korda, M. and Kristensen, H. M., 'Putin deepens confusion about Russian nuclear policy', Russia Matters, Harvard Kennedy School, 25 Oct. 2018; Tertrais, B., 'Russia's nuclear policy: Worrying for the wrong reasons', *Survival*, vol. 60, no. 2 (Apr. 2018); Ven Bruusgaard, K., 'The myth of Russia's lowered nuclear threshold', War on the Rocks, 22 Sep. 2017; and Kaushal, S. and Cranny-Evans, S., 'Russia's nonstrategic nuclear weapons and its views on limited nuclear war', Royal United Services Institute, 21 June 2022.

[42] Berrier, S., Director, US Defense Intelligence Agency, 'Worldwide threat assessment', Statement for the record, US Senate, Armed Services Committee, 26 Apr. 2021; and US Department of State, 'Report to the Senate on the status of tactical (nonstrategic) nuclear weapons negotiations pursuant to subparagraph (A)(12)(b) of the Senate resolution of advice and consent to ratification of the New START Treaty', May 2023.

as of January 2024, Russia had nearly 1560 warheads assigned for potential use by non-strategic forces—a lower estimate than for January 2023 as a result of a revised assessment by the authors based on modified assumptions. However, this new estimate still comes with a high degree of uncertainty. 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.

Nuclear weapon sharing with Belarus

Russia and Belarus made numerous claims in 2023 about the deployment of non-strategic nuclear weapons to Belarus. President Putin announced in March that Russia had re-equipped 10 Belarusian Su-25 (Frogfoot) aircraft with the ability to deliver nuclear weapons and had transferred dual-capable, road-mobile 9K720 Iskander-M (SS-26) short-range ballistic missiles (SRBMs) to Belarus.[43] Training of Russian launch crews was apparently completed by April, and in late December 2023 Belarusian President Alexander Lukashenko stated that Russia had completed its shipments of nuclear weapons to Belarus.[44] Belarusian railway workers claimed during the latter half of 2023 that 'Russian tactical nuclear weapons and related equipment' had entered Belarus through multiple transfers.[45]

Despite these official statements and some possible open-source indicators, there remain several unknowns relating to the status of this deployment. While open sources and satellite imagery imply that these warheads could be stored at a new high-security depot near Asipovichy, Mahilyou oblast, there was no conclusive visual evidence as of January 2024 that Russian nuclear warheads and related personnel were deployed in Belarus.

Navy weapons

The Russian navy is estimated to have over 780 warheads assigned for use by land-attack cruise missiles, anti-ship cruise missiles, anti-submarine rockets, depth bombs, and torpedoes delivered by surface ships, submarines and naval aviation. Recent upgrades include the dual-capable long-range, land-attack Kalibr sea-launched cruise missile (SLCM), also known as the

[43] 'Интервью Владимира Путина Павлу Зарубину' [Interview with Vladimir Putin to Pavel Zarubin], Smotrim, 25 Mar. 2023.

[44] ASTRA (@astrapress), Telegram, 4 Apr. 2023, <https://t.me/astrapress/24412>; and 'Belarus leader says Russian nuclear weapons shipments are completed, raising concern in the region', AP, 25 Dec. 2023.

[45] Community of Railway Workers of Belarus, 'Очередной этап ввоза в Беларусь компонентов российского тактического ядерного оружия и связанного с ним оборудования' [The next stage of the import of components of Russian tactical nuclear weapons and related equipment to Belarus], 12 Sep. 2023; and Community of Railway Workers of Belarus, 'Порядок ввоза российского ядерного оружия в Беларусь' [The procedure for the import of Russian nuclear weapons to Belarus], 27 June 2023.

3M14 (SS-N-30A), and the dual-capable 3M55 (SS-N-26) SLCM.[46] These missiles are replacing Soviet-era missiles and being integrated on numerous types of surface ship and attack submarine.[47] Among these vessels is the new Project 855/855M Yasen/Yasen-M (Severodvinsk) SSGN, of which four boats are currently operational after the latest—named *Krasnoyarsk*—was commissioned in December 2023. Five more are under construction. The first of these—named *Arkhangelsk*—left the Sevmash shipyard in November 2023 to prepare for its launch and sea trials.[48] Russia is reportedly considering building three additional Project 855M SSGNs, although this has not been officially confirmed.[49]

Air force weapons

Over 330 non-strategic nuclear weapons are estimated to be assigned to the Russian Air Force for use by Tu-22M3M intermediate-range bombers, Su-24M (Fencer-D) fighter-bombers, Su-34 (Fullback) fighter-bombers and MiG-31K (Foxhound) attack aircraft.[50] The new Su-57 (Felon) combat aircraft is also dual-capable. Deliveries of the Su-57 to the air force continued in 2023, with 22 aircraft scheduled for delivery by the end of 2024.[51]

The MiG-31K is equipped with the new dual-capable 9A-7760 Kinzhal air-launched ballistic missile (ALBM). In 2022 it was operational with the Southern Military District and Northern Fleet and will eventually be integrated into the Western and Central Military Districts by 2024.[52]

[46] There is considerable confusion about the designation of what is commonly referred to as the Kalibr missile. The Kalibr name does not refer to a specific missile but to a launcher for a family of weapons that, in addition to the 3M14 (SS-N-30/A) land-attack versions, includes the 3M54 (SS-N-27) anti-ship cruise missile and the 91R anti-submarine missile. For further detail see US Navy, Office of Naval Intelligence (ONI), *The Russian Navy: A Historic Transition* (ONI: Washington, DC, Dec. 2015), pp. 34–35.

[47] It is important to caution that although a growing number of vessels can launch the dual-capable 3M14, it is uncertain how many of them have been assigned a nuclear role.

[48] MilitaryRussia.Ru (@DnKornev), X, 24 Jan. 2024, <https://twitter.com/DnKornev/status/1750366578200178964>.

[49] 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.

[50] US Department of Defense, 'US nuclear deterrence policy', 1 Apr. 2019, p. 3; International Institute for Strategic Studies, *The Military Balance 2021* (Routledge: London, 2021); and authors' estimates. It is possible that the Su-30SM is also capable of delivering nuclear weapons.

[51] D'Urso, S., 'First serial production Su-57 Felon delivered to the Russian Aerospace Forces', The Aviationist, 30 Dec. 2020; Rob Lee (@RALee85), Twitter, 3 Feb. 2022, <https://twitter.com/RALee85/status/1489302156729593869>; and United Aircraft Corporation (UAC), 'ОАК передала Минобороны очередную партию серийных самолётов пятого поколения Су-57' [UAC handed over another batch of fifth-generation Su-57s to the Defence Ministry], 28 Dec. 2022.

[52] President of Russia (note 23); '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.

Conventional Kinzhals have been used against Ukraine.[53] President Putin announced in February 2023 that Russia would accelerate mass production of the Kinzhal.[54]

Russia is also fielding the dual-capable Kh-32 (AS-4A) air-to-surface missile, an upgrade of the Kh-22N (AS-4), for use on the Tu-22M3.[55]

Air-, coastal- and missile-defence weapons

Russian air-, coastal- and missile-defence forces are estimated to have been assigned around 345 nuclear warheads, although this estimate comes with a high degree of uncertainty. Most have been assigned for use by dual-capable S-300 (SA-20) and S-400 (SA-21) air-defence forces and the Moscow A-135 missile-defence system. Russian coastal-defence units are believed to have been assigned a small number of nuclear weapons for anti-ship missions. In 2023 a US State Department assessment suggested that Russia continued to use non-strategic nuclear warheads for 'anti-aircraft' and 'anti-ballistic missile systems'.[56]

It is likely that the stock of warheads associated with Russia's air-, coastal- and missile-defence forces will eventually decrease as conventional air-defences improve—including the Nudol and Aerostat systems under development in 2023—and as legacy warheads are retired.

Army weapons

The Russian Army has an estimated 95 warheads to arm dual-capable 9K720 Iskander-M SRBMs and 9M729 (SSC-8) ground-launched cruise missiles (GLCMs). As of January 2024 the Iskander-M had completely replaced the Tochka (SS-21) SRBM in 12 missile brigades.[57] The 9M728 (SSC-7) may also have a nuclear capability.

The dual-capable 9M729 GLCM was cited by the USA as its main reason for withdrawing from the 1987 Treaty on the Elimination of Intermediate-range and Shorter-range Missiles (INF Treaty) in 2019.[58] SIPRI estimates that four or five 9M729 battalions have so far been co-deployed with four or five of the Iskander-M brigades.

[53] 'Shoigu reveals Kinzhal hypersonic missile was used three times during special operation', TASS, 21 Aug. 2022.

[54] 'Russia to continue mass production of Kinzhal hypersonic systems—Putin', TASS, 22 Feb. 2023.

[55] US Department of Defense (note 41), p. 8.

[56] US Department of State (note 42).

[57] Authors' assessment based on analysis of satellite imagery and Russian reports.

[58] US Department of State, Bureau of Arms Control, Verification and Compliance, 'INF Treaty at a glance', Fact sheet, 8 Dec. 2017. For a summary and other details of the INF Treaty see annex A, section III, in this volume. See also Topychkanov, P. and Davis, I., 'Russian–US nuclear arms control and disarmament', *SIPRI Yearbook 2020*; and Kile, S. N., 'Russian–US nuclear arms control and disarmament', *SIPRI Yearbook 2018*.

Table 7.3. Russian nuclear forces, January 2024

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)[a]	Warheads x yield	No. of warheads[b]
Strategic nuclear forces	**590**				**2 822**[c]
Aircraft (bombers)	*67*[d]				*586*[e]
Tu-95MS/M (Bear-H)[f]	52	1984/ 2015	6 500–10 500	6–14 x 200 kt Kh-55 (AS-15A) or Kh-102 (AS-23B) ALCMs	430[g]
Tu-160M1/M2 (Blackjack)	15	1987/ 2021	10 500–13 200	12 x 200 kt Kh-55 or Kh-102 ALCMs, [Kh-BD], bombs	156[h]
Land-based missiles (ICBMs)	*329*				*1 244*[i]
RS-20V Voevoda (SS-18 Mod 5 Satan)	34	1988	11 000–15 000	10 x 500–800 kt[j]	340
Avangard (SS-19 Mod 4)[k]	10	2019	10 000	1 x HGV	10
RS-12M1 Topol-M (SS-27 Mod 1/mobile)	18	2006	10 500	1 x [800 kt]	18
RS-12M2 Topol-M (SS-27 Mod 1/silo)	60	1997	10 500	1 x [800 kt]	60
RS-24 Yars (SS-27 Mod 2/mobile)	180	2010	10 500	[4 x 250 kt][l]	720
RS-24 Yars (SS-27 Mod 2/silo)	24	2014	10 500	4 x [250 kt]	96
RS-28 Sarmat (SS-29)	. .	[2024]	>10 000	[10 x 500 kt]	–
Sirena-M[m]	3	2022	–	Command and control module	–
Sea-based missiles (SLBMs)	*12/192*[n]				*992*[o]
RSM-54 Sineva/Layner (SS-N-23 M2/3)[p]	5/80	2007/ 2014	9 000	4 x 100 kt[q]	320[r]
RSM-56 Bulava (SS-N-32)	7/112	2012	>8 050	[6 x 100 kt][s]	672
Non-strategic nuclear forces					**1 558**[t]
Navy weapons	. .				*784*
Submarines/surface ships/naval aircraft	. .	Land-attack cruise missiles, sea-launched cruise missiles, anti-submarine weapons, surface-to-air missiles, depth bombs, torpedoes[u]			784
Air force weapons	*289*				*334*
Tu-22M3M (Backfire-C)	57	1974	. .	2 x ASMs	114
Su-24M/M2 (Fencer-D)	68	1974	. .	2 x bombs	68[v]
Su-34 (Fullback)	122	2006	. .	2 x bombs	122[v]
Su-57 (Felon)	18	[2024]	. .	[bombs, ASMs]	18
MiG-31K (Foxhound)	24	2018	. .	1 x ALBM	12

Type/ Russian designation (NATO designation)	No. of launchers	Year first deployed	Range (km)[a]	Warheads x yield	No. of warheads[b]
Air, coastal and missile defence	*882*				*345*
53T6 (SH-08 Gazelle)	68	1986	30	1 x 10 kt	68
S-300/400 (SA-20/21)	750[w]	1992/ 2007	. .	1 x low kt	250
3M55/P-800 Oniks (SS-N-26 Strobile), 3K55/K300-P Bastion (SSC-5 Stooge)	56	2015	>400	1 x [10–100 kt]	23
SPU-35V Redut (SSC-1B Sepal)	8[x]	1973	500	1 x 350 kt	4
Army weapons	*170*				*95*
9K720 Iskander-M (SS-26 Stone), 9M728 Iskander-K (SSC-7 Southpaw)	150	2005	500	1 x [10–100 kt]	75[y]
9M729 (SSC-8 Screwdriver)	20	2016	2 350	1 x [10–100 kt]	20[z]
Total stockpile					**4 380**
Deployed strategic warheads					1 710
Reserve warheads					2 670
Strategic					1 112
Non-strategic					1 558
Retired warheads awaiting dismantlement					**1 200**
Total inventory					**5 580**

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

[a] For aircraft, the listed range is for illustrative purposes only; actual mission range will vary according to flight profile, weapon payload and in-flight refuelling.

[b] These figures show the total number of warheads estimated to be assigned to nuclear-capable delivery systems. Only some of these warheads have been deployed on missiles and at airbases, as described in the notes below.

[c] Of these strategic warheads, *c.* 1710 were deployed on land- and sea-based ballistic missiles and at bomber bases. The remaining warheads were in central storage. This number differs from the number of deployed strategic warheads counted by the 2010 Russian–United States Treaty on Measures for the Further Reduction and Limitation of Strategic Offensive Arms (New START) because the treaty attributes 1 weapon to each deployed bomber, even though bombers do not carry weapons under normal circumstances. Additionally, the treaty does not count weapons stored at bomber bases and, at any given time, some nuclear-powered ballistic missile submarines (SSBNs) are not fully loaded with warheads and are thus not counted under the treaty. Russia no longer publishes aggregate figures for strategic nuclear forces limited by New START.

[d] All of Russia's long-range strategic bombers are nuclear-capable. Of these, only *c.* 58 are thought to be counted as deployed under New START. Because of ongoing bomber modernization, there is considerable uncertainty about how many bombers are operational.

[e] 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.* 580 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.

[f] The 1991 Russian–US Strategic Arms Reduction Treaty (START) distinguished between 2 variants of the Tu-95MS: the Tu-95MS6 (Bear-H6), which can carry 6 ALCMs internally, and the Tu-95MS16 (Bear-H16), which can carry an additional 10 ALCMs on wing pylons for a total of 16 ALCMs. However, it is unclear whether the MS16 configuration is still in use or whether the external pylons have been removed, which would effectively turn the MS16s into MS6s. The Tu-95MS is being upgraded to the Tu-95MSM. The upgrade adds 4 pylons, allowing the aircraft to carry 8 Kh-101/102 (AS-23A/B) missiles externally as well as, potentially, 6 Kh-55 (AS-15B) missiles internally, for a total of 14 ALCMs.

[g] This estimate assumes that *c.* 20 of the Tu-95MS aircraft have been upgraded and together can carry up to 280 warheads (see note f), while *c.* 25 Tu-95MS6s can carry up to 150 warheads. It also assumes that 7 aircraft are in overhaul either for maintenance or for modernization.

[h] This estimate assumes that 2 Tu-160 (Blackjack) aircraft are in overhaul either for maintenance or for modernization; the remaining 13 can carry up to 156 warheads.

[i] These ICBMs can carry a total of *c.* 1244 warheads, but SIPRI estimates that they have had their warhead load reduced to *c.* 872 warheads, with the remaining warheads in storage.

[j] It is possible that, as of Jan. 2024, the RS-20Vs (SS-18 Mod 5 Satan) carried only 5 warheads each to meet the New START limit for deployed strategic warheads.

[k] The missile uses a modified RS-18 (SS-19 Stiletto) ICBM booster with an HGV payload.

[l] It is possible that, as of Jan. 2024, the RS-24s (SS-27 Mod 2) carried only 3 warheads each to meet the New START limit on deployed strategic warheads.

[m] The division at Yurya is equipped with the new Sirena-M nuclear command and control missile, which is based on the RS-24 ICBM. The missiles are not nuclear-armed, but rather serve as an emergency launch communication module. They are included in this table because their launchers are counted against the limits permitted under New START.

[n] The first figure is the total number of nuclear-powered ballistic missile submarines (SSBNs) in the Russian fleet; the second is the maximum number of missiles that they can carry. Of Russia's 12 operational SSBNs (as of Jan. 2024), 1–2 are in overhaul at any given time and do not carry their assigned nuclear missiles and warheads (see note o).

[o] The warhead load on SLBMs is thought to have been reduced for Russia to stay below the New START warhead limit. Additionally, at any given time, 1–2 SSBNs are in overhaul and do not carry nuclear weapons. Therefore, it is estimated here that only *c.* 640 of the 992 SLBM warheads have been deployed.

[p] The current version of the RSM-54 SLBM might be the Layner (SS-N-23 M3), a modification of the previous version—the Sineva (SS-N-23 M2). However, the US Air Force's National Air and Space Intelligence Center (NASIC) did not include the Layner in its 2020 report on ballistic and cruise missile threats, and there is some uncertainty regarding its status and capability.

[q] In 2006 US intelligence estimated that the RSM-54 missile could carry up to 10 warheads, but it lowered the estimate to 4 in 2009. The average number of warheads carried on each missile has probably been limited to 4 multiple independently targetable re-entry vehicles (MIRVs) to meet the New START limits.

[r] SIPRI estimates that, at any given time, only 256 of these warheads are deployed on 4 operational Delfin-class (Delta IV) submarines, with the fifth boat in overhaul. The actual number may even be lower as 2 boats often undergo maintenance at the same time.

[s] It is possible that, as of Jan. 2024, RSM-56 Bulava (SS-N-32) SLBMs carried only 4 warheads each for Russia to meet the New START limit on deployed strategic warheads.

[t] 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.

[u] Only submarines are assumed to be assigned nuclear torpedoes.

[v] This estimate assumes that half of the aircraft have a nuclear role.

[w] As of Jan. 2024 there were at least 80 S-300/400 (SA-20/21) sites across Russia, each with an average of 12 launchers, each with 2–4 interceptors. Each launcher has several reloads, which are assumed likely to be conventional.

[x] It is assumed that all SPU-35V Redut (SSC-1B Sepal) units, except for a single silo-based version in Crimea, had been replaced by the K-300P Bastion (SSC-5 Stooge) by Jan. 2024.

[y] This estimate assumes that around half of the dual-capable launchers have a secondary nuclear role. In its 2020 report, NASIC listed the 9M728 (SSC-7 Southpaw) as 'Conventional, Nuclear Possible'.

[z] This estimate assumes that there are 5 9M729 (SSC-8 Screwdriver) battalions, each of which is equipped with 4 launchers. Since each launcher appears to be equipped to carry 4 missiles, this would indicate a total of 80 missiles per battalion (possibly 160 if each battalion has 1 reload missile). However, it is assumed here that each launcher is only assigned an average of 1 nuclear warhead (with the rest being equipped with conventional munitions), for a total of 20 warheads across 5 battalions.

Sources: Russian Ministry of Defence, various press releases; US Department of State, START Treaty Memoranda of Understanding, 1990–July 2009; New START aggregate data releases, various years; US Air Force, National Air and Space Intelligence Center (NASIC), *Ballistic and Cruise Missile Threat 2020* (NASIC: Wright-Patterson Air Force Base, OH, July 2020); US Department of Defense (DOD), *2022 National Defense Strategy of the United States of America* (DOD: Washington, DC, Oct. 2022); US Office of the Deputy Assistant Secretary of Defense for Nuclear Matters, *Nuclear Matters Handbook 2020* (DOD: Washington, DC, Mar. 2020); DOD, various Congressional testimonies; BBC Monitoring; Russian news media; Russian Strategic Nuclear Forces website; International Institute for Strategic Studies, *The Military Balance*, various years; Cochran, T. B. et al., *Nuclear Weapons Databook*, vol. 4, *Soviet Nuclear Weapons* (Harper & Row: New York, 1989); *IHS Jane's Strategic Weapon Systems*, various issues; US Naval Institute, *Proceedings*, various issues; *Bulletin of the Atomic Scientists*, 'Nuclear notebook', various issues; and authors' estimates.

III. British nuclear forces

HANS M. KRISTENSEN AND MATT KORDA*

As of January 2024 the United Kingdom's nuclear weapon stockpile consisted of approximately 225 warheads (see table 7.4, end of section)—an unchanged estimate from the previous year. SIPRI assesses that around 120 of these are operationally available for delivery by Trident II D5 submarine-launched ballistic missiles (SLBMs), with about 40 being carried on a nuclear-powered ballistic missile submarine (SSBN) that is on patrol at all times. The UK is expected to increase the number of warheads it possesses in the coming years.

These estimates are based on open-source information on the British nuclear arsenal and conversations with British officials. The UK has generally been more transparent about its nuclear activities than many other nuclear-armed states. However, it has never declassified the history of its stockpile or the actual number of warheads it possesses, and in 2021 it declared that it will no longer publicly disclose figures for the country's operational stockpile, deployed warheads or deployed missiles.[1]

This section briefly outlines the role played by nuclear weapons in the UK's military doctrine and then describes its sea-based missiles and its nuclear weapon modernization programme.

The role of nuclear weapons in British military doctrine

In 2023 the British government published a 'refresh' of its Integrated Review of Security, Defence, Development and Foreign Policy that it had previously published in 2021. The document included much of the same nuclear-related language as its predecessor, noting that the UK's negative security assurance 'remains unchanged', and that the UK 'would consider using . . . nuclear weapons only in extreme circumstances of self-defence, including the defence of [North Atlantic Treaty Organization (NATO)] Allies'.[2] Despite this language, the UK has also stated that it remains 'deliberately ambiguous about precisely when, how and at what scale [it] would contemplate the

[1] 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. On the challenges of collecting information on world nuclear forces more generally see Kristensen, H. M. and Korda, M., 'Estimating world nuclear forces: An overview and assessment of sources', SIPRI Commentary, 14 June 2021.

[2] British Government, CP 403 (note 1), p. 76; 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), p. 33.

* The authors wish to thank Eliana Johns and Mackenzie Knight for contributing invaluable research to this publication.

use of nuclear weapons'.[3] A promised Defence Nuclear Strategy to further flesh out a recapitalization strategy for the UK's 'defence nuclear enterprise', which is 'collectively responsible for the development, build, maintenance and . . . delivery' of the UK's nuclear deterrent, had not been published by the end of 2023.[4]

Like the United States, the UK operates its submarines with detargeted missiles, although it would take only moments to load the targeting coordinates. Unlike US SSBNs, which can launch in minutes, the UK says that its submarines 'are at several days' notice to fire'.[5]

Sea-based missiles

The UK is the only nuclear-armed state that operates a single type of nuclear weapon: the country's nuclear deterrent is entirely sea-based. The UK possesses four Vanguard-class SSBNs, based at Faslane on the west coast of Scotland, each of which can carry up to 16 Trident II D5 submarine-launched ballistic missiles. In a posture known as continuous at-sea deterrence (CASD), which began in 1969, one British SSBN carrying approximately 40 warheads is on patrol at all times.[6] The second and third SSBNs remain in port but could be put to sea in a crisis. The fourth is in overhaul at any given time and is unable to deploy.

In the 2021 Integrated Review of Security, Defence, Development and Foreign Policy, the British government announced a significant increase to the upper limit of its nuclear weapon stockpile, to a maximum of 260 warheads.[7] Previously, the goal had been to reach 180 warheads by the mid 2020s, as described in the UK's strategic defence and security reviews (SDSRs) of 2010 and 2015.[8] British officials clarified in 2021 that the target of 180 warheads stated in the SDSRs 'was indeed a goal, but it was never reached'.[9] Instead, in its statement submitted to the 10th Review Conference of the 1968 Treaty on the Non-Proliferation of Nuclear Weapons, held in 2022, the British

[3] 10th NPT Review Conference, National report of the United Kingdom, NPT/CONF.2020/33, 5 Nov. 2021, para. 13.

[4] British Government, CP 811 (note 2), p. 34.

[5] British Ministry of Defence, 'The UK's nuclear deterrent: What you need to know', 17 Feb. 2022.

[6] British Ministry of Defence, 'UK's nuclear deterrent (CASD)', 17 Mar. 2021.

[7] British Government, CP 403 (note 1), p. 76. For further detail see Kristensen, H. M. and Korda, M., 'British nuclear forces', *SIPRI Yearbook 2022*, pp. 371–72.

[8] British Government, *Securing Britain in an Age of Uncertainty: The Strategic Defence and Security Review*, Cm 7948 (Her Majesty's Stationery Office: London, Oct. 2010), p. 38; and 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), p. 34. See also Kristensen, H. M. and Korda, M., 'United Kingdom nuclear weapons, 2021', Nuclear notebook, *Bulletin of the Atomic Scientists*, vol. 77, no. 3 (May 2021).

[9] Aidan Liddle (@AidanLiddle)Twitter, 16 Mar. 2021, <https://twitter.com/aidanliddle/status/1371912132141445120>. This information was also later confirmed by other officials. British officials, Interviews with the authors, May 2021.

government stated that the new and higher number of 260 warheads 'is a ceiling, not a target, and it is not our current stockpile number'.[10] While it is expected that the British nuclear stockpile will eventually increase in size, SIPRI assesses that there had been no change in the stockpile number as of January 2024.

Replacement of the submarines

The UK's four Vanguard-class SSBNs entered service between December 1994 and February 2001, each with an expected service life of 25 years.[11] The 2015 SDSR stated the government's intention to replace the Vanguard-class submarines with four new SSBNs, known as the Dreadnought class.[12] Construction of the third submarine, HMS *Warspite*, began in February 2023.[13]

The new submarines were originally expected to begin entering service by 2028, but this has been delayed until the early 2030s at the earliest. Reports from 2023 suggest that the production of key components, including the reactor cores, is several years behind schedule and significantly over-budget.[14] The service life of the Vanguard-class SSBNs has been commensurately extended to an overall lifespan of about 37–38 years.[15] The work to upgrade the ageing SSBNs has also been subject to significant delays and budget over-runs. For example, the UK's lead SSBN, HMS *Vanguard*, completed its refit in May 2023 and remained in sea trials at the end of the year.[16] The cost of the *Vanguard* upgrade rose from an initial projection of about £200 million (US$307 million) in 2015 to more than £500 million ($688 million) in 2021, and the refit took 89 months, which was 6 months longer than it took to build the submarine.[17] The next SSBN to begin a planned refit—HMS *Victorious*—arrived in port in June 2023.[18]

The delay in the *Vanguard* upgrade meant that the UK's three other SSBNs 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

[10] 10th NPT Review Conference, NPT/CONF.2020/33 (note 3), para. 22.

[11] Mills, C., *Replacing the UK's Strategic Nuclear Deterrent: Progress of the Dreadnought Class*, Research Briefing no. 8010 (House of Commons Library: London, 3 May 2023), p. 10.

[12] British government, Cm 9161 (note 8), para. 4.73.

[13] Mills (note 11), p. 5.

[14] UK National Audit Office (NAO), *The Equipment Plan 2023-2033: Ministry of Defence* (NAO: London, 4 Dec. 2023), pp. 8, 17, 38; and Nuclear Information Service, 'Increasing risk of problems in Derby delaying Dreadnought schedule', 7 Aug. 2023.

[15] Mills (note 11), p. 10.

[16] Nuclear Information Service, 'HMS Vanguard leaves Devonport after 7 years of maintenance', 7 July 2023.

[17] 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.

[18] Royal Navy, 'HMS Victorious arrives in Plymouth for major refit in boost to 1,000 local jobs', 26 June 2023.

1970s to 150–200 days in recent years; in September 2023 one of the UK's SSBNs reportedly returned from a 195-day patrol.[19] These extended patrols were potentially factors contributing to several operating errors, accidents and personnel issues that have dogged the UK's nuclear forces in recent years.[20] In the latest incident in November 2023, a faulty depth gauge reportedly misled the SSBN's crew into thinking that the submarine was level when it was still diving, nearly triggering a catastrophic accident.[21]

The missiles and warhead

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 service life of the Trident II D5 missile. The first and second life-extended versions are known as the D5LE and the D5LE2, respectively; the D5LE will function until the early 2060s and the D5LE2 until the mid 2080s (see section I of this chapter).[22]

The warhead carried on the Trident II D5 is called the Holbrook, which is produced by the UK but thought to be based closely on the USA's W76 warhead design. It is being incorporated into the more effective USA-produced Mk4A re-entry body (aeroshell).[23] It is possible that sufficient Mk4A-upgraded warheads had been produced by the end of 2021 to arm the UK's Vanguard-class SSBNs; however, the full upgrade has not yet been completed.[24]

In 2020 the British government announced its intention to replace the Holbrook with a new warhead that will use the Mk7 aeroshell being developed for the USA's new W93 warhead (see section I).[25] According to the British Ministry of Defence (MOD), the replacement warhead is 'not exactly

[19] Sabbagh, D. and Edwards, R., 'Safety fears as UK Trident submarines are put to sea for longest-ever patrols', *The Guardian*, 6 Dec. 2022; and 'Royal Navy nuclear deterrent submarines conducting increasingly long patrols', Navy Lookout, 22 Sep. 2023.

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

[21] Starkey, J., 'Deep trouble: Major malfunction on Royal Navy nuclear submarine plunges warship into "danger zone" almost crushing 140 crew to death', *The Sun*, 19 Nov. 2023; and Beale, J., 'Nuclear-armed submarine suffered malfunction', BBC, 20 Nov. 2023.

[22] Mills (note 11), p. 11.

[23] For detail on how the upgrade improves the weapon's capability see Cullen, D., *Extreme Circumstances: The UK's New Nuclear Warhead in Context* (Nuclear Information Service: Reading, Aug. 2022).

[24] NukewatchUK, 'Warhead convoy movements summary 2021', 2021; and British Ministry of Defence, 'The United Kingdom's future nuclear deterrent: 2022 update to Parliament', 8 Mar. 2023.

[25] 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, 'FY2022 budget request for nuclear forces and atomic energy defense activities', Statement before the US Senate, Armed Forces Committee, Subcommittee on Strategic Forces, 12 May 2021, pp. 6–7. For further detail see Kristensen, H. M. and Korda, M., 'British nuclear forces', *SIPRI Yearbook 2021*, pp. 360–61.

the same warhead [as the W93] but . . . there is a very close connection, in design terms and production terms'.[26]

Although the future of the W93 programme is being debated in the USA, British officials stated in 2021 that the UK's warhead-replacement programme would move forward regardless of the status of the USA's W93 programme.[27] In both the UK and the USA, the decision to introduce new warheads is thought to stem from strong internal political pressure to enhance nuclear infrastructure and capabilities.[28] In 2022 the warhead-replacement programme entered into the 'concept' stage of development—the first of six MOD acquisition stages.[29]

The UK has not issued an official cost estimate or timeline for its programme, but it is likely that the new warhead will come into service sometime in the late 2030s or early 2040s.[30]

[26] Lovegrove, S., Permanent Secretary, Ministry of Defence, Statement, British House of Commons, Defence Committee, Oral evidence: MOD annual report and accounts 2019–20, HC 1051, 8 Dec. 2020, Q31.

[27] Mehta, A., 'UK official: American warhead decision won't impact British nuclear plans', *Defense News*, 13 Apr. 2021.

[28] Cullen (note 23), p. 6.

[29] British Ministry of Defence (note 24).

[30] Cullen (note 23), p. 4.

Table 7.4. British nuclear forces, January 2024

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	No. of warheads
Sea-based missiles (SLBMs)	*4/64*[a]				*120*
Trident II D5	48[b]	1994	>10 000[c]	1–8 x 100 kt[d]	120
Total operationally available warheads					**120**[e]
Other stored warheads					*105*[f]
Total stockpile					**225**[g]

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

[a] The first figure is the total number of nuclear-powered ballistic missile submarines (SSBNs) in the British fleet; the second is the maximum number of missiles that they can carry. However, the total number of missiles carried is lower (see note b). Of the 4 SSBNs, 1 is in overhaul at any given time.

[b] The 3 operational SSBNs can carry a total of 48 Trident SLBMs. The United Kingdom has purchased the right to 58 missiles from a pool shared with the United States Navy.

[c] 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.

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

[e] 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.

[f] This 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 (see note g). Many of the stored warheads that have not been retired are thought to be undergoing upgrade from the Mk4 re-entry body to the Mk4A.

[g] 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.

Sources: British Ministry of Defence, white papers, press releases and website; British House of Commons, *Hansard*, various issues; *Bulletin of the Atomic Scientists*, 'Nuclear notebook', various issues; and authors' estimates.

IV. French nuclear forces

HANS M. KRISTENSEN AND MATT KORDA*

As of January 2024 France's nuclear weapon stockpile consisted of about 290 warheads, the same number as in January 2023. The warheads are allocated for delivery by 48 submarine-launched ballistic missiles (SLBMs) and approximately 50 air-launched cruise missiles (ALCMs) produced for land- and carrier-based aircraft (see table 7.5, end of section). However, the 10 warheads assigned to France's carrier-based aircraft are thought to be kept in central storage and are not normally deployed.

The estimate of France's nuclear weapon stockpile is based on publicly available information.[1] France is relatively transparent about many of its nuclear weapon activities and has in the past publicly disclosed the size of its stockpile and details of its nuclear-related operations.[2]

This section begins by outlining the role played by nuclear weapons in France's military doctrine. It then assesses France's nuclear modernization programmes and describes its air-delivered and sea-based weapons.

The role of nuclear weapons in French military doctrine

France has stated that its nuclear weapons remain de-targeted during peacetime and are not postured against any particular country, but rather are intended to be used against 'any State' in support of an 'all-azimuths' concept of nuclear deterrence.[3] France considers all of its nuclear weapons to be strategic and reserved for the defence of France's 'vital interests'.[4] Its vital interests include 'the integrity of [its] . . . territory and the protection of [its] . . . population' but 'cannot be restricted to the national scope, because France does not conceive its defence strategy in isolation, even in the nuclear field'.[5] This was highlighted in 2020 when President Emmanuel Macron invited France's European Union partners to a 'strategic dialogue . . . on the role played by France's nuclear deterrence in our collective security'.[6] However, the suggestion of a European dimension of nuclear deterrence is controversial because it remains unclear how such a mission would interact

[1] Kristensen, H. M. and Korda, M., 'Estimating world nuclear forces: An overview and assessment of sources', SIPRI Commentary, 14 June 2021.

[2] 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).

[3] Macron (note 2); French Government, *Defense and National Security Strategic Review 2017* (French Government: Paris, 2017); and Tertrais, B., *French Nuclear Deterrence Policy, Forces and Future: A Handbook*, Recherches & Documents no. 04/2020 (Fondation pour la Recherche Stratégique: Paris, Feb. 2020), pp. 15–16.

[4] Tertrais (note 3) pp. 25–29, 62–63.

[5] French Government (note 3), p. 52.

[6] Macron (note 2), p. 10.

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with the North Atlantic Treaty Organization's existing 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'.[7]

Other than a statement in October 2022 that France's 'vital interests . . . would not be at stake if there was a nuclear ballistic attack in Ukraine or in the region', France is deliberately ambiguous about the circumstances under which it would use its nuclear weapons.[8] In January 2023 France's Chief of Staff of the Armed Forces, General Thierry Burkhard, stated that France's doctrine 'is neither that of no first use nor that of sole purpose'—the concept that the sole purpose of nuclear weapons is to deter only nuclear weapon use by other countries—and that French deterrence 'does not revolve around the notion of threshold, because this would allow our adversaries to consciously manoeuvre around it and circumvent our deterrence "from the bottom up"'.[9]

France reserves the right to issue 'a sole, one-time-only nuclear warning', suggesting that it could use a nuclear weapon against a symbolic target as a signal to a potential adversary.[10] Although France's doctrine includes this 'nuclear warning' as a potential precursor to the general use of nuclear weapons, its long-standing policy is that it 'will never engage into a nuclear battle or any forms of graduated response'.[11] Rather, French doctrine appears to emphasize the deterrence value of delivering massive retaliation in the form of a single strike.[12]

Aircraft and air-delivered weapons

The airborne component of the French nuclear forces consists of land- and carrier-based aircraft. The French Air and Space Force has 40 deployed nuclear-capable Rafale B aircraft based at Saint-Dizier Airbase in north-east France. The French Naval Nuclear Air Force (*Force aéronavale nucléaire*, FANu) consists of a squadron of 10 Rafale M aircraft for deployment on the aircraft carrier *Charles de Gaulle*. The FANu and its nuclear-armed missiles are not permanently onboard the carrier but can be rapidly deployed by the

[7] 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.

[8] 'Avec Emmanuel Macron' [With Emmanuel Macron], L'événement, France 2, 12 Oct. 2022 (author translation). On France's policy of ambiguity see e.g. 10th NPT Review Conference, National report of France, NPT/CONF.2020/42/Rev.1, 1 Aug. 2022, p. 3.

[9] Burkhard, T., Statement before the Committee on National Defence and the Armed Forces, French National Assembly, 11 Jan. 2023 (in French).

[10] 10th NPT Review Conference, NPT/CONF.2020/42/Rev.1 (note 8), p. 4.

[11] Macron (note 2), p. 10.

[12] Tertrais, B., '"*Destruction assurée*": The origins and development of French nuclear strategy, 1945–1981', ed. H. D. Sokolski, *Getting Mad: Nuclear Mutual Assured Destruction, Its Origins and Practice* (US Army War College, Strategic Studies Institute: Carlisle, PA, 2004), p. 66.

French president in support of nuclear operations.[13] In 2023 France began to upgrade its Rafale aircraft to the new F4 standard; the full upgrade is scheduled to be complete by 2025.[14]

The Rafale aircraft are equipped with medium-range air-to-surface cruise missiles (*air–sol moyenne portée–améliorée*, ASMPA), which are currently being refurbished.[15] In March 2022 France conducted a second successful flight test of the new version, the *air–sol moyenne portée–amélioré rénové* (ASMPA-R). It subsequently approved the start of serial production of the missiles and midlife refurbishment of the upgraded missile inventory, which will keep the ASMPA in service until 2035.[16] The ASMPA-R missiles were scheduled to enter into service in October 2023 but this may have been delayed until 2024.[17] The missiles are equipped with the same warhead as the ASMPA, the *tête nucléaire aéroportée* (TNA, air-launched nuclear warhead), which the missile's producer (MBDA) says has a 'medium energy' yield.[18]

A fourth-generation air-to-surface nuclear missile (*air–sol nucléaire de 4e génération*, ASN4G) is being developed with enhanced stealth and manoeuvrability to counter potential technological improvements in air defences.[19] The ASN4G is scheduled to reach initial operational capability in 2035 to replace the ASMPA-R and will be initially carried by the next-generation Rafale F5 before being integrated onto a future replacement aircraft for the Rafale.[20]

[13] Pintat, X. et al., 'Rapport d'information fait au nom de la commission des affaires étrangères, de la défense et des forces armées par le groupe de travail "La modernisation de la dissuasion nucléaire"' [Information report made on behalf of the Committee on Foreign Affairs, Defence and the Armed Forces by the working group 'Modernization of nuclear deterrence'], Report no. 560, French Senate, 23 May 2017.

[14] Mille, S. and Bellanger, J., Statements before the Committee on National Defence and the Armed Forces, French National Assembly, 25 Jan. 2023 (in French); Hoyle, C., '"Now fight connected": Why F4-standard Rafale is a game-changer for France', FlightGlobal, 19 June 2023; and Machi, V., 'France receives first new Rafale fighter jet after four-year pause', *Defense News*, 11 Jan. 2023.

[15] For further detail see Kristensen, H. M. and Korda, M., 'French nuclear forces', *SIPRI Yearbook 2021*, p. 366.

[16] Mills, C., *Nuclear Weapons at a Glance: France*, Research Briefing no. 9074 (House of Commons Library: London, 28 July 2022), p. 10; and Scott, R., 'Successful flight test of upgraded ASMPA missile paves way for refurbishment', Janes, 30 Mar. 2022.

[17] Mille and Bellanger (note 14); and Air and Space Force (@Armee_de_lair), X, 26 Jan. 2024, <https://twitter.com/Armee_de_lair/status/1750839921529507871>.

[18] MBDA, 'ASMPA: Air-to-ground missile, medium range, enhanced', Jan. 2015.

[19] French Ministry of the Armed Forces, 'La dissuasion nucléaire' [Nuclear deterrence], *Actu Défense*, 14 June 2018, p. 1; and Tran, P., 'France studies nuclear missile replacement', *Defense News*, 29 Nov. 2014.

[20] Mille and Bellanger (note 14); and Medeiros, J., '"Faire FAS" : 55 ans de dissuasion nucléaire aéroportée' ['Go FAS': 55 years of airborne nuclear deterrence], *Air Actualités*, Oct. 2019, p. 36.

Sea-based missiles

The main component of France's nuclear forces is the Strategic Oceanic Force (*Force océanique stratégique*, FOST). It consists of four Le Triomphant-class nuclear-powered ballistic missile submarines (SSBNs, or *sous-marins nucléaires lanceurs d'engins*, SNLEs) based on the Île Longue peninsula near Brest, north-west France. Each can carry 16 SLBMs. France has 48 SLBMs in service—enough to equip the three operational SSBNs. The fourth SSBN is out of service for overhaul and maintenance work and is therefore not armed.

The French Navy maintains a continuous at-sea deterrence posture with one SSBN on patrol at all times. In March 2022 there were reports that the French Navy tested deploying more than one SSBN for the first time since the 1980s, possibly in response to Russia's invasion of Ukraine.[21]

France's SLBM, the M51, is undergoing a series of upgrades. The missile is equipped with multiple independently targetable re-entry vehicles (MIRVs) and the first version, the M51.1, can carry up to six 100-kiloton TN 75 warheads. The second version, the M51.2, is armed with a new warhead, the *tête nucléaire océanique* (TNO, sea-based nuclear warhead), which is assumed to have a yield of 100 kt.[22] In April 2023 one of France's submarines—*Le Terrible*—tested an M51 SLBM following a lengthy period in overhaul, probably indicating the completion of its upgrade to the M51.2 standard.[23] Based on recent statements from French officials, SIPRI estimates that only one of France's four SSBNs, *Le Vigilant*, has yet to be upgraded to carry the M51.2 SLBM and its accompanying TNO warhead.[24] To allow for targeting flexibility, some of the SLBMs carried by France's SSBNs carry fewer warheads than others.[25] France has also commenced design work on another upgrade, the M51.3, which is intended to have improved accuracy. France

[21] Jézéquel, S., 'Pourquoi la France a-t-elle fait appareiller trois sous-marins nucléaires au départ de l'Ile-Longue?' [Why did France sail three nuclear submarines from Île-Longue?], *Le Télégramme*, 21 Mar. 2022.

[22] 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.

[23] Belhamiti, M., 'Avis fait au nom de la commission de la défense nationale et des forces armées sur le projet de loi de finances pour 2024, Tome VII, Défense: Équipement des forces—Dissuasion' [Notice on behalf of the Committee on National Defence and the Armed Forces on the Draft Finance Bill for 2024, vol. VII, Defence: Equipment of the forces—Deterrence', no. 1680, French National Assembly, 26 Oct. 2023.

[24] Salvetti, V., Director of Military Applications at the French Alternative Energies and Atomic Energy Commission (CEA), and Jacq, F., General Administrator of the CEA, Statements before the Committee on National Defence and the Armed Forces, French National Assembly, 18 Jan. 2023 (in French).

[25] Tertrais (note 3), p. 57.

conducted its first test launch of the M51.3 in November 2023; the missile is due to be operational in 2025.[26]

A production programme for a third-generation SSBN, designated the SNLE 3G, was officially launched in early 2021.[27] The SNLE 3G will eventually be equipped with a further modification of the M51 SLBM, the M51.4.[28] The construction of the first of four submarines in the class was scheduled to start in 2023, but work had not begun by the end of the year.[29] The first submarine is expected to be completed by 2035 and the other three submarines will be delivered on a schedule of one boat every five years.[30]

[26] Sébastien Lecornu (@SebLecornu), X, 18 Nov. 2023, <https://twitter.com/seblecornu/status/1725964236780621950>. See also French Ministry of the Armed Forces, 'Missiles balistiques stratégiques (MSBS)' [Strategic ballistic missiles], 28 Jan. 2020; and Parly, F., French Minister of the Armed Forces, Speech (in French), ArianeGroup, Les Mureaux, 14 Dec. 2017.

[27] French Ministry of the Armed Forces, 'Florence Parly, ministre des armées, annonce le lancement en réalisation des sous-marins nucléaires lanceurs d'engins de 3e génération (SNLE 3G)' [Florence Parly, minister of the armed forces, announces the launch of the 3rd-generation nuclear-powered ballistic missile submarines (SNLE 3G)], 19 Feb. 2021; and Mackenzie, C., 'France to begin building new ballistic missile subs', *Defense News*, 22 Feb. 2021.

[28] Tertrais (note 3), pp. 56, 60, 65.

[29] 'La première tôle des futurs sous-marins nucléaires lanceurs d'engins sera découpée fin 2023', La Presse de la Manche, 18 Feb. 2023.

[30] French Ministry of the Armed Forces (note 27); Groizeleau, 'Dissuasion : 25 milliards en cinq ans' (note 22); and Mackenzie (note 27).

Table 7.5. French nuclear forces, January 2024

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

Type/designation	No. of launchers	Year first deployed	Range (km)[a]	Warheads x yield	No. of warheads
Land-based aircraft					
Rafale BF3/4[b]	40	2010–11	2 000	1 x [<300 kt] TNA[c]	40
Carrier-based aircraft					
Rafale MF3/4[b]	10	2010–11	2 000	1 x [<300 kt] TNA[c]	10[d]
Sea-based missiles (SLBMs)	*4/64*[e]				*240*
M51.1	16	2010	>6 000	4–6 x 100 kt TN 75	80
M51.2[f]	32	2016	>9 000[g]	4–6 x 100 kt TNO	160
M51.3[h]	–	[2025]	>[9 000]	[up to 6] x 100 kt TNO	–
Total stockpile					**290**[i]

– = 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).

[a] For aircraft, the listed range is for illustrative purposes only; actual mission range will vary according to flight profile, weapon payload and in-flight refuelling.

[b] 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 is scheduled to be complete by 2025.

[c] 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 TN81 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. In the absence of official or consistent authoritative sources, these numbers should be treated as uncertain estimates.

[d] The 10 warheads assigned to France’s carrier-based aircraft are thought to be kept in central storage and are not normally deployed.

[e] The first figure is the total number of nuclear-powered ballistic missile submarines (SSBNs) in the French fleet; the second is the maximum number of missiles that they can carry. However, the total number of missiles carried is lower. Of the 4 SSBNs, 1 is in overhaul at any given time. France has 48 SLBMs in service—enough to equip the 3 operational SSBNs.

[f] SIPRI estimates that 1 SSBN—*Le Vigilant*—has yet to be upgraded to carry the M51.2 SLBM and its accompanying TNO warhead.

[g] The M51.2 has a ‘much greater range’ than the 6000-km range of the M51.1 according to the French Ministry of the Armed Forces.

[h] The M51.3 is under development and has not yet been deployed.

[i] 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.

Sources: Speeches (in French) of French presidents and defence ministers: Macron, E., Speech on defence and deterrence strategy, École de Guerre, Paris, 7 Feb. 2020; Parly, F., French Minister of the Armed Forces, Speech, ArianeGroup, Les Mureaux, 14 Dec. 2017; Hollande, F., Speech on nuclear deterrence, Istres Airbase, 19 Feb. 2015; Sarkozy, N., Speech on the new defence policy, Porte de Versailles, 17 June 2008; Sarkozy, N., Speech on the white paper on national defence and security, nuclear deterrence and the non-proliferation of nuclear weapons, Cherbourg, 21 Mar. 2008; and Chirac, J., Speech on France's defence policy, Île Longue, Brest, 19 Jan. 2006. Other sources: French Ministry of Defence/Ministry of the Armed Forces, various publications; French National Assembly, various defence bills; *Air Actualités*, various issues; *Aviation Week & Space Technology*, various issues; *Bulletin of the Atomic Scientists*, 'Nuclear Notebook', various issues; Tertrais, B., *French Nuclear Deterrence Policy, Forces and Future: A Handbook*, Recherches & Documents no. 04/2020 (Fondation pour la Recherche Stratégique: Paris, Feb. 2020); and authors' estimates.

V. Chinese nuclear forces

HANS M. KRISTENSEN AND MATT KORDA*

As of January 2024 China maintained an estimated total stockpile of about 500 nuclear warheads. This is around 90 more than SIPRI's estimate for the previous year—although an estimated 60 warheads are probably assigned to launchers that are still in production. China's warheads are assigned to its operational land- and sea-based ballistic missiles and to nuclear-configured aircraft (see table 7.6, end of section). Although the Chinese nuclear stockpile is projected to continue growing over the coming decade and the number of Chinese intercontinental ballistic missiles (ICBMs) is likely to reach or even exceed the numbers held by either the Russian Federation or the United States, China's overall nuclear warhead stockpile is still expected to remain smaller than those states' stockpiles. It has long been assumed that China stores its nuclear warheads separately from its deployed launchers during peacetime. However, the country's recent moves towards placing solid-fuelled missiles in silos, conducting sea-based deterrence patrols and, potentially, developing a launch-on-warning (LOW) capability suggest that China might have started mating a small number of its warheads (possibly around 24, corresponding to one missile brigade and one fully loaded ballistic missile submarine) with their launchers.

SIPRI's estimate of 500 warheads relies on publicly available information on the Chinese nuclear arsenal.[1] Since China has never declared the size of its nuclear arsenal, many of the assessments here rely on data from the US Department of Defense (DOD) and must therefore be treated with caution. For example, in its 2023 report to the US Congress on Chinese military and security developments, the US DOD projected that China might field a stockpile of roughly 1000 warheads by 2030.[2] This projection relies, however, on several assumptions about China's future force posture and plutonium production; it remains to be seen how accurate they are.[3] Notable developments in 2023 included significant construction at China's nuclear test site at Lop Nur, as well as the completion and operation of China's new

[1] Kristensen, H. M. and Korda, M., 'Estimating world nuclear forces: An overview and assessment of sources', SIPRI Commentary, 14 June 2021.

[2] 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. 104.

[3] Sokolski, H. D. (ed.), *China's Civil Nuclear Sector: Plowshares to Swords?*, Nonproliferation Policy Education Center (NPEC) Occasional Paper no. 2102 (NPEC: Arlington, VA, Mar. 2021).

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CFR-600 fast-breeder reactors with Russian fuel assistance, which could be used to increase China's plutonium stocks.[4]

This section summarizes the role played by nuclear weapons in China's military doctrine and then describes the air-delivered, land-based and sea-based nuclear weapons that constitute the three legs of China's nascent nuclear triad.

The role of nuclear weapons in Chinese military doctrine

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'.[5] 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.[6]

The dramatic changes in China's nuclear posture, especially its deployment of quick-launch solid-fuelled missiles in silos and the possible development of a LOW capability, have triggered widespread discussions about long-standing elements of Chinese nuclear doctrine, including its stated nuclear 'no-first-use' (NFU) policy.[7] 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.[8] According to the US DOD, China has deployed at least three early-warning satellites to facilitate this posture.[9]

Despite the continuing increase in the sophistication and size of China's nuclear arsenal—and the absence of an explicit affirmation of an NFU policy in China's September 2023 proposal for 'Reform and Development of Global Governance'—there is no official public evidence that the Chinese government has deviated from its long-standing core nuclear policies, including its

[4] Lewis, J., 'Nuclear test sites are too damn busy', Arms Control Wonk, 23 Sep. 2023; Babiarz, R., 'Satellite imagery of the Lop Nur site', *New York Times*, 20 Dec. 2023; Kobayashi, Y., 'China's fast breeder reactor operating? Possibility of accelerating nuclear arms race', SPF China Observer, 30 Nov. 2023; and Zhang, H., 'China started operation of its first CFR-600 breeder reactor', IPFM Blog, International Panel on Fissile Materials, 15 Dec. 2023.

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

[6] 'China reiterates non-first-use principle of nuclear weapons', Xinhua, 18 Feb. 2018; and US Department of Defense (note 2), p. 105.

[7] 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.

[8] US Department of Defense (note 2), p. 112.

[9] US Department of Defense (note 2), p. 112.

NFU policy.[10] Additionally, in its 2023 report the US DOD stated that China 'seems to believe a LOW posture is consistent with its no first use policy'.[11]

The Chinese nuclear posture has traditionally involved procedures for loading warheads on to launchers in a crisis, but with warheads, missiles and launchers kept separate during peacetime.[12] However, according to the US DOD's 2023 report, China's ballistic missile submarines conduct 'near-continuous at-sea deterrence patrols' and a small number of land-based missile units conduct 'combat readiness duty' and 'high alert duty' drills, which 'apparently includes assigning a missile battalion to be ready to launch and rotating to standby positions as much as monthly for unspecified periods of time'.[13] The US DOD also noted that this readiness posture allows the People's Liberation Army (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', suggesting that a few of China's warheads are deployed on launchers.[14]

Aircraft and air-delivered weapons

From the 1960s to 2017 some of China's medium-range Hong-6 or H-6 (B-6) bombers probably served an inactive back-up contingency nuclear mission.[15] In 2018, however, the US DOD reported that the PLA Air Force (PLAAF) was 'newly re-assigned a nuclear mission'.[16] The H-6N (B-6N), first fielded in 2020, is apparently China's 'first nuclear-capable air-to-air refuelable bomber'.[17] In addition, the PLAAF has been developing its first long-range strategic bomber, the H-20 (B-20), with an anticipated range of more than 10 000 kilometres, a stealthy design and dual-capability—that is, able to deliver both conventional and nuclear weapons.[18]

[10] Chinese Ministry of Foreign Affairs, Proposal of the People's Republic of China on the Reform and Development of Global Governance, 13 Sep. 2023.

[11] US Department of Defense (note 2), p. 112.

[12] 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.

[13] US Department of Defense (note 2), pp. 106, 108.

[14] US Department of Defense (note 2), p. 106.

[15] For the aircraft, missiles and submarines discussed here, a designation in parentheses (in this case B-6) following the Chinese designation (in this case H-6) is that assigned by the USA.

[16] US Department of Defense, *Military and Security Developments Involving the People's Republic of China 2018*, Annual Report to Congress (Office of the Secretary of Defense: Washington, DC, 16 May 2018), p. 75.

[17] US Department of Defense (note 2), pp. 62–63.

[18] US Department of Defense (note 2), p. 92; and US Office of the Deputy Assistant Secretary of Defense for Nuclear Matters, *Nuclear Matters Handbook 2020* (US Department of Defense: Washington, DC, Mar. 2020), figure 1.1, p. 3.

To arm the H-6N, China has been developing two new air-launched ballistic missiles (ALBMs), one of which is assessed by the USA to be potentially nuclear-capable.[19] The US DOD stated in its 2023 report that the PLAAF's operational airborne nuclear capability was still 'developing tactics and procedures' to conduct the nuclear mission and noted that this capability gave China a 'nascent nuclear triad'.[20] SIPRI estimates that, as of January 2024, around 20 nuclear warheads were assigned to PLAAF aircraft.

Land-based missiles

SIPRI estimates that approximately 346 nuclear warheads were assigned to China's nuclear-capable land-based ballistic missiles as of January 2024. This arsenal has been undergoing significant modernization as China complements its ageing silo-based, liquid-fuelled missiles with large numbers of new mobile and silo-based, solid-fuelled models.[21] However, the reliability of some of these newer missiles is in question after reports emerged in 2023 that widespread corruption in the PLARF may have undermined the modernization programme. There were several purges of senior PLARF officials in 2023 and US intelligence assessments suggested that the high level of corruption meant that some of the silos had been poorly constructed, affecting their ability to launch missiles effectively.[22]

Intercontinental ballistic missiles

In 2021 commercial satellite imagery revealed that China had started construction of hundreds of new missile silos across northern China.[23] By January 2024 the number of new silos under construction was approximately 350, spread out among three large fields in northern China and three mountainous areas in east-central China. The northern silo fields are thought

[19] US Department of Defense (note 2), p. 63; Ashley, R., Director, US Defense Intelligence Agency, 'Worldwide threat assessment', Statement for the record, US Senate, Armed Services Committee, 6 Mar. 2018, p. 8; US Air Force, National Air and Space Intelligence Center (NASIC), *Ballistic and Cruise Missile Threat 2020* (NASIC: Wright-Patterson Air Force Base, OH, July 2020), p. 7; and Stewart, V. R., Director, US Defense Intelligence Agency, 'Worldwide threat assessment', Statement for the record, US Senate, Armed Services Committee, 9 Feb. 2016. See also Kristensen, H. M. and Korda, M., 'Chinese nuclear forces', *SIPRI Yearbook 2022*, pp. 384–85.

[20] US Department of Defense (note 2), p. 63.

[21] Missile ranges specified here refer to Western definitions. China defines missile ranges differently: short, <1000 kilometres; medium, 1000–3000 km; long, 3000–8000 km; and intercontinental, >8000 km.

[22] 'China's defense purge strikes at heart of Xi's military reforms', Bloomberg, 4 Jan. 2024; and Martin, P. and Jacobs, J., 'US intelligence shows flawed China missiles led Xi to purge army', Bloomberg, 4 Jan. 2024.

[23] Lewis, J. and Eveleth, D., 'Chinese ICBM silos', Arms Control Wonk, 2 July 2021; Korda, M. and Kristensen, H. M., 'China is building a second nuclear missile silo field', FAS Strategic Security Blog, Federation of American Scientists, 26 July 2021; and Lee, R., 'PLA likely begins construction of an intercontinental ballistic missile silo site near Hanggin Banner', China Aerospace Studies Institute, 12 Aug. 2021.

to be intended for solid-fuelled Dongfeng (DF) ICBMs—most likely a siloed version of the DF-31A (CSS-10 Mod 2) at first as well as possibly the DF-41 (CSS-20)—while the more mountainous sites are thought to be intended for liquid-fuelled DF-5B (CSS-4 Mod 3) and DF-5C (CSS-4 Mod 4) ICBMs.[24] By January 2024 silo construction at the northern fields had been largely completed, along with inner and outer perimeter fences, electrical and radio towers, and air defence systems.[25] In its 2023 report the US DOD assessed that China had 'loaded at least some ICBMs into these silos'.[26] Notably, China's new northern silo fields are located deeper inside China than any other known ICBM base, including the new silos in east-central China, making them less vulnerable to long-range conventional strikes.[27]

The US DOD estimated in its 2023 report that China possessed approximately 500 ICBM launchers with 350 missiles in its inventory, although SIPRI assesses that these probably included training launchers and launchers under construction, in addition to operational launchers.[28]

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. If each silo were filled with a missile equipped with three multiple independently targetable re-entry vehicles (MIRVs), this number could rise to more than 1200 warheads. However, as of January 2024 it remained unclear how China ultimately plans to operate the new silos: whether they will all be filled, whether they will be loaded with DF-31-class or DF-41 ICBMs or a mixture of the two, how many warheads each missile would carry, and whether some of the missiles could potentially have a conventional strike role.[29]

China has three basic classes of ICBM: the DF-5, the DF-31 and the DF-41, with variants of each type. Most have a single warhead, while a smaller but growing number can deliver multiple warheads.

As of January 2024 SIPRI assesses that the numbers of deployed missiles in the DF-5 (CSS-4) family of ICBMs were around the same as the previous year but may be starting to increase as China has probably begun to deploy upgraded versions in the new silos currently under construction in east-central China. The DF-5B version can reportedly carry up to five warheads per missile, while the DF-5C has a multi-megaton yield.[30]

[24] US Department of Defense (note 2), p. 104; and authors' estimates.

[25] Authors' assessment based on analysis of satellite imagery.

[26] US Department of Defense (note 2), p. 104.

[27] Korda and Kristensen (note 23).

[28] US Department of Defense (note 2), p. 67.

[29] The assessment of a potential partial conventional strike role is based on circumstantial evidence in Lee, R., 'A case for China's pursuit of conventionally armed ICBMs', The Diplomat, 17 Nov. 2021, as well as the US DOD's assessment that China 'may be exploring development of conventionally-armed intercontinental range missile systems'. US Department of Defense (note 2), p. 67.

[30] US Department of Defense (note 2), pp. 67, 107.

In its 2023 report the US DOD confirmed non-governmental organization findings that China appeared to be doubling the number of launchers in some mobile ICBM brigades from 6 to 12, although some new bases appear to have only 8 launchers.[31] China is believed to have deployed at least 2 mobile DF-41 brigades, and a third base appears to have been completed—giving a total of around 28 launchers.[32] Preparations for the integration of additional DF-41 brigades into the PLARF also seem to be under way. The US DOD has assessed that China might ultimately plan to deploy the DF-41 in road-mobile and silo-based modes, in some or all of China's new missile silo fields, and potentially in a rail-based mode as well.[33] According to the US DOD, the DF-41 can carry no more than three warheads.[34]

The US DOD's 2023 report stated that China has also begun developing a new missile called the DF-27, which could have a range of 5000–8000 km.[35] However, public information about this new missile is scarce and its purported range can already be covered by China's other ICBMs. One possibility is that the DF-27 could eventually be used in a conventional strike role, a capability that the US DOD assesses that China might be exploring.[36]

In August 2021 China reportedly conducted a test of what appeared to be a fractional orbital bombardment system (FOBS) equipped with a hypersonic boost-glide system.[37] According to the US DOD, the tested system came close to striking its target after flying completely around the world for approximately 40 000 km and over 100 minutes.[38] While details about this new system are scarce, if the initial reporting is accurate, then it may be intended to counter advances in US missile defences. China has disputed that it is developing such a system, instead calling it a 'space vehicle'.[39]

Intermediate- and medium-range ballistic missiles

China has deployed nuclear-capable intermediate- and medium-range ballistic missiles since the 1960s, including a modernized version of the medium-range DF-21 (CSS-5) since the early 1990s and the intermediate-range DF-26 (CSS-18) since at least 2016. In recent years, however, China has converted several DF-21 brigades to brigades for longer-range missiles.

[31] US Department of Defense (note 2), p. 107; Decker Eveleth (@dex_eve), Twitter, 3 Nov. 2021, <https://twitter.com/dex_eve/status/1456009540982374404>; and assessments based on the authors' observations.

[32] US Department of Defense (note 2), p. 107; Rod Lee (@roderick_s_lee), Twitter, 28 Dec. 2021, <https://twitter.com/roderick_s_lee/status/1475885536254599172>; and authors' estimates.

[33] US Department of Defense (note 12), p. 65; and US Department of Defense (note 2), p. 107.

[34] US Department of Defense (note 2), pp. 67, 107.

[35] US Department of Defense (note 2), p. 67.

[36] US Department of Defense (note 2), p. 67.

[37] Sevastopulo, D., 'China conducted two hypersonic weapons tests this summer', *Financial Times*, 20 Oct. 2021. See also Raju, N., 'Developments in space security', *SIPRI Yearbook 2022*, pp. 573–74.

[38] US Department of Defense (note 2), p. 103.

[39] 'China denies report of hypersonic missile test, says tested space vehicle', Reuters, 18 Oct. 2021.

In 2023, for the first time, the US DOD's annual report to the US Congress did not include the DF-21 in a nuclear role, implying that only conventional DF-21Cs and DF-21Ds remain in service.[40] The dual-capable DF-26 is therefore assessed to be the sole intermediate- or medium-range missile type with a nuclear strike role in China's arsenal. With an estimated range of 3000–4000 km, the missile can reach targets in India, Russia, the South China Sea and the western Pacific Ocean, probably including US bases on Guam.[41] The missile is equipped with a manoeuvrable re-entry vehicle (MaRV) that can be rapidly swapped with another warhead. This theoretically allows the PLARF to switch the missile's mission between precision conventional strikes and nuclear strikes against ground targets—and even conventional strikes against naval targets—relatively quickly.[42]

Given the apparent ending of the DF-21's nuclear mission, it seems likely that the DF-26 now covers the targets previously assigned to the DF-21. In its 2023 report the US DOD noted that, among China's nuclear forces, the DF-26 is the weapon system that is most likely to be fielded with a lower-yield warhead 'in the near-term', although it remains unclear whether such options have been produced for China's nuclear forces, and what would constitute a 'lower' yield (which is not necessarily the same as a 'low-yield warhead').[43]

The US DOD estimated in its 2023 report that China might have up to 250 DF-26 launchers and 500 or more DF-26 missiles in its inventory.[44] However, this is a larger number than is indicated by the apparent operational base infrastructure; the US DOD's estimate may thus include launchers that are in production or otherwise not yet fully operational. There were sightings of the missile at several PLARF brigade bases during 2023, and SIPRI assesses that six DF-26 brigades appear to be operational, with around 216 launchers in total, although only about half of those are assumed to have a nuclear mission.

Sea-based missiles

In 2023 China continued to pursue its strategic goal from the early 1980s of developing and deploying sea-based nuclear weapons. The PLA Navy (PLAN) currently fields six Type 094 (Jin class) nuclear-powered ballistic missile submarines (SSBNs), two of which are Type 094As—upgraded variants

[40] US Department of Defense (note 2), pp. 66–67.
[41] US Department of Defense (note 2), p. 66.
[42] Pollack, J. H. and LaFoy, S., 'China's DF-26: A hot-swappable missile?', Arms Control Wonk, 17 May 2020; Deng, X., 'China deploys Dongfeng-26 ballistic missile with PLA Rocket Force', *Global Times*, 26 Apr. 2018; and US Department of Defense (note 2), p. 67.
[43] US Department of Defense (note 2), pp. 111–12.
[44] US Department of Defense (note 2), p. 67.

of the original design.[45] The US DOD's 2023 report assessed that these six operational SSBNs constitute China's 'first credible, sea-based nuclear deterrent'.[46] China's SSBN fleet is based at Hainan Island in the South China Sea.

Each of China's Type 094 submarines can carry up to 12 three-stage, solid-fuelled Julang (JL) submarine-launched ballistic missiles (SLBMs), which exist in two types: the JL-2 (CSS-N-14) and the JL-3 (CSS-N-20). China has probably begun replacing the JL-2s with JL-3s and it is possible that this process had already been completed by January 2024.[47] The JL-3 is capable of carrying multiple warheads and has an estimated range of more than 10 000 km.[48] However, unless the range is significantly more than 10 000 km, the JL-3 would not be able to strike the continental USA if fired from the South China Sea. Moreover, an SSBN carrying the missile would not be able to target Washington, DC, without first passing north-east Japan where it would be especially vulnerable to US anti-submarine defences.

There has been considerable speculation about whether the missiles on China's SSBNs are routinely fitted with nuclear warheads. The US DOD stated in its 2022 report to the US Congress that China 'likely began near-continuous at-sea deterrence patrols' in 2021. It noted in its 2023 report that China 'probably continued' such patrols throughout 2022.[49] This wording implies that China may have begun intermittent patrols with nuclear weapons onboard, which would constitute a significant change to its long-standing doctrine.

As the Type 094 SSBN is of a relatively noisy design, it was assumed that China would end production of that class and begin construction of its next-generation Type 096 class, which is expected to be larger and quieter and could potentially be equipped with more missile-launch tubes. The US DOD's 2023 report, however, stated that China has continued to build Type 094 SSBNs, possibly due to delays in the development of the Type 096 class.[50] Given the expected lifespans of the current Type 094 and the next-generation Type 096 SSBNs, the PLAN is expected to operate both types concurrently.[51]

It remains unclear how many SSBNs the PLAN ultimately intends to operate. Commercial satellite imagery from July 2023 showed that China was nearing completion of two new piers at the Longpo Naval Base. This would raise the total number of potential submarine berths at the base from 8 to 12, although some of these could be intended for attack submarines.

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

[46] US Department of Defense (note 2), p. 55.

[47] Capaccio, A., 'China has put longer-range ICBMs on its nuclear subs, US says', Bloomberg, 19 Nov. 2022; and US Department of Defense (note 2), p. 55.

[48] US Department of Defense (note 2), p. 59.

[49] US Department of Defense (note 12), p. 96; and US Department of Defense (note 2), p. 108.

[50] US Department of Defense (note 2), p. 108.

[51] US Department of Defense (note 2), p. 59.

Table 7.6. Chinese nuclear forces, January 2024

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)[a]	Warheads x yield[b]	No. of warheads[c]
Aircraft	*20*[d]				*20*
H-6K (B-6)	10	2009	3 100	1 x bomb	10
H-6N (B-6N)	10	2020	3 100	1 x ALBM	10
H-20 (B-20)	–	[2030]	. .	. .	–
Land-based missiles	*350*				*346*
DF-5A (CSS-4 Mod 2)	6	1981	12 000	1 x 4–5 Mt	6
DF-5B (CSS-4 Mod 3)	12	2015	13 000	5 x 200–300 kt	60
DF-5C (CSS-4 Mod 4)	. .	[2024]	13 000	1 x multi-Mt	. .
DF-21A/E (CSS-5 Mod 2/6)	. .	2000/2016	>2 100[e]	1 x 200–300 kt	–[f]
DF-26 (CSS-18)	216	2016	>3 000	1 x 200–300 kt	108[g]
DF-27 (CSS-X-24)	–	[2026]	5 000–8 000	. .	–[h]
DF-31 (CSS-10 Mod 1)	. .	2006	7 200	1 x 200–300 kt	. .[i]
DF-31A/AG (CSS-10 Mod 2)[j]	88	2007/2018	11 200	1 x 200–300 kt	88
DF-41 (mobile version) (CSS-20)	28[k]	2020	12 000	3 x 200–300 kt	84
DF-41 (silo version) (CSS-20)	. .	[2025]	12 000	[up to 3 x 200–300 kt]	. .
Sea-based missiles (SLBMs)	*6/72*[l]				*72*
JL-2 (CSS-N-14)	–	2016	>7 000	1 x 200–300 kt	–
JL-3 (CSS-N-20)	72[m]	2022	>10 000	[Multiple]	72
Other stored warheads[n]					[62]
Total stockpile	**442**				**500**[n]

. . = not available or not applicable; – = nil or a negligible value; [ ] = uncertain SIPRI estimate; ALBM = air-launched ballistic missile; kt = kiloton; Mt = megaton; SLBM = submarine-launched ballistic missile.

[a] For aircraft, the listed range is for illustrative purposes only; actual mission range will vary according to flight profile, weapon payload and in-flight refuelling.

[b] Warhead yields are listed for illustrative purposes. Actual yields 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.

[c] Figures are based on estimates of 1 warhead per nuclear-capable launcher, except for the DF-5B (CSS-4 Mod 3), which is thought to be equipped with multiple independently targetable re-entry vehicles (MIRVs) and can carry up to 5 warheads, and the MIRV-capable DF-41 (CSS-20), which is estimated to carry up to 3 warheads. All estimates are approximate.

It has long been assumed that China's warheads are not deployed on launchers under normal circumstances but are instead kept in storage facilities; however, as of Jan. 2024, SIPRI assesses that China might have started to mate a small number of its warheads (*c.* 24) with their launchers.

[d] The number of bombers only counts those estimated to be assigned a nuclear role. H-6 (B-6) bombers were used to deliver nuclear weapons during China's nuclear weapon testing programme (1 test used a fighter–bomber) and models of nuclear bombs are exhibited in military museums. It is thought (but not certain) that a small number of H-6 bombers previously had a secondary contingency mission with nuclear bombs. The United States Department of Defense (DOD) reported in 2018 that the People's Liberation Army Air Force has been reassigned a

nuclear mission, which is expected to revolve primarily around China’s new dual-capable ALBM.

[e] The range of the previously nuclear-armed DF-21 variants (see note f), the DF-21A (CSS-5 Mod 2) and the DF-21E (Mod 6), is thought to be greater than the 1750 km reported for the original DF-21 (CSS-5 Mod 1), which has been retired. The US Air Force (USAF) has reported the range as 2150 km.

[f] In recent years China has converted several DF-21 brigades to brigades for longer-range missiles. In 2023, for the first time, the US DOD’s annual report to the US Congress did not include the DF-21 in a nuclear role, implying that all of China’s remaining DF-21s now serve exclusively in conventional strike roles.

[g] The DF-26 (CSS-18) is a dual-capable launcher. It is believed that some DF-26 brigades have inherited the nuclear mission from the DF-21A/E (see note f) and perhaps up to half had been assigned nuclear warheads as of Jan. 2024. Only 1 nuclear warhead is assumed for each of the DF-26’s missiles that have been assigned a nuclear mission, with any reloads assumed to be conventional.

[h] The range class of the DF-27 (CSS-X-24) is somewhat redundant for the nuclear strike mission as these distances can be easily covered by China’s intercontinental ballistic missiles (ICBMs). This, coupled with the US DOD’s 2023 assessment that China ‘may be exploring development of conventionally-armed intercontinental range missile systems’, suggests that the DF-27 could serve in an exclusively conventional strike role—although this is unconfirmed.

[i] The DF-31 (CSS-10 Mod 1) was not listed in the US DOD’s 2023 report to the US Congress and is believed to have been retired.

[j] The DF-31AG is thought to carry the same missile as the DF-31A (both have the US CSS-10 Mod 2 designation). A siloed version of the DF-31A/AG, possibly carrying the same designation, is believed to be nearing completion for eventual loading into China’s new solid-fuel silo fields.

[k] This number assumes that at least 2 brigades were operational as of Jan. 2024.

[l] The first figure is the total number of operational nuclear-powered ballistic missile submarines (SSBNs) in the Chinese fleet; the second is the maximum number of missiles that they can carry.

[m] In Nov. 2022 the commander of the US Pacific Fleet stated that China was replacing its deployed JL-2 SLBMs with JL-3 SLBMs. This is likely taking place 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.

[n] In addition to the *c.* 438 warheads estimated to be assigned to operational forces, SIPRI estimates that *c.* 62 warheads might have been produced for missiles nearing operational status, for a total estimated stockpile of *c.* 500 warheads. China’s warhead stockpile is expected to continue to increase.

Sources: US Air Force (USAF), National Air and Space Intelligence Center, *Ballistic and Cruise Missile Threat*, various years; USAF Global Strike Command, various documents; US Central Intelligence Agency, various documents; US Defense Intelligence Agency, various documents; US Department of Defense, *Military and Security Developments Involving the People’s Republic of China*, Annual Report to Congress, various years; Kristensen, H. M., Norris, R. S. and McKinzie, M. G., *Chinese Nuclear Forces and US Nuclear War Planning* (Federation of American Scientists/Natural Resources Defense Council: Washington, DC, Nov. 2006); *Bulletin of the Atomic Scientists*, ‘Nuclear notebook’, various issues; Google Earth satellite imagery; and authors’ estimates.

VI. Indian nuclear forces

HANS M. KRISTENSEN AND MATT KORDA*

As of January 2024 India was estimated to have a growing stockpile of about 172 nuclear weapons—a small increase from the previous year (see table 7.7, end of section). These weapons were assigned to a maturing nuclear triad of aircraft, land-based missiles and nuclear-powered ballistic missile submarines (SSBNs). It has long been assumed that India stores its nuclear warheads separately 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.

The warhead estimate is based on calculations of India's inventory of weapon-grade plutonium (see section X of this chapter), the estimated number of operational nuclear-capable delivery systems, India's nuclear doctrine, publicly available information on the Indian nuclear arsenal, and private conversations with defence officials.[1] The Indian government has provided little public information about the size of its nuclear forces, other than conducting occasional parade displays and announcing missile flight tests.

This section starts by outlining the role played by nuclear weapons in Indian military doctrine. It then details India's holdings of nuclear weapons—its aircraft and air-delivered weapons and its land- and sea-based missiles.

The role of nuclear weapons in Indian military doctrine

The limited ranges of India's initial nuclear systems meant that, until the early 2010s, their only credible role was to deter Pakistan. However, with the development since then of longer-range missiles capable of targeting all of China, in recent years it appears that India has placed increased emphasis on deterring China.

While India has adhered to a nuclear no-first-use (NFU) policy since 1999, this pledge was qualified by a 2003 caveat (reaffirmed in 2018) that India could also use nuclear forces to retaliate against attacks by non-nuclear

[1] Kristensen, H. M. and Korda, M., 'Estimating world nuclear forces: An overview and assessment of sources', SIPRI Commentary, 14 June 2021.

* The authors wish to thank Eliana Johns and Mackenzie Knight for contributing invaluable research to this publication.

weapons of mass destruction (WMD).[2] Debate about India's commitment to the NFU policy has increased with indications since 2018 that some parts of India's nuclear arsenal are being kept at a higher state of readiness, including possible mating of a portion of India's warheads and launchers.[3] This raises questions about whether India might be transitioning towards a limited counterforce nuclear posture to target an adversary's nuclear weapons earlier in a crisis, even before they could be used.[4]

Similar to Pakistan (see section VII of this chapter), India has long maintained a policy of not using or threatening to use nuclear weapons against non-nuclear-armed states.[5] But given India's 2003 statement about potential use of nuclear weapons against non-nuclear WMD attacks, the conditions for this pledge are uncertain.

Aircraft and air-delivered weapons

India has several types of combat aircraft with performance characteristics that potentially make them suitable as nuclear-delivery platforms, including the Mirage 2000H, Jaguar IS and Rafale. However, there is scarcely any official information about a nuclear role for these aircraft, with one exception: a detailed source describes how the Mirage 2000H was converted for a nuclear strike role in the 1990s.[6] SIPRI estimates that approximately 48 nuclear gravity bombs were assigned to Indian aircraft as of January 2024.

Land-based missiles

The Indian Army's Strategic Forces Command operates five types of mobile nuclear-capable ballistic missile: the short-range Prithvi-II and Agni-I; the medium-range Agni-II; and the intermediate-range Agni-III and Agni-IV.

[2] Indian Ministry of External Affairs, 'The Cabinet Committee on Security reviews [o]perationalization of India's nuclear doctrine', Press release, 4 Jan. 2003; Indian Ministry of External Affairs, 'Draft report of National Security Advisory Board on Indian nuclear doctrine', 17 Aug. 1999; and Indian Prime Minister's Office, 'Prime Minister felicitates crew of INS Arihant on completion of nuclear triad', Press release, 5 Nov. 2018.

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

[4] Clary, C. and Narang, V., 'India's counterforce temptations: Strategic dilemmas, doctrine, and capabilities', *International Security*, vol. 43, no. 3 (winter 2018/19); Kaushal, S. et al., 'India's nuclear doctrine: The Agni-P and the stability–instability paradox', Royal United Services Institute (RUSI), 8 July 2021; and Rajagopalan, R., *India and Counterforce: A Question of Evidence*, ORF Occasional Paper no. 247 (Observer Research Foundation: New Delhi, May 2020).

[5] See e.g. Indian Ministry of External Affairs, 'The Cabinet Committee on Security reviews [o]perationalization of India's nuclear doctrine' (note 2); and Indian Ministry of External Affairs, 'India statement delivered by Secretary (West) at the annual high level meeting on "International Day for The Total Elimination of Nuclear Weapons"', 27 Sep. 2023, accessible via Internet Archive.

[6] Kampani, G., 'New Delhi's long nuclear journey: How secrecy and institutional roadblocks delayed India's weaponization', *International Security*, vol. 38, no. 4 (spring 2014), pp. 94, 97–98. For further detail see Kristensen, H. M. and Korda, M., 'Indian nuclear forces', *SIPRI Yearbook 2022*, pp. 393–94.

SIPRI estimates that India had around 80 operational missiles as of January 2024. At least three new land-based ballistic missiles were in development: the medium-range Agni-P and the intermediate-range Agni-V were nearing operational deployment, while a variant with intercontinental range, the Agni-VI, was in the design stage.[7] In 2023 unconfirmed reports emerged suggesting that India could reconfigure some of its nuclear medium-range ballistic missiles to give them conventional strike roles. However, in the absence of additional information it remains unclear whether this will happen.[8]

In 2023 India conducted test launches of older missiles and a critical test for one of its new developmental missiles. In June 2023 the Agni-P completed its first 'pre-induction' flight test (and fourth test of the system overall), thus 'pav[ing] the way for induction of the system into the Armed Forces', according to the Indian Ministry of Defence (MOD).[9] However, it is likely that India will undertake additional tests of the system before the Agni-P becomes operational.

The Agni-P is described by the Indian MOD as a 'next-generation' nuclear-capable ballistic missile. It reportedly incorporates technology developed specifically for the Agni-V programme, including an advanced navigation system and a new mobile canisterized launch system, which will reduce the time required to place the missiles on alert in a crisis.[10] The warhead for the solid-fuelled Agni-P can reportedly manoeuvre during re-entry, which could allow the missile to evade future missile defences of states in the region (e.g. China and Pakistan). An unidentified government source initially denied that the Agni-P was intended to replace older Agni missiles.[11]

In 2023 India also conducted test launches of the Prithvi-II and the Agni-I, both of which were described by the Indian MOD as 'proven systems'.[12]

India is developing a land-based version of the short-range K-15 submarine-launched ballistic missile (SLBM), known as the Shaurya.[13] However,

[7] Vikas, S. V., 'Why India may not test Agni 6 even if DRDO is ready with technology', OneIndia, 10 July 2019.

[8] Dubey, A. K., 'After Pralay, defence forces may opt for medium-range ballistic missiles in conventional roles for rocket force', ANI, 5 Nov. 2023.

[9] Indian Ministry of Defence, '"Agni Prime" ballistic missile successfully flight-tested by DRDO off Odisha coast', Press release, 8 June 2023.

[10] Indian Ministry of Defence, 'DRDO successfully flight tests new generation Agni P ballistic missile', Press release, 28 June 2021; and Rout, H. K., 'India test fires new generation nuclear capable Agni-Prime missile off Odisha coast', *New Indian Express*, 28 June 2021.

[11] Philip, S. A., 'Agni Prime is the new missile in India's nuclear arsenal. This is why it's special', ThePrint, 30 June 2021; and Zhen, L., 'India's latest Agni-P missile no great threat to China: Experts', *South China Morning Post*, 1 July 2021.

[12] Indian Ministry of Defence, 'Successful training launch of short-range ballistic missile, Prithvi-II, carried out off Odisha coast', Press release, 10 Jan. 2023; and Indian Ministry of Defence, 'Successful training launch of Agni-1 ballistic missile', Press release, 1 June 2023.

[13] See e.g. Press Trust of India, 'India successfully test-fires nuclear capable hypersonic missile Shaurya', *Hindustan Times*, 3 Oct. 2020; and Gupta, S., 'Govt okays induction of nuke-capable Shaurya missile amid Ladakh standoff', *Hindustan Times*, 6 Oct. 2020.

because of the high level of uncertainty about the status of the Shaurya, it is not included in SIPRI's estimate for January 2024.[14]

India is believed to be developing the technology to deliver multiple independently targetable re-entry vehicles (MIRVs), but as of January 2024 the status of the programme remained unclear. The technology has reportedly been tested on the Agni-P and could potentially be used on the intermediate-range Agni-V as well as the intercontinental Agni-VI that is currently in development.[15] The Agni-VI is controversial because its expected range may extend well beyond India's possible regional targets in Pakistan and China. In 2023 there were reports that a scientist, who had previously worked at the Indian Defence Research and Development Organisation (DRDO), had claimed that the Agni-VI's indigenously designed launcher had completed a successful test. However, the claim—which was revealed during the scientist's trial on charges of espionage—should be treated with caution because it is highly likely that the system remains several years away from deployment.[16]

Sea-based missiles

With the aim of creating an assured second-strike capability, India has continued to develop the naval component of its nascent nuclear triad and to build a fleet of four to six SSBNs.[17] The first of these SSBNs, INS *Arihant*, completed what the Indian government described as its first 'deterrence patrol' in 2018—although it seems unlikely that the missiles carried on the SSBN were armed with nuclear warheads.[18] A second SSBN, INS *Arighat*, was launched in November 2017 and underwent advanced sea trials in 2021–22, but its commissioning into the Indian Navy has been delayed and is now expected sometime in 2024.[19] 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 (which may have been renamed the B-05).[20] SIPRI estimates that 12 nuclear warheads have been delivered for potential deployment by INS *Arihant* and another 12 have been produced for INS *Arighat*.

[14] For further detail see Kristensen and Korda (note 6), p. 395.

[15] Rout, H. K., 'India to conduct first user trial of Agni-V missile', *New Indian Express*, 13 Sep. 2021.

[16] Inamdar, N., 'Honey-trapped DRDO scientist shared details of India's missile, drone programmes', *Hindustan Times*, 8 July 2023.

[17] Davenport, K., 'Indian submarine completes first patrol', *Arms Control Today*, vol. 48, no. 10 (Dec. 2018).

[18] Peri, D., 'Now, India has a nuclear triad', *The Hindu*, 18 Oct. 2016; Indian Prime Minister's Office (note 2); Davenport (note 17); and Joshi, Y., 'Angels and dangles: Arihant and the dilemma of India's undersea nuclear weapons', War on the Rocks, 14 Jan. 2019.

[19] Gupta, S., 'Aircraft carrier INS Vikramaditya is back on high seas', *Hindustan Times*, 19 Feb. 2023.

[20] Indian Defence Research and Development Organisation (DRDO), 'MSS—Achievements', 6 Sep. 2019.

At least two additional Arihant-class submarines are planned: India's third SSBN, currently known by its S4 developmental name, was reportedly launched in November 2021, and a fourth is under construction for possible launch in 2024.[21] These submarines are believed to be significantly larger than the first two, with satellite imagery indicating that they are approximately 20 metres longer.[22] They will reportedly have eight launch tubes able to hold up to 24 K-15 missiles or 8 K-4 missiles.[23] A next generation of SSBNs, known as S5, is reportedly also in the design stage.[24] The K-4 missile is in development but probably remains several years away from being operational. Two potential test launches of the K-4 in 2022 were apparently disrupted by the presence of Chinese spy ships but no known tests of the missile took place in 2023—although India did test launch a K-15 SLBM in July 2023.[25]

India's first naval nuclear weapon, the short-range Dhanush missile, is a version of the dual-capable Prithvi-II that can be launched from two Sukanya-class offshore patrol vessels.[26] Given the slow speed and high degree of vulnerability of the Sukanya-class vessels, the system will probably be retired when the SSBN programme with longer-range missiles matures.

[21] Chris Biggers (@CSBiggers), Twitter, 28 Dec. 2021, <https://twitter.com/CSBiggers/status/1476048094580117509>; Unnithan, S., 'A peek into India's top secret and costliest defence project, nuclear submarines', *India Today*, 10 Dec. 2017; and Bhattacharjee, S., 'Third Arihant class submarine quietly launched in November', *The Hindu*, 4 Jan. 2022.

[22] Sutton, H. I., 'Indian Navy's third ballistic missile submarine doubles missile armament', Covert Shores, 29 Dec. 2021.

[23] Bhattacharjee (note 21). See also Kristensen and Korda (note 6), p. 397.

[24] See e.g. Sterk, R., 'India levels up in nuclear submarines', Defense and Security Monitor, 1 May 2023.

[25] 'Chinese spy ships may complicate India's missile test plans in Indian Ocean for the second month in a row', *Swarajya*, 7 Dec. 2022; and 'DRDO test fires short range B-05LV missile from Kalam Island', *Pragativadi*, 2 July 2023.

[26] 'Nuke-capable Dhanush and Prithvi-II launched', *New Indian Express*, 12 Mar. 2011; and Indian Ministry of Defence (MOD), *Annual Report 2018–19* (MOD: New Delhi, 2019), p. 100.

Table 7.7. Indian nuclear forces, January 2024

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

Type/designation	No. of launchers	Year first deployed	Range (km)[a]	Warheads x yield[b]	No. of warheads[c]
Aircraft[d]	*84*				*48*
Mirage 2000H	32	1985	1 850	1 x 12 kt bomb	32
Jaguar IS	16	1981	1 600	1 x 12 kt bomb	16
Rafale	36	2022	2 000	. .	–
Land-based missiles	*80*				*80*
Prithvi-II	24	2003	250[e]	1 x 12 kt	24
Agni-I	16	2007	>700	1 x 10–40 kt	16
Agni-II	16	2011	>2 000	1 x 10–40 kt	16
Agni-III	16	2018	>3 200	1 x 10–40 kt	16
Agni-IV	8	2022	>3 500	1 x 10–40 kt	8
Agni-V	. .	[2024]	>5 000	1 x 10–40 kt	. .
Agni-VI	–	[2027]	>6 000	1 x 10–40 kt [possible MIRV]	–
Agni-P	–	[2025]	1 000–2 000	[1 x 10–40 kt]	–
Sea-based missiles	*3/14*[f]				*16*
Dhanush	2	2013	400	1 x 12 kt	4[g]
K-15 (B-05)[h]	12[i]	2018	700	1 x 12 kt	12
K-4	–[j]	[2025]	3 500	1 x 10–40 kt	–
Other stored warheads[k]					[*28*]
Total stockpile	**178**				**172**[k]

. . = not available or not applicable; – = nil or a negligible value; [ ] = uncertain SIPRI estimate; kt = kiloton; MIRV = multiple independently targetable re-entry vehicle.

[a] For aircraft, the listed range is for illustrative purposes only; actual mission range will vary according to flight profile, weapon payload and in-flight refuelling.

[b] 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.

[c] Aircraft and several missile types are 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. All estimates are approximate.

[d] The Rafale is listed as a potential future nuclear delivery platform. It seems likely that it would probably initially replace the Jaguar in that role. However, in the absence of official or authoritative sources, SIPRI has not attributed nuclear weapons to Rafale aircraft in its estimate for Jan. 2024. Other aircraft that could potentially have a secondary nuclear role include the Su-30MKI.

[e] The Prithvi-II's range is often reported as 350 kilometres. However, the United States Air Force's National Air and Space Intelligence Center sets the range at 250 km.

[f] The first figure is the number of operational vessels—2 ships and 1 nuclear-powered ballistic missile submarine (SSBN); the second is the maximum number of missiles that they can carry. India has launched 3 SSBNs, but only 1—INS *Arihant*—was believed to be operational as of Jan. 2024, and it was believed to have only a limited operational capability. The second SSBN—INS *Arighat*—has conducted sea trials and might become fully operational in 2024. The third, known as S4, was reportedly launched in Nov. 2021 but, as of Jan. 2024, its status remained unclear.

[g] Each Sukanya-class patrol ship equipped with Dhanush missiles was thought to have possibly 1 reload.

[h] The K-15 may have been renamed the B-05. Some sources have referred to the K-15 missile as 'Sagarika', which was the name of the missile-development project, rather than the missile itself.

[i] Each of India's first 2 SSBNs has 4 missile tubes, each of which can carry 3 K-15 submarine-launched ballistic missiles (SLBMs), for a total of 12 missiles per SSBN. Only 1 SSBN was believed to be operational as of Jan. 2024 (see note f).

[j] Each of the 8 missile tubes on India's third and fourth SSBNs will be able to carry 3 K-15 SLBMs or 1 K-4 SLBM once the latter missile becomes operational.

[k] In addition to the *c.* 144 warheads estimated to be assigned to operational forces, SIPRI estimates that *c.* 28 warheads might have been produced for missiles nearing operational status, including the Agni-V and Agni-P (*c.* 16 warheads) and the K-15 (*c.* 12 warheads for INS *Arighat*), for a total estimated stockpile of *c.* 172 warheads. India's warhead stockpile is expected to continue to increase.

Sources: Indian Ministry of Defence, annual reports and press releases; International Institute for Strategic Studies, *The Military Balance*, various years; US Air Force (USAF), National Air and Space Intelligence Center, *Ballistic and Cruise Missile Threat*, various years; Indian news media reports; *Bulletin of the Atomic Scientists*, 'Nuclear notebook', various issues; and authors' estimates.

VII. Pakistani nuclear forces

HANS M. KRISTENSEN AND MATT KORDA*

According to SIPRI estimates, Pakistan possessed approximately 170 nuclear warheads as of January 2024—the same number as the previous year (see table 7.8, end of section). These weapons were assigned to Pakistan's nascent triad of aircraft, ground-launched ballistic and cruise missiles, and sea-launched cruise missiles. The development of several new delivery systems and Pakistan's growing accumulation of fissile material (see section X of this chapter) suggest that its nuclear weapon arsenal and fissile material stockpile are likely to continue to expand over the next decade, although projections vary considerably.[1]

The Pakistani government has never publicly disclosed the size of its nuclear arsenal. Limited official public data and exaggerated news stories about Pakistan's nuclear weapons mean that analysing the number and types of Pakistani warheads and delivery vehicles is fraught with uncertainty. SIPRI's estimates of Pakistan's nuclear forces thus come with less confidence than those for most other nuclear-armed countries.[2] The estimates in this section are based on the authors' analysis of Pakistan's nuclear posture and fissile material production, analysis of commercial satellite imagery, public statements by Western officials, and private conversations with Pakistani officials.

This section starts by outlining the role played by nuclear weapons in Pakistan's military doctrine. It then describes Pakistan's air-delivered and land-based weapons and the nascent sea-based capability.

The role of nuclear weapons in Pakistani military doctrine

Pakistan does not have a no-first-use (NFU) doctrine and reserves the right to use nuclear weapons first in wartime, primarily due to what it perceives as an asymmetry in the strength of its conventional forces relative to India. Pakistan has placed an emphasis on non-strategic nuclear weapons specifically in

[1] See e.g. Sundaresan, L. and Ashok, K., 'Uranium constraints in Pakistan: How many nuclear weapons does Pakistan have?', *Current Science*, vol. 115, no. 6 (25 Sep. 2018); Salik, N., 'Pakistan's nuclear force structure in 2025', Regional Insight, Carnegie Endowment for International Peace, 30 June 2016; and Jones, G. S., 'Pakistan's nuclear material production for nuclear weapons', Proliferation Matters, 16 Feb. 2021. See also Berrier, S., Director, US Defense Intelligence Agency, 'Worldwide threat assessment', Statement for the record, US Senate, Armed Services Committee, 26 Apr. 2021. On Pakistan's fissile material stockpile see Kile, S. N. and Kristensen, H. M., 'Pakistani nuclear forces', *SIPRI Yearbook 2019*; and International Panel on Fissile Materials, 'Pakistan', 31 Aug. 2021.

[2] Kristensen, H. M. and Korda, M., 'Estimating world nuclear forces: An overview and assessment of sources', SIPRI Commentary, 14 June 2021.

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response to India's 'Cold Start' doctrine.[3] While it has no NFU doctrine, Pakistan has regularly co-sponsored resolutions in the United Nations General Assembly with the stated aim of assuring non-nuclear-armed states that it would not use or threaten to use nuclear weapons against them.[4]

Pakistan has been pursuing the development and deployment of new nuclear weapons and delivery systems as part of its 'full spectrum deterrence posture' in relation to India.[5] In May 2023 an advisor to Pakistan's National Command Authority—which oversees the country's nuclear doctrine and weapon programmes—explained that 'full spectrum deterrence' denotes Pakistan's possession of 'strategic, operational, and tactical' nuclear weapons with a wide range of yields, and noted that these could be used against 'a full spectrum of targets' in India, including countervalue, counterforce and battlefield targets.[6]

Aircraft and air-delivered weapons

As of January 2024 Pakistan was estimated to operate a small stockpile of nuclear gravity bombs, with cruise missiles in development.

Two versions of the Ra'ad (Hatf-8) air-launched cruise missile (ALCM) were being developed to supplement this stockpile by providing the Pakistan Air Force (PAF) with a nuclear-capable stand-off capability at ranges of 350–600 kilometres.[7] Neither version was thought to have been operationally deployed as of January 2024.

[3] On the doctrine—under which India looks to maintain the capability to launch large-scale conventional strikes or incursions against Pakistani territory at a level below the threshold at which Pakistan would retaliate with nuclear weapons—see Kidwai, K., Advisor, Pakistani National Command Authority, Keynote address and discussion session, 7th South Asian Strategic Stability workshop, 'Deterrence, nuclear weapons and arms control', International Institute for Strategic Studies (IISS) and Centre for International Strategic Studies (CISS), London, 6 Feb. 2020; and Saalman, L. and Topychkanov, P., *South Asia's Nuclear Challenges: Interlocking Views from India, Pakistan, China, Russia and the United States* (SIPRI: Stockholm, Apr. 2021). For a US diplomatic assessment of India's 'Cold Start' strategy see Roemer, T., US Ambassador to India, 'Cold Start: A mixture of myth and reality', Cable New Delhi 000295, 16 Feb. 2010, accessible via WikiLeaks. Although Indian officials had previously denied the existence of the Cold Start doctrine, India's chief of the army staff acknowledged its existence in an interview in 2017. Unnithan, S., '"We will cross again"', *India Today*, 4 Jan. 2017.

[4] See e.g. United Nations, General Assembly, 'Conclusion of effective international arrangements to assure non-nuclear-weapon states against the use or threat of use of nuclear weapons', A/C.1/75/L.22, 7 Oct. 2020.

[5] Kidwai (note 3). For a detailed assessment of Pakistan's nuclear posture see Tasleem, S. and Dalton, T., 'Nuclear emulation: Pakistan's nuclear trajectory', *Washington Quarterly*, vol. 41, no. 4 (winter 2019). See also Kristensen, H. M. and Korda, M., 'Pakistani nuclear forces', *SIPRI Yearbook 2023*, p. 301.

[6] Kidwai, K., Advisor, Pakistani National Command Authority, Speech at '25 years of Yom Takbeer: Promoting Peace, Stability and Development' seminar, Arms Control and Disarmament Centre, Institute of Strategic Studies Islamabad, Islamabad, 24 May 2023.

[7] For further detail on the Ra'ad ALCM see Kristensen, H. M. and Korda, M., 'Pakistani nuclear forces', *SIPRI Yearbook 2021*, p. 387.

Pakistan has several types of combat aircraft with performance characteristics that make them suitable as nuclear-delivery platforms, including the Mirage III, the Mirage V, the F-16 and the JF-17. However, no official sources have confirmed their nuclear-capable roles. Given this significant uncertainty, SIPRI assesses that the Mirage III and possibly the Mirage V are the most likely to have a nuclear-delivery role. The Mirage III has been used for developmental test flights of the nuclear-capable Ra'ad ALCM, while the Mirage V is believed to have been given a strike role with Pakistan's small arsenal of nuclear gravity bombs.[8]

When the Mirage aircraft are eventually phased out, it is possible that the JF-17 will take over their nuclear role in the PAF and that the Ra'ad ALCM will be integrated on to the JF-17.[9] In March 2023 images emerged for the first time of a JF-17 carrying what resembled a Ra'ad ALCM, suggesting a potential dual-capable role for the aircraft—although this had not been officially confirmed as of January 2024.[10]

Land-based missiles

As of January 2024 Pakistan's nuclear-capable land-based missile arsenal comprised an estimated 126 short- and medium-range systems.

Pakistan has deployed four types of solid-fuelled, road-mobile short-range ballistic missile: the Abdali (also designated Hatf-2), the Ghaznavi (Hatf-3), the Shaheen-I/IA (Hatf-4) and the Nasr (Hatf-9). Except for the Abdali, all of these missiles were showcased at the annual Pakistan Day parades in 2021 and 2022 (the scheduled 2023 parade did not take place), suggesting that they are still operational.[11] The Abdali—Pakistan's oldest ballistic missile type—was not displayed at these parades and has not been tested since 2013, perhaps indicating that the missile is being superseded by newer systems.

The arsenal also included two types of operational medium-range ballistic missile: the liquid-fuelled, road-mobile Ghauri (Hatf-5); and the two-stage, solid-fuelled, road-mobile Shaheen-II (Hatf-6).[12] A longer-range variant in

[8] International Institute for Strategic Studies (IISS), *The Military Balance 2022* (Routledge: London, 2022), p. 297; and Dominguez, G., 'Pakistan test-launches longer-range variant of Ra'ad II ALCM', Janes, 19 Feb. 2020. For further detail on the nuclear capability of the F-16s see Kristensen, H. M. and Kile, S. N., 'Pakistani nuclear forces', *SIPRI Yearbook 2020*, p. 370.

[9] 'Ra'ad ALCM: The custodian of Pakistan's airborne nuclear deterrence', PakDefense, 6 Dec. 2020; and Pakistan Strategic Forum, 'Update on Pakistan: "JF-17 Thunder's integration with RA'AD II ALCM"', 8 July 2020.

[10] 'Pakistani Thunder', Scramble, 21 Mar. 2023.

[11] Pakistani Inter Services Public Relations (ISPR), 'Pakistan Day Parade: 23 March 2022', ISPR Official, YouTube, 24 Mar. 2022; and Pakistani Inter Services Public Relations (ISPR), 'Pakistan Day Parade: March 2021', ISPR Official, YouTube, 25 Mar. 2021.

[12] United States Air Force, National Air and Space Intelligence Center (NASIC), *Ballistic and Cruise Missile Threat 2020* (NASIC: Wright-Patterson Air Force Base, OH, July 2020), p. 25; and Pakistani Inter Services Public Relations (ISPR), 'Pakistan conducted successful training launch of surface to surface ballistic missile Shaheen-II', Press release no. PR-104/2019-ISPR, 23 May 2019.

development, the Shaheen-III, has been test launched at least three times—in 2015, 2021 and 2022—but was probably not yet deployed as of January 2024.[13] This missile has a claimed range of 2750 km, making it the longest-range system that Pakistan has tested to date. The Ghauri, Shaheen-II and Shaheen-III were all displayed at the Pakistan Day Parade in 2022.

In October 2023 Pakistan conducted its second test launch (and the first since 2017) of the Ababeel—a developmental medium-range ballistic missile that can reportedly deliver multiple independently-targetable re-entry vehicles (MIRVs).[14] The Pakistani government stated that the test was 'aimed at re-validating various design, technical parameters and performance evaluation of different sub-systems of the weapon system', suggesting that the Ababeel was probably not yet operationally deployed as of January 2024.[15] 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 the Russian Federation.[16]

In addition to expanding its arsenal of land-based ballistic missiles, Pakistan has continued to develop the nuclear-capable Babur (Hatf-7) ground-launched cruise missile, with an estimated range of 350 km.[17] The Babur has been test launched about 12 times since 2005 and has been used in army field training since 2011, indicating that the system is probably operational—although there is some uncertainty as to whether the nuclear version is also operational. An upgraded version, with a claimed range of 450 km, is known as the Babur-1A and was featured in the Pakistan Day Parade in 2022.[18] A version known as the Babur-2 (sometimes referred to as the Babur-1B) has a claimed range of 900 km and was tested most recently in December 2021.[19]

[13] Pakistani Inter Services Public Relations (ISPR), 'Shaheen 3 missile test', Press release no. PR-61/2015-ISPR, 9 Mar. 2015; Jamal, S., 'Pakistan tests nuclear-capable Shaheen-III ballistic missile', *Gulf News*, 20 Jan. 2021; and DG ISPR (@OfficialDGISPR), Twitter, 9 Apr. 2022, <https://twitter.com/OfficialDGISPR/status/1512710884518359042>.

[14] '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. The US Air Force's National Air and Space Intelligence Center also describes the 2017 test as involving 'the MIRV version of the Ababeel'. US Air Force, National Air and Space Intelligence Center (NASIC), *Ballistic and Cruise Missile Threat 2017* (NASIC: Wright-Patterson Air Force Base, OH, June 2017), p. 25. On the Ababeel see also Kile and Kristensen (note 1), p. 335.

[15] 'Pakistan conducts successful flight test of Ababeel weapon system' (note 14).

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

[17] US Air Force (note 14), p. 37.

[18] Pakistani Inter Services Public Relations, 'Pakistan Day Parade: 23 March 2022' (note 11); and Pakistani Inter Services Public Relations (ISPR), 'Press release no. PR24/2021, Pak conducted successful launch of Babur cruise missile—11 Feb 2021(ISPR)', ISPR Official, YouTube, 11 Feb. 2021.

[19] Pakistani Inter Services Public Relations (ISPR), 'Pakistan conducted a successful test of an enhanced range version of the indigenously developed Babur cruise missile', Press release no. PR-142/2018-ISPR, 14 Apr. 2018; Gupta, S., 'Pakistan's effort to launch 750km range missile crashes', *Hindustan Times*, 23 Mar. 2020; and Pakistani Inter Services Public Relations (ISPR), 'Pakistan conducted a successful test of an enhanced range version of the indigenously developed Babur cruise missile 1B', Press release no. PR-222/2021-ISPR, 21 Dec. 2021.

Overall, in 2022 and 2023 Pakistan conducted significantly fewer public missile test launches than in previous years, which may be related to Pakistan's ongoing political and military instability following the removal of Imran Khan as prime minister in 2022 and his subsequent arrest in 2023.[20]

Sea-based missiles

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 submarine-launched cruise missile (SLCM) is intended to establish a nuclear capability for the Pakistan Navy's three Agosta-90B diesel–electric submarines.[21] Pakistan test-launched the Babur-3 in 2017 and 2018.[22]

[20] Turak, N., 'Former Pakistani Prime Minister Imran Khan arrested amid tensions with military', CNBC, 9 May 2023.

[21] Pakistani Inter Services Public Relations (ISPR), Press release no. PR-10/2017-ISPR, 9 Jan. 2017; and Panda, A. and Narang, V., 'Pakistan tests new sub-launched nuclear-capable cruise missile. What now?', The Diplomat, 10 Jan. 2017.

[22] 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.

Table 7.8. Pakistani nuclear forces, January 2024

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

Type/designation	No. of launchers	Year first deployed	Range (km)[a]	Warheads x yield[b]	No. of warheads[c]
Aircraft[d]	*36*				*36*
Mirage III/V	36[e]	1998	2 100	1 x 5–12 kt bomb or Ra'ad-I/II ALCM[f]	36
[JF-17]	–	. .	. .	Ra'ad-I/II ALCM[f]	–
Land-based missiles	*126*[g]				*126*
Abdali (Hatf-2)	10	2002	200	1 x 5–12 kt	10
Ghaznavi (Hatf-3)	16	2004	300	1 x 5–12 kt	16
Shaheen-I/IA (Hatf-4)[h]	16	2003/2022	750/900	1 x 5–12 kt	16
Shaheen-II (Hatf-6)	24	2014	2 000	1 x 10–40 kt	24
Shaheen-III[i]	–	[2024]	2 750	1 x 10–40 kt	–
Ghauri (Hatf-5)	24	2003	1 250	1 x 10–40 kt	24
Nasr (Hatf-9)	24	2013	70	1 x 5–12 kt	24
Ababeel	–	. .	2 200	[MRV or MIRV][j]	–
Babur/-1A GLCM (Hatf-7)[k]	12	2014/[early 2020s]	350/450	1 x 5–12 kt	12
Babur-2/-1B GLCM[l]	–	. .	900	1 x 5–12 kt	–
Sea-based missiles					
Babur-3 SLCM	–	[2025]	450	1 x 5–12 kt	–
Other stored warheads[m]					[*8*]
Total stockpile	**162**				**170**[m]

. . = not available or not applicable; – = nil or a negligible value; [ ] = uncertain SIPRI estimate; ALCM = air-launched cruise missile; GLCM = ground-launched cruise missile; kt = kiloton; MIRV = multiple independently targetable re-entry vehicle; MRV = multiple re-entry vehicle; SLCM = sea-launched cruise missile.

[a] For aircraft, the listed range is for illustrative purposes only; actual mission range will vary according to flight profile, weapon payload and in-flight refuelling.

[b] 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.

[c] Aircraft and several missile types are dual-capable—that is, they can be armed with either conventional or nuclear warheads. Cruise missile launchers (aircraft and land- and sea-based missiles) can carry more than 1 missile. This estimate counts an average of 1 nuclear warhead per launcher. Pakistan does not deploy its warheads on launchers but keeps them in separate storage facilities.

[d] There are unconfirmed reports that Pakistan modified for a nuclear weapon-delivery role some of the 40 F-16 aircraft procured from the United States in the 1980s. However, it is assumed here that the nuclear weapons assigned to aircraft are for use by Mirage aircraft. When the Mirage IIIs and Vs are eventually phased out, it is possible that the JF-17 will take over their nuclear role in the Pakistan Air Force.

[e] Pakistan possesses many more than 36 Mirage aircraft, but this table only includes those that are assumed to have a nuclear weapon-delivery role.

[f] The Ra'ad (Hatf-8) ALCM has a claimed range of 350 km and an estimated yield of 5–12 kt. However, there is no available evidence to suggest that the Ra'ad has been deployed and it is therefore not included in the operational warhead count. In 2017 the Pakistani military displayed

a Ra'ad-II variant with a reported range of 600 km. It was test flown for the first time in 2020 and several additional flights will be needed before it becomes operational. In 2023 images emerged for the first time of a JF-17 carrying what resembled a Ra'ad ALCM, suggesting a potential dual-capable role for the aircraft—although this had not been officially confirmed as of Jan. 2024.

[g] Some launchers might have 1 or more missile reloads.

[h] It is unclear whether the Shaheen-IA has the same 'Hatf-4' designation as the Shaheen-I.

[i] The designation for the Shaheen-III is unknown.

[j] The Pakistani military claimed in 2017 that the Ababeel can deliver multiple warheads using MIRV technology, but does not appear to have provided any further information since then.

[k] Pakistan has been upgrading its original Babur GLCMs to Babur-1As by improving their avionics and target-engagement systems to hit both land and sea targets. The range of the original Babur is listed as 350 km by the US Air Force's National Air and Space Intelligence Center, while Pakistan claims that the range of the improved Babur-1A is 450 km.

[l] The Babur-2 GLCM is sometimes referred to as the Babur-1B.

[m] In addition to the *c.* 162 warheads estimated to be assigned to operational forces, SIPRI estimates that *c.* 8 warheads have been produced to arm future Shaheen-III missiles, for a total estimated stockpile of *c.* 170 warheads. Pakistan's warhead stockpile is expected to continue to increase.

Sources: Pakistani Ministry of Defence, various documents; US Air Force (USAF), National Air and Space Intelligence Center, *Ballistic and Cruise Missile Threat*, various years; International Institute for Strategic Studies, *The Military Balance*, various years; *Bulletin of the Atomic Scientists*, 'Nuclear notebook', various issues; and authors' estimates.

VIII. North Korean nuclear forces

HANS M. KRISTENSEN AND MATT KORDA*

The Democratic People's Republic of Korea (DPRK, or North Korea) maintains an active but highly opaque nuclear weapon programme. SIPRI estimates that, as of January 2024, North Korea possessed around 50 nuclear weapons (see table 7.9, end of section), but that it probably possessed sufficient fissile material for an approximate total of up to 90 nuclear devices, depending on warhead design. Based on statements by the North Korean leader, Kim Jong Un, and North Korea's expanding force posture, it seems likely that North Korea intends to increase its nuclear warhead inventory significantly.

The estimates for North Korea are based on calculations of the amount of fissile material—plutonium and highly enriched uranium (HEU)—that North Korea is believed to have produced for use in nuclear weapons (see section X of this chapter), its nuclear weapon testing history, its observable missile forces and assessments by the authors. Analysing the numbers and types of North Korean warheads and delivery vehicles is fraught with uncertainty due to limited or untrustworthy public sources. Much of the data presented here is derived from sources outside North Korea, including satellite imagery, United States government reports and statements (which may also be biased), and expert analyses, as well as state media publications.[1]

North Korea has conducted a total of six nuclear explosive tests: in 2006, 2009, 2013, twice in 2016, and most recently in 2017.[2] Despite construction work at the Punggye-ri nuclear test site during 2023 and other apparent preparations for a seventh nuclear test, no test had taken place by the end of the year.[3] North Korea claims to have non-strategic (tactical) nuclear weapons and 'super-large hydrogen bomb[s]' in its inventory.[4]

This section continues by summarizing the role played by nuclear weapons in North Korea's military doctrine. It then outlines the country's capabilities for production of fissile material and nuclear warheads before describing its missiles and missile programmes.

[1] Kristensen, H. M. and Korda, M., 'Estimating world nuclear forces: An overview and assessment of sources', SIPRI Commentary, 14 June 2021.

[2] Fedchencko, V., 'Nuclear explosions, 1945–2017', *SIPRI Yearbook 2018*.

[3] Bermudez Jr., J. S., Cha, V. and Jun, J., 'Punggye-ri update: New activity at tunnel no. 4', Beyond Parallel, Center for Strategic and International Studies, 4 May 2023.

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

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The role of nuclear weapons in North Korean military doctrine

North Korea has repeatedly signalled through doctrinal commitments and the testing of new capabilities that it will continue to develop its long- and short-range nuclear capabilities to serve as both a deterrent and potentially a response to any perceived threat.

According to the 2022 Law on the Nuclear Weapons Policy of the Democratic People's Republic of Korea (which updated and repealed legislation from 2013), North Korea's nuclear forces are required to be 'regularly ready for action'.[5] The new law also clarified that nuclear weapons could be used pre-emptively—contradicting an earlier pledge from October 2020 that they would not be used in this way—in response to a perceived nuclear or non-nuclear attack on North Korea's leadership or the command structure of its nuclear forces, or other significant attack against a strategic target.[6] It also suggested that North Korea could use nuclear weapons to 'seize the initiative' during wartime.[7] In September 2022 Kim Jong Un declared that the law codified North Korea's 'irreversible' status as a nuclear-armed state and that it would 'never give up' its nuclear weapons.[8] North Korea amended its constitution in September 2023 to enshrine its status as a nuclear-armed state.[9]

North Korea's doctrine includes a form of negative security assurance. According to the 2022 law, North Korea 'shall neither threaten non-nuclear weapon states with its nuclear weapons nor use nuclear weapons against them unless they join aggression or attack against North Korea in collusion with other nuclear weapon possessing states', with the caveat probably referring to the Republic of Korea (South Korea) and Japan.[10] In December 2022 the plenary meeting of the Central Committee of the Worker's Party of Korea (WPK) noted that the first mission of North Korea's nuclear force is to

[5] [Law on the Nuclear Weapons Policy of the Democratic People's Republic of Korea], adopted by the Supreme People's Assembly 8 Sep. 2022 (in Korean), Article 7. For an English translation see Korean Central News Agency, 'Law on DPRK's policy on nuclear forces promulgated', DPRK Today, 9 Sep. 2022. For details of the 2013 legislation see Kristensen, H. M. and Korda, M., 'North Korean nuclear forces', *SIPRI Yearbook 2023*, p. 307.

[6] [Law on the Nuclear Weapons Policy of the Democratic People's Republic of Korea] (note 5), Article 6. On the earlier pledge not to use nuclear weapons 'pre-emptively' see 'Kim Jong Un's October speech: More than missiles', 38 North, 13 Oct. 2020.

[7] [Law on the Nuclear Weapons Policy of the Democratic People's Republic of Korea] (note 5), Article 6.

[8] *Rodong Sinmun*, [State administration speech by dear comrade Kim Jong Un at the 7th session of the 14th Supreme People's Assembly of the Democratic People's Republic of Korea 8 September Juche 111 (2022)], KCNA Watch, 9 Sep. 2022 (in Korean, author translation).

[9] Korean Central News Agency, '9th session of 14th SPA of DPRK held', KCNA Watch, 28 Sep. 2023.

[10] [Law on the Nuclear Weapons Policy of the Democratic People's Republic of Korea] (note 5), Article 5.

'deter war and safeguard peace and stability', but that, if deterrence fails, it will 'carry out the second mission, which will not be for defense'.[11]

Fissile material and warhead production

Plutonium-production and -separation capabilities

North Korea's plutonium-production and -separation capabilities for manufacturing nuclear weapons are located at the Yongbyon Nuclear Scientific Research Centre in North Pyongan province.[12] Since its inspectors were required to leave the country in 2009, the International Atomic Energy Agency (IAEA) has monitored North Korea's nuclear programme using open-source information and commercial satellite imagery.[13]

The Yongbyon complex houses an ageing 5-megawatt-electric (MW(e)) graphite-moderated research reactor, from which plutonium can be extracted. The reactor has been operational since late 2021 with intermittent pauses for maintenance or plutonium reprocessing.[14] The latest such pause was in September 2023, when a joint intelligence assessment by South Korea and the USA reportedly indicated that North Korea had halted reactor operations to begin reprocessing again.[15]

It remains unclear whether North Korea has resumed construction of the 50-MW(e) reactor at Yongbyon that began in the 1980s. Various activities observable at the site through satellite imagery suggest that construction may have restarted in early 2022. However, there has not been significant construction activity visible since then.[16]

Over the past decade, North Korea has also been constructing an Experimental Light Water Reactor (ELWR) at Yongbyon.[17] In December 2023 the IAEA director general, Rafael Grossi, confirmed open-source reporting that

[11] 'Report on 6th enlarged plenary meeting of 8th WPK Central Committee', *Minju Choson*, 1 Jan. 2023. See also [Law on the Nuclear Weapons Policy of the Democratic People's Republic of Korea] (note 5), Article 1.

[12] For an assessment of North Korea's nuclear weapon production facilities and infrastructure see Hecker, S. S., Carlin, R. L. and Serbin, E. A., 'A comprehensive history of North Korea's nuclear program: 2018 update', Stanford University, Center for International Security and Cooperation, 11 Feb. 2019.

[13] Dixit, A., 'IAEA ready to undertake verification and monitoring in North Korea', International Atomic Energy Agency (IAEA), 4 Mar. 2019.

[14] United Nations, Security Council, Midterm report of the Panel of Experts submitted pursuant to Resolution 2680 (2023), S/2023/656, 12 Sep. 2023.

[15] Shin, J., 'Yongbyon nuclear reactor could yield weapon-grade plutonium', *Dong-a Ilbo*, 5 Oct. 2023.

[16] Lewis, J., Pollack, J. and Schmerler, D., 'North Korea resuming construction at the Yongbyon 50 MW(e) reactor', Arms Control Wonk, 10 May 2022.

[17] Early statements from North Korean officials and more recent statements from Western officials refer to the reactor as a light water reactor; however, North Korea has not explicitly referred to it as such for years. Some analysts speculate that this change in nomenclature could imply that North Korea has redesigned the reactor to produce weapon-grade plutonium rather than reactor-grade plutonium. Sokolin, A., 'North Korea regularly operating new nuclear reactor at Yongbyon: Report', NK News, 26 Jan. 2024.

warm water discharge observed at the complex indicated that the reactor had reached criticality and was likely operational.[18] While it is more challenging to process fuel derived from light water reactors than from gas-graphite reactors, one estimate suggests that North Korea could potentially produce approximately 20 additional kilograms of weapon-grade plutonium per year with its ELWR—a rate approximately four or five times greater than that of North Korea's 5-MW(e) reactor—from 2025 onwards.[19]

Producing reliable estimates of North Korea's plutonium stockpile is a highly challenging undertaking because it is difficult to assess the efficiency, power levels and operating schedules of the respective reactors, as well as how much plutonium has been expended in each of North Korea's nuclear tests and produced warheads. Different assumptions for each of these factors result in different stockpile estimates.[20] However, most estimates suggest that North Korea probably maintained a growing stockpile of 60–80 kg of plutonium by the end of 2023.[21]

Uranium-enrichment capabilities

To overcome a limited capacity to produce weapon-grade plutonium, it is widely believed that North Korea has focused on the production of HEU for use in its nuclear warheads. However, there is considerable uncertainty about North Korea's uranium-enrichment capabilities and its stock of HEU.

North Korea produces yellowcake—the raw material for reactor fuel rods—at its Pyongsan Uranium Concentrate Plant (Nam-chon Chemical Complex) in North Hwanghae province.[22] The IAEA director general reported in August 2023 that North Korea continued to operate its expanded gas centrifuge enrichment facility at Yongbyon as well as a possible covert centrifuge

[18] International Atomic Energy Agency (IAEA), 'IAEA director general statement on recent developments in the DPRK's nuclear programme', 147/2023, Press release, 21 Dec. 2023; and Lewis, J. and Schmerler, D., 'North Korea's ELWR now appears operating', Arms Control Wonk, 21 Dec. 2023.

[19] Albright, D. et al., 'North Korea's ELWR: Finally operational after a long delay', Institute for Science and International Security, 23 Jan. 2024; and Park, S. and Puccioni, A., 'North Korea's pursuit of an ELWR: Potential power in nuclear ambitions?', 38 North, 24 Jan. 2024.

[20] Verification Research, Training and Information Centre (VERTIC) and James Martin Center for Nonproliferation Studies (CNS), 'Estimating North Korea's nuclear material inventory', 2023.

[21] South Korean Ministry of National Defense (MND), [2022 defence white paper] (MND: Seoul, 24 Feb. 2023) (in Korean); Dr Jeffrey Lewis (@ArmsControlWonk), Twitter, 19 Feb. 2023, <https://twitter.com/ArmsControlWonk/status/1627399193936678913>; Park, Y. and Lee, S., 'North Korea's nuclear warhead quantity estimates and prospects', Korea Institute for Defense Analyses, 2023 (in Korean); de Troullioud de Lanversin, J. and Kütt, M., 'Verifying North Korea's plutonium production with nuclear archaeology', *Science and Global Security*, vol. 29, no. 3 (2021), pp. 145–66; and Albright, D., 'North Korean nuclear weapons arsenal: New estimates of its size and configuration', Institute for Science and International Security, 10 Apr. 2023.

[22] Bermudez, J. S., Cha, V. and Jun, J., 'Current status of the Pyongsan Uranium Concentrate Plant (Nam-chon Chemical Complex) and January Industrial Mine', Beyond Parallel, Center for Strategic and International Studies, 8 Nov. 2021; and Bermudez, J. S., Cha, V. and Kim, D., 'Recent activity at the Pyongsan Uranium Concentrate Plant (Nam-chon Chemical Complex) and January Industrial Mine', Beyond Parallel, Center for Strategic and International Studies, 26 Mar. 2021.

enrichment facility at Kangson (or Kangsong), to the south-west of Pyongyang.[23]

Analysts agree that North Korea has HEU production capabilities, but there are many unknowns about how much HEU has been produced, especially given the uncertainties around activities at the Kangson site and the possibility of additional covert enrichment sites. The stockpile estimate used for SIPRI's assessment of North Korea's nuclear weapon holdings suggests a range of 280–1500 kg of HEU (see section X).

Nuclear warhead production

It is unclear how many nuclear weapons North Korea has produced with its fissile material, how many have been deployed on missiles, and what the designs and military characteristics of the country's weapons are. North Korea has demonstrated a thermonuclear capability (or a nuclear explosive test with suspected thermonuclear yield) only once, in 2017.[24] In addition, most of North Korea's nuclear tests demonstrated yields in the range of 5–15 kilotons.[25] As a result, SIPRI estimates that North Korea has used only a small portion of its HEU for thermonuclear weapons and has probably used the majority for a larger number of fission-only single-stage weapons deliverable by medium-range ballistic missiles (MRBMs) or possibly by intermediate-range ballistic missiles (IRBMs).[26]

SIPRI estimates that, as of January 2024, North Korea could potentially produce up to 90 nuclear weapons with its inventory of fissile material, depending on warhead design; however, it is likely that the number of operational warheads is smaller, potentially 50. Most of those warheads are likely to be simple fission weapons with possible yields of 10–20 kt, similar to those demonstrated in the 2013 and 2016 tests, along with possibly some more powerful uranium and plutonium composite pit or basic thermonuclear designs. 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).[27] The number of nuclear warheads North Korea actually possesses is highly uncertain. In 2023 Kim Jong Un made several statements indicating

[23] International Atomic Energy Agency, Board of Governors and General Conference, 'Application of safeguards in the Democratic People's Republic of Korea', Report by the Director General, GOV/2023/41-GC(67)/20, 25 Aug. 2023.

[24] Fedchencko (note 2), p. 299.

[25] Fedchencko, V., 'Nuclear explosions, 1945–2016', *SIPRI Yearbook 2017*.

[26] Ballistic missiles are typically divided into 4 range categories: short range (less than 1000 km), medium range (1000–3000 km), intermediate range (3000–5500 km) and intercontinental (>5500 km).

[27] 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.

plans to increase 'exponentially' North Korea's nuclear arsenal.[28] 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.

Non-strategic nuclear weapons

While much media attention has been paid to North Korea's development of nuclear weapons for its longer-range strategic missiles, in recent years Kim Jong Un has placed a strong emphasis on 'mak[ing] nuclear weapons smaller and lighter for more tactical uses'.[29] This could indicate an ambition to have the capability to respond on a more limited scale to threats that do not reach the threshold for a full-scale nuclear attack. The eventual deployment of tactical weapons also raises questions about North Korea's nuclear command and control, particularly surrounding whether Kim has pre-delegated nuclear launch authority to his battlefield commanders.

In March 2023 state media showed Kim Jong Un inspecting 10 objects that he claimed were Hwasan-31 'tactical' nuclear devices, designed for interoperability between at least 8 different delivery systems, although it is possible that they were mock-ups.[30] However, the development of interoperable warheads is fraught with difficulty, given necessary differences between systems in terms of size, shape, mass, centre of gravity and many other technological factors. While it is likely that North Korea's tactical nuclear weapons have a lower yield than warheads designed for longer-range systems, a 2023 report by a United Nations panel of experts suggested the possibility that these weapons could possess multiple yield settings.[31] Although the Russian Federation and the USA designed their tactical nuclear weapons with multiple yield settings, it is unknown to what extent North Korea can and will do so.

Land-based missiles

North Korea is increasing both the size and capability of its ballistic missile force, which consists of indigenously produced missile systems with ranges from a few hundred kilometres to more than 12 000 km (see table 7.9).[32] Since 2016, it has pursued the development and production of several missile systems with progressively longer ranges and increasingly sophisticated

[28] See e.g. Korean Central News Agency, 'Respected comrade Kim Jong Un guides work for mounting nuclear warheads on ballistic missiles', KCNA Watch, 28 Mar. 2023.

[29] Korean Central News Agency (note 4); and 'Respected comrade Kim Jong Un guides military drills of KPA units for operation of tactical nukes', *Rodong Sinmun*, 10 Oct. 2022.

[30] Korean Central News Agency (note 28); and United Nations, S/2023/656 (note 14).

[31] United Nations, S/2023/656 (note 14).

[32] US Air Force, National Air and Space Intelligence Center (NASIC), *Ballistic and Cruise Missile Threat 2020* (NASIC: Wright-Patterson Air Force Base, OH, July 2020).

delivery capabilities.[33] It is unclear which of North Korea's missiles can carry nuclear weapons, and there is considerable uncertainty about the operational status of North Korea's IRBMs and intercontinental ballistic missiles (ICBMs)—particularly given that several systems that have been displayed or test launched over the years may have been for technology demonstrator programmes rather than for operational deployment. According to independent analyses, North Korea may have deployed long-range missiles at several missile bases.[34]

It must be emphasized that inclusion of a specific North Korean missile in the following overview (and in table 7.9) does not necessarily indicate that it is confirmed as nuclear-capable or as having a nuclear role.

Short-range ballistic missiles

As of January 2024 North Korea had several types of short-range ballistic missiles (SRBMs), including older liquid-fuelled systems—possibly based on Soviet R-17 (Scud) missiles—and newer solid-fuelled missiles of indigenous design. The USA has given these newer missiles the designations KN23, KN24 and KN25, the first two of which are known by the common North Korean designation of Hwasong-11, with different suffixes for each missile. Between the beginning of 2019 and the end of 2023 these missiles had been tested or launched around 70 times (but possibly many more).[35] They have been tested from several different basing modes, including wheeled and tracked transporter-erector-launchers (TELs), rail-based launchers, underwater launchers and land-based silos.[36] In March 2023 North Korea apparently carried out its first test of an SRBM from what appeared to be a rudimentary silo, a notable change from the country's long history of prioritizing mobile basing modes for its missiles.[37] North Korea has also been modernizing its older SRBMs by equipping them with manoeuvrable

[33] James Martin Center for Nonproliferation Studies (CNS), CNS North Korea Missile Test Database, Nuclear Threat Initiative, as of 24 Mar. 2022.

[34] Bermudez, J. S. and Cha, V., 'Undeclared North Korea: The Yusang-ni missile operating base', Beyond Parallel, Center for Strategic and International Studies, 9 May 2019; Frank, M., 'Continued construction at Yusang-ni missile base', Open Nuclear Network, 26 July 2021; and United Nations, Security Council, Final report of the panel of experts submitted pursuant to Resolution 2515 (2020), S/2021/211, 4 Mar. 2021, annexes 16–18.

[35] James Martin Center for Nonproliferation Studies (note 33); United Nations, S/2023/656 (note 14); Zwirko, C., 'North Korea reveals internal names for several missile systems: Analysis', NK News, 3 Apr. 2023; and Colin Zwirko (@ColinZwirko), X, 27 July 2023, <https://twitter.com/colinzwirko/status/1684458112441540608?s=12&t=JpCAcqsmOTgFYzs5XwS_Hg>.

[36] United Nations, S/2023/656 (note 14).

[37] Joseph Dempsey (@JosephHDempsey), Twitter, 19 Mar. 2023, <https://twitter.com/JosephHDempsey/status/1637605502262673408>; and Zwirko, C., 'New North Korean film reveals secret Kim Jong Un visits to weapons factories', NK News, 15 Jan. 2024.

re-entry vehicles (MaRVs) designed to evade the missile-defence systems of nearby states (particularly South Korea and Japan).[38]

Medium- and intermediate-range ballistic missiles

North Korea has four types of MRBM: the Hwasong-7 (Nodong/Rodong), the Hwasong-9 (KN04), the Pukguksong-2 (KN15) and two variants of the Hwasong-12 (Ga and Na) with different types of hypersonic glide vehicle (HGV).[39] All except the Hwasong-12 variants were probably operational as of January 2024. Assuming that North Korea can produce a sufficiently compact warhead, these MRBMs are its most likely nuclear-delivery systems.[40] All three operational missiles have ranges of 1000–1200 km, meaning that they could reach targets anywhere in South Korea or Japan.[41]

The Hwasong-10 (BM-25/Musudan) IRBM, with an estimated range exceeding 3000 km, has had no flight tests since 2016–17. It is likely to have been superseded by more sophisticated missile programmes—in particular the Hwasong-12 (KN17), a single-stage, liquid-fuelled IRBM carried on a road-mobile (TEL).[42] For this reason, the Hwasong-10 is excluded from SIPRI's estimate for January 2024. North Korean state media showed Kim Jong Un inspecting at least 26 unassembled Hwasong-12 IRBMs in January 2023.[43]

The two Hwasong-12 MRBM variants, which were first tested in 2021 and 2022, appear to be composed of modified Hwasong-12 boosters, each carrying different payloads—an HGV (designated the Hwasong-12Na) and a conical MaRV (probably designated the Hwasong-12Ga)—allowing them to conduct what North Korea has called 'corkscrew' manoeuvres.[44]

In November 2023 North Korea announced that it had successfully conducted ground tests of new first- and second-stage solid-fuelled motors for the development of a new IRBM.[45]

[38] Panda, A., 'Introducing the KN21, North Korea's new take on its oldest ballistic missile', The Diplomat, 14 Sep. 2017.

[39] For the missiles and submarines discussed in this section, a designation in parentheses (e.g. Nodong/Rodong) following the North Korean designation (e.g. Hwasong-7) is the designation assigned by the US Department of Defense. On the Pukguksong-2 see Kristensen, H. M. and Korda, M., 'North Korean nuclear forces', *SIPRI Yearbook 2022*, p. 420.

[40] On North Korea's potential warhead miniaturization capability see Kile, S. N. and Kristensen, H. M., *SIPRI Yearbook 2019*, p. 343; and Robles, P. and Choe, S., 'Why North Korea's latest nuclear claims are raising alarms', *New York Times*, 2 June 2023.

[41] US Air Force (note 32), p. 25.

[42] James Martin Center for Nonproliferation Studies (note 33).

[43] NK News (@nknewsorg), Twitter, 1 Jan. 2023, <https://twitter.com/nknewsorg/status/1609439952093446145>.

[44] *Chongnyon Chonwi,* 'Distinguished feat of WPK in history of leading Juche-based defence industry success in another hypersonic missile test-fire respected comrade Kim Jong Un watches test-fire in field', KCNA Watch, 12 Jan. 2022; and Liebermann, O., Muntean, P. and Starr, B., 'US grounded planes as a "precaution" after a North Korean missile launch', CNN, 11 Jan. 2022.

[45] *Rodong Sinmun*, 'New IRBM solid-fuel engine test conducted in DPRK', KCNA Watch, 16 Nov. 2023.

Intercontinental ballistic missiles

North Korea has displayed five types of ICBM: the Hwasong-13 (KN08/KN14), -14 (KN20), -15 (KN22), -17 (KN28) and -18 (no known US designation). It has prioritized building and deploying an ICBM that could potentially deliver a nuclear warhead to targets in the USA. There remains considerable uncertainty in US assessments of North Korea's long-range missile capabilities. However, even though North Korea has never test launched an ICBM to its maximum range on an operational trajectory, it seems highly likely that at least some of these systems have been operationally deployed. It is likely that the Hwasong-13 has been superseded by more sophisticated ICBM programmes and, as a result, this system is excluded from table 7.9.[46] It is also possible that the Hwasong-14 has been superseded.

The Hwasong-15, which SIPRI assesses to be operationally deployed, has a significantly larger second stage and more powerful booster engines than the Hwasong-14.[47] The Hwasong-15 was tested once in 2023 as part of a 'surprise ICBM launching drill' to demonstrate the launch unit's combat readiness.[48] The Hwasong-17 could be large enough to accommodate multiple warheads, but this capability had not been demonstrated as of January 2024.[49] The Hwasong-17 has been test launched at least twice, with the most recent test taking place in March 2023, to a possible range of approximately 15 000 km.[50] In April 2023 North Korea test launched a new solid-fuelled ICBM known as the Hwasong-18, which state media described as 'the future core pivotal means of the strategic force of the DPRK'.[51] The system was subsequently tested two more times, in July and December 2023.[52]

North Korean state media's characterization of the most recent Hwasong-15, -17 and -18 tests as 'launching drills'—rather than 'test-fires' meant to validate technical performance—suggests that all three systems

[46] NK News, 'North Korea military parade 2020: Livestream & analysis', YouTube, 10 Oct. 2020.

[47] Kristensen, H. M. and Korda, M., 'North Korean nuclear forces', *SIPRI Yearbook 2021*, p. 402.

[48] DPRK Today, 'ICBM launching drill staged in DPRK', KCNA Watch, 20 Feb. 2023.

[49] Ankit Panda (@nktpnd), Twitter, 13 Oct. 2021, <https://twitter.com/nktpnd/status/1448073861363290124>.

[50] On 24 March 2022 North Korea claimed to have test launched the Hwasong-17 with a possible range of approximately 15 000 km. However, some analysts believe that the ICBM may have been unsuccessfully tested on 16 March and that the missile tested on 24 March may instead have been a Hwasong-15. Zwirko, C., 'Imagery casts doubt over North Korea's Hwasong-17 ICBM claims', NK News, 25 Mar. 2022.

[51] *Minju Choson*, 'Another mighty entity showing continuous development of strategic force unveiled in DPRK. Respected comrade Kim Jong Un guides first test-fire of new-type ICBM Hwasongpho-18 on spot', KCNA Watch, 14 Apr. 2023.

[52] Korean Central News Agency, 'Respected comrade Kim Jong Un guides test-fire of ICBM Hwasongpho-18', KCNA Watch, 13 July 2023; and Korean Central News Agency, 'Clear display of DPRK strategic forces' toughest retaliation will and overwhelming strength launch drill of ICBM Hwasongpho-18 conducted', KCNA Watch, 19 Dec. 2023.

have been operationally deployed.[53] Given the differences between the three missiles, it seems likely that they are intended to operate simultaneously rather than as replacements for each other.

Notably, North Korea's military parade in February 2023 showcased 16 heavy TELs for its ICBMs—an unprecedented number—suggesting that the country may have overcome its previous constraints in indigenous heavy TEL production.[54] This could potentially allow North Korea's mobile ICBM force to expand more rapidly over the coming years.

Cruise missiles

By the end of 2023 North Korea had developed at least two types of land-attack cruise missile (LACM) that it explicitly claims are designed to deliver nuclear weapons: the Hwasal-1 and the Hwasal-2. Combined, these two missile types had been tested at least a dozen times as of the end of 2023. Although North Korea has described these LACMs as 'strategic weapons', it also clarified in October 2022 that the missiles were 'deployed at the units of the Korean People's Army for the operation of tactical nukes'.[55] Both types of cruise missile were successfully tested to ranges of between 1500 and 1800 km in March 2023. North Korean state media's description of the tests as 'launching drills' designed to 'let the strategic cruise missile sub-units get familiar with action methods and handling of equipment through repeated practice' suggests that both systems have been operationally deployed.[56]

Sea-based missiles

North Korea for several years operated only one ballistic missile submarine—the Gorae-class (Sinpo) experimental submarine, named *8.24 Yongung*. This submarine can hold and launch only a single submarine-launched ballistic missile (SLBM).[57] In September 2023, however, North Korea launched a 'newly built . . . tactical nuclear submarine No. 841' named the *Hero Kim Kun Ok*, which appears to be a heavily modified Project-633 (Romeo)

[53] DPRK Today, 'ICBM launching drill staged in DPRK', KCNA Watch, 20 Feb. 2023; *Rodong Sinmun*, 'Demonstration of toughest response posture of DPRK's strategic forces ICBM Hwasongpho-17 launched', KCNA Watch, 17 Mar. 2023; and Korean Central News Agency, 'Respected comrade Kim Jong Un guides test-fire of ICBM Hwasongpho-18' (note 52).

[54] Korean Central Television (KCTV), 'North Korean Military Parade February 8, 2023 (KCTV)', YouTube, 12 Feb. 2023.

[55] Shin, H. and Smith, J., 'N. Korea tests first "strategic" cruise missile with possible nuclear capability', Reuters, 13 Sep. 2021. See also Kristensen and Korda (note 39), pp. 421–22; and 'Respected comrade Kim Jong Un guides test-fire of long-range strategic cruise missiles', Korea Central News Agency, 13 Oct. 2022.

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

[57] Bermudez, J. S., Cha, V. and Jun, J., 'Sinpo-class submarine damaged during October 19 test launch', Beyond Parallel, Center for Strategic and International Studies, 7 Jan. 2022.

diesel–electric submarine fitted with 10 vertical missile-launch tubes: four for large-diameter Pukguksong SLBMs and six for smaller-diameter missiles.[58] Although it would bring a significant improvement in payload once operational, this Soviet-era submarine class has a noisy design and limited underwater range. In a speech at the launch of the new submarine, Kim Jong Un announced a 'plan to convert all existing medium-sized submarines into attack submarines equipped with tactical nuclear weapons'.[59]

North Korea has continued to develop its family of Pukguksong ('Polaris') solid-fuelled SLBMs, with at least six increasingly larger Pukguksong iterations having been displayed or tested over the years.[60] However, North Korea has conducted relatively few tests of its SLBM force and it appears likely that the country will continue to prioritize its land-based force over its sea-based force for the foreseeable future.

North Korea is developing a new submarine-launched cruise missile, known as Pulhwasal-3-31. The system has been labelled a 'strategic cruise missile'—implying a nuclear-capable status—and state media noted that a test of the missile took place in the context of the 'nuclear weaponization of our navy'.[61] The 'Pulhwasal' designation suggests that the missile is part of the same family as the land-based Hwasal-1 and Hwasal-2 cruise missiles but this was unconfirmed as of January 2024. Because of the high level of uncertainty about the status of the Pulhwasal-3-31 system, it is not included in table 7.9.

In 2023 North Korea unveiled and test launched several new iterations of an 'underwater nuclear attack drone', all of which are part of the 'Haeil' family. 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'.[62] North Korea claims to have tested various iterations of the 'Haeil' system dozens of times, some of which included test durations of between 40 and 70 hours. However, SIPRI assesses that the system had not been deployed as of January 2024.[63]

[58] 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.

[59] *Rodong Sinmun*, 'Respected comrade Kim Jong Un makes congratulatory speech at ceremony for launching newly-built submarine', KCNA Watch, 9 Sep. 2023.

[60] On North Korea's earlier Pukguksong family of missiles see Kristensen and Korda (note 47), p. 403.

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

[62] Korean Central News Agency (note 56).

[63] Korean Central News Agency (note 56); and Naenara, 'An underwater strategic weapon system test conducted', KCNA Watch, 8 Apr. 2023.

Table 7.9. North Korean forces with potential nuclear capability, January 2024

All figures are approximate and some are based on assessments by the authors. The inclusion of a missile in this table does not necessarily indicate it is known to have a nuclear role. Systems that are unlikely to have a nuclear or operational role are excluded.

Type/ North Korean designation (US designation)	Year first displayed	Range (km)	Description and status
Land-based missiles			
Hwasong-5/-6 (Scud-B/-C)	1984/1990	300/500	Single-stage, liquid-fuelled SRBMs launched from 4-axle wheeled TEL. NASIC estimates fewer than 100 Hwasong-5 and -6 launchers. Operational.
. . (KN18/KN21)	2017	250/450	Hwasong-5 and -6 variants with separating manoeuvrable warhead. Flight-tested in May and Aug. 2017 from wheeled and tracked TELs. Deployment status unknown; may have been superseded by newer solid-fuelled SRBMs.
Hwasong-11A/B[a] (KN23/ KN24) . . (KN25)	2018/2019	380–800	New generation of solid-fuelled SRBMs. Resemble Russia's Iskander-M, South Korea's Hyunmoo-2B and the USA's ATACMS SRBMs. Successfully flight-tested at least 70 times, and possibly many more, from wheeled, tracked, rail-based, underwater and silo-based launchers since 2019. Deployment status unknown; probably operational.
Hwasong-7 (Nodong/ Rodong)	1993	>1 200	Single-stage, liquid-fuelled MRBM launched from 5-axle wheeled TEL. NASIC estimates fewer than 100 Hwasong-7 launchers. Two test-launched on 18 Dec. 2022. Operational.
Hwasong-9 (KN04/ Scud-ER)	2016	1 000	Single-stage, liquid-fuelled Scud extended-range MRBM variant launched from 4-axle wheeled TEL. Flight-tested in 2016. Probably operational.
Pukguksong-2 (KN15)	2017	>1 000	Two-stage, solid-fuelled MRBM launched from tracked TEL. Land-based version of Pukguksong-1 SLBM. Flight-tested in 2017. Probably operational.

Type/ North Korean designation (US designation)	Year first displayed	Range (km)	Description and status
Hwasal-1/-2	2021	1 500/2 000	Land-attack cruise missiles flight-tested multiple times between 2021 and 2023 from wheeled TELs. Deployment status unknown; probably operational.
Hwasong-12A/B[b]	2021	>1 000	Two versions of HGV carried by a shortened Hwasong-12 booster. No flight tests of either system in 2023 after a short testing campaign in 2021–22. Under development.
Hwasong-12 (KN17)/ 'New type' IRBM	2017/2022	>4 500	Single-stage, liquid-fuelled IRBM launched from 8-axle wheeled TEL. Flight-tested several times in 2017 with mixed success. Last known test was on 30 Jan. 2022. A 'new type' IRBM variant strongly resembling the existing Hwasong-12 design, but with potential modifications to the nose cone and propulsion system, was test launched on 4 Oct. 2022. Deployment status unknown; probably operational.
Hwasong-14 (KN20)	2017	>10 000	Two-stage, liquid-fuelled ICBM launched from 8-axle wheeled TEL. Successfully flight-tested twice in 2017. Deployment status unknown; may have been superseded.
Hwasong-15 (KN22)	2017	>13 000	Two-stage, liquid-fuelled ICBM launched from 9-axle wheeled TEL. Flight-tested in Feb. 2023. Deployment status unknown; probably operational.
Hwasong-17 (KN28)[c]	2020	15 000	Two-stage, liquid-fuelled ICBM launched from 11-axle wheeled TEL. Possibly capable of carrying MIRVs and penetration aids. Flight-tested in Mar. 2023. Deployment status unknown; probably operational.

Type/ North Korean designation (US designation)	Year first displayed	Range (km)	Description and status
Hwasong-18	2023	15 000	Three-stage, solid-fuelled ICBM launched from 9-axle wheeled TEL (same launcher as Hwasong-15). Unveiled and flight-tested three times in 2023, with the latest test being described as a ‘launching drill’. Deployment status unknown; probably operational.
Sea-based missiles			
Pukguksong-1 (KN11)	2014	>1 000	Two-stage, solid-fuelled SLBM. Flight-tested several times in 2015 and 2016 with mixed success. Displayed at exhibition in Oct. 2021. Deployment status unknown; may have been superseded.
Pukguksong-3 (KN26)	2017	1 900– 2 500	Two-stage, solid-fuelled SLBM. Successfully flight-tested in Oct. 2019. Deployment status unknown; probably not yet operational.
Pukguksong-4	2020	3 500– 5 400	Two-stage, solid-fuelled SLBM. Appears wider than Pukguksong-1 and shorter than Pukguksong-3. No known flight tests. Displayed at parade in Oct. 2020. Deployment status unknown; probably not yet operational.
Pukguksong-5	2021	. .	Two-stage, solid-fuelled SLBM. Roughly same length as Pukguksong-3 with elongated shroud; possibly capable of carrying MIRVs and penetration aids. No known flight tests. Displayed at parade in Jan. 2021 and at exhibition in Oct. 2021. Deployment status unknown; probably not yet operational.
Small ‘new type’ SLBM	2021	400–600	Appears to deviate from traditional Pukguksong SLBM design, instead bearing similarities to KN23 SRBM. Displayed at exhibition in Oct. 2021 and successfully flight-tested a week later. Deployment status unknown; probably not yet operational.

Type/ North Korean designation (US designation)	Year first displayed	Range (km)	Description and status
Unknown SLBM	2022	. .	Revealed at military parade in Apr. 2022. Name not yet formally announced, but appears to be a member of the Pukguksong family of SLBMs, possibly Pukguksong-6. No known flight tests. Deployment status unknown; probably not yet operational.
Total warheads			**50**[d]

. . = not available or not applicable; HGV = hypersonic glide vehicle; ICBM = intercontinental ballistic missile; IRBM = intermediate-range ballistic missile; MIRV = multiple independently targetable re-entry vehicle; MRBM = medium-range ballistic missile; NASIC = US Air Force National Air and Space Intelligence Center; SLBM = submarine-launched ballistic missile; SRBM = short-range ballistic missile; TEL = transporter-erector-launcher.

Notes: Information about the status and capability of North Korea's missiles comes with significant uncertainty. This table includes missiles that could potentially have a nuclear capability, whether or not confirmed as being equipped with nuclear warheads or assigned nuclear missions. Several missiles may have been intended for development of technologies that will eventually become operational on newer missiles. There is no publicly available evidence that North Korea has produced an operational nuclear warhead for delivery by an ICBM.

[a] North Korea refers to the KN23 as the Hwasong-11Ga and the KN24 as the Hwasong-11Na. These can be considered akin to Hwasong-11A and -11B, since Ga (가) and Na (나) are the first and second letters in the Korean alphabet (Hangul). This indicates that these missiles are improvements on or replacements for the original Hwasong-11 (KN02 Toksa) SRBM.

[b] These missiles were previously labelled as Hwasong-8 by North Korean state media, but were redesignated as Hwasong-12Ga and -12Na sometime between 2021 and 2023. As with the Hwasong-11 (see note a), the designations can be considered akin to Hwasong-12A and -12B. Only the Na suffix for the Hwasong-12 variant carrying an HGV has been confirmed in official documentation; however, SIPRI assesses that the Hwasong-12 variant carrying a conical re-entry vehicle is probably designated with the Ga suffix.

[c] This missile was previously assumed to be designated the Hwasong-16; however, it was revealed at North Korea's Oct. 2021 Defence Development Exhibition that it is called the Hwasong-17.

[d] SIPRI estimates that 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, of which only a few would be thermonuclear warheads and nearly all would be lower-yield single-stage fission warheads.

Sources: US Department of Defense (DOD), *2019 Missile Defense Review* (DOD: Washington, DC, 2019); US Air Force, National Air and Space Intelligence Center, *Ballistic and Cruise Missile Threat*, various years; *IHS Jane's Strategic Weapon Systems*, various editions; Hecker, S., Stanford University, Personal communication, 2020; *Bulletin of the Atomic Scientists*, 'Nuclear notebook', various issues; published expert analyses; and authors' estimates. For the estimated number of warheads see also Hecker, S., 'What do we know about North Korea's nuclear program?', Presentation, Dialogue on DPRK Denuclearization Roadmaps and Verification, Kyung Hee University, Global America Business Institute (GABI) and Natural Resources Defense Council (NRDC), 20 Oct. 2020; 'Estimating North Korea's nuclear stockpiles: An interview with Siegfried Hecker', 38 North, 30 Apr. 2021; and Fedchenko, V. and Kelley, R., 'New methodology offers estimates for North Korean thermonuclear stockpile', *Janes Intelligence Review*, Sep. 2020, pp. 44–49.

IX. Israeli nuclear forces

HANS M. KRISTENSEN AND MATT KORDA*

As of January 2024 Israel was estimated to have a stockpile of around 90 nuclear warheads (see table 7.10, end of section), the same number as in January 2023. This estimate is at the lower end of a possible range that some analysts have suggested could reach as high as 300 nuclear weapons.[1] It is assumed that Israel stores its warheads separately from its deployed launchers during peacetime.

Israel continues to maintain its long-standing policy of nuclear ambiguity: it neither officially confirms nor denies that it possesses nuclear weapons.[2] This lack of transparency means that there is significant uncertainty about the size of Israel's nuclear arsenal and the yields and characteristics of its weapons.[3] The estimate here is largely based on calculations of Israel's inventory of weapon-grade plutonium (see section X of this chapter) and the number of operational nuclear-capable delivery systems. The locations of the storage sites for the warheads, which are thought to be stored partially unassembled, are unknown.

This section continues by briefly outlining the role played by nuclear weapons in Israel's military doctrine. It then outlines the country's capabilities for production of fissile material before describing its air-delivered, land-based and sea-based weapons.

The role of nuclear weapons in Israeli military doctrine

Since the late 1960s the Israeli government has repeated that Israel 'won't be the first to introduce nuclear weapons into the Middle East'. However, to accommodate the apparent fact that Israel possesses a significant nuclear arsenal, Israeli policymakers have previously interpreted 'introduce nuclear weapons' as publicly declaring, testing or actually using the nuclear capability, which Israel says it has not yet done.[4]

Given that Israel does not officially acknowledge its apparent possession of nuclear weapons, the circumstances under which it would use them are highly unclear. Reports, based on interviews with a retired Israeli general,

[1] See e.g. Luscombe, B., '10 questions: Jimmy Carter', *Time*, 30 Jan. 2012; and Clifton, E., 'Powell acknowledges Israeli nukes', Lobe Log, 14 Sep. 2016.

[2] 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).

[3] Kristensen, H. M. and Korda, M., 'Estimating world nuclear forces: An overview and assessment of sources', SIPRI Commentary, 14 June 2021.

[4] For further detail see Kristensen, H. M. and Korda, M., 'Israeli nuclear forces', *SIPRI Yearbook 2022*, pp. 404–405.

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indicate that Israel would have considered using nuclear weapons if it feared that it would lose the Arab–Israeli War in 1967.[5] In addition, towards the end of 2023 several Israeli policymakers and commentators—including a minister who was later suspended from the cabinet—suggested that Israel should use nuclear weapons against Hamas fighters in Gaza.[6] These two cases are notable as they are rare examples of high-ranking Israeli officials seemingly acknowledging the existence of Israel's nuclear arsenal.

Military fissile material production

Declassified United States government documents indicate that Israel may have assembled its first nuclear weapons in the late 1960s, using plutonium produced by the Israel Research Reactor 2 (IRR-2) at the Negev Nuclear Research Center (NNRC) near Dimona, in southern Israel.[7] This heavy water reactor is not under International Atomic Energy Agency (IAEA) safeguards. There is little publicly available information about its operating history and power capacity (see section X).[8] 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.

Israel is estimated to have had a stockpile of 750–1110 kilograms of plutonium at the start of 2023, depending on the rate at which the reactor was also used for tritium production (see section X). Based on this estimate and assuming that Israel's warhead arsenal is likely to consist of single-stage, boosted fission weapons, Israel could hypothetically have built anywhere between 187 and 277 nuclear weapons, assuming approximately 4 kg of plutonium per weapon. However, as with other nuclear-armed states, Israel is unlikely to have converted all of its plutonium into warheads and has probably assigned nuclear weapons to only a limited number of launchers. Moreover, the available tritium required to boost the warheads would represent an additional constraint on the number of weapons Israel could build. As a result, SIPRI estimates that Israel had approximately 90 warheads as of January 2024, rather than several hundred.

[5] See e.g. Broad, W. and Sanger. D., '"Last secret" of 1967 war: Israel's doomsday plan for nuclear display', *New York Times*, 3 June 2017.

[6] Bachner, M., 'Far-right minister says nuking Gaza an option, PM suspends him from cabinet meetings', *Times of Israel*, 5 Nov. 2023. For further detail on the Israel–Hamas war see chapter 1, chapter 2, section I, and chapter 10, section II, in this volume.

[7] For a history of Israel's nuclear weapon programme see Cohen, A., *The Worst-kept Secret: Israel's Bargain with the Bomb* (Columbia University Press: New York, 2010); Burr, W. and Cohen, A., 'Duplicity and self-deception: Israel, the United States, and the Dimona inspections, 1964–65', Briefing Book no. 733, National Security Archive, 10 Nov. 2020; and Cohen, A. and Burr, W., 'How Israel built a nuclear program right under the Americans' nose', *Haaretz*, 17 Jan. 2021. See also Kristensen and Korda (note 4), pp. 405–407.

[8] Glaser, A. and Miller, M., 'Estimating plutonium production at Israel's Dimona reactor', 52nd annual meeting of the Institute of Nuclear Materials Management (INMM), 17–21 July 2011.

Aircraft and air-delivered weapons

Approximately 30 of Israel's nuclear weapons are estimated to be gravity bombs for delivery by F-16I or F-15 aircraft. The status of Israel's F-15s is unclear, but in 2019 a US official privately referred to them as Israel's 'nuclear squadron'.[9] Nuclear gravity bombs without nuclear cores would probably be stored at protected facilities near one or two air force bases, such as Tel Nof Airbase in central Israel and Hatzerim Airbase in the Negev desert. Israel is also acquiring 50 F-35 combat aircraft from the USA. The USA and some of its North Atlantic Treaty Organization (NATO) allies have assigned a nuclear mission to the F-35A (see section I), but it it is unclear whether Israel plans to assign such a mission to its F-35s.[10]

Land-based missiles

Up to 50 warheads are thought to be assigned for delivery by land-based Jericho ballistic missiles, although the Israeli government has never publicly confirmed that it possesses the missiles. The missiles are believed to be located, along with their mobile transporter-erector-launchers (TELs), in caves or bunkers at Sdot Micha Airbase near Zekharia, about 25 kilometres west of Jerusalem. SIPRI assesses that each of the 23 bunkers might be capable of storing two launchers. A nearby complex with its own internal perimeter has four tunnels to underground facilities that could potentially be used for warhead storage, although SIPRI assesses that the nuclear cores are probably stored elsewhere.

Israel is upgrading its arsenal of missiles from the solid-fuelled, two-stage Jericho II medium-range ballistic missile to the three-stage Jericho III missile with a longer range, exceeding 4000 km. The latter first became operational in 2011 and might already have replaced the Jericho II.[11] In recent years, Israel has conducted several test launches of what it calls 'rocket propulsion systems'. These could be related to upgrades to its ballistic missile force or to the development of Israeli space-launch vehicles, which use solid rocket motors.[12]

[9] US military official, Interview with the author (H. M. Kristensen), Oct. 2019.

[10] Lockheed Martin, 'Israel's 5th generation fighter', [n.d.].

[11] O'Halloran, J. C. (ed.), 'Jericho missiles', *IHS Jane's Weapons: Strategic, 2015–16* (IHS Jane's: Coulsdon, 2015), p. 53.

[12] Israeli Ministry of Defense (@Israel_MOD), Twitter, 31 Jan. 2020, <https://twitter.com/Israel_MOD/status/1223172528992149504>; and Lewis, J., 'Israeli rocket motor test', Arms Control Wonk, 23 Apr. 2021.

Sea-based missiles

Israel operates five German-built Dolphin-class (Dolphin-I and Dolphin-II) diesel–electric submarines.[13] The submarines are based at Haifa on the Mediterranean coast. There are unconfirmed reports that all or some of the submarines have been equipped to launch an indigenously produced nuclear-armed sea-launched variant of the Popeye cruise missile, giving Israel a sea-based nuclear strike capability.[14] The German government has denied that the submarines have the capability to carry nuclear warheads.[15] However, if the submarines have been equipped with nuclear missiles, SIPRI assesses that around 10 cruise missile warheads might be available for the submarine fleet.

A sixth submarine, INS *Drakon*, was launched in August 2023 but had not entered service by the end of the year. Despite it being part of the Dolphin-II class, INS *Drakon* differs from the other submarines in its class. Most notably, initial images suggest that the boat may be longer and probably has a vertical-launch system embedded in the sail, which could be intended for another type of missile that the submarine would carry in addition to the Popeye sea-launched cruise missile.[16]

In early 2022 Israel signed an agreement with Germany to procure three new submarines, which will be known as the Dakar class, to replace the three oldest Dolphin-I-class boats.[17] Concept art for the Dakar-class submarines includes an enlarged sail that, as with INS *Drakon*, will probably be fitted with a vertical-launch system capable of launching existing or future missile types.[18]

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

[14] Bergman, R. et al., 'Israel's deployment of nuclear missiles on subs from Germany', *Der Spiegel*, 4 June 2012. See also Frantz, D., 'Israel's arsenal is point of contention', *Los Angeles Times*, 12 Oct. 2003; and Sutton, H. I., 'History of Israeli subs', Covert Shores, 20 May 2017.

[15] Fisher, G., 'Israel's German-built submarines are equipped with nuclear weapons, Der Spiegel reports', *Times of Israel*, 3 June 2012.

[16] Sutton, H. I., 'Israel launches new submarine, first in world with modern missiles in sail', Naval News, 14 Aug. 2023.

[17] 'Israel signs $3.4 bln submarines deal with Germany's Thyssenkrupp', Reuters, 20 Jan. 2022.

[18] Newdick, T., 'Our first look at Israel's new Dakar class submarine reveals a very peculiar feature', The Drive, 20 Jan. 2022.

Table 7.10. Israeli nuclear forces, January 2024

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

Type/designation	No. of launchers	Year first deployed	Range (km)[a]	No. of warheads
Aircraft	*125/50*[b]			*30*
F-16I	100/25	1980	1 600	30
F-15	25/25	1998	4 450	. .[c]
Land-based missiles	*50*[d]			*50*
Jericho II	25	1990	>1 500	25
Jericho III[e]	25	[2011]	[>4 000]	25
Sea-based missiles	*5/20*[f]			*10*
Popeye Turbo SLCM	20	[2002]	[<1 500]	10
Total stockpile	**120**			**90**[g]

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

[a] Aircraft range is for illustrative purposes only; actual range will vary according to flight profile, weapon payload and in-flight refuelling.

[b] The first figure is the total number of aircraft in the inventory; the second is the number of aircraft that might be adapted for a nuclear strike mission. It is estimated that aircraft from 2 squadrons might serve a nuclear strike role.

[c] It is not known whether the Israeli Air Force has added nuclear capability to the F-15 aircraft as the United States has done, but one US official has privately described Israel's F-15s as its 'nuclear squadron'.

[d] Commercial satellite images show what appear to be 23 caves or bunkers for mobile Jericho launchers at Sdot Micha Airbase. High-resolution satellite imagery that became available in 2021 indicates that each cave appears to have 2 entrances, which suggests that each cave could hold up to 2 launchers. If all 23 caves are full, this would amount to 46 launchers.

[e] The Jericho III is gradually replacing the older Jericho II, if this has not happened already. A longer-range version with a new solid rocket motor may be under development.

[f] The first figure is the total number of Dolphin-class submarines in the Israeli fleet; the second is the estimated maximum number of large-diameter missiles that they can carry. In addition to 6 standard 533-millimetre torpedo tubes, the submarines are reportedly equipped with 4 other specially designed 650-mm tubes that could potentially be used to launch larger nuclear-armed SLCMs. A sixth submarine, INS *Drakon*, was launched in Aug. 2023 but had not entered service as of Jan. 2024. It appears to be equipped with a vertical launch system for launching additional missiles.

[g] Given the unique lack of publicly available information about Israel's nuclear arsenal, this estimate comes with a considerable degree of uncertainty.

Sources: Cohen, A., *The Worst-kept Secret: Israel's Bargain with the Bomb* (Columbia University Press: New York, 2010); Cohen, A., *Israel and the Bomb* (Columbia University Press: New York, 1998); US National Security Archive, various declassified US government document collections related to Israel's nuclear weapon programme; International Institute for Strategic Studies, *The Military Balance*, various years; *IHS Jane's Strategic Weapon Systems*, various issues; Fetter, S., 'Israeli ballistic missile capabilities', *Physics and Society*, vol. 19, no. 3 (July 1990); *Bulletin of the Atomic Scientists*, 'Nuclear Notebook', various issues; and authors' estimates.

X. Global stocks and production of fissile materials, 2023

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INTERNATIONAL PANEL ON FISSILE MATERIALS

Materials that can sustain an explosive fission chain reaction are essential for all types of nuclear explosives, from first-generation fission weapons to advanced thermonuclear weapons. The most common of these fissile materials are highly enriched uranium (HEU) and plutonium. This section gives details of military and civilian stocks, as of the beginning of 2023, of HEU (table 7.11) and separated plutonium (table 7.12)—including in weapons—and details of the capacity to produce these materials (tables 7.13 and 7.14). The information in the tables is based on estimates prepared for the International Panel on Fissile Materials (IPFM). The most recent annual declarations on civilian plutonium and HEU stocks to the International Atomic Energy Agency (IAEA) give data for 31 December 2022 (INFCIRC/549).

The production of both HEU and plutonium starts with natural uranium. Natural uranium consists almost entirely of the non-chain-reacting isotope uranium-238 (U-238) and is only about 0.7 per cent uranium-235 (U-235). The concentration of U-235 can be increased through enrichment—typically using gas centrifuges. Uranium that has been enriched to less than 20 per cent U-235 (typically, 3–5 per cent)—known as low-enriched uranium—is suitable for use in power reactors. Uranium that has been enriched to contain at least 20 per cent U-235—known as HEU—is generally taken to be the lowest concentration practicable for use in weapons. However, to minimize the mass of the nuclear explosive, weapon-grade uranium is usually enriched to over 90 per cent U-235.

Plutonium is produced in nuclear reactors when U-238 in the fuel is exposed to neutrons. The plutonium is subsequently chemically separated from spent fuel in a reprocessing operation. Plutonium comes in a variety of isotopic mixtures, most of which are weapon-usable. Weapon designers prefer to work with a mixture that predominantly consists of plutonium-239 (Pu-239) because of its relatively low rate of spontaneous emission of neutrons and gamma rays and the low level of heat generation from alpha decay. Weapon-grade plutonium usually contains more than 90 per cent Pu-239. The plutonium in typical spent fuel from power reactors (reactor-grade plutonium) contains 50–60 per cent Pu-239 but is weapon-usable, even in a first-generation weapon design.

All states that have a civil nuclear industry (i.e. that operate a nuclear reactor or a uranium-enrichment plant) have some capability to produce fissile materials that could be used for weapons. The categories for fissile materials in tables 7.11 and 7.12 reflect the availability of these materials for weapon purposes. Material described as ‘Not directly available for weapons' and 'Unsafeguarded' is either material produced outside weapon programmes or weapon-related material that states have pledged not to use in weapons. This material is not placed under international safeguards (e.g. IAEA or Euratom) or under bilateral monitoring. The category 'Safeguarded/ monitored' includes material that is subject to such controls. The data presented in tables 7.11 and 7.12 accounts only for unirradiated fissile material, a category that corresponds to the IAEA definition of 'unirradiated direct use material'.

Table 7.11. Global stocks of highly enriched uranium, 2023

All figures are tonnes and are for unirradiated highly enriched uranium (HEU) as of the beginning of 2023. Most of this material is 90–93% enriched uranium-235 (U-235), which is typically considered weapon-grade. Important exceptions are noted. Final totals are rounded to the nearest 5 tonnes.

			Not directly available for weapons		
State	Total stock	In or available for weapons	Unsafeguarded	Safeguarded/ monitored	Production status
China	14	14 ± 3	–[a]	–	Stopped 1987–89
France[b]	29	25 ± 6	–	3.8	Stopped 1996
India[c]	5	–	5.3 ± 2	–	Continuing
Iran[d]	0.1	–	0.09	–	Continuing
Israel[e]	0.3	0.3	–	–	Unknown
Korea, North[f]	Uncertain	Uncertain	–	–	Uncertain
Pakistan[g]	5	5.1 ± 1.5	–	–	Continuing
Russia[h]	680	672 ± 120	6[i]	–	Continuing[j]
UK[k]	23	22	0.6[l]	–	Stopped 1962
USA[m]	483	361	122.1	–	Stopped 1992
Other states[n]	>3.9	–	–	>3.9	
Total	**1 245**	**1 100**	**135**	**10**	

[a] China receives HEU in fuel from Russia for its fast-neutron reactors. Since it is assumed that this fuel is irradiated soon after the delivery, it is not included here.

[b] A 2014 analysis offers grounds for a significantly lower estimate of France's stockpile of weapon-grade HEU (between 6 ± 2 tonnes and 10 ± 2 tonnes) based on evidence that the Pierrelatte enrichment plant may have had both a much shorter effective period of operation and a smaller capacity to produce weapon-grade HEU than previously assumed.

[c] It is believed that India is producing HEU (enriched to 30–45%) for use as naval reactor fuel. The estimate is for HEU enriched to 30%.

[d] The data for Iran is the estimate by the International Atomic Energy Agency (IAEA) as of 11 Feb. 2023 (87.5 kg). Iran started enriching uranium up to 20% on 4 Jan. 2021 and started enriching HEU up to 60% enrichment level on 17 Apr. 2021.

[e] Israel may have acquired *c.* 300 kg of weapon-grade HEU illicitly from the USA in or before 1965. Some of this material may have been consumed in the process of producing tritium.

[f] North Korea is known to have a uranium-enrichment plant at Yongbyon and possibly others elsewhere. Independent estimates of uranium-enrichment capability and possible HEU production extrapolated to the beginning of 2023 suggest a potential accumulated HEU stockpile in the range 280–1500 kg.

[g] This estimate for Pakistan assumes total HEU production of 5.2 tonnes, of which *c.* 100 kg was used in nuclear weapon tests.

[h] This estimate assumes that the Soviet Union stopped all HEU production in 1988. It may therefore understate the amount of HEU in Russia (see also note j).

[i] This material is believed to be in use in various research facilities, civilian as well as military-related.

[j] The Soviet Union stopped production of HEU for weapons in 1988 but kept producing HEU for civilian and non-weapon military uses. Russia continues this practice. It is assumed that the HEU for naval and other reactors is newly produced material.

[k] The estimate for the UK reflects a declaration of 21.9 tonnes of military HEU as of 31 Mar. 2002, the average enrichment of which was not given.

[l] This figure (550 kg) is from the UK's INFCIRC/549 declaration to the IAEA for the end of 2022. As the UK has left the European Union, the material is no longer under Euratom safeguards.

[m] The amount of US HEU is given in actual tonnes, not 93%-enriched equivalent. In 2016 the USA declared that, as of 30 Sep. 2013, its HEU inventory was 585.6 tonnes, of which 499.4 tonnes was declared to be for 'national security or non-national security programs including nuclear weapons, naval propulsion, nuclear energy, and science'. This material was estimated to include *c*. 360.9 tonnes of HEU in weapons and available for weapons, 121.1 tonnes of HEU reserved for naval fuel and 17.3 tonnes of HEU reserved for research reactors. The remaining 86.2 tonnes of the 2013 declaration comprised 41.6 tonnes 'available for potential down-blend to low enriched uranium or, if not possible, disposal as low-level waste', and 44.6 tonnes in spent reactor fuel. As of the end of 2022 the amount available for use had been reduced to *c*. 465.1 tonnes, which is estimated to include 89.5 tonnes of HEU in naval reserve and 14.6 tonnes reserved for research reactors. It is estimated that at the end of 2022 the amount of material to be down-blended had been reduced to 18 tonnes.

[n] The IAEA's 2022 annual report lists 156 significant quantities of HEU under comprehensive safeguards in non-nuclear weapon states as of the end of 2022. Without knowing the exact enrichment levels, that means these states hold at least 3.9 tonnes of HEU since, for HEU, a significant quantity is defined as 25 kg of U-235.

In INFCIRC/912 (from 2017) more than 20 states committed to reducing civilian HEU stocks and providing regular reports. So far, only 2 states have reported under this scheme. At the end of 2018 (time of last declaration), Norway held less than 4 kg of HEU for civilian purposes. As of 30 June 2019, Australia held 2.7 kg of HEU for civilian purposes.

Sources: International Panel on Fissile Materials (IPFM), *Global Fissile Material Report 2022: Fifty Years of the Nuclear Non-Proliferation Treaty: Nuclear Weapons, Fissile Materials, and Nuclear Energy* (IPFM: Princeton, NJ, 2022). *China*: Zhang, H., *China's Fissile Material Production and Stockpile* (IPFM: Princeton, NJ, 2017). *France*: International Atomic Energy Agency (IAEA), 'Communication received from France concerning its policies regarding the management of plutonium', INFCIRC/549/Add.5/27, 7 Sep. 2023; and Philippe, S. and Glaser, A., 'Nuclear archaeology for gaseous diffusion enrichment plants', *Science & Global Security*, vol. 22, no. 1 (2014). *Iran*: IAEA, Board of Governors, 'Verification and monitoring in the Islamic Republic of Iran in light of United Nations Security Council Resolution 2231 (2015)', Report of the director general, GOV/2023/8, 28 Feb. 2023. *Israel*: Myers, H., 'The real source of Israel's first fissile material', *Arms Control Today*, vol. 37, no. 8 (Oct. 2007), p. 56; and Gilinsky, V. and Mattson, R. J., 'Revisiting the NUMEC affair', *Bulletin of the Atomic Scientists*, vol. 66, no. 2 (Mar./Apr. 2010). *North Korea*: Hecker, S. S., Braun, C. and Lawrence, C., 'North Korea's stockpiles of fissile material', *Korea Observer*, vol. 47, no. 4 (winter 2016). *Russia*: Podvig, P. (ed.), *The Use of Highly-Enriched Uranium as Fuel in Russia* (IPFM: Washington, DC, 2017). *UK*: British Ministry of Defence, 'Historical accounting for UK defence highly enriched uranium', Mar. 2006; and IAEA, 'Communications received from the United Kingdom of Great Britain and Northern Ireland concerning its policies regarding the management of plutonium', INFCIRC/549/Add.8/26, 16 Nov. 2023. *USA*: US Department of Energy (DOE), National Nuclear Security Administration, *Highly Enriched Uranium, Striking a Balance: A Historical Report on the United States Highly Enriched Uranium Production, Acquisition, and Utilization Activities from 1945 through September 30, 1996* (DOE: Washington, DC, Jan. 2001); White House, 'Transparency in the US highly enriched uranium inventory', Fact sheet, 31 Mar. 2016; US DOE, *FY 2021 Congressional Budget Request*, vol. 1, *National Nuclear Security Administration* (DOE: Washington, DC, Feb. 2020), p. 593; and US DOE, *Tritium and Enriched Uranium Management Plan through 2060*, Report to Congress (DOE: Washington, DC, Oct. 2015). *Other states*: IAEA, *IAEA Annual Report 2022* (IAEA: Vienna, 2022), annex, table A4, p. 171; IAEA, 'Communication dated 19 July 2019 received from the Permanent Mission of Norway concerning a joint statement on minimising and eliminating the use of highly enriched uranium in civilian applications', INFCIRC/912/Add.3, 15 Aug. 2019; and IAEA, 'Communication dated 23 January 2020 received from the Permanent Mission of Australia concerning the joint statement on minimising and eliminating the use of highly enriched uranium in civilian applications', INFCIRC/912/Add.4, 5 Mar. 2020.

Table 7.12. Global stocks of separated plutonium, 2023

All figures are tonnes and are for unirradiated plutonium as of the beginning of 2023. Important exceptions are noted. Final totals are rounded to the nearest 5 tonnes.

State	Total stock	In or available for weapons	Not directly available for weapons[a]		Military production status
			Unsafeguarded	Safeguarded/ monitored	
China	3	2.9 ± 0.6	0.04[b]	–	Stopped in 1991
France	98	6 ± 1.0	–	91.9	Stopped in 1992
India	10	0.68 ± 0.16	9.2 ± 5.3[c]	0.4	Continuing
Israel[d]	0.9	0.85 ± 0.1	–	–	Continuing
Japan[e]	45.1	–	–	45.1	–
Korea, North[f]	0.04	0.04	–	–	Continuing
Pakistan[g]	0.54	0.54 ± 0.18	–	–	Continuing
Russia	193	88 ± 8	89.5[h]	15[i]	Stopped in 2010
UK	119.6	3.2	116.4	–	Stopped in 1995
USA[j]	87.6	38.4	46.2	3[k]	Stopped in 1988
Total	**555**	**140**	**260**	**155**	

[a] With the exception of India, figures for civilian stocks are based on INFCIRC/549 declarations to the International Atomic Energy Agency (IAEA). The data for France, Japan, Russia, the UK and the USA is for the end of 2022, reflecting their most recent INFCIRC/549 declaration to the IAEA. Some countries with civilian plutonium stocks do not submit an INFCIRC/549 declaration. Of these countries, the Netherlands, Spain and Sweden store their plutonium abroad, but the total amounts are too small to be noted in the table.

[b] These numbers are based on China's INFCIRC/549 declaration to the IAEA for the end of 2016. As of Mar. 2024, this is the most recent declaration.

[c] India's unsafeguarded civilian material is the plutonium separated from spent power-reactor fuel. While such reactor-grade plutonium can in principle be used in weapons, it is labelled as 'Not directly available for weapons' here since it is intended for breeder reactor fuel. It was not placed under safeguards in the 'India-specific' safeguards agreement signed by the Indian government and the IAEA on 2 Feb. 2009. India does not submit an INFCIRC/549 declaration to the IAEA.

[d] Israel is believed to be operating the Dimona plutonium-production reactor. The estimate assumes partial use of the reactor for tritium production from 1997 onwards. The estimate is for the beginning of 2023. Without tritium production, stockpiles could be as high as 1110 kg.

[e] Of Japan's plutonium stock, 35.9 tonnes are stored abroad in France (14.1 tonnes) and the UK (21.8 tonnes), the remaining 9.2 tonnes are under IAEA safeguards in Japan.

[f] North Korea reportedly declared a plutonium stock of 37 kg in June 2008. It is believed that it subsequently unloaded plutonium from its 5-MW(e) reactor 3 more times, in 2009, 2016 and 2018. The stockpile estimate has been reduced to account for the 6 nuclear tests conducted by the country. North Korea's reprocessing facility operated again in 2021 for 5 months.

[g] At the beginning of 2023 Pakistan was operating 4 plutonium-production reactors at its Khushab site. This estimate assumes that Pakistan is separating plutonium from all 4 reactors.

[h] This material includes 64.5 tonnes of separated plutonium declared in Russia's 2022 INFCIRC/549 declaration as civilian. Russia does not make the plutonium it reports as civilian available to IAEA safeguards. This amount also includes 25 tonnes of weapon-origin plutonium stored at the Mayak Fissile Material Storage Facility, which Russia pledged not to use for military purposes.

[i] This material is weapon-grade plutonium produced between 1 Jan. 1995 and 15 Apr. 2010, when the last Russian plutonium-production reactor was shut down. It cannot be used for weapon purposes under the terms of a 1997 Russian–US agreement on plutonium-production

reactors. The material is currently stored at Zheleznogorsk and is subject to monitoring by US inspectors.

[j] In 2012 the USA declared a government-owned plutonium inventory of 95.4 tonnes as of 30 Sep. 2009. In its INFCIRC/549 declaration of stocks as of 31 Dec. 2022, the USA declared 49.2 tonnes of unirradiated plutonium (both separated and in mixed oxide, MOX) as part of the stock identified as excess to military purposes.

[k] The USA has placed *c.* 3 tonnes of its excess plutonium, stored at the K-Area Material Storage Facility at the Savannah River Site, under IAEA safeguards.

Sources: International Panel on Fissile Materials (IPFM), *Global Fissile Material Report 2022: Fifty Years of the Nuclear Non-Proliferation Treaty: Nuclear Weapons, Fissile Materials, and Nuclear Energy* (IPFM: Princeton, NJ, 2022). *Civilian stocks (except for India)*: International Atomic Energy Agency (IAEA), 'Communication received from certain member states concerning their policies regarding the management of plutonium', INFCIRC/549, various dates. *China*: Zhang, H., *China's Fissile Material Production and Stockpile* (IPFM: Princeton, NJ, 2017). *Israel*: Glaser, A. and de Troullioud de Lanversin, J., 'Plutonium and tritium production in Israel's Dimona reactor, 1964–2020', *Science & Global Security*, vol. 29, no. 2 (2021). *North Korea*: Kessler, G., 'Message to US preceded nuclear declaration by North Korea', *Washington Post*, 2 July 2008; Hecker, S. S., Braun, C. and Lawrence, C., 'North Korea's stockpiles of fissile material', *Korea Observer*, vol. 47, no. 4 (winter 2016); and IAEA, Board of Governors and General Conference, 'Application of safeguards in the Democratic People's Republic of Korea', Report by the Acting Director General, GOV/2019/33-GC(63)/20, 19 Aug. 2019. *Russia*: Russian–US Agreement Concerning the Management and Disposition of Plutonium Designated as No Longer Required for Defense Purposes and Related Cooperation (Plutonium Management and Disposition Agreement), signed 29 Aug. and 1 Sep. 2000, amendment signed 5 Sep. 2006, entered into force 13 July 2011. *USA*: National Nuclear Security Administration (NNSA), *The United States Plutonium Balance, 1944–2009* (NNSA: Washington, DC, June 2012); and Gunter, A., 'K-Area overview/update', US Department of Energy, Savannah River Site, 28 July 2015.

Table 7.13. Significant uranium-enrichment facilities and capacity worldwide, 2023

With the exception of two facilities (marked *) that continue to use gaseous diffusion to enrich uranium in uranium-235 (U-235), all facilities use gas centrifuge isotope-separation technology.

State	Facility name or location	Type	Status	Capacity (thousands SWU/yr)[a]
Argentina[b]	Pilcaniyeu*	Civilian	Uncertain	20
Brazil	Resende	Civilian	Expanding capacity	50–60
China[c]	Lanzhou	Civilian	Operational	4 400
	Hanzhong (Shaanxi)	Civilian	Operational	2 700
	Emeishan	Civilian	Operational	4 000
	Heping*	Dual-use	Operational	230
France	Georges Besse II	Civilian	Operational	7 500
Germany	Urenco Gronau[d]	Civilian	Operational	3 600
India	Rattehalli	Military	Operational	15–30
Iran[e]	Natanz	Civilian	Expanding capacity	27
	Qom (Fordow)	Civilian	Expanding capacity	2.5
Japan	Rokkasho[f]	Civilian	Not operational	. .
Korea, North	Yongbyon[g]	Uncertain	Operational	8
Netherlands	Urenco Almelo[d]	Civilian	Operational	5 100
Pakistan	Gadwal	Military	Operational	. .
	Kahuta	Military	Operational	15–45
Russia	Angarsk	Civilian	Operational	4 000
	Novouralsk	Civilian	Operational	13 300
	Seversk	Civilian	Operational	3 800
	Zelenogorsk[h]	Civilian	Operational	7 900
UK	Capenhurst[d]	Civilian	Operational	4 500
USA	Urenco Eunice[d]	Civilian	Operational	4 400
	American Centrifuge Plant	Civilian	Operational	4.5

[a] Separative work units per year (SWU/yr) is a measure of the effort required in an enrichment facility to separate uranium of a given content of U-235 into two components, one with a higher and one with a lower percentage of U-235. Where a range of capacities is shown, the capacity is uncertain or the facility is expanding its capacity.

[b] In Dec. 2015 Argentina announced the reopening of its Pilcaniyeu gaseous diffusion uranium-enrichment plant, which was shut down in the 1990s. There is no evidence of actual production.

[c] An assessment of China's enrichment capacity in 2023 suggested the addition of new enrichment plants, resulting in a larger total capacity compared with the estimates of previous years. The figures for China are for Dec. 2023.

[d] Capacities for Urenco facilities are given for Mar. 2024 as presented at that time on the company's website.

[e] The figures for Iran are for Nov. 2023. Since the USA's withdrawal in 2018 from the Joint Comprehensive Plan of Action (JCPOA), which agreed limits on and made more transparent Iran's nuclear programme, Iran continues to increase enrichment capacities and levels at its Natanz and Fordow facilities. In Apr. 2023 Iran informed the International Atomic Energy Agency (IAEA) of plans for new research and development production lines in Building A1000 at Natanz.

[f] According to a Japan Nuclear Fuel Limited report from 31 Mar. 2024, no enriched uranium has been produced since 2019.

[g] North Korea revealed its Yongbyon enrichment facility in 2010. It appears to be operational as of 2020. It is believed that North Korea is operating at least one other enrichment facility.

[h] Zelenogorsk operates a centrifuge cascade for HEU production of fuel for fast reactors and research reactors.

Sources: Indo-Asian News Service (IANS), 'Argentina president inaugurates enriched uranium plant', *Business Standard* (New Delhi), 1 Dec. 2015; Nuclear Engineering International, 'Brazil's INB launches new centrifuge cascade', 25 Nov. 2021; Zhang, H., 'China's uranium enrichment complex', *Science & Global Security*, vol. 23, no. 3 (2015); Zhang, H., *China's Fissile Material Production and Stockpile* (International Panel on Fissile Materials, IPFM: Princeton, NJ, 2017); Zhang, H., 'China started operation of two new enrichment plants in 2023', IPFM Blog, 15 Dec. 2023; International Atomic Energy Agency (IAEA), Board of Governors, 'Verification and monitoring in the Islamic Republic of Iran in light of United Nations Security Council Resolution 2231 (2015)', Report by the director general, GOV/2023/57, 15 Nov. 2023; Albright, D., Burkhard, S. and Faragasso, S., 'Updated highlights of comprehensive survey of Iran's advanced centrifuges', Institute for Science and International Security, 21 Mar. 2023; Albright, D. et al., 'Analysis of IAEA Iran Verification and Monitoring Report: November 2023', Institute for Science and International Security, 20. Nov. 2023; Japan Nuclear Fuel Limited, 'Operational status at uranium enrichment plant', 31 Mar. 2024; Hecker, S. S., Carlin, R. L. and Serbin, E. A., 'A comprehensive history of North Korea's nuclear program: 2018 update', Stanford University, Center for International Security and Cooperation, 11 Feb. 2019; and 'Enrichment operations start at US HALEU plant', World Nuclear News, 12 Oct. 2023. Enrichment capacity data is further based on IAEA, Integrated Nuclear Fuel Cycle Information Systems (iNFCIS); Urenco, 'Global operations'; US Department of Energy (DOE), *Tritium and Enriched Uranium Management Plan through 2060*, Report to Congress (DOE: Washington, DC, Oct. 2015); and IPFM, *Global Fissile Material Report 2022: Fifty Years of the Nuclear Non-Proliferation Treaty: Nuclear Weapons, Fissile Materials, and Nuclear Energy* (IPFM: Princeton, NJ, 2022).

Table 7.14. Significant reprocessing facilities worldwide, 2023

State	Facility name or location	Fuel	Type	Status	Design capacity (tHM/yr)[a]
China[b]	Jiuquan pilot plant	LWR	Civilian	Operational	50
France	La Hague UP2	LWR	Civilian	Operational	1 000
	La Hague UP3	LWR	Civilian	Operational	1 000
India[c]	Kalpakkam	HWR	Dual-use	Operational	100
	Tarapur	HWR	Dual-use	Operational	100
	Tarapur-II	HWR	Dual-use	Operational	100
	Trombay	HWR	Military	Operational	50
Israel	Dimona	HWR	Military	Operational	40–100
Japan	Rokkasho	LWR	Civilian	Start planned for 2024[d]	800
Korea, North	Yongbyon	GCR	Military	Operational	100–150
Pakistan	Chashma	HWR	Military	Starting up	50–100
	Nilore	HWR	Military	Operational	20–40
Russia	Mayak RT-1, Ozersk	LWR	Civilian	Operational	400
	EDC, Zheleznogorsk[e]	LWR	Civilian	Starting up	250
UK	Sellafield[f]	–	Civilian	Shut down	–
USA	H-canyon, Savannah River Site	LWR	Civilian	Operational	15

GCR = gas-cooled reactor; HWR = heavy water reactor; LWR = light water reactor.

[a] Design capacity refers to the highest amount of spent fuel the plant is designed to process and is measured in tonnes of heavy metal per year (tHM/yr), tHM being a measure of the amount of heavy metal—uranium in these cases—that is in the spent fuel. Actual throughput is often a small fraction of the design capacity. LWR spent fuel contains *c*. 1% plutonium; HWR and GCR fuel contain *c*. 0.4% plutonium.

[b] China is building a pilot reprocessing facility near Jinta, Gansu province, with a capacity of 200 tHM/yr, to be commissioned in 2025. A second reprocessing plant of the same capacity is planned for the same site.

[c] As part of the 2005 Indian–US Civil Nuclear Cooperation Initiative, India has decided that none of its reprocessing plants will be opened for International Atomic Energy Agency safeguards inspections.

[d] Construction of the facility started in 1993. Since then, the planned starting date has been postponed regularly.

[e] Russia continues to construct the 250 tHM/yr pilot Experimental and Demonstration Centre (EDC) at Zheleznogorsk. A pilot reprocessing line with a capacity of 5 tHM/yr was launched in June 2018.

[f] The UK operated two large civilian reprocessing facilities at Sellafield, THORP and B205. These facilities were shut down in 2018 and 2022, respectively.

Sources: 'Japan approves 70-year plan to scrap nuclear reprocessing plant', Kyodo News, 13 June 2018; Suzuki, T., 'Japan's never ending reprocessing saga', IPFM Blog, 23 Nov. 2023; [Rosatom ready to start 'green' processing of spent nuclear fuel], RIA Novosti, 29 May 2018 (in Russian); and Sellafield Ltd and Nuclear Decommissioning Authority, 'Job done: Sellafield plant safely completes its mission', 19 July 2022. Data on design capacity is based on International Atomic Energy Agency, Integrated Nuclear Fuel Cycle Information Systems (iNFCIS); and International Panel on Fissile Materials (IPFM), *Global Fissile Material Report 2022: Fifty Years of the Nuclear Non-Proliferation Treaty: Nuclear Weapons, Fissile Materials, and Nuclear Energy* (IPFM: Princeton, NJ, 2022).