7. World nuclear forces

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I. Introduction

At the start of 2011 eight states possessed approximately 20 500 nuclear weapons, of which more than 5000 were deployed and ready for use (see table 7.1). Nearly 2000 of these are kept in a state of high operational alert.

All five legally recognized nuclear weapon states, as defined by the 1968 Treaty on the Non-Proliferation of Nuclear Weapons (Non-Proliferation Treaty, NPT)—China, France, Russia, the United Kingdom and the United States—appear determined to remain nuclear powers and are either modernizing or about to modernize their nuclear forces.[1] At the same time, Russia and the USA have undertaken to make further reductions in their strategic nuclear forces in the 2010 Treaty on Measures for the Further Reduction and Limitation of Strategic Offensive Arms (New START), a follow-on treaty to the expired 1991 Treaty on the Reduction and Limitation of Strategic Offensive Arms (START). New START, which was signed in April 2010, supersedes the 2002 Treaty on Strategic Offensive Reductions (SORT).[2] Sections II and III of this chapter discuss the composition of the deployed nuclear forces of the USA and Russia, respectively. The nuclear arsenals of the other three nuclear weapon states are considerably smaller, but all are either deploying new weapons or have announced their intention to do so. Sections IV–VI present data on the delivery vehicles and warhead stockpiles of the UK, France and China, respectively.

Reliable information on the operational status of the nuclear arsenals and capabilities of the three states that have never been party to the NPT—India, Israel and Pakistan—is difficult to find. In the absence of official declarations, the available information is often contradictory or incorrect. India and Pakistan are expanding their nuclear strike capabilities, while Israel appears to be waiting to see how the situation in Iran develops. Sections VII–IX provide information on the Indian, Pakistani and Israeli nuclear arsenals, respectively. The nuclear weapon capabilities of the

[1] According to the NPT, only states that manufactured and exploded a nuclear device prior to 1 Jan. 1967 are recognized as nuclear weapon states. For a summary and other details of the NPT see annex A in this volume.

[2] For summaries and other details of START, SORT and New START see annex A in this volume.

Table 7.1. World nuclear forces, January 2011

All figures are approximate.

Country	Year of first nuclear test	Deployed warheads[a]	Other warheads[b]	Total inventory
United States	1945	2 150[c]	6 350	~8 500[d]
Russia	1949	~2 427[e]	8 570[f]	~11 000[g]
United Kingdom	1952	160	65	225
France	1960	290	10	~300
China	1964	..	200[h]	~240
India	1974	..	80–100[h]	80–100
Pakistan	1998	..	90–110[h]	90–110
Israel	..	..	~80[h]	~80
North Korea	2006	..	..	?[i]
Total		**~5 027**	**~15 500**	**~20 530**

[a] 'Deployed' means warheads placed on missiles or located on bases with operational forces.

[b] These are warheads in reserve, awaiting dismantlement or that require some preparation (e.g. assembly or loading on launchers) before they become fully operationally available.

[c] This figure includes *c.* 200 non-strategic (tactical) nuclear weapons deployed in Europe. In addition, *c.* 300 non-strategic weapons are in storage in the USA and a further 260 will be retired.

[d] The US Department of Defense nuclear stockpile contains *c.* 5000 warheads. Another *c.* 3500 retired warheads are scheduled to be dismantled by 2022.

[e] This represents a decrease from the figure published in *SIPRI Yearbook 2010* and reflects the Russian Government's declaration in 2010 that all non-strategic (tactical) nuclear weapons are in storage and not deployed.

[f] This figure includes up to 5400 non-strategic nuclear weapons for use by short-range naval, air force and air defence forces.

[g] The Russian stockpile contains *c.* 8000 nuclear warheads. Another *c.* 3000 retired warheads await dismantlement.

[h] The nuclear stockpiles of China, India, Pakistan and Israel are not thought to be fully deployed.

[i] North Korea conducted nuclear test explosions in 2006 and 2009, but there is no public information to verify that it possesses operational nuclear weapons.

Democratic People's Republic of Korea (DPRK, or North Korea) are discussed in section X. Brief conclusions are given in section XI.

Appendix 7A contains tables of global stocks and production of fissile materials—highly enriched uranium (HEU) and separated plutonium, the raw material for nuclear weapons.

The figures presented here are estimates based on public information and contain some uncertainties, as reflected in the notes to the tables.

II. US nuclear forces

As of January 2011 the USA maintained an estimated arsenal of approximately 2150 operational nuclear warheads, consisting of roughly 1950 stra-

tegic and 200 non-strategic warheads (see table 7.2). In addition to this operational arsenal, about 2850 warheads are held in reserve, for a total stockpile of approximately 5000 warheads.[3] Another 3500 retired warheads are awaiting dismantlement.

This force level is a slight decrease compared with the estimate presented in *SIPRI Yearbook 2010*.[4] The change reflects the limited additional withdrawal from deployment of warheads on intercontinental ballistic missiles (ICBMs) and the removal of warheads for the Tomahawk sea-launched cruise missile (SLCM) from the active stockpile.

The Nuclear Posture Review and New START

The year 2010 was dominated by the publication of the Nuclear Posture Review (NPR) and the signing and subsequent debate of New START.[5] With US President Barack Obama's intention to complete New START before START expired in December 2009, the first priority of the NPR process was to assess the impact of the force level goals envisioned by New START.[6] The analysis quickly settled on retaining a triad of land-, sea- and air-based strategic nuclear forces and protecting the force structure against significant changes.

The NPR and New START were both completed in April 2010, setting the direction of the US nuclear posture for the next 5–10 years. The 2010 NPR was the first such review to explicitly include a commitment to the ultimate goal of eliminating all nuclear weapons. Also, for the first time, the NPR elevated the non-proliferation of weapons of mass destruction (WMD) to the same level of importance in the US nuclear posture as nuclear weapon policy itself.

Overall, the NPR and New START will result in modest reductions in the number of deployed strategic warheads and delivery vehicles. However, the NPR did not meet Obama's pledge made in Prague in 2009 to 'reduce the role of nuclear weapons in [the USA's] national security strategy' to 'put an

[3] Kristensen H. M. and Norris, R. S., 'US nuclear forces, 2011', *Bulletin of the Atomic Scientists*, vol. 67, no. 2 (Mar./Apr. 2011). The stockpile estimate of 5000 warheads was subsequently confirmed by the US National Security Advisor, Thomas Donilon. Donilon, T., Keynote speech, 2011 Carnegie International Nuclear Policy Conference, Washington, DC, 29 Mar. 2011, <http://www.carnegieendowment.org/events/?fa=viewSubEvent&id=43486>.

[4] Kile, S. N. et al., 'World nuclear forces', *SIPRI Yearbook 2010*, pp. 333–70.

[5] US Department of Defense (DOD), *Nuclear Posture Review Report* (DOD: Washington, DC, Apr. 2010), p. 7; and New START (note 2). For official sources and background material on New START and the NPR see US Department of State, 'New START', <http://www.state.gov/t/avc/newstart/>; and US Department of Defense, 'Nuclear Posture Review', <http://www.defense.gov/npr/>.

[6] US Department of Defense, 'Nuclear Posture Review 2010: the NPR, arms control and deterrence', Fact sheet, 6 Aug. 2009, p. 2.

Table 7.2. US nuclear forces, January 2011

Type	Designation	No. deployed	Year first deployed	Range (km)[a]	Warheads x yield	No. of warheads
Strategic forces						**~1 950**
Bombers[b]		*113/60*				*300*
B-52H	Stratofortress	93/44	1961	16 000	ALCM 5–150 kt	200[c]
B-2	Spirit	20/16	1994	11 000	B61-7, -11, B83-1 bombs	100[d]
ICBMs		*450*				*500*[e]
LGM-30G	Minuteman III					
	Mk-12A	250	1979	13 000	1–3 x 335 kt	200
	Mk-21 SERV	200	2006	13 000	1 x 300 kt	300
SSBNs/SLBMs[f]		*288*				*1 152*
UGM-133A	Trident II (D5)[g]					
	Mk-4	. .	1992	>7 400	4 x 100 kt	568
	Mk-4A	. .	2008	>7 400	4 x 100 kt	200
	Mk-5	. .	1990	>7 400	4 x 475 kt	384
Non-strategic forces						**200**
B61-3, -4 bombs		. .	1979	. .	0.3–170 kt	200[h]
Tomahawk SLCM		(0)	1984	2 500	1 x 5–150 kt	(0)[i]
Total deployed warheads						**~2 150**[j]

. . = not available or not applicable; ( ) = uncertain figure; ALCM = air-launched cruise missile; ICBM = intercontinental ballistic missile; kt = kiloton; SERV = security-enhanced re-entry vehicle; SLBM = submarine-launched ballistic missile; SLCM = sea-launched cruise missile; SSBN = nuclear-powered ballistic missile submarine.

[a] Aircraft range is for illustrative purposes only; actual mission range will vary according to flight profile and weapon loading.

[b] For bombers, the first figure in the 'No. deployed' column is the total number in the inventory, including those for training, test and reserve. The second figure is for the primary mission inventory aircraft, i.e. the number of operational aircraft assigned for nuclear and conventional wartime missions.

[c] The total ALCM inventory has been reduced to 528, of which an estimated 200 are deployed. Under New START, each nuclear bomber is only attributed 1 weapon although many more may be stored at bomber bases.

[d] Operational gravity bombs are only included for the B-2A bomber. The B-52H can also deliver bombs, but its nuclear mission is thought to be focused on ALCM since the bomber is not capable of penetrating modern air defence systems.

[e] The 2010 Nuclear Posture Review (NPR) decided to download each ICBM to carry a single warhead in the near future and also to retain an upload capability to re-MIRV the W78 portion of the force if necessary.

[f] Two additional SSBNs are undergoing overhaul at any given time, and their 48 missiles and 192 warheads are not included in the total.

[g] Although D5 missiles were counted under START as carrying 8 warheads each, the US Navy is estimated to have downloaded each missile to an average of 4–5 warheads to meet the SORT-mandated warhead ceiling. Delivery of the W76-1 warhead began in Oct. 2008.

[h] Since 2001 the number of B61 bombs deployed in Europe has been unilaterally reduced by almost two-thirds from 480 to *c*. 180. Additional warheads are in reserve.

[i] The TLAM/N is being retired in accordance with the 2010 NPR.

[j] Including the additional *c.* 2850 warheads in reserve, the total stockpile is *c.* 5000 warheads. There are another *c.* 3500 warheads awaiting dismantlement for a total inventory of *c.* 8500 warheads. A further *c.* 15 000 plutonium pits are stored at the Pantex Plant in Texas.

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

end to Cold War thinking'.[7] Instead, the NPR reaffirmed the importance of nuclear weapons to US national security and recommended retaining a triad of long-range offensive nuclear forces, maintaining the current readiness level of hundreds of ballistic missiles on high alert, retaining large numbers of nuclear warheads in reserve to increase the deployed force if necessary, modernizing delivery vehicles and warheads, and building new warhead production factories. It also rejected a no-first-use policy for the time being and continued nuclear strike planning against non-nuclear armed adversaries.

New START does not contain any sub-limits on strategic forces. Thus, provided that strategic forces remain under the overall limits for deployed warheads and deployed and non-deployed delivery vehicles, there are no limits on how the nuclear forces recommended by the NPR must be structured. The NPR determined that the USA will retain the following nuclear force structure: (*a*) up to 420 deployed ICBMs, each carrying a single nuclear warhead, with hundreds of additional warheads in reserve for upload; (*b*) 14 nuclear-powered ballistic missile submarines (SSBNs), possibly 12 towards the end of the 2010s, with up to 240 deployed submarine-launched ballistic missile (SLBMs), each carrying multiple nuclear warheads with hundreds more in reserve for upload; and (*c*) up to 60 nuclear-capable heavy bombers equipped for gravity bombs and cruise missiles, each bomber counted as a single nuclear warhead but with hundreds of warheads in reserve for upload.

SLBMs and heavy bombers will be the main upload platforms for reserve warheads to increase the number of deployed nuclear warheads if so ordered. It is unclear whether the US Department of Defense (DOD) will decide to retire an additional 20 ICBMs or 20 bombers to meet the New START limit on deployed delivery vehicles. If the USA were to retain all 60 bombers with a maximum force loading of 1136 nuclear weapons, the total US force level of 2626 warheads would still count only as 1550 under New START due to the attribution of only one weapon per bomber.

[7] White House, 'Remarks by President Barack Obama, Hradcany Square, Prague, Czech Republic', 5 Apr. 2009, <http://www.whitehouse.gov/the-press-office/remarks-president-barack-obama-prague-delivered>.

The nuclear weapon production complex

With the NPR and statements made during the New START ratification hearings, the Obama Administration made it clear that the USA intends to retain a large nuclear weapon complex for the foreseeable future. Over the next decade, the DOD 'will invest well over $100 billion in nuclear delivery systems to sustain existing capabilities and modernize some strategic systems'.[8] Likewise, the administration increased its funding request for the nuclear weapon activities of the National Nuclear Security Administration (NNSA) in financial year (FY) 2011 by nearly 10 per cent and another 8.4 per cent for FY 2012. Over the next decade, the NNSA will spend more than $92 billion on maintaining and modernizing nuclear warheads and production facilities.[9] All existing warheads will undergo life-extension programmes and be equipped with new, improved or significantly modified components. Three nuclear weapon production facilities will be constructed with a capacity to produce 80 warheads per year, including the Uranium Processing Facility in Oak Ridge, Tennessee; the Chemistry and Metallurgy Research Replacement (CMRR) in Los Alamos, New Mexico; and the Kansas City Plant in Kansas City, Missouri. The estimated cost of these construction projects up to 2030 is $180 billion.[10]

In addition to maintaining, dismantling and producing modified versions of existing warheads, the new facilities will have a capacity to produce up to 80 plutonium pits for replacement warheads each year. This capacity is about 10 times greater than the number of warheads lost each year to non-nuclear testing of the nuclear explosive package. According to the NPR, the extra capacity will allow a 'substantial' reduction of the nuclear stockpile:

> By modernizing our aging nuclear weapons-supporting facilities and investing in human capital, we can substantially reduce the number of stockpiled nuclear weapons we retain as a hedge against technical or geopolitical surprise, accelerate the dismantlement of nuclear weapons no longer required for our deterrent, and improve our understanding of foreign nuclear weapons activities.[11]

Nuclear operations and organization

Maintenance of the US strategic war plan—OPLAN (Operations Plan) 8010-08 Strategic Deterrence and Global Strike—continued in 2010, with

[8] US Senate, Committee on Foreign Relations, *The New START Treaty*, Treaty doc. 111-5 (US Government Printing Office: Washington, DC, Dec. 2010), p. 87.

[9] US Department of Defense and US National Nuclear Security Administration, 'November 2010 update to the National Defense Authorization Act of FY2010 Section 1251 Report: New START Treaty framework and nuclear force structure plans', Nov. 2010, pp. 1, 2, 9.

[10] Kristensen, H. M., 'Nuclear plan shows cuts and massive investments', FAS Strategic Security Blog, Federation of American Scientists, 12 July 2010, <http://www.fas.org/blog/ssp/2010/07/stockpileplan.php>.

[11] US Department of Defense (note 5), p. 7.

Strategic Command (STRATCOM) conducting the Global Thunder nuclear exercise in November 2010 to test the readiness of ICBMs, SLBMs, long-range bombers, refuelling aircraft, and command and control. In recent years, STRATCOM has expanded Global Thunder from a command post exercise to a full nuclear employment exercise that includes force generation and flying operations.[12]

Air Force Global Strike Command achieved full operational capability on 30 September 2010, after having taken command of all ICBMs and heavy bombers previously organized under US Space Command and Air Combat Command, respectively.[13] The centralization of US Air Force (USAF) strategic nuclear assets under a single command, the first completely new command activated by the USAF in 27 years, was a response to a serious incident at Minot Air Force Base (AFB), North Dakota, in 2007 in which six cruise missiles carrying nuclear warheads were mistakenly loaded onto a B-52H aircraft and transported to Barksdale AFB, Louisiana.[14]

Land-based ballistic missiles

The NPR decided that the USA will retain 400–420 ICBMs under New START. The force currently consists of 450 missiles with 500 warheads; within the next few years those missiles still equipped with multiple warheads will be downloaded to carry a single warhead each. The multiple independently targetable re-entry vehicle (MIRV) capability of the ICBM force will be retained, however, to preserve the option to upload hundreds of reserve warheads if necessary.

The last W62 warhead was dismantled on 11 August 2010, leaving only W78 and W87 warheads on the ICBM force.[15] The 170-kiloton W62 has been replaced by the more powerful 300-kt W87/Mk-21 re-entry vehicle, which broadens the range of Minuteman ICBM force targets.

A multi-billion dollar modernization programme is under way to extend the service life of the Minuteman III missile to 2030. The NPR decided that an initial study will begin in 2011–12 to consider a range of deployment options for a replacement missile. This will involve exploring 'new modes of ICBM basing that could enhance survivability and further reduce any incentives for prompt launch. Such an assessment will be part of the DOD's

[12] Kristensen, H. M., 'Obama and the nuclear war plan', FAS Strategic Security Blog, Federation of American Scientists, 25 Feb. 2010, <http://www.fas.org/blog/ssp/2010/02/warplan.php>.

[13] The ICBMs were transferred on 1 Dec. 2009 and the bombers on 1 Feb. 2010.

[14] US Department of Defense, Defense Science Board, Permanent Task Force on Nuclear Weapons Surety, 'Report on the unauthorized movement of nuclear weapons', Feb. 2008.

[15] US National Nuclear Security Administration, 'Energy Secretary announces completion of W62 dismantlement program', Press release, 12 Aug. 2010, <http://nnsa.energy.gov/mediaroom/pressreleases/chupantex081210>.

study of possible replacements for the current ICBM force'.[16] In 2014 the DOD will recommend a specific way ahead for a follow-on programme.[17]

There were two Minuteman III flight tests in 2010, the same number as in 2009.

Ballistic missile submarines

All 14 US Navy Ohio Class SSBNs carry D5 missiles. Twelve operational SSBNs carry a total of 288 D5 SLBMs, each of which is estimated to carry 4 warheads for a total of about 1152 warheads.[18] With eight SSBNs based in the Pacific Ocean and six in the Atlantic Ocean, and a patrol rate comparable to that during the cold war, more than 60 per cent of US SSBN patrols now take place in the Pacific, compared to an average of only 15 per cent during the 1980s. The SSBN force is organized in two fleets: one overseeing Submarine Group 10 at Kings Bay Naval Submarine Base, Georgia, and the other overseeing Submarine Group 9 at Kitsap Naval Submarine Base near Bangor, Washington.

The US Navy is planning to replace the Ohio Class with 12 boats of a next-generation SSBN, known as SSBNX. Construction will begin in 2019 with launch in 2026. The SSBNX will enter service from 2029 after the first two Ohio Class SSBNs have been retired. The new class will carry 16 SLBMs to permit more boats under future arms control agreements and provide more operational flexibility. The new SSBNX programme is projected to cost $60–80 billion.

Twenty-four additional modified D5 SLBMs were procured in 2010, of a total of 108 missiles being purchased up to 2012 at a cost of more than $4 billion. The first modified D5 (D5LE), which was scheduled for deployment in 2010, will arm the Ohio Class SSBNs for the rest of their service lives up to 2042. Deployment of the W76-1/Mk-4A warhead is under way, with approximately 1200 warheads to be refurbished by 2018. The W76-1/Mk-4 warhead is equipped with a new fuse that allows more flexibility in setting the height of burst to 'enable W76 to take advantage of [the] higher accuracy of [the] D5 missile' and bring more targets, including hard targets, within range.[19]

[16] US Department of Defense (note 5), pp. 23, 27.

[17] US Department of Defense and US National Nuclear Security Administration (note 9).

[18] Two additional SSBNs are undergoing overhaul at any given time, and their 48 missiles and 192 warheads are not included in the total.

[19] US Department of Energy (DOE), Office of Defense Programs, *Stockpile Stewardship and Management Plan: First Annual Update*, partially declassified and released under the US Freedom of Information Act (DOE: Washington, DC, Oct. 1997), pp. 1–14.

Strategic bombers

The US Air Force has 20 B-2 and 93 B-52H bombers, 94 of which—18 B-2s and 76 B-52Hs—are nuclear-capable. However, only 60 of these—16 B-2s and 44 B-52Hs—are thought to have nuclear missions.

Approximately 200 nuclear warheads are estimated to be deployed with the bombers on three bases. These include the aircraft-delivered B61-7, B61-11 (on the B-2 only) and B83-1 gravity bombs and the W80-1 warhead carried on air-launched cruise missiles (ALCMs, on B-52Hs only). Hundreds of additional bombs and cruise missiles are in storage and could be returned to the bases if necessary.

The USAF intends to keep the B-52H in the inventory until at least 2035 for both nuclear and conventional missions. A long-range strike study will be completed in early 2011 to define future options for a replacement bomber, with approximately $1.7 billion earmarked for a follow-on bomber. The USAF also intends to replace the ALCM, which will expire in 2030, with the Advanced Long Range Standoff (LRSO) nuclear cruise missile. Studies will be conducted up to 2013 with a goal of beginning low-rate initial production around 2025.[20]

Non-strategic nuclear weapons

As of January 2011 the USA retained approximately 760 non-strategic nuclear warheads. This includes nearly 200 B61 gravity bombs deployed in Europe, 300 reserve bombs in the USA, and approximately 260 warheads for the Tomahawk Land-Attack Cruise Missile (TLAM/N).

The B61 bombs are deployed at six airbases in five European member states of the North Atlantic Treaty Organization (NATO): Belgium, Germany, Italy, the Netherlands and Turkey.[21] Approximately half of the bombs are earmarked for delivery by US F-15E and F-16 aircraft. The aircraft of non-nuclear weapon NATO countries that are assigned nuclear strike missions with US nuclear weapons include Belgian, Dutch and Turkish F-16s and German and Italian Tornados.

The NPR decided to equip a portion of the F-35 Joint Strike Fighter (Block IV) aircraft with nuclear capability but did not explicitly state that

[20] US Department of Defense and US National Nuclear Security Administration (note 9), pp. 11–12.

[21] During a NATO briefing on the NPR in Sep. 2009, the US Principal Under Secretary of Defense for Policy, James Miller, mentioned '180 NATO sub-strategic warheads'. He may have been referring to the number of weapons listed in the US deployment authorization plan for Europe. The plan allows for a deviation of ±10% from the authorized warhead number. US Mission to Council of the North Atlantic Treaty Organization, 'PDUSDP Miller consults with allies on Nuclear Posture Review', Cable USNATO000378, 4 Sep. 2009, <http://www.hedgehogs.net/pg/newsfeeds/hhwebadmin/item/6728052/us-embassy-cables-us-targets-terrorists-with-conventional-warheads-fitted-to-nuclear-weapons>, para. 17.

nuclear weapons should be deployed in Europe. The F-35 will be equipped with the new B61-12, a modified version of the B61-3/4/10 and -7. The NPR also decided to retire the TLAM/N.

Nuclear warhead modernization

Extensive life-extension and modernization programmes for all remaining US nuclear warhead types are scheduled for the next decades. The NPR decided that the USA 'will not develop new nuclear warheads' but consider the 'full range' of life-extension programme options, including 'refurbishment of existing warheads, reuse of nuclear components from different warheads, and replacement of nuclear components'.[22] This is intended to preclude resumption of live nuclear testing and enable adherence to the 1996 Comprehensive Nuclear-Test-Ban Treaty (CTBT). The NPR also decided that any life-extension programme 'will only use nuclear components based on previously tested designs, and will not support new military capabilities'.[23] However, this will depend on how 'new' military capabilities are defined, since the installation of a new arming, fusing and firing unit, for example, can significantly alter a warhead's military capability.[24]

III. Russian nuclear forces

As of January 2011 Russia had an estimated 2427 operational nuclear warheads (see table 7.3). This number has been adjusted down from that given in *SIPRI Yearbook 2010* to reflect the Russian Government's declaration in 2010 that all non-strategic nuclear weapons are in storage as well as the retirement of older ICBMs.

Russia continues to reduce its strategic nuclear forces in accordance with its arms treaty commitments and as part of a doctrinal shift away from a 'substantially redundant' (*suschestvenno izbytochnyi*) towards a 'minimally sufficient' (*garantirovanno dostatochnyi*) deterrence posture. Russia's national security strategy, approved in May 2009, states that it will maintain numerical parity with the USA's offensive strategic weapons in the most cost-effective way.[25]

On 5 February 2010 Russian President Dmitry Medvedev approved Russia's newest military doctrine.[26] The doctrine slightly reduces the role

[22] US Department of Defense (note 5), p. xiv.

[23] US Department of Defense (note 5), p. xiv.

[24] Kristensen, H. M., 'Small fuze—big effect', FAS Strategic Security Blog, Federation of American Scientists, 14 Mar. 2007, <http://www.fas.org/blog/ssp/2007/03/small_fuze_-_big_effect.php>.

[25] [National security strategy of the Russian Federation for the period until 2020], Presidential Decree no. 537, 12 May 2009, <http://www.scrf.gov.ru/documents/99.html>.

[26] President of Russia, [Military doctrine of the Russian Federation], 5 Feb. 2010, <http://news.kremlin.ru/ref_notes/461>.

of nuclear weapons in Russia's national security policy by introducing stricter criteria for their use.[27] According to the new doctrine, Russia declared the right to use nuclear weapons in response to an attack from WMD as well as an attack from conventional weapons if 'the very existence of the state is threatened'. The previous military doctrine, adopted in 2000, approved the use of nuclear weapons 'in situations critical for the national security'.[28] The 2010 military doctrine confirms Russia's military task to maintain 'strategic stability and the nuclear deterrence capability at the level of sufficiency' and defines the term 'sufficiency' as 'an ability to inflict "predetermined" damage to an aggressor under any circumstances'.[29]

According to senior military experts, Russia's strategic nuclear forces can guarantee 'minimally sufficient' deterrence but need qualitative improvements to enhance their survivability for an assured second-strike capability and their ability to penetrate missile defences.[30] In light of these criteria, Russia continues to prioritize the deployment of a road-mobile ICBM with MIRVs and a new type of SLBM.

Strategic bombers

Russia's strategic aviation units include two heavy bomber divisions consisting of 13 Tu-160, 31 Tu-95MS16 and 32 Tu-95MS6 aircraft. Russia continues its efforts to overhaul, upgrade and extend the service life of all its strategic bombers.[31] One of the Tu-160 bombers finished an overhaul in June 2010.[32] Russia's non-strategic aviation units include four divisions of Tu-22M3 bombers.

Land-based ballistic missiles

Russia's Strategic Rocket Forces (SRF) consist of three missile armies, which will be reduced to two by 1 January 2016.[33]

[27] Sokov, N., 'The new, 2010 Russian military doctrine: the nuclear angle', James Martin Center for Nonproliferation Studies, 5 Feb. 2010, <http://cns.miis.edu/stories/100205_russian_nuclear_doctrine.htm>.

[28] President of Russia (note 26); and Sokov, N. (note 27).

[29] President of Russia (note 26).

[30] Umnov, S., [Russia's SNF: building up ballistic missile defence penetration capacities], *Voenno-Promyshlennyi Kur'er*, 8–14 Mar. 2006; and Esin, V., [The United States: in pursuit of a global missile defence], *Voenno-Promyshlennyi Kur'er*, 25–31 Aug. 2010.

[31] Kramnik, I., 'What's next for the Russian Air Force?', RIA Novosti, 3 Dec. 2010, <http://en.rian.ru/analysis/20101203/161617495.html>.

[32] 'KAPO transferred to the Air Force the refurbished missile carrier Tu-160', *Kommersant-Kazan*, 28 Aug. 2010.

[33] Isby, D. C., 'Russian SRF plans structural changes', *Jane's Missiles and Rockets*, vol. 13, no. 2 (Feb. 2009).

Table 7.3. Russian nuclear forces, January 2011

Type/Russian designation (NATO designation)	No. deployed	Year first deployed	Range (km)[a]	Warhead loading	No. of warheads
Strategic offensive forces					**~2 427**
Bombers	*76*				*844*[b]
Tu-95MS6 (Bear-H6)	32	1981	6 500–10 500	6 x AS-15A ALCMs, bombs	192
Tu-95MS16 (Bear-H16)	31	1981	6 500–10 500	16 x AS-15A ALCMs, bombs	496
Tu-160 (Blackjack)	13	1987	10 500–13 200	12 x AS-15B ALCMs or AS-16 SRAMs, bombs	156
ICBMs	*~295*				*~1 007*
RS-20V (SS-18 Satan)	~50	1992	11 000–15 000	10 x 500–800 kt	500
RS-18 (SS-19 Stiletto)	~50	1980	10 000	6 x 400 kt	~300
RS-12M Topol (SS-25 Sickle)	~120	1985	10 500	1 x 800 kt	~120
RS-12M2 Topol-M (SS-27)	~51	1997	10 500	1 x 800 kt	~51
RS-12M1 Topol-M (SS-27)	18	2006	10 500	1 x (800 kt)	18
RS-24 (SS-27 Mod 2)	6	2010	10 500	3 x (400 kt)	18
SLBMs	*160*				*576*
RSM-50 Volna (SS-N-18 M1 Stingray)	64	1978	6 500	3 x 50 kt	192
RSM-54 Sineva (SS-N-23 Skiff)	96	1986/2007	9 000	4 x 100 kt	384
RSM-56 Bulava (SS-NX-32)	0	(2011)	8 050+	6 x (100 kt)	0
Strategic defensive forces					
ABMs[c]	*~2 068*				(*~700*)
53T6 (SH-08 Gazelle)	68	1986	. .	1 x 10 kt	68)
S-300 (SA-10/20 Grumble)	1 900	1980	. .	low kt	(~600)
S-400 Triumf (SA-21 Growler)	~100	2007	. .	. .	. .
Non-strategic forces					**(~1 380)***
Land-based non-strategic bombers[d]	*682*				(*~800*)*
Tu-22M (Backfire)	116	1974	. .	2 x AS-4 ASM, bombs	
Su-24 (Fencer)	550	1974	. .	2 x bombs	
Su-34 (Fullback)	16	2006			
Naval non-strategic attack aircraft	*147*				(*~200*)*
Tu-22M (Backfire)	56	1974	. .	2 x AS-4 ASM, bombs	
Su-24 (Fencer)	47	1974	. .	2 x bombs	
Be-12 (Mail)/Il-38 (May)	44	1967/68	. .	1 x depth bomb	
Ground-launched weapons[e]					
Short-range ballistic missiles	?			1 x ?	(?)*
SLCMs					(*~220*)*
SS-N-9, SS-N-12, SS-N-19, SS-N-21, SS-N-22					
ASW and SAM weapons					(*~160*)*
SS-N-15/16, SA-N-1/3/6, depth bombs, torpedoes[f]					
Total defensive and non-strategic					**(~2 080)***
Total deployed warheads					**~2 427**[g]

. . = not available or not applicable; ( ) = uncertain figure; ABM = anti-ballistic missiles; ALCM = air-launched cruise missile; ASM = air-to-surface missile; ASW = Anti-submarine warfare; ICBM = intercontinental ballistic missile; kt = kiloton; NATO = North Atlantic Treaty Organization; SAM = surface-to-air missile; SLBM = submarine-launched ballistic missile; SLCM = sea-launched cruise missile; SRAM = short-range attack missile.

* All non-strategic nuclear warheads are in storage, according to the Russian Government, and are not counted in the total deployed warheads. In addition to the nominal load available for non-strategic nuclear-capable forces listed in the table, another 1600–3300 warheads are estimated to be in reserve or awaiting dismantlement for a total inventory of 3700–5400 non-strategic warheads.

[a] Aircraft range is for illustrative purposes only; actual mission range will vary according to flight profile and weapon loading.

[b] The bomber weapons are not deployed on the aircraft. It is estimated that most of the weapons have been moved to storage facilities and that only a few hundred weapons are present at bomber bases.

[c] The 51T6 (SH-11 Gorgon) is no longer operational. The S-300P (SA-10 Grumble), S-300V (SA-12A Gladiator, SA-12B Giant) and S-400 may have some capability against some ballistic missiles. Only a third of the 1900 deployed S-300s are counted as having nuclear capability.

[d] These figures assume that only half of land-based strike aircraft have nuclear missions.

[e] According to NATO's International Military Staff, the Russian Zapad and Ladoga exercises held in Aug.–Sep. 2009 included 'missile launches, some of which may have simulated the use of tactical nuclear weapons'. Daalder, I., US Ambassador to NATO, 'NATO–Russia: NAC discusses Russian military exercises', Cable to SIPDIS, USNATO546, 23 Nov. 2009, <http://www.aftenposten.no/spesial/wikileaksdokumenter/article4028273.ece>.

[f] Surface ships are not estimated to be assigned nuclear torpedoes.

[g] In addition to the 2427 deployed strategic warheads and 3700–5400 non-strategic warheads in storage, another 3170–4870 strategic warheads are estimated to be in reserve or awaiting dismantlement for a total stockpile of *c*. 11 000 warheads.

Sources: Russian Ministry of Defence press releases; US Department of State, START Treaty Memoranda of Understanding, 1990–July 2009; US Air Force, National Air and Space Intelligence Center (NASIC), *Ballistic and Cruise Missile Threat* (NASIC: Wright-Patterson Air Force Base, OH, June 2009); World News Connection, National Technical Information Service (NTIS), US Department of Commerce, various issues; Russians news media; Russian Strategic Nuclear Forces, <http://www.russianforces.org/>; International Institute for Strategic Studies, *The Military Balance 2010* (Routledge: London, 2010); Cochran, T. B. et al., *Nuclear Weapons Databook*, vol. 4, *Soviet Nuclear Weapons* (Harper & Row: New York, 1989); *Jane's Strategic Weapon Systems*, various issues; *Proceedings*, US Naval Institute, various issues; 'Nuclear notebook', *Bulletin of the Atomic Scientists*, various issues; and authors' estimates.

As of January 2011 Russia had approximately 50 RS-20V Voevoda heavy ICBMs on combat duty.[34] Russia has an ongoing life-extension programme for the missiles and has announced plans to keep them in service until

[34] Norris, R. S. and Kristensen, H. M., 'Nuclear notebook: Russian nuclear forces, 2010', *Bulletin of the Atomic Scientists*, vol. 66, no. 1 (Jan. 2010), p. 76; and Lennox, D. (ed.), *Jane's Strategic Weapon Systems*, no. 53 (IHS Global Limited: Coulsdon, 2010), p. 167. NATO designations are given in table 7.3.

2026.[35] The development of a new heavy ICBM to replace the RS-20V continued to be discussed in Russia in 2010.[36]

Russia has approximately 120 RS-12M Topol ICBMs deployed, a reduction of nearly 30 missiles compared with early 2010.[37] The RS-12M is a three-stage, solid-fuelled, road-mobile ICBM with a single warhead, which entered into service in 1985.[38] The RS-12M system is undergoing a life-extension programme.[39] As part of this programme, there were two successful test launches of the missile in 2010.[40]

The RS-12 Topol-M has been developed in both road-mobile (RS-12M1) and silo-based (RS-12M2) versions.[41] As of January 2011 Russia was believed to have 18 RS-12M1 and 51 RS-12M2 missiles in service.

In 2010 Russia began deploying the RS-24 missile, a modified version of the RS-12M1 which carries three MIRVs.[42] Adding the MIRV capability to the existing single-warhead version of the missile was made possible by the expiry of START in December 2009. As of January 2011 Russia had reportedly deployed six RS-24 missiles.[43]

In November 2010 Russian military officials confirmed that the production of the RS-12M1 would be abandoned in favour of the RS-24, and the commander of the SRF announced that 'the Topol-M mobile missile system will not be supplied to the [SRF] in the future'.[44] However, deployment of the silo-based RS-12M2 appears to continue, with four more missiles planned for 2011 and another four for 2012.[45]

The RS-12M2 missile and the RS-24 missile are expected to become the backbone of the SRF. The SRF stated that by 2016 the Topol-M and RS-24 systems will constitute at least 80 per cent of the ICBM force.[46] To reach this goal, Russia will have to retire many of its RS-20V, RS-18 and RS-12M

[35] [Military council], Echo Moskvy, 18 Dec. 2010, <http://echo.msk.ru/programs/voensovet/734274-echo/>; and 'Russia to keep Satan ballistic missiles in service until 2016', RIA Novosti, 17 Dec. 2010, <http://en.rian.ru/mlitary_news/20101217/161824781.html>.

[36] Isby, D. C., 'No go-ahead yet for Russian heavy ICBM', *Jane's Missiles and Rockets*, vol. 14, no. 12 (Dec. 2010), p. 14; and 'Russia to develop new heavy ICBM by 2020', RIA Novosti, 20 Dec. 2010, <http://en.rian.ru/russia/20101220/161856876.html>.

[37] Norris and Kristensen (note 34), p. 76.

[38] Lennox (note 34), pp. 160–62.

[39] Isby, D. C., 'Mobile Topol-M production ends', *Jane's Missiles and Rockets*, vol. 13, no. 6 (June 2009), p. 6.

[40] 'Russia conducts routine test of Topol ballistic missile', RIA Novosti, 28 Oct. 2010, <http://en.rian.ru/mlitary_news/20101028/161117451.html>; and 'Topol hits target at firing range in Kazakhstan', RIA Novosti, 5 Dec. 2010, <http://en.rian.ru/mlitary_news/20101205/161640678.html>.

[41] Lennox (note 34), pp. 162–63.

[42] Isby, D. C., 'RS-24 makes third successful flight', *Jane's Missiles and Rockets*, vol. 13, no. 1 (Jan. 2009), p. 3; and Petrova, A., [Better missiles, fewer regiments], *Vzglyad*, 17 Dec. 2010, <http://www.vz.ru/society/2010/12/17/455639.html>.

[43] Petrova (note 42).

[44] 'Russia's missile forces to replace Topol-M with multiple-warhead RS-24', RIA Novosti, 30 Nov. 2010, <http://en.rian.ru/mlitary_news/20101130/161558446.html>.

[45] Petrova (note 42).

[46] 'Russia's missile forces to replace Topol-M with multiple-warhead RS-24' (note 44).

missiles as well as increase the production and deployment of RS-24s from the current 6–10 missiles per year to at least 14.

Ballistic missile submarines and sea-launched ballistic missiles

As of January 2011 the Russian Navy operated a total of 11 SSBNs, down from 12 in early 2010 due to the retirement of a Delta III Class (Project 667BDR Kalmar) submarine. Four remaining Delta III submarines, each carrying 16 RSM-50 SLBMs, are deployed with the Pacific Fleet.[47] Six Delta IV Class (Project 667BDRM Delfin) submarines are deployed with the Northern Fleet. Five of these have undergone an overhaul which extended their service life by 10 years and included the installation of the new modification of the RSM-54 Sineva missile. Russia also keeps in service one Project 941 Akula (Typhoon Class) submarine for use as a test platform.[48] In 2010 Russia successfully conducted four underwater test launches of currently deployed types of SLBM: the RSM-50 and RSM-54.[49]

Russia is building three SSBNs of a new class, the Project 955 Borei. The lead boat in the class, the *Yurii Dolgorukii*, conducted a number of successful sea trials in 2010.[50] Russia announced plans to build up to eight SSBNs of this class, each of which are designed to be armed with 16 RSM-56 Bulava missiles.[51]

In 2010 the troubled development of the Bulava, a three-stage, solid-fuelled SLBM, continued to receive attention from the media and senior officials in Russia. Once fitted on the Project 955 SSBNs, the Bulava is supposed to supplement and eventually replace the Delta IV/RSM-54 system. During 2010, Bulava missiles were successfully test-launched on 7 and 29 October.[52] Seven of the previous 12 tests of the Bulava were unsuccessful.[53] This brought the total number of test flights of the Bulava to

[47] 'Nuclear submarine "Zelenograd" will be dismantled', Zelenograd Information Portal, 23 July 2010, <http://www.netall.ru/gnn/130/573/462840.html>.

[48] 'Russia set to keep Typhoon class nuclear subs until 2019—Navy', RIA Novosti, 7 May 2010, <http://en.rian.ru/mlitary_news/20100507/158917310.html>.

[49] 'Russia carries out successful tests of two SLBMs', RIA Novosti, 28 Oct. 2010, <http://en.rian.ru/mlitary_news/20101028/161118380.html>; and Russian Ministry of Defence, Information and Public Relations Service, [Message of the Information and Public Relations Service of the MOD RF], 7 Aug. 2010, <http://www.mil.ru/info/1069/details/index.shtml?id=75168>

[50] Isby, D. C., '*Yuri Dolgoruky* completes more sea trials', *Jane's Missiles and Rockets*, vol. 14, no. 9 (Sep. 2010), p. 5.

[51] [In the framework of the State Armament Program for 2007–2015 it is planned to introduce eight SSBNs of "Borei" class to the Russian Navy], ARMS-TASS, 19 Mar. 2010, <http://armstass.su/?page=article&aid=82203&cid=25>.

[52] 'Russia's Bulava missile hits target in test', RIA Novosti, 7 Oct. 2010, <http://en.rian.ru/russia/20101007/160865732.html>; and 'Russia conducts successful test launch of Bulava ballistic missile', RIA Novosti, 29 Oct. 2010, <http://en.rian.ru/russia/ 20101029/161125380.html>.

[53] 'Bulava missile test history', Russian Strategic Nuclear Forces, 29 Oct. 2010, <http://russianforces.org/navy/slbms/bulava.shtml>; and 'Bulava missile: test-launch history', RIA Novosti, 29 Oct. 2010, <http://en.rian.ru/infographics/20101029/161128116.html>.

14, with an additional 2 pop-up tests (i.e. tests of the mechanism which ejects the missile from the submarine). A test launch from the *Yurii Dolgorukii* scheduled for December 2010 was postponed until mid-2011.[54]

Non-strategic nuclear weapons

The Russian Government indicated in 2010 that it had reduced its inventory of non-strategic (or tactical) nuclear weapons by 75 per cent.[55] This was done pursuant to the implementation of two non-legally binding unilateral initiatives on non-strategic nuclear weapons, undertaken in 1991–92 together with parallel initiatives by the USA.[56] The figure exceeded the 60 per cent reduction declared by a Russian official in 2007, and it may reflect the dismantlement by Russia of additional weapons.[57]

There is considerable uncertainty about the size and location of Russia's non-strategic nuclear inventory, which continues to be characterized by a high degree of secrecy and a lack of transparency. Estimates about the size of the Soviet inventory of non-strategic nuclear weapons in 1991 ranged from approximately 15 000 to 21 700.[58] Using the Russian Government's claim of an approximate 75 per cent reduction since 1991, the number of non-strategic nuclear weapons today would include 3700–5400 warheads. This number roughly fits the '3000–5000 plus' range used during a NATO briefing on the NPR in September 2009.[59]

Yet these warhead numbers are well in excess of the nominal warhead capacity of Russia's remaining nuclear-capable naval, air force and air defence delivery platforms, which is an estimated 2080 warheads. Most of the remaining 1600–3300 non-strategic weapons are probably retired and awaiting dismantlement.

In 2010 new claims and media reports arose concerning alleged Russian deployment of non-strategic nuclear weapons near NATO territory. These were denied by Russian officials.[60]

[54] Grove, T., 'Russia delays Bulava missile test to 2011–agency', Reuters, 15 Dec. 2010, <http://in.reuters.com/article/idINIndia-53585920101215>.

[55] Delegation of the Russian Federation, 'Practical steps of the Russian Federation in the field of nuclear disarmament', Statement, 2010 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons, New York, 3–28 May 2010, p. 8.

[56] Fieldhouse, R., 'Nuclear weapon developments and unilateral reduction initiatives', *SIPRI Yearbook 1992*, pp. 72–73, 89–92.

[57] 'Russia determined to keep tactical nuclear arms for potential aggressors', *Pravda*, 31 Oct. 2007.

[58] For an estimated range see Norris, R. S. and Arkin, W. M., 'Nuclear notebook: estimated Soviet nuclear stockpile (July 1991)', *Bulletin of the Atomic Scientists*, vol. 47, no. 6 (July/Aug. 1991), p. 48; and Arbatov, A., 'Deep cuts and de-alerting: a Russian perspective', ed. H. A. Feiveson, *The Nuclear Turning Point: A Blueprint for Deep Cuts and De-Alerting of Nuclear Weapons* (Brookings Institution Press: Washington, DC, 1999), p. 320.

[59] US Mission to Council of the North Atlantic Treaty Organization (note 21).

[60] Entous, A. and Weisman, J., 'Russian missiles fuel U.S. worries', *Wall Street Journal*, 30 Nov. 2010; 'Lithuania claims Russia deployed warheads near border', Agence France-Presse, 8 Feb. 2011;

IV. British nuclear forces

The United Kingdom's nuclear deterrent consists exclusively of a sea-based component: four Vanguard Class Trident SSBNs, Trident II (D5) SLBMs and associated warheads, and support infrastructure (see table 7.4). The UK leases the SLBMs from the US Navy, under a system of 'mingled asset ownership'. D5 missiles are randomly selected from the stockpile at the US Navy's Trident facility in Kings Bay, Georgia, and loaded onto British submarines. The submarines then go to the Royal Naval Armaments Depot at Coulport, Argyll, where the missiles are fitted with nuclear warheads designed and manufactured at the Atomic Weapons Establishment (AWE), in Aldermaston, Berkshire. The UK possesses an arsenal of about 160 operational nuclear warheads available for use by the Trident SSBNs.[61]

Each Vanguard Class SSBN is equipped with 16 Trident II (D5) missiles, carrying up to 48 warheads in total. It is believed that a number of the D5 missiles are deployed with only one warhead instead of three; this warhead may also have a reduced explosive yield.[62] The flexibility in warhead loadings reflects the decision by the British Ministry of Defence (MOD) in 1998 to give a 'sub-strategic', or limited-strike, role to the Trident fleet aimed at enhancing the credibility of the British deterrent.[63]

In a posture known as Continuous at Sea Deterrence (CASD), one British SSBN is on patrol at all times.[64] The second and third SSBNs can be put to sea rapidly, but there are not enough missiles in the British inventory to simultaneously arm the fourth submarine. Since the end of the cold war, the SSBN on patrol has been kept at a level of reduced readiness with its missiles de-targeted and a 'notice to fire' measured in days.

The Vanguard Class SSBNs will reach the end of their service lives from 2024.[65] The Royal Navy plans to renew the Trident system by replacing the

and [Lithuania calls for limitations of the Russian tactical nuclear weapons near Kaliningrad], *Vzglyad*, 8 Feb. 2011.

[61] British Prime Minister's Office, 'Speech on nuclear energy and proliferation', London, 17 Mar. 2009, <http://www.number10.gov.uk/Page18631>.

[62] Quinlan, M., 'The future of United Kingdom nuclear weapons: shaping the debate', *International Affairs*, vol. 82, no. 4 (July 2006), pp. 627–37; and British House of Commons, Defence Committee, *The Future of the UK's Strategic Nuclear Deterrent: The Strategic Context*, HC 986, 8th report of session 2005–06 (The Stationery Office: Norwich, 20 June 2006), Written evidence, annex A, para. 26; and Bilton, M., 'Dive bombers', *Sunday Times*, 20 Jan. 2008.

[63] British Ministry of Defence, *The Strategic Defence Review*, Cm 3999 (The Stationery Office: Norwich, July 1998), para. 63. An addendum in 2002 extended the role of nuclear weapons to include deterring 'leaders of states of concern and terrorist organisations'. British Ministry of Defence, *The Strategic Defence Review: A New Chapter*, Cm 5566, vol. I (The Stationery Office: Norwich, July 2002), para. 21.

[64] British Ministry of Defence and British Foreign and Commonwealth Office, *The Future of the United Kingdom's Nuclear Deterrent*, Cm 6994 (The Stationery Office: Norwich, Dec. 2006), p. 27.

[65] The lead ship of the class, HMS *Vanguard*, entered service in 1994. The original 25-year service life has been extended to 30 years.

Table 7.4. British nuclear forces, January 2011

Type	Designation	No. deployed	Year first deployed	Range (km)[a]	Warheads x yield	Warheads in stockpile
Submarine-launched ballistic missiles						
D5	Trident II	48	1994	>7 400	1–3 x 100 kilotons	225[b]

[a] Range is for illustrative purposes only; actual mission range will vary according to flight profile and weapon loading.

[b] Fewer than 160 warheads are operationally available, *c*. 144 to arm 48 missiles on 3 of 4 nuclear-powered ballistic missile submarines (SSBNs). Only 1 SSBN is on patrol at any time, with up to 48 warheads. In 2010 it was decided that the number of operational warheads will be reduced to a maximum of 120, of which 40 will be on patrol at any given time.

Sources: British Ministry of Defence, white papers, press releases and website, <http://www.mod.uk/>; British House of Commons, *Parliamentary Debates (Hansard)*, various issues; Norris, R. S. et al., *Nuclear Weapons Databook*, vol. 5, *British, French, and Chinese Nuclear Weapons* (Westview: Boulder, CO, 1994), p. 9; 'Nuclear notebook', *Bulletin of the Atomic Scientists*, various issues; and authors' estimate.

existing submarines with a new class of SSBNs and equipping them with the modified Trident II D5LE SLBM being developed by the USA.

In October 2010 the British MOD released a new Strategic Defence and Security Review, the first since 1997, that affirmed the government's commitment to develop a submarine-based nuclear deterrent based on the current Trident system.[66] As a cost-saving measure, the new submarines will have a smaller missile compartment equipped with 12 launch tubes rather than the 16 carried by the Vanguard Class submarines. Only 8 launch tubes will be operational in normal circumstances. The maximum number of nuclear warheads carried on each submarine will decrease from 48 to 40, a posture that would require deployment of five warheads on each missile.[67]

In announcing the results of the review, the British Prime Minister, David Cameron, said that in light of the current budget crisis the government would delay the 'main gate' decision—on the detailed acquisition plans, design and number of submarines—until 'about 2016', after the next general election.[68] This means that the first of the new generation of SSBNs may not be in operation until 2028 or 2029, four to five years after the first Vanguard submarine is due to be withdrawn, in 2024. The service lives of the Vanguard submarines are to be prolonged in accordance with the government's commitment to reliably sustain the CASD posture. The British Secretary of State for Defence, Liam Fox, estimated the additional cost of maintaining the Vanguard Class submarines until 2028 to be £1.2–1.4 bil-

[66] British Ministry of Defence, *Securing Britain in an Age of Uncertainty: The Strategic Defence and Security Review*, Cm 7948 (The Stationery Office: Norwich, Oct. 2010), para. 3.8, p. 38.

[67] British Ministry of Defence (note 66), para. 3.11, p. 38.

[68] Watt, N., 'David Cameron to delay Trident replacement, *The Guardian*, 19 Oct. 2010.

lion ($1.8–2.1 billion).[69] The Trident replacement programme will cost an estimated £20 billion ($30 billion). It was announced in July 2010 that the programme will be paid for from the MOD's core budget, rather than Treasury reserve funds.[70]

The 2010 Strategic Defence and Security Review revealed that the inventory of operational nuclear warheads will be reduced from about 160 to no more than 120. Likewise, the overall size of the nuclear stockpile, including non-deployed weapons, will decrease from the current 225 warheads to 'not more than 180 by the mid 2020s'.[71] The review indicated that the government would defer a decision about whether to refurbish or replace the nuclear warhead carried on the D5 SLBM until the next parliamentary term; the current warhead could remain in service until at least the late 2030s.[72] The delay will defer an estimated £500 million ($750 million) of spending over the next 10 years. In the meantime, British SLBMs appear to be earmarked to receive the W76-1/Mk-4A, an upgraded version currently in production in the USA to replace the W76/Mk-4 deployed on US SLBMs. The upgraded weapon has increased military capabilities, according to British and US defence officials.[73]

The United Kingdom–France nuclear cooperation agreement

On 2 November 2010 the British Prime Minister, David Cameron, and French President Nicolas Sarkozy signed bilateral treaties on defence and on nuclear cooperation.[74] The nuclear agreement envisioned the establishment of 'joint radiographic/hydrodynamics facilities', one in France and one in the UK, to conduct computer-based testing of nuclear weapon components to ensure their safety and reliability in the absence of explosive testing of nuclear weapons.[75] A nuclear simulation centre will be built in Valduc, France, and start operating from 2014. The Valduc laboratory will be supported by a joint technology development centre at Aldermaston, which will enable French and British scientists to model the performances

[69] British House of Commons, 'Oral answers to questions, defence: Trident replacement', *Hansard*, 8 Nov. 2010, column 1.

[70] Rayment, S., 'Armed forces stunned by Trident bill', *Daily Telegraph*, 31 July 2010.

[71] British Ministry of Defence (note 66), para. 3.8, p. 38; and Norton-Taylor, R., 'Britain's nuclear arsenal is 225 warheads, reveals William Hague', *The Guardian*, 26 May 2010.

[72] British Ministry of Defence (note 66), para. 3.9, p. 39.

[73] Kristensen, H. M., 'British submarines to receive upgraded US nuclear warhead', FAS Strategic Security Blog, Federation of American Scientists, 1 Apr. 2011, <http://www.fas.org/blog/ssp/2011/04/britishw76-1.php>; and Norton-Taylor, R., 'Trident more effective with US arming device, tests suggest', *The Guardian*, 6 Apr. 2011.

[74] UK–France Summit 2010, Declaration on defence and security cooperation, 2 Nov. 2010, <http://www.number10.gov.uk/news/statements-and-articles/2010/11/>.

[75] Treaty between the United Kingdom of Great Britain and Northern Ireland and the French Republic relating to Joint Radiographic/Hydrodynamics Facilities, signed 2 Nov. 2010, Cm 7975 (The Stationery Office: Norwich, 10 Nov. 2010).

Table 7.5. French nuclear forces, January 2011

Type	No. deployed	Year first deployed	Range (km)[a]	Warheads x yield	Warheads in stockpile
Land-based aircraft[b]					
Mirage 2000N	~20	1988	2 750	1 x up to 300 kt TNA	~20
Rafale F3	~20	2010–11	2 000	1 x up to 300 kt TNA	~20
Carrier-based aircraft[b]					
Rafale MK3	~10	2010–11	2 000	1 x up to 300 kt TNA	~10
Submarine-launched ballistic missiles[c]					
M45	32	1996	6 000[d]	4–6 x 100 kt TN-75	160[e]
M51.1	16	2010–11	6 000	4–6 x 100 kt TN-75	80
M51.2	0	(2015)	6 000	4–6 x TNO	0
Total					**~300**[f]

( ) = uncertain figure; kt = kiloton; TNA = Tête Nucléaire Aéroportée (Airborne Nuclear Warhead); TNO = Tête Nucléaire Océanique (Oceanic Nuclear Warhead).

[a] Aircraft range is for illustrative purposes only; actual mission range will vary according to flight profile and weapon loading.

[b] A small number of the previous-generation Air–Sol Moyenne Portée (ASMP, medium-range air-to-surface) missiles may remain in service until completely replaced by the ASMP-A in 2011.

[c] France transitioned to a posture of 4 SSBNs in the mid-1990s, which meant having enough SLBMs to equip 3 operational SSBNs, with the fourth SSBN being overhauled.

[d] The range of the M45 is listed as only 4000 km in a 2001 report from the French National Assembly's National Defence Commission.

[e] The missile upgrade started with the *Le Vigilant* submarine does not affect its warheads, which will be fitted back to the new M51.1 missiles.

[f] France does not have a reserve but may have a small inventory of spare warheads for a total stockpile of *c*. 300 warheads.

Sources: Sarkozy, N., French President, Speech on defence and national security, Porte de Versailles, 17 June 2008, <http://www.elysee.fr/president/les-dossiers/defense/livre-blanc/paris-17-juin-2008/livre-blanc-sur-la-defense-et-la-securite.6651.html>; Sarkozy, N., French President, 'Presentation of SSBM "Le Terrible"', Speech, Cherbourg, 21 Mar. 2008, <https://pastel.diplomatie.gouv.fr/editorial/actual/ael2/bulletin.gb.asp?liste=20080331.gb.html>; French Ministry of Defence, various publications, <http://www.defense.gouv.fr/>; French National Assembly, various defence bills; Norris, R. S. et al., *Nuclear Weapons Databook*, vol. 5, *British, French, and Chinese Nuclear Weapons* (Westview: Boulder, CO, 1994), p. 10; *Air Actualités*, various issues; *Aviation Week & Space Technology*, various issues; 'Nuclear notebook', *Bulletin of the Atomic Scientists*, various issues; and authors' estimates.

of nuclear materials and technologies to ensure the 'viability, safety and security in the long term' of their nuclear weapon arsenals.[76] Officials emphasized that the two countries would continue to maintain independent nuclear deterrent forces under the agreement.

[76] UK–France Summit 2010 (note 74).

V. French nuclear forces

France's nuclear forces consist of aircraft and SSBNs, carrying a total of about 300 warheads (see table 7.5). A 2008 white paper on defence and national security included important clarifications concerning French nuclear forces. France will continue to rely on the 'principle of strict sufficiency' (corresponding to a 'minimum deterrence' policy) as a guarantor of its security and the 'operational credibility' of the French nuclear arsenal, which relies on 'permanent submarine patrols and airborne capability'.[77]

In September 2010 the new Triomphant Class SSBN, *Le Terrible,* entered service, joining a fleet of three previously commissioned SSBNs of the same class—*Le Triomphant*, *Le Téméraire* and *Le Vigilant*.[78] *Le Terrible* is equipped with 16 M51.1 SLBMs. The M51.1 is a three-stage, solid-fuelled missile with an estimated maximum range of 6000–8000 kilometres that can carry up to six TN-75 warheads. Before entering service, *Le Terrible* successfully test-launched the M51.1 SLBM on 27 January and 10 July 2010. The other three Triomphant Class SSBNs will be rearmed with the M51.1 by 2017.[79] The upgrade of *Le Vigilant* began in July 2010.[80] An improved version of the M51.1, the M51.2, is designed to carry the new Tête Nucléaire Océanique (TNO, oceanic nuclear warhead) and will replace the M51.1 after 2015.[81]

By the end of 2010 the aircraft component of the French nuclear forces consisted of two land- and one sea-based nuclear-capable aircraft squadrons, comprised of Mirage and Rafale combat aircraft.[82] The Mirage 2000N aircraft of the 3/4 Limousin Fighter Squadron will be replaced by Rafales in 2018. The aircraft can carry either the Air–Sol Moyenne Portée (ASMP,

[77] French Government, *Défense et sécurité nationale: Le livre blanc* [Defence and national security: the white paper] (Odile Jacob: Paris, June 2008). English translation: French Government, *The French White Paper on Defence and National Security* (Odile Jacob: New York, 2008), pp. 161–63.

[78] French Navy, '*Le Terrible* livré à la marine' [*Le Terrible* delivered to the navy], Press release, 4 Oct. 2010, <http://www.defense.gouv.fr/marine/actu-marine/le-terrible-livre-a-la-marine>.

[79] Richardson, D., 'France tests M51 SLBM under operational conditions', *Jane's Missiles and Rockets*, vol. 14, no. 9 (Sep. 2010), p. 6; and Richardson, D., 'M51 SLBM performs fourth test-flight', *Jane's Missiles and Rockets*, vol. 14, no. 3 (Mar. 2010), p. 3.

[80] French Senate, *Avis présenté au nom de la commission des affaires étrangères, de la défense et des forces armées (1) sur le projet de loi de finances pour 2011*, vol. 5, *Défense: Equipement des forces* [Opinions submitted on behalf of the Committee on Foreign Affairs, Defence and Armed Forces (1) on the finance bill for 2011, vol. 5, Defence: Equipping the forces], no. 112 (French Senate: Paris, 18 Nov. 2010), chapter 1, section II.

[81] Lennox (note 34), p. 47.

[82] French Senate, *Avis présenté au nom de la commission des affaires étrangères, de la défense et des forces armées (1) sur le projet de loi de finances pour 2010*, vol. 5, *Défense: Equipement des forces* [Opinions submitted on behalf of the Committee on Foreign Affairs, Defence and Armed Forces (1) on the finance bill for 2010, vol. 5, Defence: Equipping the forces], no. 102 (French Senate: Paris, 19 Nov. 2009), chapter 2, section I.C; French Senate (note 80); and French Air Force, 'Mise en service opérationelle: Rafale/ASMP-A' [Operational implementation: Rafale/ASMP-A], Press release, 13 July 2010, <http://www.defense.gouv.fr/air/actus-air/rafale-asmp-a>.

medium-range air-to-surface) or the ASMP-Améliorée (ASMP-A) missile. A total of 90 ASMP missiles were produced, along with 80 TN-81 300-kt warheads for them. The follow-on cruise missile ASMP-A is currently being introduced to all three squadrons. The ASMP-A missiles carry the Tête Nucléaire Aeroportée (TNA, airborne nuclear warhead), which is a new thermonuclear warhead that is reported to have a selectable yield of 20 kt, 90 kt and 300 kt.[83] The delivery of the remaining ASMP-A missiles and the retirement of the ASMP will be completed in 2011.[84]

France remains committed to sustaining its nuclear weapon complex, including research and development capabilities. In 2010 it signed an agreement with the UK for technical cooperation and the exchange of classified information in the areas of nuclear weapon safety and security and stockpile certification (see section IV above).

VI. Chinese nuclear forces

China is estimated to have an arsenal of approximately 200 nuclear weapons earmarked for delivery mainly by ballistic missiles and aircraft (see table 7.6). Additional warheads may be in reserve, giving a total stockpile of about 240.

There are no credible reports indicating that the size of the Chinese nuclear weapon stockpile has changed significantly in recent years. However, China has been increasing the number of medium- and long-range missile-delivery systems as part of a long-term modernization programme aimed at developing a more survivable force and more flexible nuclear retaliatory options. According to a 2009 report by the US Air Force, China has 'the most active and diverse ballistic missile development program in the world' and its 'ballistic missile force is expanding in both size and types of missiles'.[85]

In March 2011 the Chinese Government released the latest of its biennial defence white papers.[86] The new document reiterated China's commitment to the policy of no-first-use of nuclear weapons and its intention to limit its nuclear capabilities to the minimum level required for national security. However, the white paper did not provide information about the capabilities and operational status of the country's nuclear forces. The 2008 white paper had described how China's nuclear forces would grad-

[83] Lennox (note 34), p. 44.
[84] French Senate (note 80), chapter 2, section I.C.
[85] US Air Force, National Air and Space Intelligence Center (NASIC), *Ballistic and Cruise Missile Threat* (NASIC: Wright–Patterson Air Force Base, OH, Mar. 2009), p. 3.
[86] Chinese State Council, *China's National Defense in 2010* (Information Office of the Chinese State Council: Beijing, Mar. 2011).

ually be brought to increased levels of alert during a crisis to deter an adversary and prepare for a retaliatory nuclear attack.[87]

China's land-based ballistic missiles are operated by the People's Liberation Army (PLA) Second Artillery. According to the data published annually by the US DOD, in 2010 China's nuclear-capable missile arsenal consisted of the ageing liquid-fuelled DF-3A (Dong Feng, or East Wind) intermediate-range ballistic missile and the more modern road-mobile, solid-fuelled DF-21 medium-range ballistic missile, which was assigned 'regional deterrence missions'.[88] In addition, China had two older types of ICBM: the silo-based, liquid-fuelled DF-5A missile and the smaller, liquid-fuelled DF-4. The Second Artillery is deploying modern mobile ICBM systems that are intended to enhance the survivability of the Chinese missile force by enabling the weapons to operate over a larger area.[89] This includes the DF-31, a road-mobile, solid-fuelled missile that was first deployed in 2006, as well as a longer-range (in excess of 11 200 km) variant, the DF-31A.

China has had difficulty in developing a sea-based nuclear deterrent. It built a single Type 092 (Xia Class) SSBN armed with 12 intermediate-range solid-fuel, single-warhead JL-1 (Ju Long, or Great Wave) SLBMs. The submarine has never conducted a deterrent patrol and is not thought to be fully operational. China is currently building and deploying the Type 094 (Jin Class) SSBN. As of 2010, three submarines were reportedly either in service or in various stages of construction and outfitting. The US DOD estimated that China may eventfully deploy 'up to five' Type 094 SSBNs.[90] There have been reports indicating that one of the submarines had been deployed to a new base near Yulin, Hainan, on the South China Sea.[91]

Each Jin Class SSBN will carry 12 three-stage, solid-fuelled SLBMs, the JL-2, which is a sea-based variant of the DF-31 ICBM. The JL-2 has an estimated range of 7200 km. The missile is believed to be armed with a single nuclear warhead.[92] According to the US DOD, the JL-2 has encountered technical difficulties, 'failing several of what should have been the final

[87] Chinese State Council, *China's National Defense in 2008* (Information Office of the Chinese State Council: Beijing, Jan. 2009); and Kristensen, H. K., 'China Defense White Paper describes nuclear escalation', FAS Strategic Security Blog, Federation of American Sciences, 23 Jan. 2009, <http://www.fas.org/blog/ssp/2009/01/chinapaper.php>.

[88] US Department of Defense (DOD), *Military and Security Developments Involving the People's Republic of China 2010*, Annual Report to Congress (DOD: Washington, DC, Mar. 2010), p. 66. Although China has its own system for defining missile ranges (see table 7.6), the US DOD definitions are used here: short range = <1100 km; medium range = 1100–2750 km; intermediate range = 2750–5500 km; and intercontinental range = >5500 km.

[89] US Department of Defense (note 88), p. 34.

[90] US Department of Defense (note 88), pp. 2–3.

[91] Kristensen, H. M., 'New Chinese SSBN deploys to Hainan Island', 24 Apr. 2008, FAS Strategic Security Blog, Federation of American Sciences, <http://www.fas.org/blog/ssp/2008/04/new-chinese-ssbn-deploys-to-hainan-island-naval-base.php>.

[92] US Department of Defense (note 88), p. 34.

Table 7.6. Chinese nuclear forces, January 2011

Type/Chinese designation (US designation)	No. deployed	Year first deployed	Range (km)[a]	Warhead loading	No. of warheads
Land-based missiles[b]	*~130*				*~130*
DF-3A (CSS-2)	~12	1971	3 100[c]	1 x 3.3 Mt	~12
DF-4 (CSS-3)	~12	1980	5 500	1 x 3.3 Mt	~12
DF-5A (CSS-4)	20	1981	13 000	1 x 4–5 Mt	20
DF-21 (CSS-5)	60	1991	2 100[d]	1 x 200–300 kt	60
DF-31 (CSS-10 Mod 1)	<10	2006	>7 200	1 x . .	<10
DF-31A (CSS-10 Mod 2)	<15	2007	>11 200	1 x . .	<15
SLBMs	*(36)*				*(36)*
JL-1 (CSS-N-3)	(12)	1986	>1 770	1 x 200–300 kt	(12)
JL-2 (CSS-NX-14)	(24)	(2011)	>7 200	1 x . .	(24)
Aircraft[e]	*>20*				*(40)*
H-6 (B-6)	20	1965	3 100	1 x bomb	(20)
Attack (. .)	. .	1972–. .	. .	1 x bomb	(20)
Cruise missiles	*150–350*				. .
DH-10	150–350	2007	>1 500	1 x . .	. .[f]
Total					**(~240)**[g]

. . = not available or not applicable; ( ) = uncertain figure; kt = kiloton; Mt = Megaton; SLBM = submarine-launched ballistic missile.

[a] Aircraft range is for illustrative purposes only; actual mission range will vary.

[b] China defines missile ranges as short-range, <1000 km; medium-range, 1000–3000 km; long-range, 3000–8000 km; and intercontinental range, >8000 km.

[c] The range of the DF-3A may be greater than is normally reported.

[d] The DF-21A (CSS-5 Mod 2) variant is believed to have a range of up to 2500 km.

[e] Figures for aircraft are for nuclear-configured versions only.

[f] It is unclear if the DH-10 has nuclear capability, but US Air Force intelligence lists the weapon as 'conventional or nuclear', the same as for the Russian nuclear-capable AS-4.

[g] Additional warheads are thought to be in storage to arm future DF-31, DF-31A and JL-2 missiles. The total stockpile is believed to comprise *c.* 240 warheads.

Sources: US Department of Defense, *Military Power of the People's Republic of China*, various years; US Air Force, National Air and Space Intelligence Center (NASIC), various documents; US Central Intelligence Agency, various documents; Kristensen, H. M., Norris, R. S. and McKinzie, M. G., *Chinese Nuclear Forces and U.S. Nuclear War Planning* (Federation of American Scientists/Natural Resources Defense Council: Washington, DC, Nov. 2006); Norris, R. S. et al., *Nuclear Weapons Databook*, vol. 5, *British, French, and Chinese Nuclear Weapons* (Westview: Boulder, CO, 1994); 'Nuclear notebook', *Bulletin of the Atomic Scientists*, various issues; Google Earth; and authors' estimates.

round of flight tests', and it was unclear when the system would become operational.[93]

[93] US Department of Defense (note 88), p. 34; and [Chinese underwater test-launched missile smashes into its own submarine], *Liberty Times* (Taiwan), 25 Jan. 2010, <http://www.libertytimes.com.tw/2010/new/jan/25/today-p8.htm>.

It is thought that China has a small stockpile of nuclear bombs for delivery by aircraft. Although the PLA Air Force is not believed to have units whose primary purpose is to deliver the bombs, a declassified 1993 US report assesses that 'some units may be tasked for nuclear delivery as a contingency mission'.[94] The most likely aircraft for nuclear missions is the ageing H-6 bomber and possibly a more modern fighter-bomber. China is also developing an air-launched version of a ground-launched land-attack cruise missile, the DH-10 (also designated CJ-10) that may be for delivery by the H-6 aircraft. The US Air Force describes the capability of the DH-10 as 'conventional or nuclear', the same designation used for other dual-capable cruise missiles.[95] However, it is uncertain whether China has assigned a nuclear role to air- or ground-launched cruise missiles.

VII. Indian nuclear forces

It is estimated that India has an arsenal of 80–100 nuclear weapons. This estimate is based on calculations of India's inventory of weapon-grade plutonium as well as the number of operational nuclear-capable delivery systems.

India's nuclear weapons are believed to be plutonium-based. As of 2010 India's weapon-grade plutonium stockpile was estimated to be between 0.36 and 0.64 tonnes.[96] The plutonium was produced by the 50-year old 40-megawatt-thermal (MW(t)) plutonium-production reactor (CIRUS) near Mumbai, which shut down at the end of 2010, and the 25-year old 100-MW(t) Dhruva reactor. Dhruva is capable of producing an estimated 11–18 kilogram weapon-grade plutonium per year, sufficient for 2–6 bombs, depending on weapon design and fabrication skills.[97] India appears to be basing its future weapon plutonium needs on production in fast breeder reactors. A 1250-MW(t) prototype fast breeder reactor is nearing completion at Kalpakkam, which also houses a reprocessing facility that is not subject to International Atomic Energy Agency (IAEA) safeguards. The reactor has recently experienced delays, but at 75 per cent operating capacity it could potentially produce around 140 kg of weapon-grade plutonium per year, or enough for 28–35 weapons.[98]

[94] US National Security Council, 'Report to Congress on status of China, India and Pakistan nuclear and ballistic missile programs', [28 July 1993], obtained under the US Freedom of Information Act by the Federation of American Scientists, <http://fas.org/irp/threat/930728-wmd.htm>.

[95] US Air Force (note 85), p. 29.

[96] See appendix 7A, table 7A.2.

[97] International Panel on Fissile Material (IPFM), *Global Fissile Material Report 2010: Balancing the Books—Production and Stocks* (IPFM: Princeton, NJ, Dec. 2010), p. 100.

[98] Cochran, T., et al., *Fast Breeder Reactor Programs: History and Status* (International Panel on Fissile Material: Princeton, NJ, Feb. 2010), pp. 41, 45.

Table 7.7. Indian nuclear forces, January 2011

Type	Range (km)[a]	Payload (kg)	Status
Aircraft			
Mirage 2000H Vajra	1 850	6 300	Has reportedly been certified for delivery of nuclear gravity bombs
Jaguar IS Shamsher	1 400	4 760	Some of 4 squadrons may have a nuclear delivery role
Land-based ballistic missiles[b]			
Prithvi I (P-I)	150	800	Entered service in 1994; widely believed to have a nuclear delivery role; fewer than 50 launchers deployed; most recent test flight on 15 Apr. 2009
Agni I[c]	>700	1 000	Most recent Indian Army operational test on 25 Nov. 2010; deployed with the Indian Army's 334 Missile Group
Agni II	>2 000	1 000	Most recent Indian Army operational launch 17 May 2010; possibly operational soon
Agni II Prime	>2 500	1 000	Launch on 10 Dec. 2010 failed; status unknown
Agni III	>3 000	1 500	Under development; test-launched 3 times, most recently on 7 Feb. 2010; induction possibly in 2011
Agni IV	~5 000	. .	Under development; test launch possible in 2011
Sea-based ballistic missiles			
Dhanush	350	500	Test-launched on 11 Mar. 2011; induction under way
K-15[d]	700	500–600	Under development; test-launched from a submerged pontoon on 26 Feb. 2008; will probably test-launch from the INS *Arihant* in 2012

. . = not available or not applicable.

[a] Aircraft range is for illustrative purposes only; actual mission range will vary according to flight profile and weapon loading. Missile payloads may have to be reduced in order to achieve maximum range.

[b] India has also begun developing a subsonic cruise missile with a range of 1000 km, known as the Nirbhay (Fearless), which may have a nuclear capability.

[c] The original Agni I, now known as the Agni, was a technology demonstrator programme that ended in 1996. The Indian Ministry of Defence refers to Agni I as A1.

[d] The K-15 is possibly the same missile as the Sagarika described by US intelligence. According to unconfirmed Indian media reports, a land-based version of the K-15, known as the Shourya, was test-launched for the first time on 12 Nov. 2008.

Sources: Indian Ministry of Defence, annual reports and press releases; International Institute for Strategic Studies, *The Military Balance 2010* (Routledge: London, 2010); US Air Force, National Air and Space Intelligence Center (NASIC), *Ballistic and Cruise Missile Threat* (NASIC: Wright-Patterson Air Force Base, OH, June 2009); Indian news media reports; 'Nuclear notebook', *Bulletin of the Atomic Scientists*, various issues; and authors' estimates.

In addition, India has an estimated stockpile of about 1.0–1.6 tonnes of uranium enriched to 93 per cent uranium-235.[99] The enrichment is taking place at the uranium centrifuge facility at Rattehalli Rare Materials Plant to produce HEU for use as naval reactor fuel.[100]

Indian warheads are not thought to be routinely mated with their delivery systems but rather are kept separate in storage facilities.[101]

Strike aircraft

Aircraft constitute the most mature component of India's nuclear strike capabilities (see table 7.7). The Indian Air Force (IAF) has reportedly certified the Mirage 2000H Vajra multi-role aircraft for delivery of nuclear gravity bombs. In addition, it is believed that some of the IAF's four squadrons of Jaguar IS Shamsher combat aircraft may have a nuclear delivery role.[102]

Land-based missiles

India's land-based missile arsenal consists of the Prithvi and the Agni series. The Prithvi I (SS-150) is a single-stage, liquid-fuelled, road-mobile short-range ballistic missile (SRBM) that can carry a 1000-kg warhead to a maximum range of 150 km. It is widely believed that a number of Prithvi I missiles have been modified for nuclear roles. The Prithvi I was first tested in 1988 and was inducted into service in 1994.[103] The Prithvi II and the Prithvi III SRBMs are variants of the Prithvi I, but they are not believed to have nuclear delivery roles.

In recent years, the Prithvi's nuclear role has been largely taken over by the Agni series. The Agni was developed by India's Defence Research and Development Organisation (DRDO) as a part of its problem-plagued integrated guided missile development programme.[104] The Agni I is a single-stage, solid-fuelled missile that is capable of delivering a 1000-kg warhead to a maximum distance of approximately 700–800 km. The Indian Army successfully test-launched an Agni I missile on 25 November 2010.[105] The Agni II is a two-stage, solid-fuelled missile that can deliver a similar pay-

[99] See appendix 7A, table 7A.1.

[100] International Panel on Fissile Material (note 97), pp. 123–24. See also appendix 7A, table 7A.3.

[101] Norris, R. S. and Kristensen, H. M., 'Indian nuclear forces, 2010', *Bulletin of the Atomic Scientists*, vol. 66, no. 5 (Sep./Oct. 2010), pp. 76–81.

[102] Naik, P. V., 'IAF aiming for diverse capabilities, says vice chief of air staff, Air Marshall V. P. Naik in his keynote address on fighter technology and advance systems', *India Strategic*, Oct. 2008.

[103] Mian, Z., Nayyar, A. H. and Ramana, M. V., 'Bringing Prithvi down to earth: the capabilities and potential effectiveness of India's Prithvi missile', *Science and Global Security*, vol. 7, no. 3 (1998).

[104] Verma, B., 'How DRDO failed India's military', Rediff, 15 Jan. 2008, <http://www.rediff.com/news/2008/jan/15guest.htm>.

[105] Rout, H. K., 'India test-fires nuclear-capable Agni-I missile', *Times of India*, 25 Nov. 2010.

load to a maximum range of 2000 km. The DRDO has been developing a variant of the Agni II, known as the Agni II Prime (sometimes called Plus), which has an extended range of 2500 km and incorporates several technological advances, including improved propulsion and stage-separation systems. The missile's inaugural flight test, on 10 December 2010, was unsuccessful.[106] In addition, the DRDO continues to develop the Agni III, a two-stage, solid-fuelled missile capable of delivering a 1500-kg payload to a range of 3000–3500 km. The Agni III was successfully flight-tested for the third time on 7 February 2010, after which DRDO officials declared that the missile was ready for induction into service.[107]

Sea-based missiles

The DRDO has tested components of an underwater missile launch system and is developing a two-stage ballistic missile that can be launched from a submerged submarine using a gas-charged booster.[108] Indian MOD statements have designated the missile as the K-15, although other sources have referred to it as the Sagarika (Oceanic) project.[109] The new nuclear-capable missile will be able to deliver a 500-kg payload to a distance of up to 700 km. The DRDO is reportedly developing a larger SLBM, known as the K-4, which may have a range of up to 3500 km.[110] Both missiles are expected to be eventually deployed on an indigenously constructed SSBN that is the product of India's long-running Advanced Technology Vessel (ATV) programme. The first of the submarines, the INS *Arihant*, was launched in 2009 and may enter service by 2012.[111]

India also continues to work on the Dhanush missile, a naval version of the Prithvi II, which is launched from a stabilization platform mounted on surface ships. It can reportedly carry a 500-kg warhead to a maximum range of 350 km and is designed to be able to hit both sea- and shore-based targets.

VIII. Pakistani nuclear forces

Pakistan is estimated to possess 90–110 nuclear weapons that can be delivered by aircraft and missiles (see table 7.8). This represents an increase

[106] Subramanian, T. S. and Mallikarjun, Y., 'Agni-II prime launch fails', *The Hindu*, 11 Dec. 2010.

[107] 'Nuclear-capable Agni-III missile test-fired', *Times of India*, 7 Feb. 2010; and 'Agni 3 clears test, all set to be inducted into the armed forces', *Indian Express*, 8 Feb. 2010.

[108] Subramanian, T. S., 'DRDO plans another K-15 missile launch', *The Hindu*, 28 Jan. 2011.

[109] In 2006 the Indian MOD stated that 'There is no missile project by name "Sagarika"'. Indian Ministry of Defence, 'Development and trials missiles', Press release, 2 Aug. 2006, <http://pib.nic.in/release/rel_print_page1.asp?relid=19395>.

[110] Unnithan, S., 'The secret "K" missile family', *India Today*, 20 Nov. 2010.

[111] Pandit, R., 'In a year India will have nuclear triad: Navy chief', *Times of India*, 3 Dec. 2010.

over the figure presented in *SIPRI Yearbook 2010* and reflects a revised estimate of Pakistan's military plutonium production capabilities and delivery platforms.

Pakistan's current nuclear arsenal is believed to use HEU, but there is evidence that Pakistan is moving towards an arsenal based on plutonium. Warheads using plutonium could be lighter and more compact than those using HEU to achieve the same yield. Such warheads could either be fitted onto smaller missiles, possibly including cruise missiles, or would give already deployed ballistic missiles longer ranges.

As of 2010 Pakistan was estimated to have a stockpile of 2.2–3.0 tonnes of 90 per cent HEU, and is currently producing 120–180 kg HEU each year, enough for 10–15 warheads. The enrichment is believed to be taking place at the uranium centrifuge facilities at Kahuta and Gadwal. As of 2010 Pakistan had accumulated an estimated inventory of 80–120 kg of separated weapon-grade plutonium.[112] Pakistan is expanding its plutonium-production capabilities at the nuclear complex at Khushab, Punjab. Its first plutonium production reactor, the 40–50 MW(t) Khushab-I, produces 5.7–11.5 kg of plutonium annually, depending on operational efficiency, enough for 1–3 nuclear weapons, depending on weapon design and fabrication skills.[113] A second plutonium production reactor, Kushab-II, appears to have a similar design and power. It may have started operation in late 2009 or 2010.[114] The first weapon-grade plutonium from Khushab-II could become available in 2011. Construction work on a third reactor at the Khushab site began in 2006, and satellite imagery indicates that work on a fourth reactor has also started.[115] Rumours of possible Chinese assistance in building the fourth reactor appear to have been unfounded.[116] When the two new reactors become fully operational, Pakistan's annual weapon-grade plutonium-production capacity could eventually double. Combined with the annual HEU production, this could potentially boost Pakistan's annual production of fissile material to the equivalent of 13–27 bombs per year. This will depend, however, on the country having sufficient capacity to reprocess spent fuel.[117]

[112] See appendix 7A, tables 7A.1–7A.3.

[113] International Panel on Fissile Material (note 97), p. 132.

[114] Brannan, P., 'Steam emitted from second Khushab reactor cooling towers; Pakistan may have started operating second reactor', Institute for Science and International Security (ISIS) Report, 24 Mar. 2010, <http://isis-online.org/isis-reports/category/pakistan/>.

[115] Albright, D. and Brannan, P., 'Pakistan appears to be building a fourth military reactor at the Khushab nuclear site', Institute for Science and International Security (ISIS) Report, 11 Feb 2011, <http://isis-online.org/isis-reports/category/pakistan/>.

[116] Hibbs, M., 'Chinese help on Khushab-4?', Arms Control Wonk, 22 Feb. 2011, <http://hibbs.armscontrolwonk.com/archive/162/chinese-help-on-khushab>.

[117] Albright, D. and Brannan, P., 'Commercial satellite imagery suggests Pakistan is building a second much larger plutonium production reactor: is South Asia headed for a dramatic buildup in nuclear arsenals?', Institute for Science and International Security (ISIS) Report, 24 July 2006, <http://isis-online.org/isis-reports/category/pakistan/>.

Table 7.8. Pakistani nuclear forces, January 2011

Type	Range (km)[a]	Payload (kg)	Status
Aircraft			
F-16A/B	1 600	4 500	32 aircraft, deployed in 3 squadrons; most likely aircraft to have a nuclear delivery role
Land-based ballistic missiles			
Ghaznavi (Hatf-3)	~400	500	Entered service with the Pakistani Army in 2004; fewer than 50 launchers deployed; most recent test launch on 8 May 2010; believed to be a copy of the M-11 missile acquired from China in the 1990s
Shaheen I (Hatf-4)	>450[b]	750–1 000	Entered service with the Pakistani Army in 2003; fewer than 50 launchers deployed; most recent test launch on 8 May 2010
Shaheen II (Hatf-6)	2 500	(~1 000)	First 2 army operational readiness launches on 19 and 21 Apr. 2008; expected to become operational soon
Ghauri I (Hatf-5)	>1 200	700–1 000	Entered service with the Pakistani Army in 2003; fewer than 50 launchers deployed; last test-launched on 20 Dec. 2010
Cruise missiles			
Babur (Hatf-7)	600–700[c]	. .	Under development; test-launched on 10 Feb. 2011; sea- and air-launched versions also under development
Ra'ad (Hatf-8)	350	. .	Under development; air-launched; first 2 test launches on 25 Aug. 2007 and on 8 May 2008

. . = not available or not applicable; ( ) = uncertain figure.

[a] Aircraft range is for illustrative purposes only; actual mission range will vary according to flight profile and weapon loading. Missile payloads may have to be reduced in order to achieve maximum range.

[b] Some Pakistani sources state that the Shaheen I has a range exceeding 600 km.

[c] Since 2006 the range of flight tests has increased from 500 km and the goal is now 1000 km.

Sources: US Air Force, National Air and Space Intelligence Center (NASIC), *Ballistic and Cruise Missile Threat* (NASIC: Wright-Patterson Air Force Base, OH, June 2009); US Central Intelligence Agency, 'Unclassified report to Congress on the acquisition of technology relating to weapons of mass destruction and advanced conventional munitions, 1 January through 30 June 2002', Apr. 2003, <https://www.cia.gov/library/reports/archived-reports-1/>; US National Intelligence Council, 'Foreign missile developments and the ballistic missile threat through 2015' (unclassified summary), Dec. 2001, <http://www.dni.gov/nic/special_missile threat2001.html>; International Institute for Strategic Studies, *The Military Balance 2006–2007* (Routledge: London, 2007); 'Nuclear notebook', *Bulletin of the Atomic Scientists*, various issues; and authors' estimates.

Strike aircraft

In its nuclear weapon delivery role, the Pakistani Air Force (PAF) is most likely to use the US-produced F-16 combat aircraft. The PAF also operates approximately 156 Mirage III and Mirage V aircraft, of which the latter might also have a nuclear role.

Pakistan is developing an air-launched cruise missile, known as the Ra'ad (Hatf-8), which will have a range of 350 km. The Ra'ad was test-launched in August 2007 and May 2008 from a Mirage III aircraft.[118] The missile is believed to be nuclear capable.

Land-based missiles

Pakistan has two land-based, short-range ballistic missiles that are believed to have nuclear delivery roles. The Ghaznavi (Hatf-3) is a single-stage, solid-fuelled, road-mobile missile which was inducted into service in 2004. The Shaheen (Hatf-4) is a solid-fuelled missile that entered into service in 2003. The two missiles were most recently test-launched on 8 May 2010.[119]

The Ghauri I (Hatf-5) is Pakistan's only medium-range ballistic missile. It is a single-stage, liquid-fuelled, road-mobile missile with a range exceeding 1200 km. A Ghauri I missile was successfully tested by the Army Strategic Force Command's strategic missile group on 20 December 2010.[120] The Shaheen II (Hatf-6) is a two-stage, solid-fuelled, road-mobile missile with a range of 2500 km. It has been under development for more than a decade and may soon become operational.

Pakistan is continuing to develop the Babur (Hatf-7) ground-launched cruise missile. On 10 February 2011 it conducted the latest in a series of a flight tests of the nuclear-capable cruise missile.[121] Pakistan plans to develop air- and sea-launched versions.

IX. Israeli nuclear forces

Israel continues to maintain its long-standing policy of nuclear opacity: it neither officially confirms nor denies that it possesses nuclear weapons.[122]

[118] Khan, I. A., 'Cruise missile fired from aerial platform', *Dawn*, 9 May 2008.

[119] Pakistani Inter Services Public Relations, Press Release no. PR186/2010-ISPR, 8 May 2010, <http://www.ispr.gov.pk/front/main.asp?o=t-press_release&date=2010/5/8>.

[120] Agence France-Presse, 'Pakistan successfully test fires Hatf-V missile: ISPR', *Dawn*, 20 Dec. 2010.

[121] According to an official press release, the Babur cruise missile has a range of 600 km. Pakistani Inter Services Public Relations, Press Release no. PR40/2011-ISPR, 10 Feb. 2011, <http://www.ispr.gov.pk/front/main.asp?o=t-press_release&id=1666>.

[122] On the role of this policy in Israel's national security decision making see 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).

Table 7.9. Israeli nuclear forces, January 2011

Type	Range (km)[a]	Payload (kg)	Status
Aircraft[b]			
F-16A/B/C/D/I Falcon	1 600	5 400	205 aircraft in the inventory; some are believed to be certified for nuclear weapon delivery
Ballistic missiles[c]			
Jericho II	1 500–1 800	750–1 000	*c.* 50 missiles; first deployed in 1990; test-launched on 27 June 2001
Jericho III	>4 000	1 000–1 300	Test-launched on 17 Jan. 2008; status unknown

[a] Aircraft range is for illustrative purposes only; actual mission range will vary. Missile payloads may have to be reduced in order to achieve maximum range.

[b] Some of Israel's 25 F-15I aircraft may also have a long-range nuclear delivery role.

[c] The Shavit space launch vehicle, if converted to a ballistic missile, could deliver a 775-kg payload to a distance of 4000 km.

Sources: Cohen, A., *The Worst-Kept Secret: Israel's Bargain with the Bomb* (Columbia University Press: New York, 2010); Cohen, A. and Burr, W., 'Israel crosses the threshold', *Bulletin of the Atomic Scientists*, vol. 62, no. 3 (May/June 2006); Cohen, A., *Israel and the Bomb* (Columbia University Press: New York, 1998); Albright, D., Berkhout, F. and Walker, W., SIPRI, *Plutonium and Highly Enriched Uranium 1996: World Inventories, Capabilities and Policies* (Oxford University Press: Oxford, 1997); *Jane's Strategic Weapon Systems*, various issues; Fetter, S., 'Israeli ballistic missile capabilities', *Physics and Society*, vol. 19, no. 3 (July 1990)—for an updated analysis, see unpublished 'A ballistic missile primer', <http://www.publicpolicy.umd.edu/Fetter/Publications>; 'Nuclear notebook', *Bulletin of the Atomic Scientists*, various issues; and authors' estimates.

In May 2010 a British newspaper published what it claimed were secret South African documents from the 1970s that purportedly revealed an Israeli offer to sell nuclear weapons to the South African Government.[123] Israeli officials denied that such an offer had ever been made.

The size of the Israeli nuclear weapon stockpile is unknown, but Israel is widely believed to have produced enough plutonium for 100–200 warheads. According to one estimate, Israel possessed 0.8 tonnes of weapon-grade plutonium as of 2010.[124] Only part of this plutonium may have been used to produce weapons. It is estimated here that Israel has approximately 80 intact nuclear weapons, of which 50 are warheads for delivery by ballistic missiles and the rest are bombs for delivery by aircraft (see table 7.9). In 2010 there continued to be media speculation that Israel may have developed a nuclear-capable SLCM, based on the US-made Harpoon mis-

[123] McGreal, C., 'Revealed: how Israel offered to sell South Africa nuclear weapons', *The Guardian*, 24 May 2010.

[124] See appendix 7A, table 7A.2.

sile, for its fleet of three Type 800 Dolphin Class diesel-electric submarines purchased from Germany.[125] Israel has denied these reports.[126]

X. North Korea's military nuclear capabilities

North Korea demonstrated a military nuclear capability by carrying out underground nuclear test explosions in October 2006 (with an estimated yield of less than 1 kt) and May 2009 (with an estimated yield of about 2–3 kt).[127] In both tests the estimated yield of the explosions was much lower than the yields of the initial nuclear tests conducted by other states. The US intelligence community called the 2006 test a failure and considered that the 2009 test 'was apparently more successful than the 2006 test'.[128] It also assessed that North Korea had the capability to produce nuclear weapons, although it was unclear whether it had done so.[129] There has been considerable speculation that North Korea may have obtained weapon design assistance from abroad.[130]

As of December 2010 North Korea was estimated to have produced and separated 24–42 kg of plutonium. This would be sufficient to build up to eight nuclear weapons, assuming that each weapon used 5 kg of plutonium.[131] The amount of plutonium that North Korea has separated from the spent fuel of its 5-megawatt electric graphite-moderated research reactor at Yongbyon, North Pyongan, and hence the number of warheads it may have produced, has been the subject of debate. North Korea announced in 2009 that it had resumed the reprocessing of the remaining fuel rods from the Yongbyon reactor.[132] In 2010 commercial satellite imagery showed new

[125] Williams, D., 'Admiral stirs question on Israel's "nuclear" subs', Reuters, 22 Sep. 2010; and Mahnaimi, U., 'Israel stations nuclear missile subs off Iran', *The Times*, 30 May 2010.

[126] Ben-David, A., 'Israel orders two more Dolphin subs', *Jane's Defense Weekly*, 30 Aug. 2006, p. 5; and Williams, D., 'Israeli sub sails Suez, signalling reach to Iran', Reuters, 3 July 2009.

[127] Clapper, J. R., Director of US National Intelligence, 'US intelligence community worldwide threat assessment', Statement for the record, US Senate, Select Committee on Intelligence, 16 Feb. 2011, <http://dni.gov/testimonies.htm>, p. 6. See also Fedchenko, V., 'North Korea's nuclear test explosion, 2009', SIPRI Fact Sheet, Dec. 2009, <http://books.sipri.org/product_info?c_product_id=397>; and Fedchenko, V., 'Nuclear explosions, 1945–2009', *SIPRI Yearbook 2010*, pp. 371–73.

[128] Blair, D. C., Director of US National Intelligence, 'US intelligence community annual threat assessment', Statement for the record, US House of Representatives, Permanent Select Committee on Intelligence, 3 Feb. 2010, <http://dni.gov/testimonies_2010.htm>, p. 14.

[129] Clapper (note 127). Doubt remains among non-governmental analysts about whether North Korea has the design and engineering skills needed to manufacture a fully functional nuclear weapon that could be used in an operational military capacity.

[130] Li, B., 'An alternative view to North Korea's bomb acquisition', *Bulletin of the Atomic Scientists*, vol. 66, no. 3 (May/June 2010), p. 38; and Pollack, J., 'North Korea's indigenous bomb design', Arms Control Wonk, 6 May 2010, <http://pollack.armscontrolwonk.com/archive/2718/north-koreas-indigenous-bomb-design>.

[131] Some reports suggested that North Korea may have used a smaller amount of plutonium in its weapon design. See 'N. Korea plutonium figures vary', *Chosun Ilbo*, 30 June 2008; and Fifield, A., 'Defector says North Korea "has one-tonne nuclear bomb"', *Financial Times*, 20 July 2005.

[132] Korea Central News Agency, 'Foreign Ministry spokesman on reprocessing of spent fuel rods', 25 Apr. 2009, <http://www.kcna.co.jp/item/2009/200904/news25/20090425-20ee.html>.

construction and excavation activity at the Yongbyon site, although the purpose of the activity was unclear.[133]

North Korea has long been suspected by the USA of pursuing an undeclared uranium enrichment programme aimed at producing HEU for use in nuclear weapons. In 2009 North Korea issued a number of statements acknowledging that it had an enrichment programme under way for producing fuel for future nuclear power reactors.[134] James R. Clapper, the Director of US National Intelligence, reiterated in February 2011 that North Korea 'has pursued a uranium enrichment activity in the past, which we assess was for weapons'.[135] In November 2010 North Korea showed a delegation of US scientists a new uranium enrichment facility, located in a former fuel-rod fabrication building at Yongbyon.[136] The scientists were told that the facility 'contained 2000 centrifuges in six cascades'; that it was built between April 2009 and November 2010; and that it was producing uranium with an average enrichment level of 3.5 per cent for a civilian light-water reactor programme. One of the visiting scientists reported that the plant was significantly more advanced than he had expected, although he could not confirm whether the centrifuges were operational.[137] US officials concluded that the plant could not have been built in the stated time frame without a network of undeclared nuclear facilities and activities elsewhere in the country.[138] In early 2011 a confidential report prepared by a panel of experts for the United Nations Security Council similarly concluded that North Korea might have additional nuclear-related facilities.[139]

XI. Conclusions

In 2010 Russia and the USA continued to reduce their deployed strategic nuclear offensive forces pursuant to meeting the warhead limit set by SORT. Under New START, concluded during the year, the two states will make further modest reductions in these forces. The new agreement did

[133] Albright, D. and Brannan, P., 'What is North Korea building in the area of the destroyed cooling tower? It bears watching', Institute for Science and International Security (ISIS) Report, 30 Sep. 2010, <http://isis-online.org/isis-reports/category/korean-peninsula/>.

[134] See Korea Central News Agency, 'DPRK Foreign Ministry declares strong counter-measures against UNSC's "Resolution 1874"', 13 June 2009, <http://www.kcna.co.jp/item/2009/200906/news13/20090613-10ee.html>; and Korea Central News Agency, 'DPRK Permanent Representative sends letter to president of UNSC', 4 Sep. 2009, <http://www.kcna.co.jp/item/2009/200909/news04/20090904-04ee.html>.

[135] Clapper (note 127), p. 14.

[136] Hecker, S. S., 'What I found in North Korea', *Foreign Affairs*, 9 Dec. 2010, p. 4.

[137] Hecker (note 136), p. 4.

[138] Sanger, D. E. and Broad, W. J., 'U.S. concludes N. Korea has more nuclear sites', *New York Times*, 14 Dec. 2010.

[139] Harlan, C., 'U.N. report suggests N. Korea has secret nuclear sites', *Washington Post*, 1 Feb. 2011.

not place limits on the Russian and US stockpiles of non-strategic and non-deployed nuclear warheads.

Despite signs of growing momentum for nuclear arms control and disarmament efforts in 2010, all of the legally recognized nuclear weapon states appeared determined to retain their nuclear arsenals for the indefinite future and were either modernizing their nuclear forces or had announced plans to do so. The US Nuclear Posture Review reaffirmed the importance of the current nuclear force posture to US national security and recommended modernizing the nuclear weapon production complex. France and the UK signed a bilateral agreement on technical cooperation to ensure the long-term safety and reliability of their nuclear weapons. China is deploying a new generation of land- and sea-based nuclear forces.

Among the de facto nuclear weapon states, India and Pakistan continued to expand their nuclear strike capabilities, while Israel appeared to be waiting to see how Iran's nuclear programme developed. There remained considerable uncertainty about North Korea's nuclear weapon capabilities.