

## I. United States nuclear forces

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As of January 2022, the United States maintained a military stockpile of approximately 3708 nuclear warheads, around 100 fewer than the estimate for January 2021. Approximately 1744 of these—consisting of about 1644 strategic and roughly 100 non-strategic (tactical) warheads—were deployed on ballistic missiles and bomber bases. In addition, about 1964 warheads were held in reserve and around 1720 retired warheads were awaiting dismantlement (30 fewer than the previous year's estimate), giving a total inventory of approximately 5428 nuclear warheads (see table 10.2).

These estimates are based on publicly available information regarding the US nuclear arsenal and SIPRI estimates.<sup>1</sup> In 2010 the USA for the first time declassified the entire history of its nuclear weapon stockpile size.<sup>2</sup> Both the annual US stockpile size and the annual number of dismantled warheads were declassified every subsequent year. However, the administration of President Donald J. Trump halted this transparency process in 2019, refusing to disclose any numbers for 2018–19.<sup>3</sup> In 2021 the administration of President Joe Biden restored nuclear transparency by declassifying both numbers for the entire history of the US nuclear arsenal until September 2020.<sup>4</sup> This effort revealed that the US nuclear stockpile consisted of 3750 warheads in September 2020, 3805 warheads in 2019 and 3785 warheads in 2018.<sup>5</sup> The US stockpile is expected to continue to decline gradually over the next decade as nuclear modernization programmes consolidate some nuclear weapon types.

In 2021 the USA remained in compliance with the final warhead limits prescribed by the 2010 Russian–US Treaty on Measures for the Further Reduction and Limitation of Strategic Offensive Arms (New START), which places a cap on the numbers of US and Russian deployed strategic nuclear forces.<sup>6</sup> The most recent data exchange, on 1 September 2021, listed the USA deploying 1389 warheads attributed to 665 ballistic missiles and heavy

<sup>1</sup> Kristensen, H. M. and Korda, M., 'Estimating world nuclear forces: An overview and assessment of sources', SIPRI Topical Background, 14 June 2021.

<sup>2</sup> See e.g. US Department of Defense, 'Increasing transparency in the US nuclear weapons stockpile', Fact sheet, 3 May 2010.

<sup>3</sup> Kristensen, H. M., 'Trump administration again refuses to disclose nuclear stockpile size', FAS Strategic Security Blog, Federation of American Scientists, 3 Dec. 2020.

<sup>4</sup> US Department of State, 'Transparency in the US nuclear weapons stockpile', Fact sheet, 5 Oct. 2021.

<sup>5</sup> US Department of State (note 4).

<sup>6</sup> For a summary and other details of New START see annex A, section III, in this volume. On the negotiation of the renewal of New START see chapter 11, section I, in this volume.

**Table 10.2.** United States nuclear forces, January 2022

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

| Type   | Designation    | No. of launchers          | Year first deployed | Range (km) <sup>a</sup> | Warheads x yield                             | No. of warheads <sup>b</sup> |
|--|----------------|---------------------------|---------------------|-------------------------|--|------------------------------|
| <b>Strategic nuclear forces</b>                |                | <b>746</b>                |                     |                         |  | <b>3 508<sup>c</sup></b>     |
| <i>Aircraft (bombers)</i>                      |                | <i>107/66<sup>d</sup></i> |                     |                         |  | <i>788<sup>e</sup></i>       |
| B-52H  | Stratofortress | 87/46                     | 1961                | 16 000                  | 20 x AGM-86B<br>ALCMs 5-150 kt <sup>f</sup>  | 500 <sup>g</sup>             |
| B-2A   | Spirit         | 20/20                     | 1994                | 11 000                  | 16 x B61-7, -11,<br>B83-1 bombs <sup>h</sup> | 288                          |
| <i>Land-based missiles (ICBMs)</i>             |                | <i>400</i>                |                     |                         |  | <i>800<sup>i</sup></i>       |
| LGM-30G Minuteman III                          |                |                           |                     |                         |  |                              |
|  | Mk12A          | 200                       | 1979                | 13 000                  | 1-3 x W78 335 kt                             | 600 <sup>j</sup>             |
|  | Mk21 SERV      | 200                       | 2006                | 13 000                  | 1 x W87 300 kt                               | 200 <sup>k</sup>             |
| <i>Sea-based missiles (SLBMs)</i>              |                | <i>14/280<sup>l</sup></i> |                     |                         |  | <i>1 920<sup>m</sup></i>     |
| UGM-133A Trident II D5(LE)                     |                |                           |                     |                         |  |                              |
|  | Mk4            | ..                        | 1992                | >12 000                 | 1-8 x W76-0 100 kt                           | - <sup>n</sup>               |
|  | Mk4A           | ..                        | 2008                | >12 000                 | 1-8 x W76-1 90 kt                            | 1 511                        |
|  | Mk4A           | ..                        | 2019                | >12 000                 | 1 x W76-2 <sup>o</sup> 8 kt                  | 25                           |
|  | Mk5            | ..                        | 1990                | >12 000                 | 1-8 x W88 455 kt                             | 384                          |
| <b>Non-strategic nuclear forces</b>            |                |                           |                     |                         |  | <b>200<sup>p</sup></b>       |
| F-15E  | Strike Eagle   | ..                        | 1988                | 3 840                   | 5 x B61-3, -4                                | 80                           |
| F-16C/D  | Falcon         | ..                        | 1987                | 3 200 <sup>q</sup>      | 2 x B61-3, -4                                | 60                           |
| F-16MLU  | Falcon (NATO)  | ..                        | 1985                | 3 200                   | 2 x B61-3, -4                                | 30                           |
| PA-200   | Tornado (NATO) | ..                        | 1983                | 2 400                   | 2 x B61-3, -4                                | 30                           |
| <b>Total stockpile</b>                         |                |                           |                     |                         |  | <b>3 708<sup>r</sup></b>     |
| Deployed warheads                              |                |                           |                     |                         |  | 1 744                        |
| Reserve warheads                               |                |                           |                     |                         |  | 1 964                        |
| <b>Retired warheads awaiting dismantlement</b> |                |                           |                     |                         |  | <b>1 720<sup>s</sup></b>     |
| <b>Total inventory</b>                         |                |                           |                     |                         |  | <b>5 428<sup>t</sup></b>     |

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

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

<sup>b</sup> These figures show the total number of warheads estimated to be assigned to nuclear-capable delivery systems. Only some of these warheads have been deployed on missiles and at air bases.

<sup>c</sup> Approximately 1644 of these strategic warheads were deployed on land- and sea-based ballistic missiles and at bomber bases. The remaining warheads were in central storage. This number is different from the number of deployed strategic warheads counted by the 2010 Russian-US Treaty on Measures for the Further Reduction and Limitation of Strategic Offensive Arms (New START) because the treaty attributes one weapon to each deployed bomber, even though bombers do not carry weapons under normal circumstances. Additionally, the treaty does not count weapons stored at bomber bases and, at any given time, some nuclear-powered ballistic missile submarines (SSBNs) are not fully loaded with warheads and are thus not counted under the treaty.

<sup>d</sup> The first figure is the total number of bombers in the inventory; the second is the number of bombers that are counted as nuclear-capable under New START. The USA has declared that it

will deploy no more than 60 nuclear bombers at any given time but normally only about 50 are deployed (45 were counted as deployed under New START as of Sep. 2021), with the remaining aircraft in overhaul.

<sup>e</sup> The estimate of c. 788 warheads assigned to strategic bombers is a decrease from the estimate of c. 848 warheads in *SIPRI Yearbook 2021*. The decrease is not the result of a recent retirement of weapons but of a reassessment of the number of warheads that are assigned to the bombers. Of the c. 788 bomber weapons, c. 300 (200 ALCMs and 100 bombs) were deployed at the bomber bases; all the rest were in central storage. Many of the gravity bombs are no longer fully active and are slated for retirement after deployment of the B61-12 in the early 2020s.

<sup>f</sup> The B-52H is no longer configured to carry nuclear gravity bombs.

<sup>g</sup> In 2006 the US Department of Defense decided to reduce the number of ALCMs to 528 missiles. Burg, R., Director of Strategic Security in the Air, Space and Information Operations, 'ICBMs, helicopters, cruise missiles, bombers and warheads', Statement before the Subcommittee on Strategic Forces, US Senate Armed Services Committee, 28. Mar. 2007, p. 7. Since then, the number has probably decreased gradually to around 500 as some missiles and warheads have probably been taken out of service and not been replaced.

<sup>h</sup> Strategic gravity bombs are assigned to B-2A bombers only. The maximum yields of strategic bombs are 360 kt for the B61-7, 400 kt for the B61-11 and 1200 kt for the B83-1. However, all these bombs, except the B-11, have lower-yield options. Most B83-1s have been moved to the inactive stockpile and B-2As rarely exercise with the bomb.

<sup>i</sup> Of the 800 ICBM warheads, only 400 were deployed on the missiles. The remaining warheads were in central storage.

<sup>j</sup> Only 200 of these W78 warheads were deployed, as each ICBM has had its warhead load reduced to carry a single warhead; all of the remaining warheads were in central storage.

<sup>k</sup> SIPRI estimates that another 340 W87 warheads might be in long-term storage outside the stockpile for use in the W78 replacement warhead (W87-1) programme.

<sup>l</sup> The first figure is the total number of nuclear-powered ballistic missile submarines (SSBNs) in the US fleet; the second is the maximum number of missiles that they can carry. However, although the 14 SSBNs can carry up to 280 missiles, 2 vessels are normally undergoing refuelling overhaul at any given time and are not assigned missiles. The remaining 12 SSBNs can carry up to 240 missiles, but 1 or 2 of these vessels are usually undergoing maintenance at any given time and may not be carrying missiles.

<sup>m</sup> Of the 1920 SLBM warheads, c. 944 were deployed on submarines as of Sep. 2021; all the rest were in central storage. Although each D5 missile was counted under the 1991 Strategic Arms Reduction Treaty as carrying 8 warheads and the missile was initially flight tested with 14, the US Navy has reduced the warhead load of each missile to an average of 4–5 warheads. D5 missiles equipped with the new low-yield W76-2 are estimated to carry only 1 warhead each.

<sup>n</sup> It is assumed here that all W76-0 warheads have been replaced by the W76-1.

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

<sup>p</sup> Approximately 100 of the 200 tactical bombs are thought to be deployed across six NATO air bases outside the USA. The remaining bombs were in central storage in the USA. Older B61 versions will be dismantled once the B61-12 is deployed. The maximum yields of tactical bombs are 170 kt for the B61-3 and 50 kt for the B61-4. All have selective lower yields. The B61-10 was retired in 2016.

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

<sup>r</sup> Of these 3708 weapons, c. 1744 were deployed on ballistic missiles, at bomber bases in the USA and at six NATO air bases outside the USA; all the rest were in central storage.

<sup>s</sup> Up until 2018, the US government published the number of warheads dismantled each year, but the administration of President Donald J. Trump ended this practice. The administration of President Joe Biden restored transparency in 2021, but publication of the 2018, 2019 and 2020 data showed that far fewer warheads had been dismantled than assumed (e.g. only 184 in 2020).

Nonetheless, dismantlement of the warheads has continued, leaving an estimated 1720 warheads in the dismantlement queue.

<sup>‡</sup>In addition to these intact warheads, more than 20 000 plutonium pits were stored at the Pantex Plant, Texas, and perhaps 4000 uranium secondaries were stored at the Y-12 facility at Oak Ridge, Tennessee.

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

bombers.<sup>7</sup> The numbers of deployed warheads presented here differ from the numbers reported under New START because the treaty attributes one weapon to each deployed bomber, even though bombers do not carry weapons under normal circumstances. Additionally, the treaty does not count weapons stored at bomber bases and, at any given time, some nuclear-powered ballistic missile submarines (SSBNs) are not fully loaded with warheads and are thus not counted under the treaty.

### **The role of nuclear weapons in US military doctrine**

According to the 2018 Nuclear Posture Review (NPR), 'The United States would only consider the employment of nuclear weapons in extreme circumstances to defend the vital interests of the United States, its allies, and partners.'<sup>8</sup> The NPR further clarifies that the USA reserves the right to first use of nuclear weapons in a conflict, and could use nuclear weapons in response to 'significant non-nuclear strategic attacks' on 'the US, allied, or partner civilian population or infrastructure, and attacks on US or allied nuclear forces, their command and control, or warning and attack assessment capabilities'.<sup>9</sup>

The USA under the Biden administration continued to implement the 2018 NPR throughout 2021, including several large-scale nuclear weapon programmes initiated under the administration of President Barack Obama and accelerated and expanded by the Trump administration, which cover modernization programmes for all three legs of the nuclear triad (see 'Strategic nuclear forces' below).

The 2018 NPR's justification for the development of two nuclear 'supplements'—the W76-2 low-yield warhead and a nuclear sea-launched cruise missile (SLCM-N)—reflected important doctrinal changes in US nuclear

<sup>7</sup> US Department of State, 'Notification containing data for each category of data contained in part two of the protocol', 1 Sep. 2021, retrieved by request from the US Department of State, Bureau of Arms Control, Verification and Compliance, 26 Jan. 2022.

<sup>8</sup> US Department of Defense (DOD), *Nuclear Posture Review 2018* (DOD: Arlington, VA, Feb. 2018), p. 21.

<sup>9</sup> US Department of Defense (note 8), p. 21.

planning. According to the NPR, the W76-2 is intended to provide the USA with a prompt low-yield capability aimed at deterring Russia from what the NPR suggested was a greater willingness to use nuclear weapons first—an alleged doctrinal shift that independent experts have questioned.<sup>10</sup> Both the W76-2 and SLCM-N appear intended to restrengthen US non-strategic nuclear weapon capabilities, which had reduced in importance for the US military since the end of the cold war. This included, according to the NPR, the option of responding to non-nuclear strategic attacks, which would constitute first use of nuclear weapons—the very act that the NPR criticizes Russia for including in its alleged doctrine.<sup>11</sup>

### **Strategic nuclear forces**

US offensive strategic nuclear forces include heavy bomber aircraft, land-based intercontinental ballistic missiles (ICBMs) and SSBNs. These forces, together known as the triad, changed little during 2021.<sup>12</sup> SIPRI estimates that a total of 3508 nuclear warheads were assigned to the triad, of which an estimated 1644 warheads were deployed on ballistic missiles and at heavy bomber bases.

#### *Aircraft and air-delivered weapons*

As of January 2022, the US Air Force (USAF) operated a fleet of 152 heavy bombers: 45 B-1Bs, 20 B-2As and 87 B-52Hs.<sup>13</sup> Of these, 66 (20 B-2As and 46 B-52Hs) were nuclear-capable and 45 (11 B-2As and 34 B-52Hs) were counted as deployed under New START as of 1 September 2021.<sup>14</sup> The B-2A can deliver gravity bombs (B61-7, B61-11 and B83-1) and the B-52H can deliver the AGM-86B/W80-1 nuclear air-launched cruise missile (ALCM). SIPRI estimates that approximately 788 warheads were assigned to strategic bombers, of which about 300 are deployed at bomber bases and ready for

<sup>10</sup> US Department of Defense (note 8), pp. 8, 53–55. See also e.g. Ven Bruusgaard, K., ‘Here’s why US tactical nukes are a bad idea’, *National Interest*, 10 Dec. 2018; Oliker, O. and Baklitskiy, A., ‘The Nuclear Posture Review and Russian “de-escalation”: A dangerous solution to a nonexistent problem’, *War on the Rocks*, 20 Feb. 2018; and Oliker, O., ‘Russia’s nuclear doctrine: What we know, what we don’t, and what that means’, Center for Strategic and International Studies (CSIS), 5 May 2016.

<sup>11</sup> US Office of the Under Secretary of Defense for Policy, ‘Strengthening deterrence and reducing nuclear risks, part ii: The sea-launched cruise missile-nuclear (SLCM-N)’, *Arms Control and International Security Papers*, vol. 1, no. 11 (23 July 2020), p. 3; and US Department of Defense (note 8), p. xiii. For further detail on the Nuclear Posture Review see Kristensen, H. M., ‘US nuclear forces’, *SIPRI Yearbook 2019*.

<sup>12</sup> The reduction in bomber weapons compared with *SIPRI Yearbook 2021* is not the result of new cuts but of new stockpile numbers causing a reassessment of the estimate.

<sup>13</sup> In Sep. 2021 the US Air Force retired 17 B-1B heavy bombers; the remaining 45 B-1Bs will be decommissioned once the B-21 enters service in the mid 2020s.

<sup>14</sup> US Department of State (note 7).

delivery on relatively short notice.<sup>15</sup> Both the B-2As and B-52Hs are currently undergoing modernization intended to improve their ability to receive and transmit secure nuclear mission data.<sup>16</sup>

The development of the next-generation long-range strike bomber, known as the B-21 Raider, was well under way by the end of 2021 and the first two test aircraft were being constructed.<sup>17</sup> In July 2021 the USAF released its visual rendering of the B-21, indicating a flying-wing design similar to that of the B-2, along with a fact sheet noting that the B-21 would eventually be able to conduct uncrewed operations.<sup>18</sup> The B-21 will be capable of delivering two types of nuclear weapon: the B61-12 guided nuclear gravity bomb, which is scheduled to begin full-scale production in May 2022 and is also designed to be deliverable from shorter-range non-strategic aircraft (see below); and the long-range standoff weapon (LRSO) ALCM, which is in development. In June 2021 the acting administrator of the National Nuclear Security Administration (NNSA) noted in US Senate testimony that the W80-4 warhead—being developed for the LRSO—would probably be delayed due to the ongoing Covid-19 pandemic, and the first production unit was not expected until US financial year 2025.<sup>19</sup>

The B-21 is scheduled to enter service in the mid 2020s. At the end of 2021, six were in production, with roll-out and first flight expected in mid 2022.<sup>20</sup> The new bomber will replace the B-1B bombers—which are not nuclear-capable—at Dyess Air Force Base (AFB) in Texas and Ellsworth AFB in South Dakota. This, along with the reinstatement of nuclear-weapon storage capability at Barksdale AFB in Louisiana, will result in the number of US bomber bases with such capability increasing from two in 2021 to five by the early 2030s.<sup>21</sup> In June 2021 the USAF announced that Ellsworth AFB would

<sup>15</sup> The estimate of c. 788 warheads assigned to strategic bombers is a decrease from the estimate of c. 848 warheads in *SIPRI Yearbook 2021*. The decrease is not the result of a recent retirement of weapons but of a reassessment of the number of warheads that are assigned to the bombers.

<sup>16</sup> US Department of Defense (DOD), *Fiscal Year (FY) 2021 Budget Estimates: Air Force: Justification Book*, vol. 3a, Research, Development, Test & Evaluation, Air Force, vol. III, part 1 (DOD: Arlington, VA, Feb. 2020), pp. 109–82, 203–21.

<sup>17</sup> Tirpak, J., 'Second B-21 under construction as bomber moves toward first flight', *Air Force Magazine*, 15 Jan. 2021.

<sup>18</sup> US Air Force, US Secretary of the Air Force Public Affairs, 'Air Force releases new B-21 Raider artist rendering', Press release, 6 July 2021; and US Air Force, 'B-21 Raider', Fact sheet, 6 July 2021.

<sup>19</sup> Verdon, C., Statement, US Senate Armed Services Committee hearing on Department of Energy and National Nuclear Security Administration on Atomic Energy Defense Activities in Review of the Defense Authorization Request for Fiscal Year 2022 and the Future Years Defense Program, 24 June 2021; and 'NNSA assessing Covid-related delays to warhead refurb; results in spring', *Exchange Monitor*, 8 Feb. 2022.

<sup>20</sup> Hadley, G., 'Six B-21s in production, fuel control software already tested', *Air Force Magazine*, 9 Feb. 2022.

<sup>21</sup> Dawkins, J. C., Commander, 8th Air Force and Joint-Global Strike Operations Center, Barksdale AFB, 'B21 General Dawkins intro', YouTube, 19 Mar. 2020, 01:35; and Kristensen, H. M., 'USAF plans to expand nuclear bomber bases', *FAS Strategic Security Blog*, Federation of American Scientists, 17 Nov. 2020.

be the first base to receive the B-21.<sup>22</sup> The USAF plans to acquire at least 100 (but possibly as many as 145) B-21 bombers by the mid 2030s.<sup>23</sup> However, funding decisions made by the US Congress will determine the final number.

### *Land-based missiles*

As of January 2022, the USA deployed 400 Minuteman III ICBMs in 450 silos across three missile wings, with the 50 empty silos kept in a state of readiness for reloading with stored missiles if necessary.<sup>24</sup> Each Minuteman III ICBM was armed with either a 335-kiloton W78 or a 300-kt W87 warhead. Missiles carrying the W78 can be uploaded with up to two more warheads for a maximum of three multiple independently targetable re-entry vehicles (MIRVs). ICBMs with the W87 can only be loaded with one warhead. SIPRI estimates that there are 800 warheads assigned to the ICBM force, of which 400 are deployed on the missiles.<sup>25</sup>

The USAF has scheduled its next-generation ICBM, the Ground Based Strategic Deterrent (GBSD) weapon system, to begin replacing the Minuteman III in 2028, with full replacement by 2036.<sup>26</sup> Each GBSD will be able to carry up to two W87 or W87-1 MIRVs (see below)—for a maximum of 800 warheads across all GBSDs—but will probably carry only one warhead under normal circumstances. The USAF is expected to conduct its first flight test of the system in 2023.<sup>27</sup> The projected cost of the programme has continued to increase and the absence of competition in the bidding process for the contract may have eliminated any potential to make savings up front.<sup>28</sup> In May 2021 the US Congressional Budget Office (CBO) estimated that the cost of acquiring and maintaining the ICBMs would total approximately \$82 billion over the 10-year period 2021–30, approximately \$20 billion more than the CBO had previously estimated for the period 2019–28.<sup>29</sup> The cost is

<sup>22</sup> Cisneros, M., 'AFCEC leads bed-down efforts for B-21 Raider stealth bomber', Ellsworth Air Force Base, Press release, 22 Nov. 2021.

<sup>23</sup> Tirpak, J. A., 'A new bomber vision', *Air Force Magazine*, 1 June 2020.

<sup>24</sup> Willett, E., 'AF meets New START requirements', US Air Force Global Strike Command, Press release, 28 June 2017.

<sup>25</sup> For further detail on the warheads and yields see Kristensen, H. M. and Korda, M., 'US nuclear forces', *SIPRI Yearbook 2021*, p. 341.

<sup>26</sup> Richard, C. A., Commander, US Strategic Command, Statement before the US Senate Armed Services Committee, 13 Feb. 2020, p. 9. For further detail on the GBSD see Kristensen and Korda (note 25), p. 341.

<sup>27</sup> Tirpak, J., 'New GBSD will fly in 2023; no margin left for Minuteman', *Air Force Magazine*, 14 June 2021. The requirements for reaching initial operating capability are deploying 20 GBSD missiles loaded with legacy W87-0/Mk21 warheads and re-entry vehicles, upgrading 20 Minuteman III launch facilities to GBSD standards, and operationally certifying 3 GBSD launch control centres and 1 integrated command centre.

<sup>28</sup> Reif, K., 'New ICBM replacement cost revealed', *Arms Control Today*, vol. 47, no. 2 (Mar. 2017); and Burns, R., 'Pentagon estimates cost of new nuclear missiles at \$95.8B', AP News, 20 Oct. 2020.

<sup>29</sup> US Congressional Budget Office, 'Projected costs of US nuclear forces, 2021 to 2030', May 2021, p. 10; and US Congressional Budget Office, 'Projected costs of US nuclear forces, 2019 to 2028', Jan. 2019, p. 9.



likely to increase further, which perhaps calls into question the decision not to extend the life of the existing Minuteman III.

The USAF is also modernizing the nuclear warheads that will be used to arm the GBSD.<sup>30</sup> The projected cost of the programme for the replacement warhead, known as the W87-1, is between \$11.8 billion and \$15 billion, but this estimate does not include costs associated with production of plutonium pits for the warhead (see below).<sup>31</sup> In March 2021 the NNSA completed its review of requirements for the W87-1, a key milestone that allows the programme to progress to the next stage of its development.<sup>32</sup>

### *Sea-based missiles*

The US Navy operates a fleet of 14 Ohio-class SSBNs, of which 12 are normally considered to be operational and 2 are typically undergoing refuelling and overhaul at any given time. Eight of the SSBNs are based at Naval Base Kitsap in Washington state and six at Naval Submarine Base Kings Bay in Georgia.

Each Ohio-class SSBN can carry up to 20 Trident II D5 submarine-launched ballistic missiles (SLBMs). To meet the New START limit on deployed launchers, 4 of the 24 initial missile tubes on each submarine were deactivated so that the 12 deployable SSBNs can carry no more than 240 missiles.<sup>33</sup> Around 8 to 10 SSBNs are normally at sea, of which 4 or 5 are on alert in their designated patrol areas and ready to fire their missiles within 15 minutes of receiving the launch order. The US SSBN fleet conducts about 30 deterrent patrols per year.<sup>34</sup>

The Trident II D5 SLBMs carry two basic warhead types: the 455-kt W88 and the W76, which exists in two versions, the 90-kt W76-1 and the low-yield W76-2.<sup>35</sup> The NNSA has begun modernizing the ageing W88 warhead, and the first production unit for the W88 Alt 370 was completed on 1 July 2021.<sup>36</sup> Each SLBM can carry up to eight warheads but normally carries an average of four or five. SIPRI estimates that around 1920 warheads were assigned to the SSBN fleet, of which about 944 were deployed on missiles.<sup>37</sup>

<sup>30</sup> For further detail on the GBSD see Kristensen and Korda (note 25), pp. 341–42.

<sup>31</sup> US Department of Energy, National Nuclear Security Administration (NNSA), *Fiscal Year 2021 Stockpile Stewardship and Management Plan: Biennial Plan Summary*, Report to Congress (NNSA: Washington, DC, Dec. 2020), pp. 5–32, 5–33.

<sup>32</sup> Sirota, S., 'NNSA completes requirements review of GBSD's W87-1 warhead', Inside Defense, 22 Apr. 2021.

<sup>33</sup> US Navy Office of Information, 'Fleet ballistic missile submarines—SSBN', Fact sheet, updated 25 May 2021.

<sup>34</sup> See e.g. Kristensen, H., 'US SSBN patrols steady, but mysterious reduction in Pacific in 2017', FAS Strategic Security Blog, Federation of American Scientists, 24 May 2018.

<sup>35</sup> The older W76-0 version has been, or remains in the process of being, retired. For further detail on these warheads see Kristensen and Korda (note 25), pp. 342–43.

<sup>36</sup> US Department of Energy, National Nuclear Security Administration (NNSA), 'NNSA completes first production unit of W88 Alteration 370', 13 July 2021.

<sup>37</sup> US Department of State, Bureau of Arms Control, Verification and Compliance, 'New START Treaty aggregate numbers of strategic offensive arms', Fact sheet, 1 Dec. 2020.



The newest warhead, the low-yield W76-2, was first deployed in late 2019 on USS *Tennessee* (SSBN-734), which patrols the Atlantic Ocean, and has now been deployed on SSBNs in both the Atlantic and the Pacific.<sup>38</sup> It is a modification of the W76-1 and is estimated to have an explosive yield of about 8 kt.<sup>39</sup>

Since 2017, the US Navy has been replacing its Trident II D5 SLBMs with an enhanced version, known as the D5LE (LE for 'life extension'), with the upgrade scheduled for completion in 2024.<sup>40</sup> In 2021 the US Navy conducted several flight tests of the D5LE SLBM, which is equipped with the new Mk6 guidance system.<sup>41</sup> The D5LE will arm Ohio-class SSBNs for the remainder of their service lives (up to 2042) and will be deployed on the United Kingdom's Trident submarines (see section III). A new class of SSBN, the Columbia class, will initially also be armed with the D5LE, but from 2039 these will eventually be replaced with an upgraded SLBM, the D5LE2.<sup>42</sup> The first Columbia-class SSBN—USS *Columbia* (SSBN-826)—is scheduled to start patrols in 2031.<sup>43</sup>

To arm the D5LE2, the NNSA has begun early design development of a new nuclear warhead, known as the W93, to complement the W76 and W88 warheads. This would be the first brand-new warhead developed by the USA since the end of the cold war. The W93 warhead will be housed in a new Mk7 re-entry body (aeroshell) that will also be delivered to the British Royal Navy (see section III). Production of the W93 is scheduled to begin in the mid 2030s.<sup>44</sup>

### *Warhead production*

From the end of the cold war, the USA relied on refurbishment of existing warhead types for its nuclear forces, but since around 2018 it has shifted to an expanded production capacity intended to produce new warheads. This plan depends heavily on the USA's ability to produce new plutonium pits. Whereas production capacity in 2021 was limited (to around 10 plutonium pits per year), the NNSA plans to produce up to 30 pits in 2026 and

<sup>38</sup> Arkin, W. M. and Kristensen, H. M., 'US deploys new low-yield nuclear submarine warhead', FAS Strategic Security Blog, Federation of American Scientists, 29 Jan. 2020; and US Department of Defense, 'Statement on the fielding of the W76-2 low-yield submarine launched ballistic missile warhead', Press release, 4 Feb. 2020.

<sup>39</sup> US military officials, Private communications with the authors, 2019–20.

<sup>40</sup> Wolfe, J., Director of US Strategic Systems Programs, Statement before the Subcommittee on Strategic Forces, US Senate Armed Services Committee, 1 May 2019, p. 4.

<sup>41</sup> US Navy, 'USS Wyoming successfully tests Trident II D5LE missiles', Press release, 18 Sep. 2021.

<sup>42</sup> Wolfe, J., Director of US Strategic Systems Programs, 'FY2021 budget request for nuclear forces and atomic energy defense activities', Statement before the Subcommittee on Strategic Forces, US House of Representatives Armed Services Committee, 3 Mar. 2020, p. 5.

<sup>43</sup> Wolfe (note 42), p. 3.

<sup>44</sup> US Department of Defense, 'W93/Mk7 Navy warhead: Developing modern capabilities to address current and future threats', White paper, May 2020, p. 2. Part of this document is available online. For further detail on this warhead programme see Kristensen and Korda (note 25), p. 343.

at least 80 pits per year by 2030 to meet the demands of the US nuclear modernization programmes.<sup>45</sup> In order to fulfil these objectives, the NNSA is modernizing its plutonium facility (PF-4) at Los Alamos National Laboratory in New Mexico and creating a new plutonium processing facility at Savannah River in South Carolina.<sup>46</sup>

In June 2021 the acting administrator of the NNSA announced to the US Congress what outside experts had long predicted—that the NNSA's goal of producing up to 80 pits per year by 2030 would not be possible.<sup>47</sup> This indicates that some of the aforementioned nuclear weapon programmes will probably face delays or that new delivery systems could be initially deployed with legacy warheads.<sup>48</sup>

### **Non-strategic nuclear forces**

US non-strategic (tactical) nuclear forces include nuclear bombs delivered by several types of short-range fighter-bomber aircraft, as well as potentially a future nuclear-armed SLCM.

#### *Air force weapons*

The USA, as of January 2022, had one basic type of air-delivered non-strategic weapon in its stockpile—the B61 gravity bomb, which exists in two versions: the B61-3 and the B61-4.<sup>49</sup> An estimated 200 tactical B61 bombs remained in the stockpile.

SIPRI estimates that the USAF has deployed approximately 100 of the B61 bombs for potential use by fighter-bomber aircraft at six air bases in five other member states of the North Atlantic Treaty Organization (NATO): Kleine Brogel in Belgium; Büchel in Germany; Aviano and Ghedi in Italy; Volkel in the Netherlands; and İncirlik in Turkey.<sup>50</sup> The remaining (c. 100) B61 bombs

<sup>45</sup> US Department of Energy, National Nuclear Security Administration (NNSA), 'Plutonium pit production', Fact sheet, Apr. 2019; and US Government Accountability Office (GAO), *Nuclear Weapons: NNSA Should Further Develop Cost, Schedule, and Risk Information for the W87-1 Warhead Program*, Report no. GAO-20-73 (GAO: Washington, DC, Sep. 2020), pp. 14–15.

<sup>46</sup> US Department of Energy (note 45).

<sup>47</sup> Demarest, C., 'Plutonium pit production in SC might happen in 2035. The target was 2030', *Aiken Standard*, 12 June 2021. See also e.g. US Government Accountability Office (note 45), p. 5; and Hunter, D. E. et al., 'Independent assessment of the two-site pit production decision: Executive summary', Institute for Defense Analyses document no. NS D-10711, May 2019, p. 4.

<sup>48</sup> US Air Force (USAF), *Report on Development of Ground-Based Strategic Deterrent Weapon*, Report to eight congressional committees (USAF: [Arlington, VA,] May 2020), p. 4. The USAF is already anticipating that the W87-1 will not be completed on time and is therefore planning for the GBSD to reach initial operational capability with legacy warheads.

<sup>49</sup> A third version, the B61-10, was retired in Sep. 2016. US Department of Energy, National Nuclear Security Administration (NNSA), *Fiscal Year 2018 Stockpile Stewardship and Management Plan*, Report to Congress (NNSA: Washington, DC, Nov. 2017), figures 1.1–1.7, pp. 1–13.

<sup>50</sup> For a detailed overview of the dual-capable aircraft programmes of the USA and its NATO allies see Kristensen (note 11), pp. 299–300; and Andreasen, S. et al., *Building a Safe, Secure, and Credible NATO Nuclear Posture* (Nuclear Threat Initiative: Washington, DC, Jan. 2018).

are thought to be stored at Kirtland AFB in New Mexico for potential use by US aircraft in support of allies outside Europe, including in East Asia.<sup>51</sup> USA-based fighter wings for this mission include the 366th Fighter Wing at Mountain Home AFB in Idaho.<sup>52</sup>

The USA has completed development of the new B61-12 guided nuclear bomb, which will replace all existing versions of the B61 (both strategic and non-strategic). Delivery was scheduled to start in 2020 but production problems in 2019 caused delays; the first production unit was completed in November 2021, and full-scale production is scheduled for May 2022.<sup>53</sup> Certification training by the air forces of the countries where the bombs will be based is likely to begin in 2023. The new version is equipped with a guided tail-kit that enables it to hit targets more accurately, meaning that it can use lower yields against targets and thus generate less radioactive fallout.<sup>54</sup>

Operations to integrate the incoming B61-12 on existing USAF and NATO aircraft continued in 2021. The USAF plans to integrate the B61-12 on seven types of aircraft operated by the USA or its NATO allies: the B-2A, the new B-21, the F-15E, the F-16C/D, the F-16MLU, the F-35A and the PA-200 (Tornado).<sup>55</sup> The Tornado's age prevents it from using the B61-12's new guided tail-kit function, and the aircraft will instead deliver the B61-12 as a 'dumb' bomb akin to the older B61-3s and B61-4s.

Germany plans to retire its Tornado aircraft by 2030, and would require a new dual-capable aircraft if it intended to remain part of NATO's nuclear-sharing mission. In November 2021 the incoming coalition government confirmed that its intention was for Germany to remain part of the mission.<sup>56</sup>

### *Navy weapons*

As noted above, the 2018 NPR established a requirement for a new nuclear-armed SLCM—the SLCM-N.<sup>57</sup> In 2019 the US Navy began an 'analysis of alternatives' study for the new weapon, which was reportedly completed in 2021.<sup>58</sup>

<sup>51</sup> US Department of Defense (note 8), p. 48.

<sup>52</sup> Heflin, L., '53rd Wing WSEP incorporates NucWSEP, enhances readiness for real world operations', Air Combat Command, Press release, 9 Sep. 2021.

<sup>53</sup> Mehta, A., 'How a \$5 part used to modernize nuclear warheads could cost \$850 million to fix', *Defense News*, 25 Sep. 2019; and US Department of Energy, National Nuclear Security Administration (NNSA), 'NNSA completes first production unit of B61-12 life extension program', 2 Dec. 2021.

<sup>54</sup> Kristensen, H. M. and McKinzie, M., 'Video shows earth-penetrating capability of B61-12 nuclear bomb', FAS Strategic Security Blog, Federation of American Scientists, 14 Jan. 2016.

<sup>55</sup> US Air Force (USAF), *Acquisition Annual Report Fiscal Year 2018: Cost-effective Modernization* (USAF: Arlington, VA, [n.d.]), p. 24.

<sup>56</sup> Siebold, S. and Wacket, M., 'Germany to remain part of NATO's nuclear sharing under new government', Reuters, 24 Nov. 2021.

<sup>57</sup> US Department of Defense (note 8), pp. 54–55.

<sup>58</sup> Wolfe (note 42).

The USA eliminated all non-strategic naval nuclear weapons after the end of the cold war. Completion of the SLCM-N would therefore mark a significant change in US Navy strategy.<sup>59</sup> In a leaked memorandum from June 2021, the acting Secretary of the Navy recommended that the SLCM-N be defunded, noting that ‘the Navy cannot afford to simultaneously develop the next generation of air, surface, and subsurface platforms and must prioritize these programs balancing the cost of developing next generation capabilities against maintaining current capabilities’.<sup>60</sup> If the Biden administration decides to continue with the programme and the US Congress agrees to fund it, then the new missile could be deployed on attack submarines by the end of the 2020s. This could potentially result in the first significant increase in the size of the US nuclear weapon stockpile since 1996.

<sup>59</sup> Kristensen, H. M., ‘Declassified: US nuclear weapons at sea’, FAS Strategic Security Blog, Federation of American Scientists, 3 Feb. 2016.

<sup>60</sup> Shelbourne, M. and LaGrone, S., ‘SECNAV memo: New destroyer, fighter or sub: You can only pick one; cut nuclear cruise missile’, USNI News, 8 June 2021.