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NUCLEAR NOTEBOOK

# United States nuclear forces, 2016

Hans M. Kristensen and Robert S. Norris

**ABSTRACT**
The US nuclear arsenal remained roughly unchanged in the last year, with the Defense Department maintaining an estimated stockpile of some 4,670 warheads to be delivered via ballistic missiles and aircraft. Most of these warheads are not deployed but stored, and many are destined to be retired. Of the approximately 1,930 warheads that are deployed, roughly 1,750 are on ballistic missiles or at bomber bases in the United States, with another 180 tactical bombs deployed at European bases.

**KEYWORDS**
Ballistic missiles; cruise missiles; nuclear weapons; stockpile; arsenal; United States; ICBM; SLBM; nuclear modernization; SSBN; Ground Based Strategic Deterrent; Long-Range Strike Bomber; LRSO

At the beginning of 2016, the US Defense Department maintained a stockpile of an estimated 4,670 nuclear warheads for delivery by more than 800 ballistic missiles and aircraft. The stockpile did not shrink significantly over the last year, but has shrunk by roughly 350 warheads since September 2009, when the United States announced that the nuclear arsenal contained 5,113 warheads.[1]

Most of the warheads in the stockpile are not deployed but stored for potential upload onto missiles and aircraft if so decided, and many are destined for retirement in the future. We estimate that approximately 1,930 warheads are deployed, of which roughly 1,750 strategic warheads are deployed on ballistic missiles and at bomber bases in the United States. Another 180 tactical bombs are deployed in Europe. The remaining approximately 2,740 warheads – more than 58% – are in storage as a so-called hedge against technical or geopolitical surprises. Many of those are scheduled to be retired before 2030.

In addition to the warheads in the Defense Department stockpile, approximately 2,340 retired, but still intact, warheads are in storage under the custody of the Energy Department and awaiting dismantlement, for a total US inventory of roughly 6,970 warheads (Table 1).

## Implementing new START

Under New START, the United States and Russia report the size of their deployed strategic nuclear arsenals every 6 months. As of 1 September 2015, the United States reported that its nuclear arsenal contained 1,538 strategic warheads attributed to 762 deployed missiles and bombers – a decrease of 105 warheads and 30 launchers compared with a year ago. The decrease reflects a small reduction of the intercontinental ballistic missile (ICBM) force but mainly is due to fluctuations in operational forces and reductions of so-called phantom launchers that are countable but no longer assigned nuclear weapons. Since the treaty entered into force in February 2011, the United States has reported cutting a total of 263 deployed strategic warheads and 120 deployed launchers.

By 1 September 2015, the Air Force had reduced the number of deployed ICBMs by eight since March 2015, indicating the beginning of the planned reduction of deployed ICBMs from 450 to 400 under the New START Treaty.

Destruction of previously emptied silos is well underway. The last of 50 silos at Malmstrom Air Force Base in Montana, which had housed Minuteman III missiles of the 564th Missile Squadron, were destroyed in 2014, according to the Associated Press.[2] This was part of a total of 104 empty ICBM silos that the US Air Force had to destroy before 2018, including 50 silos at Francis E. Warren Air Force Base in Wyoming and one Peacekeeper and three Minuteman III test-launch silos at Vandenberg Air Force Base in California. There were only 13 nondeployed ICBM launchers left as of 1 September 2015. The remaining silos at F.E. Warren will be destroyed in 2016 and the four excess test-launch silos at Vandenberg will be eliminated in 2017.

The number of deployed bombers declined by three between March and September 2015, but not enough to clearly signal a change. The total number of deployed and nondeployed bombers remained the same: 108 aircraft. Shortly after the New START count in September, the Air Force declared that it had completed conversion of the first of 30 operational and 12

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**Table 1.** The US Nuclear Arsenal, 2016.

| TYPE/DESIGNATION | NO | YEAR DEPLOYED | WARHEADS X YIELD (KILOTONS) | DEPLOYED |
|---|---|---|---|---|
| **ICBMs** | | | | |
| LGM-30G Minuteman III | | | | |
| Mk-12A | 200 | 1979 | 1 W78 x 335 (MIRV) | 200 |
| Mk-21/SERV | 240 | 2006[1] | 1 W87 x 300 | 240 |
| **TOTAL** | **440** | | | **440** |
| **SLBMs** | | | | |
| UGM-133A Trident II D5 | 288[2] | | | |
| Mk-4 | | 1992 | 4 W76 x 100 (MIRV) | 68 |
| Mk-4A | | 2008 | 4 W76-1 x 100 (MIRV) | 700 |
| Mk-5 | | 1990 | 4 W88 x 455 (MIRV) | 384 |
| **TOTAL** | **288** | | | **1,152** |
| **Bombers** | | | | |
| B-52H Stratofortress | 93/44[3] | 1961 | ALCM/W80-1 x 5—150 | 200 |
| B-2A Spirit | 20/16 | 1994 | B61-7/-11, B83-1 | 100 |
| **TOTAL** | **113/60** | | | **300[4]** |
| **Nonstrategic forces** | | | | |
| B61-3, -4 bombs | n/a | 1979 | 0.3—170 | 180[5] |
| **TOTAL** | | | | **180** |
| **TOTAL DEPLOYED** | | | | **~2,070** |
| RESERVE | | | | ~2,598[6] |
| **TOTAL STOCKPILE** | | | | **~4,670** |
| **AWAITING DISMANTLEMENT** | | | | **~2,300** |
| **TOTAL INVENTORY** | | | | **~6,970** |

1. The W87 was initially deployed on the MX/Peacekeeper in 1986.
2. Two additional submarines with 48 missile tubes (total) are normally in refueling overhaul and not available for deployment. They are not assigned nuclear weapons. Sometimes more than two submarines are undergoing maintenance.
3. The first figure is the aircraft inventory, including those used for training, testing, and backup; the second is the portion of the primary-mission aircraft inventory estimated to be tasked for nuclear missions. As of September 2015, nuclear-capable bombers included 88 B-52Hs and 20 B-2s.
4. The pool of bombs and cruise missiles allows for multiple loading possibilities depending on the mission. The Air Force has 528 nuclear-armed ALCMs (and more spares), of which an estimated 200 are deployed at Minot Air Force Base. Although B-52Hs can also carry the B61-7 and B83-1 gravity bombs, these are only planned for delivery on the B-2s.
5. These are deployed in Europe. Another 320 bombs are in storage in the United States, for a total estimated inventory of 500 nonstrategic bombs.
6. This includes spares.

ALCM: air-launched cruise missile
ICBM: intercontinental ballistic missile
LGM: silo-launched ground-attack missile
MIRV: multiple independently targetable reentry vehicle
SERV: security-enhanced reentry vehicle
SLCM: sea-launched cruise missile
SLBM: submarine-launched ballistic missile
UGM: underwater-launched ground attack missile

nonoperational B-52Hs to non-nuclear configuration. The conversion will be completed by early 2017 (Air Force 2015a). All B-1B and B-52G aircraft have previously been denuclearized. The plan is to reduce the total number of deployed nuclear-capable bombers to no more than 60 aircraft by 2018.

The Navy has begun the process of reducing the number of missile tubes on each nuclear missile submarine from 24 to 20. The process will be completed in late 2016 or early 2017. The objective is to reduce the number of deployed submarine-launched ballistic missiles to no more than 240 by 2018.

## Nuclear weapons planning

The Pentagon and US Strategic Command are still working on updating nuclear war plans following the publication of Presidential Policy Directive 24 in June, 2013. The directive contains the White House guidance for how the military should plan for the employment of nuclear weapons.[3]

To practice execution of these plans, the armed forces conducted several nuclear strike exercises during 2015. In March, Strategic Command (STRATCOM) conducted Global Lightning 15, a nuclear command and control exercise that included rapid-launch exercises of nuclear bombers. For the first time, Global Lightning was held in conjunction with US European Command's Austere Challenge 15 exercise, US Africa Command's Judicious Response 15, and US Transportation Command's Turbo Challenge 15 to "validate current procedures and improve interoperability between each of the combatant commands through a shared notional scenario" (STRATCOM 2015a).

In response to deteriorating relations with Russia, exercise Polar Growl in April sent four B-52H bombers on simulated strike exercise over the North Pole and North Sea in support of the North Atlantic Treaty Organization (NATO).

Exercise Constant Vigilance followed in May to practice the entire bomber force's ability to plan and to "generate" (that is, to ready) aircraft during surge operations. During the exercise, a large number of aircraft at Minot Air Force Base in North Dakota were loaded with nuclear-capable air-launched cruise missiles (without warheads), and B-2s at Whiteman Air Force Base practiced loading B61-7, B61-11, and B83-1 gravity bombs.

In October, STRATCOM conducted Global Thunder, an annual nuclear command and control exercise, with involvement from component and task forces. The exercise was held in conjunction with North American Aerospace Defense Command and US Northern Command's Exercise Vigilant Shield. Global Thunder is designed to train military forces, assess joint operational readiness, and validate the ability to identify and mitigate attacks across all of STRATCOM's mission areas, with a specific focus on cyber, space, missile defense, and nuclear readiness. The exercise validates the ability to posture components, task forces, units, and command posts to deter, and if necessary, defeat a military attack against the United States and to employ forces as directed by the president. The exercise scenario integrates nearly every conceivable strategic threat to the United States and involves all the STRATCOM capabilities that would be provided to geographic combatant commanders in a real-world crisis: space, cyber, intelligence, surveillance and reconnaissance, global strike, and ballistic missile defense capabilities. According to STRATCOM commander Adm. Cecil Haney: "The United States' ability to maintain a safe, secure, effective and credible nuclear deterrent is foundational to our national security and contributes to the security of our allies and partners. This exercise, and our continued focus on maintaining key capabilities and skills, ensures US STRATCOM's strategic forces remain ready, 24/7, providing flexible and credible options for the president and the Department of Defense" (STRATCOM 2015b).

## Nuclear modernization

The United States has begun an extensive modernization of its entire nuclear weapons enterprise. Over the next decade, the US government plans to spend nearly $350 billion on modernizing and maintaining its nuclear forces and the facilities that support them (CBO 2015b). This includes a new class of nuclear-powered ballistic missile submarines (SSBNs), a new long-range bomber with nuclear capability, a new air-launched cruise missile (ALCM), a next-generation land-based ICBM, a new nuclear-capable tactical fighter aircraft, complete full-scale production of one nuclear warhead (W76-1) and initial production of two others (B61-12 and W80-4), modernizing nuclear command and control facilities, and building new nuclear weapon production and simulation facilities.

In addition to these programs, the United States is also planning significant redesigning of warheads for ballistic missiles. These modified warheads are known as interoperable warheads (IWs) and intended to be based on existing weapons designs but modified significantly by mixing warhead components from different types of warheads into designs that do not currently exist. The first of these, known as IW-1 or W78/W88-1, would create "an interoperable nuclear explosive package for use in both the Mk21A ICBM and the Mk5 SLBM aeroshells, with adaptable non-nuclear components" (Energy Department 2015a). Formal development would start in 2020 with first delivery in 2030 and production continuing through 2040 at a cost of more than $15 billion. The IW-2 would combine the W87 and W88 and start in 2023 with first delivery in 2034 and a cost of more than $17 billion. The IW-3 would be a modified W76-1 and cost more than $18 billion (Energy Department 2015b).

Whether Congress agrees to fund these expensive programs instead of building simpler and cheaper life-extended versions of existing designs remains to be seen. Moreover, the significant redesign on IWs would challenge the pledge made in the 2010 US Nuclear Posture Review Report, which stated that the United States "will not develop new nuclear warheads" but consider the "full range" of life-extension program options, including "refurbishment of existing warheads, reuse of nuclear components from different warheads, and replacement of nuclear components" (Defense Department 2010, xiv). This pledge was intended to prevent resumption of nuclear explosive testing and adhere to the 1996 Comprehensive Nuclear-Test-Ban Treaty. The report also stated that any life-extension programs "will use only nuclear components based on previously tested designs, and will not support . . . new military capabilities" (Defense Department 2010, xiv). Of course, compliance depends on how "new" military capabilities are defined, since the addition of new or improved features outside the nuclear explosive package may increase a weapon's military capabilities. It is anticipated that the United States will generally seek to increase the accuracy of its nuclear weapons in order to

lower the yield of modified warheads with improved performance margins.

## Land-based ballistic missiles

The US Air Force operates a force of 440 silo-based Minuteman III ICBMs, split across three wings: the 90th Missile Wing at F.E. Warren Air Force Base in Wyoming; the 91st Missile Wing at Minot Air Force Base in North Dakota; and the 341st Missile Wing at Malmstrom Air Force Base in Montana. Each wing has three squadrons, each with 50 silos for Minuteman III ICBMs controlled by five launch-control centers. During 2015, missiles were removed from 10 silos as part of the US implementation of New START and another 40 silos will be emptied before the treaty's limit on deployed launchers has to be met by February 2018. This will leave the United States with a force of 400 deployed Minuteman ICBMs, down from 450 in 2010 when the treaty was signed. The excess 50 missiles will be removed from silos across the three bases rather than from one base.

While New START will result in a reduction of 50 deployed warheads and as many deployed missiles, the warheads and missiles will not be destroyed but kept in storage for potential redeployment if needed. Nor will the emptied silos be destroyed but instead kept "warm" and capable of reloading the stored missiles if necessary. The New START Implementation Report lists the same inventory of Minuteman IIIs in 2014 as will exist in 2018: 454 deployed and nondeployed missiles (Defense Department 2014a).

The Minuteman force is configured for two types of nuclear warheads: either the 335-kiloton W78 warhead carried in the Mk12A re-entry vehicle, or the 300-kt W87 warhead carried in the Mk21 re-entry vehicle. Each missile carries a single warhead but those equipped for W78/Mk12A can load up to three warheads in a multiple independently targetable re-entry vehicle arrangement. Those equipped for the larger and heavier W87/Mk21 can only carry one warhead each.

A multibillion-dollar, decade-long modernization program to extend the service life of the Minuteman III to 2030 is scheduled for completion in 2015. Although the United States is officially not deploying a new ICBM, the upgraded Minuteman IIIs "are basically new missiles except for the shell," according to Air Force personnel (Pampe 2012).

Part of the upgrade involves refurbishing the arming, fuzing, and firing (AF&F) component on the Mk12A and Mk21 re-entry vehicles. The publicly stated purpose of this refurbishment is to extend the vehicles' service life, but the effort appears also to involve improving the "burst height compensation" to enhance the targeting effectiveness of the warheads (Postol 2014). Priority is on replacement of the Mk21 fuze, which entered phase 6.3 in August 2013. A total of 693 fuzes are planned at a cost of nearly $830 million. The effort complements fuze upgrades underway to the Navy's W76-1/Mk4A and W88-1/Mk5 warheads. A Sandia study in 2011 determined that "significant levels of AF&F commonality are possible with existing system architectures that support use in the Mk5, Mk12A, and Mk21 re-entry systems and enable modernization goals for the future stockpile" (Sandia National Laboratories 2011). The enhanced targeting capability might also allow for lowering the yield on future IW designs.

An upgrade is also underway to the ICBM nuclear command and control system as part of the transition from the MILSTAR satellite constellation to new Advanced Extremely High Frequency (AEHF) satellites. This involves upgrading launch control terminals at the Launch Control Centers that are used to receive the Emergency Action Messages (EAMs) from the National Command Authority. The upgrade will provide "expansion in capability, enhanced operator control, and a state-of-the-art security architecture," significantly increase the speed of EAM transfer, and enable the ICBM crews to communicate with both MILSTAR and AEHF satellites. Initial Operational Capability is expected in 2016 (Oakes 2015).

The US Air Force has begun development of a next-generation ICBM, known as the Ground Based Strategic Deterrent (GBSD), which is scheduled to replace the Minuteman III in 2028–2035. The plan is to buy 642 missiles, of which 400 would be deployed and the remaining used for test launches and spares, at an estimated 30-year lifetime cost of $62.3 billion (Reif 2015b). There is some debate about how "new" the GBSD will be compared with the Minuteman III, but the Air Force specified in early January 2015 that the entire "missile stack" (rockets, fuel, guidance, and control system) will be replaced, similar to what was done during the Minuteman III life extension during the past decade-and-a-half. The GBSD payload section "will use the existing Mk12A and Mk21 Reentry Vehicles (RV) in the single and multiple RV configurations" (Air Force 2015c). A wild-card option identified in the 2010 Nuclear Posture Review Report considers "new modes of ICBM basing that enhance survivability and further reduce any incentives for prompt launch" (Defense Department 2010, x). This has led Air Force planners to consider whether to mix the existing silo-based basing with road-mobile deployment,

although doing so would significantly increase the cost of the GBSD.

The Minuteman III flight-testing program was very busy in 2015 with five live launches and several simulated launches. This included several unique events. The first test launch happened on March 23 when a Minuteman III from the 90th Missile Wing at F.E. Warren Air Force Base was launched from Vandenberg Air Force Base on what was described as the longest flight ever of a US ICBM: more than 6,000 miles (9,656-plus kilometers) (Mesnard 2015).

Yet less than a week later, on March 27, a Minuteman III from the 490th Missile Squadron of the 341st Missile Wing at Malmstrom Air Force Base was launched from Vandenberg Air Force Base on an extended-range flight to an impact point in the Pacific Ocean described by the Air Force as approximately 805 miles (1,300 kilometers) southwest of Guam (Mesnard 2015). That location would place the impact point somewhere between Palau and Papua New Guinea, or roughly 6,700 miles (10,700 kilometers) from Vandenberg, significantly longer than the March 23 flight.

The third ICBM tests took place 2 months later, on May 20, when a Minuteman III ICBM from the 90th Missile Wing at F.E. Warren Air Force Base was launched from Vandenberg into the Pacific Ocean. The command to launch the missile was transmitted by an Air Force crew onboard a US Strategic Command Airborne Command Post Navy E-6B aircraft operated by the 625th Strategic Operations Squadron.

Three months later, on 19 August, 45 years to the day that the 91st Missile Wing at Minot Air Force Base put the first US Minuteman III ICBM on alert, the 741st Missile Squadron of the 91st Missile Wing launched a Minuteman III from Vandenberg. The missile's payload contained a telemetry package used for operational testing and traveled approximately 4,200 miles (6,760 kilometers) to an impact point in the Pacific Ocean near the Kwajalein Atoll.

The fifth and final ICBM launch of 2015, conducted on October 21, occurred when a Minuteman III ICBM from the 320th Missile Squadron of the 20th Missile Wing at F.E. Warren Air Force Base was launched from Vandenberg. The missile delivered a single reentry vehicle to an impact point said to be approximately 4,200 miles (6,760 kilometers) distant, near the Kwalajein Atoll in the Pacific Ocean (Perez 2015).

It is thought that Minuteman III ICBMs are focused on targeting time-critical targets in Russia such as ICBM silos, but the extended-range test flights of 2015 were to ranges beyond Russia; they demonstrated a capability to reach targets deep inside China as well. The March 27 test flight was the second in only a week and the culmination of 3 weeks of condensed nuclear weapons flight tests that involved three Air Launched Cruise Missiles and two Minuteman III ICBM flight tests.

In addition to the live Minuteman III test-launched from Vandenberg Air Force Base, two Simulated Electronic Launch-Minuteman (SELM) exercises are conducted each year, with each of the three missile bases conducting one approximately every other year. On April 7, the 341st Missile Wing at Malmstrom Air Force Base carried out its SELM code-named Giant Pace 15-1M. The exercise included two launch control centers and six silos and involved all launch procedures, including opening the silo hatches to the point of sending the ignition signal to the rocket engines. As an extra safety precaution, 18-wheeler trucks were parked over the silo openings to prevent the missile from launching by accident.

## Nuclear-powered ballistic missile submarines

The US Navy operates a fleet of 14 Ohio-class SSBNs, of which eight operate in the Pacific from their base near Bangor, Washington, and six operate in the Atlantic from their base at Kings Bay, Georgia. Each submarine is equipped to carry up to 24 Trident II (D5) submarine-launched ballistic missiles.

Normally, 12 of the 14 submarines are considered operational, with the 13th and 14th boat in a refueling overhaul at any given time. The unclassified New START aggregate data, however, shows that not all the remaining 12 submarines are fully loaded or operational. As of 1 September 2015, for example, only 236 missiles were counted as deployed (loaded in launch tubes), 52 fewer than the full capacity of 12 boats (State Department 2016). So at most 10 of these submarines carried all their missiles at the time of the count, although some submarines might sometimes carry less than a full complement of missiles.

Moreover, commercial satellite images show that several of the 12 submarines not in a refueling overhaul are in port rather than deployed at sea. It appears that an average of 8–10 submarines are at sea at any given time. Of those, four to five are thought to be on "hard alert" in their patrol areas within striking range of designated targets, with the remaining 4–5 boats in transit to and from port or conducting exercises with other naval forces.

Since the first deterrent patrol in 1960, US SSBNs have conducted more than 4,035 deterrent patrols at

sea. During the past 15 years, operations have changed significantly, with the annual number of deterrent patrols having declined by more than half, from 64 patrols in 1999 to approximately 32 patrols in 2015. Most submarines now conduct what are called "modified alerts," which mix deterrent patrols with exercises and occasional port visits (Kristensen 2013b).

Moreover, the duration of some of the patrols has been extended significantly beyond the 90-day patrols the boats were originally designed for. In June 2014, for example, the USS Pennsylvania (SSBN-735) returned to its Kitsap Naval Submarine Base in Washington after a 140-day deterrent patrol. Several patrols in 2013 also lasted more than 100 days.

In contrast to the Cold War, when the overwhelming number of deterrent patrols took place in the Atlantic Ocean, today more than 60% of deterrent patrols take place in the Pacific Ocean, reflecting increased nuclear war planning against China and North Korea (Kristensen 2013b).

US nuclear missile submarines normally do not conduct visits to foreign ports. But on 16 September 2015, the USS Wyoming (SSBN-742) made an exception when it suddenly arrived at Faslane (Clyde) in Scotland, the base for Britain's SSBN fleet (STRATCOM 2015c). This was the first time since 2003 that a US SSBN had visited a foreign port and a subtle signal to Russia that US submarines are part of the security guarantee provided to NATO. A few weeks after the visit, a recently retired US admiral told the Associated Press that the Wyoming visit was the first of what are expected to be occasional SSBN visits to foreign ports from now on (Melia 2015). For a four-year period in the late 1970s and early 1980s, US nuclear submarines routinely conducted port visits to South Korea (Kristensen 2011a), but occasional visits continued in Europe, the Caribbean, and Pacific during the 1980s and 1990s.

In 2015, the US Navy began the process of reducing the number of missile tubes on each SSBN by four, from 24 to 20. The reduction is intended to reduce the number of submarine-launched missiles that can be deployed at any given time to no more than 240, to meet the limit on deployed strategic delivery vehicles set by New START for February 2018. The reduction will be completed in 2017.

Three versions of two basic warhead types are deployed on the SLBMs: the 100-kiloton W76-0, the new 100-kiloton W76-1, and the 455-kiloton W88. The W76-1 is a refurbished version of the W76-0, with the same yield but with enhanced safety features added. Moreover, the Mk4A re-entry body that carries the W76-1 is equipped with a new AF&F unit with improved targeting capabilities compared with the old Mk4/W76 system. Full-scale production of nearly 1,600 W76-1s is underway at the Pantex Plant in Texas and is scheduled to be completed in 2019. The Mk4A/W76-1 combination is also being supplied to the United Kingdom for use on its nuclear-powered ballistic missile submarines (Kristensen 2011b), although the warhead on the British subs is thought to be a slightly modified version of the W76.

The warhead loading of the missiles on the deployed SSBNs is not specified in the New START aggregate data, which only lists the total number of deployed strategic warheads on all accountable launchers. But since each ICBM is known to carry only one warhead and each bomber counts as one warhead, it follows that as of September 2015 the 236 deployed SLBMs carried 1,012 warheads, or an average of four to five warheads per missile. In practice the missiles probably carry three to six warheads, depending on the requirements of their particular strike package assigned under war plans. Loading a higher number of warheads reduces the missiles' range and limits targeting flexibility.

Design of the next-generation nuclear-powered ballistic missile submarine is well underway and intended to begin replacing the current submarines in the late 2020s. The new submarine, known as SSBNX, will be 2,000 tons heavier than the Ohio class submarine and equipped with 16 missile tubes rather than 24.[4] Twelve SSBNXs are planned, a reduction of two boats compared with the current fleet of 14, at an estimated cost of $98–$103 billion (of which $10 billion to $15 billion will be research and development) (CBO 2015a), or an average of $8.2–$8.6 billion per submarine. Procurement of the first boat is scheduled for 2021, with deployment on deterrent patrol starting in 2031. During the first decade of its service life, the new SSBNX will be armed with a life-extended version of the current Trident II SLBM (the D5LE), which has a new guidance system designed to "provide flexibility to support new missions" and make the missile "more accurate," according to the Navy and Draper Laboratory (Draper 2006; Naval Surface Warfare Center 2008). Starting in 2017, the D5LE will also be back-fitted onto existing Ohio class submarines for the remainder of their service life (up to 2042) and will be deployed on British submarines, as well.

Four Trident II (D5) SLBMs were test launched from two SSBNs during 2015. The first launch event took place on February 22 off the coast of San Diego when the USS Pennsylvania (SSBN-735) launched two missiles. The event, known as FCET-51 (Follow-on

Commander's Evaluation Test), represented the 154th and 155th consecutive successful Trident II D5 test flights. This was the third flight test of components for the W88 Alt 370 warhead life-extension program. The first missile had the oldest first-stage rocket motor flown to date, at more than 26 years old. The second and third stages were 22 years old. The second missile had a first-stage rocket motor that was more than 15 years old and second- and third-stage rockets that were more than 24 years old. Despite its age, the Trident II SLBM is the most reliable ballistic missile ever built.

The second flight-testing event took place over 3 days in November 2015 from the USS Kentucky (SSBN-737), which had just completed a two-and-a-half-year complex refueling overhaul. The event was known as DASO-26 (Demonstration And Shakedown Operation) and also took place in the Pacific. The first missile launched on 7 November was the first flight test of the new Mk6 guidance system for the Trident II life-extension (D5LE) scheduled for deployment from 2017. The second missile was launched on 9 November.

## Strategic bombers

The US Air Force currently operates a fleet of 20 B-2 and 93 B-52H bombers. Of those, 18 B-2s and 76 B-52Hs are nuclear-capable. New START counts 89 B-52Hs, because of installed equipment that makes some B-52Hs accountable under the treaty, even though they no longer serve a nuclear role (State Department 2016). Of the 89 accountable bombers, approximately 60 (16 B-2s and 44 B-52Hs) are thought to be assigned nuclear missions under US nuclear war plans. The bombers are organized into nine bomb squadrons in five bomb wings at three bases: Minot Air Force Base in North Dakota, Barksdale Air Force Base in Louisiana, and Whiteman Air Force Base in Missouri.

Since 2012, two new wings and three new squadrons have been added to the heavy bomber organization using Air Reserve and Air National Guard personnel. This includes the 307th Bomb Wing and its 93rd and 343rd squadrons of B-52Hs (integrated with the 2nd Bomb Wing at Barksdale Air Force Base). The other new wing, the 313th, operates the 110th Bomb Squadron with B-2 bombers (integrated with the 509th Bomb Wing at Whiteman Air Force Base). The addition of more wings and squadrons does not increase the number of nuclear bombers but enables the existing force to maintain a higher level of readiness.

Each B-2 can carry up to 16 nuclear bombs (B61-7, B61-11, and B83-1 gravity bombs), and each B-52H can carry up to 20 ALCMs (or AGM-86B). An estimated 1,000 nuclear weapons, including 528 air-launched cruise missiles, are assigned to the bombers.[5] Altogether, no more than 200–300 weapons are deployed at the bomber bases under normal circumstances, with the remaining 700–800 weapons in central storage at Kirtland Air Force Base in New Mexico. B-52H bombers are no longer assigned gravity bombs under normal circumstances.

Four nuclear modernization programs are underway for the nuclear bomber force. On 27 October 2015, the Air Force announced that it had awarded the engineering and manufacturing and early production contract to Northrop-Grumman Corporation for the next-generation long-range nuclear bomber. The new bomber, tentatively known as LRS-B (Long-Range Strike Bomber), will begin to enter service in the late 2020s to replace the B-52H and B-1B bombers during the 2030s and 2040s. The B-2 will be retained through the 2050s. The Air Force plans to buy 100 LRS-Bs at a price of at least $550 million per plane plus development and engineering costs, but there is still no official public estimate for the expected total cost of the program, which will most likely increase.

The second bomber-related nuclear modernization program underway is the B61-12 guided, standoff gravity bomb, which is intended to begin replacing all existing gravity bombs from the mid-2020s. The bomb will use a modified version of the warhead used in the current B61-4 gravity bomb. B61-12 integration drop tests have already been conducted from the B-2 bomber (and several tactical fighter jets for deployment in Europe). The B61-12, which appears to also have earth-penetration capability (Kristensen and McKinzie 2015), is expected to cost roughly $10 billion for approximately 480 bombs.

The third bomber-related nuclear modernization program is a plan to replace the ALCM (AGM-86B) with a new and more advanced long-range air-launched cruise missile known as the LRSO (Long-Range Standoff) missile. The LRSO will carry the W80-4 warhead, a modified version of the W80-1 used in the current air-launched cruise missile.[6] The military argues that the LRSO is needed to enable bombers to strike targets from well outside the range of the modern and future air-defense systems of potential adversaries, and to provide US leaders with flexible strike options in limited regional scenarios.[7]

The LRSO missile itself is entirely new, with significantly improved military capabilities compared with the ALCM, including longer range, greater accuracy, and enhanced stealth (Young 2016). This violates the

White House pledge from 2010: "The United States will not … pursue … new capabilities for nuclear weapons" (White House 2010). A US government Request for Information to the defense industry in February 2015 listed three potential options for the LRSO engine: (1) a derivative subsonic engine with up to 5% improvement over current engine technology; (2) an advanced subsonic engine with 15–20%improvement; and (3) a supersonic engine (Air Force 2015b).

Unlike the ALCM, which is only carried by the B-52H bomber, the LRSO will be integrated on the B-52H, B-2, and next-generation bomber (Kristensen 2013c). The cost of the LRSO program is in the order of $30 billion, with the first missiles scheduled for deployment in the late 2020s. The Air Force plans to buy 1,000 missiles (Reif 2015a), but there will only be enough warheads for about half of those. The excess missiles are intended to be used as spares and for test flights over the weapon's 30-year service life. Moreover, several hundred ALCMs were converted to conventional missiles (AFM-86C/D), and Air Force Global Strike Command says "we fully intend to develop a conventional version of the LRSO as a future spiral to the nuclear variant" (Wilson 2015).

Given the deployment of several new long-range conventional cruise missiles and development of even more advanced versions,[8] however, it remains to be seen if the Air Force can persuade Congress to also pay for a conventional LRSO. Indeed, the Air Force has already decided to retire the conventional ALCM and replace it with the extended-range Joint Air-to-Surface Standoff Missile. If Congress will not pay for conventional LRSOs, the plan to buy 1,000 missiles can probably be reduced by several hundred.

The fourth nuclear-related bomber modernization underway involves the nuclear command and control (C2) systems the bombers use to plan and conduct nuclear strikes. This includes the Global Aircrew Strategic Network Terminal (Global ASNT), a new high-altitude electromagnetic pulse-hardened network of fixed and mobile nuclear command and control terminals that provide wing command posts, task forces, munitions support squadrons, and mobile support teams with survivable ground-based communications to receive launch orders and disseminate them to bomber, tanker, and reconnaissance air crews. Global ASNT full operational capability is expected in 2019.

Another C2 upgrade affecting the bombers involves the FAB-T (Family of Advanced Beyond Line-of-Sight Terminals) program that replaces existing nuclear C2 terminals designed to communicate with the MILSTAR satellite constellation. The new, FAB-T extremely high frequency (EHF) terminals are designed to communicate with several satellite constellations, including AEHF satellites. FAB-T will provide protected high data rate communication for nuclear and conventional forces, to include what is officially called Presidential National Voice Conferencing. According to the Air Force, "FAB-T will provide this new, highly secure, state-of-the-art capability for [Defense Department] platforms to include strategic platforms and airborne/ground command posts via MILSTAR, AEHF, and Enhanced Polar System (EPS) satellites. FAB-T terminals will also support the critical command and control (C2) of the MILSTAR, AEHF, and EPS satellite constellations" (Air Force 2015d).

Nuclear-capable heavy B-2 and B-52H bombers conducted several important operations during 2015, some of which were part of rotational deployments to Andersen Air Force Base in Guam and occasional deployments to Darwin Air Base in Australia. Because of the deterioration of relations with Russia, the nuclear bomber mission in Europe has changed in recent years. Operation Atlantic Resolve, which uses US military forces to increase support of NATO in response to a more aggressive Russia, also has a nuclear component. As part of this development, US European Command "has forged a link between STRATCOM Bomber Assurance and Deterrence missions to NATO regional exercises" (Breedlove 2015) that has increased the nuclear bomber mission in Europe.

One example of this came on 1 April 2015, when four nuclear-capable B-52Hs took off from their bases in the United States and flew a simulated strike mission over the North Pole and North Sea. One month later, the Air Force conducted the Constant Vigilance nuclear generation exercise at Minot Air Force Base with a line-up of B-52Hs fully loaded with their nuclear-capable cruise missiles (without warheads). Later that month, two B-52Hs flew deep into the Baltic to conduct mining operations near Sweden as part of the annual Baltops exercise. And in June 2015, two B-2s and three B-52Hs forward-deployed to the RAF Fairford base in England, the second such deployment since the Russian invasion of Ukraine and annexation of Crimea in 2014. During their extended deployment, the bombers flew missions over Eastern Europe with one B-52H flying over Latvia only a few miles from the Russian border.

## Nonstrategic nuclear weapons

The United States has one type of nonstrategic weapon in its stockpile – the B61 gravity bomb. The weapon exists in three modifications, the B61-3, B61-4, and

B61-10 (two other modifications – B61-7 and B61-11 – are strategic). Approximately 500 tactical B61 bombs of all versions remain in the stockpile. A little over 180 of these (versions 3 and 4) are deployed at six bases in five European countries: Aviano (Italy), Büchel (Germany), Ghedi (Italy), Incirlik (Turkey), Kleine Brogel (Belgium), and Volkel (Netherlands).

The Belgian, Dutch and possibly Turkish air forces (with F-16 aircraft), and German and Italian air forces (with PA-200 Tornado aircraft) are assigned nuclear strike missions with US nuclear weapons. Under normal circumstances, the weapons are kept under the control of US Air Force personnel until their use is authorized by the US president and approved by NATO in a war. (A small number of the remaining nonstrategic weapons stored in the United States are for potential use by US fighter-bombers in support of allies outside Europe, including in the Middle East and Northeast Asia.)

NATO has approved a modernization of the nuclear posture in Europe through deployment at the beginning of the next decade of the B61-12 guided, standoff nuclear gravity bomb.[9] The B61-12 will use the nuclear explosive package of the B61-4, which has a maximum yield of approximately 50 kilotons, but will be equipped with a guided tail kit to increase its accuracy and standoff capability. The B61-12, which also appears to have earth-penetration capability, will be a more effective weapon that can hold at risk hardened targets that could not be destroyed with the B61-3 or B61-4, and it will enable strike planners to select lower yields for existing targets to reduce collateral damage.[10]

Integration of the B61-12 on F-15E, F-16, and PA-200 aircraft has begun. Several flight tests took place during 2015, including a fully guided drop test from an F-15E at the Tonopah Test Range in November 2015. The integration efforts will continue through 2018 (Kristensen 2014b). The F-35A is expected to become nuclear certified in 2024.

Several of the NATO allies that currently have a nuclear strike mission plan to upgrade their fighter-bombers to the stealthy US-built F-35A (Joint Strike Fighter). The Netherlands has already received its first F-35A training aircraft and the first Italian F-35A flew for the first time in September 2015 (Kingston 2015). Turkey is also acquiring the F-35A, and Belgium is considering whether to buy the F-35A or the French Rafale. Germany does not currently have a plan to replace the PA-200 Tornado in the nuclear role but is expected to extend its service life through the 2020s.

NATO's annual nuclear strike exercise, Steadfast Noon, was held at Büchel Air Base in Germany in October 2015 and included aircraft from Belgium, Germany, Greece, Italy, Turkey, and the United States. The exercise appeared to be intertwined with the Cold Igloo exercise. In addition to these operations, nuclear-capable F-16s from US fighter wings in 2015 conducted periodic deployments to the Baltic States, Poland, and Sweden.

## Notes

1 For official statements about the size of the US nuclear arsenal, see State Department (2014) and Defense Department (2010). Since 30 September 2014, when the stockpile included 4,717 warheads, it is estimated that a small number of additional warheads have been retired for a stockpile of approximately 4,670.

2 See http://www.dailyinterlake.com/news/national_world/last-deactivated-missile-silos-destroyed/article_015b7206-2039-11e4-bc77-0019bb2963f4.html.

3 For a review of the 2013 nuclear employment strategy, see Kristensen (2013a).

4 For overviews of the SSBNX program, see Brougham (2012) and O'Rourke (2012).

5 In addition to the 528 ALCMs thought to be equipped with nuclear warheads, an additional 47 missiles will be used as test-launch missiles until 2030, when the ALCM is retired. See Reif (2015a)

6 For background on the W80-4 and LRSO program, see Kristensen (2014a).

7 For a review of official statements on the LRSO mission, see Kristensen (2015a).

8 For a comparison of the capabilities of the LRSO with advanced conventional cruise missiles, see Kristensen (2015b).

9 For NATO approval of the B61-12 modernization program, see GAO (2011).

10 For analyses of the military implications of the enhanced B61-12, see Kristensen and McKinzie (2015) and Kristensen (2011c).

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