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U.S. Strategic Nuclear Forces: Background, Developments, and Issues

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Summary

Even though the United States has reduced the number of warheads deployed on its long-range missiles and bombers, consistent with the terms of the 2010 New START Treaty, it also plans to develop new delivery systems for deployment over the next 10-30 years. The 115th Congress will continue to review these programs, and the funding requested for them, during the annual authorization and appropriations process.

During the Cold War, the U.S. nuclear arsenal contained many types of delivery vehicles for nuclear weapons. The longer-range systems, which included long-range missiles based on U.S. territory, long-range missiles based on submarines, and heavy bombers that could threaten Soviet targets from their bases in the United States, are known as strategic nuclear delivery vehicles. At the end of the Cold War, in 1991, the United States deployed more than 10,000 warheads on these delivery vehicles. With the implementation of New START completed in February 2018, the United States is limited to 1,550 accountable warheads on these delivery vehicles, a restriction that will remain in place at least through 2021, while New START Treaty remains in force.

At the present time, the U.S. land-based ballistic missile force (ICBMs) consists of 400 land-based Minuteman III ICBMs, each deployed with one warhead, spread among a total of 450 operational launchers. This force is consistent with the New START Treaty. The Air Force is also modernizing the Minuteman missiles, replacing and upgrading their rocket motors, guidance systems, and other components, so that they can remain in the force through 2030. It plans to replace the missiles with a new Ground-based Strategic Deterrent around 2029.

The U.S. ballistic missile submarine fleet currently consists of 14 Trident submarines. Each has been modified to carry 20 Trident II (D-5) missiles—a reduction from 24 missiles per submarine—to meet the launcher limits in the New START Treaty. The Navy converted 4 of the original 18 Trident submarines to carry non-nuclear cruise missiles. Nine of the submarines are deployed in the Pacific Ocean and five are in the Atlantic. The Navy also has undertaken efforts to extend the life of the missiles and warheads so that they and the submarines can remain in the fleet past 2020. It is designing a new Columbia class submarine that will replace the existing fleet beginning in 2031.

The U.S. fleet of heavy bombers includes 20 B-2 bombers and 40 nuclear-capable B-52 bombers. The B-1 bomber is no longer equipped for nuclear missions. This fleet of 60 nuclear-capable aircraft is consistent with the U.S. obligations under New START. The Air Force has also begun to retire the nuclear-armed cruise missiles carried by B-52 bombers, leaving only about half the B-52 fleet equipped to carry nuclear weapons. The Air Force plans to procure both a new long-range bomber, known as the B-21, and a new long-range standoff (LRSO) cruise missile during the 2020s. DOE is also modifying and extending the life of the B61 bomb carried on B-2 bombers and fighter aircraft and the W80 warhead for cruise missiles.

The Obama Administration completed a review of the size and structure of the U.S. nuclear force, and a review of U.S. nuclear employment policy, in June 2013. This review has advised the force structure that the United States will deploy under the New START Treaty. The Trump Administration completed its review of U.S. nuclear forces in February 2018, and reaffirmed the basic contours of the current U.S. force structure and the ongoing modernization programs. The Trump Administration has also called for the development of a new low-yield warhead for deployment on Trident II (D-5) missiles. Congress will review the Administration's plans for U.S. strategic nuclear forces during the annual authorization and appropriations process, and as it assesses the costs of these plans in the current fiscal environment. This report will be updated as needed.

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Introduction

During the Cold War, the U.S. nuclear arsenal contained many types of delivery vehicles for nuclear weapons, including short-range missiles and artillery for use on the battlefield, medium-range missiles and aircraft that could strike targets beyond the theater of battle, short- and medium-range systems based on surface ships, long-range missiles based on U.S. territory and submarines, and heavy bombers that could threaten Soviet targets from their bases in the United States. The short- and medium-range systems are considered non-strategic nuclear weapons and have been referred to as battlefield, tactical, and theater nuclear weapons.[1] The long-range missiles and heavy bombers are known as strategic nuclear delivery vehicles.

In 1990, as the Cold War was drawing to a close and the Soviet Union was entering its final year, the United States had more than 12,000 nuclear warheads deployed on 1,875 strategic nuclear delivery vehicles.[2] As of July 1, 2009, according to the counting rules in the original Strategic Arms Reduction Treaty (START), the United States had reduced to 5,916 nuclear warheads on 1,188 strategic nuclear delivery vehicles.[3] Under the terms of the 2002 Strategic Offensive Reduction Treaty (known as the Moscow Treaty) between the United States and Russia, this number was to decline to no more than 2,200 operationally deployed strategic nuclear warheads by the end of 2012. The U.S. Department of State reported that the United States has already reached that level, with only 1,968 operationally deployed strategic warheads in December 2009.[4] The New START Treaty, signed by President Obama and President Medvedev on April 8, 2010, reduces those forces further, to no more than 1,550 warheads on deployed launchers and heavy bombers.[5] According to the U.S. Department of State, on February 5, 2018, the United States had 1,350 warheads on 652 deployed ICBMs, SLBMs, and heavy bombers, within a total of 800 deployed and nondeployed ICBMs, SLBMs, and heavy bombers.[6]

Although these numbers do not count the same categories of nuclear weapons, they indicate that the number of deployed warheads on U.S. strategic nuclear forces has declined significantly in the two decades following the end of the Cold War. Yet, nuclear weapons continue to play a key role in U.S. national security strategy, and the United States does not, at this time, plan to either eliminate its nuclear weapons or abandon the strategy of nuclear deterrence that has served as a core concept in U.S. national security strategy for more than 60 years. In a speech in Prague on April 5, 2009, President Obama highlighted "America's commitment to seek the peace and security of a world without nuclear weapons." But he recognized that this goal would not be

[1] For a detailed review of U.S. nonstrategic nuclear weapons see, CRS Report RL32572, *Nonstrategic Nuclear Weapons*, by Amy F. Woolf.

[2] Natural Resources Defense Council. Table of U.S. Strategic Offensive Force Loadings. Archive of Nuclear Data. http://www.nrdc.org/nuclear/nudb/datab1.asp. The same source indicates that the Soviet Union, in 1990, had just over 11,000 warheads on 2,332 strategic nuclear delivery vehicles.

[3] Russia, by the same accounting, had 3,909 warheads on 814 delivery vehicles. See U.S. Department of State, Bureau of Verification, Compliance and Inspection. Fact Sheet. START Aggregate Numbers of Strategic Offensive Weapons. October 1, 2009. Washington, DC.

[4] U.S. Department of State, Bureau of Public Affairs, *The Nuclear Nonproliferation Treaty: Promoting Disarmament*, Washington, DC, April 27, 2010, http://www.state.gov/documents/organization/141497.pdf.

[5] The parties are to meet this limit within seven years of entry-into-force, which could occur in early 2011. For more information on the New START Treaty, see CRS Report R41219, *The New START Treaty: Central Limits and Key Provisions*, by Amy F. Woolf.

[6] U.S. Department of State, Bureau of State, Bureau of Arms Control, Verification, and Compliance, New START Treaty Aggregate Numbers of Strategic Offensive Forces, Fact Sheet, Washington, https://www.state.gov/t/avc/newstart/278775.htm.

reached quickly, and probably not in his lifetime.[7] And, even though the President pledged to reduce the roles and numbers of U.S. nuclear forces, the 2010 Nuclear Posture Review noted that "the fundamental role of U.S. nuclear weapons, which will continue as long as nuclear weapons exist, is to deter nuclear attack on the United States, our allies, and partners."[8] Moreover, in the 2010 NPR and in the June 2013 Report on the Nuclear Employment Guidance of the United States,[9] the Administration indicated that the United States will pursue programs that will allow it to modernize and adjust its strategic forces so that they remain capable in coming years.

The Trump Administration emphasized its continuing support for the U.S. nuclear arsenal in its Nuclear Posture Review, which was released on February 2, 2018. This document notes that "the current threat environment and future uncertainties now necessitate a national commitment to maintain modern and effective nuclear forces, as well as the infrastructure needed to support them."[10] The report not only reaffirms the basic contours of the current U.S. force structure and the ongoing modernization programs, it also calls for the development of a new low-yield warhead for deployment on Trident II (D-5) missiles.

This report reviews the ongoing programs that will affect the expected size and shape of the U.S. strategic nuclear force structure. It begins with an overview of this force structure during the Cold War, and summarizes the reductions and changes that have occurred since 1991. It then offers details about each category of delivery vehicle—land-based intercontinental ballistic missiles (ICBMs), submarine launched ballistic missiles (SLBMs), and heavy bombers—focusing on their current deployments and ongoing and planned modernization programs. The report concludes with a discussion of issues related to decisions about the future size and shape of the U.S. strategic nuclear force.

Background: The Strategic Triad

Force Structure and Size During the Cold War

Since the early 1960s the United States has maintained a "triad" of strategic nuclear delivery vehicles. The United States first developed these three types of nuclear delivery vehicles, in large part, because each of the military services wanted to play a role in the U.S. nuclear arsenal. However, during the 1960s and 1970s, analysts developed a more reasoned rationale for the nuclear "triad." They argued that these different basing modes had complementary strengths and weaknesses. They would enhance deterrence and discourage a Soviet first strike because they complicated Soviet attack planning and ensured the survivability of a significant portion of the U.S. force in the event of a Soviet first strike.[11] The different characteristics might also strengthen the credibility of U.S. targeting strategy. For example, ICBMs eventually had the accuracy and prompt responsiveness needed to attack hardened targets such as Soviet command posts and

[7] The White House, Office of the Press Secretary, *Remarks by President Obama*, Prague, Czech Republic, April 5, 2009, http://www.whitehouse.gov/the_press_office/Remarks-By-President-Barack-Obama-In-Prague-As-Delivered/.

[8] U.S. Department of Defense, *Nuclear Posture Review*, Washington, DC, April 6, 2010, p. 15. http://www.defense.gov/npr/docs/2010%20Nuclear%20Posture%20Review%20Report.pdf.

[9] http://www.defense.gov/pubs/ReporttoCongressonUSNuclearEmploymentStrategy_Section491.pdf.

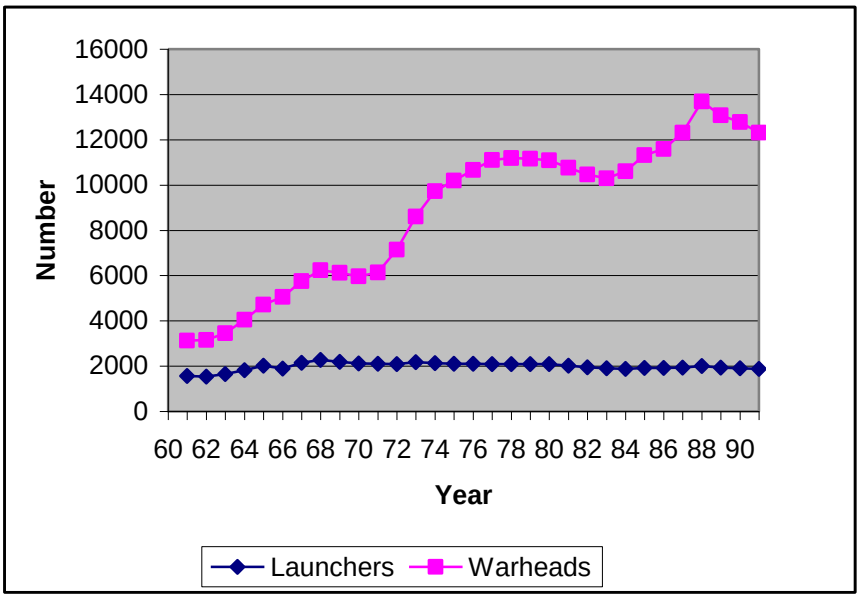
[10] Department of Defense, *Nuclear Posture Review*, Washington, DC, February 2, 2018, p. 2, https://media.defense.gov/2018/Feb/02/2001872886/-1/-1/1/2018-NUCLEAR-POSTURE-REVIEW-FINAL-REPORT.PDF.

[11] U.S. Department of Defense. *Annual Report to Congress, Fiscal Year 1989*, by Frank Carlucci, Secretary of Defense. February 18, 1988. Washington, 1988. p. 54.

ICBM silos, SLBMs had the survivability needed to complicate Soviet efforts to launch a disarming first strike and to retaliate if such an attack were attempted,[12] and heavy bombers could be dispersed quickly and launched to enhance their survivability, and they could be recalled to their bases if a crisis did not escalate into conflict.

According to unclassified estimates, the number of delivery vehicles (ICBMs, SLBMs, and nuclear-capable bombers) in the U.S. force structure grew steadily through the mid-1960s, with the greatest number of delivery vehicles, 2,268, deployed in 1967.[13] The number then held relatively steady through 1990, at between 1,875 and 2,200 ICBMs, SLBMs, and heavy bombers. The number of warheads carried on these delivery vehicles increased sharply through 1975, then, after a brief pause, again rose sharply in the early 1980s, peaking at around 13,600 warheads in 1987. **Figure 1** displays the increases in delivery vehicles and warheads between 1960, when the United States first began to deploy ICBMs, and 1990, the year before the United States and Soviet Union signed the first Strategic Arms Reduction Treaty (START).

Figure 1. U.S. Strategic Nuclear Weapons: 1960-1990



Source: Natural Resources Defense Council, Archive of Nuclear Data.

The sharp increase in warheads in the early 1970s reflects the deployment of ICBMs and SLBMs with multiple warheads, known as MIRVs (multiple independent reentry vehicles). In particular, the United States began to deploy the Minuteman III ICBM, with 3 warheads on each missile, in 1970, and the Poseidon SLBM, which could carry 10 warheads on each missile, in 1971.[14] The increase in warheads in the mid-1980s reflects the deployment of the Peacekeeper (MX) ICBM, which carried 10 warheads on each missile.

[12] In the early 1990s, SLBMs also acquired the accuracy needed to attack many hardened sites in the former Soviet Union.

[13] Natural Resources Defense Council. Table of U.S. Strategic Offensive Force Loadings. Archive of Nuclear Data. http://www.nrdc.org/nuclear/nudb/datab1.asp.

[14] GlobalSecurity.org LGM Minuteman III History and Poseidon C-3 History. http://www.globalsecurity.org/wmd/systems/lgm-30_3-hist.htm and http://www.globalsecurity.org/wmd/systems/c-3.htm.

In 1990, before it concluded the START Treaty with the Soviet Union, the United States deployed a total of around 12,304 warheads on its ICBMs, SLBMs, and heavy bombers. The ICBM force consisted of single-warhead Minuteman II missiles, 3-warhead Minuteman III missiles, and 10-warhead Peacekeeper (MX) missiles, for a total force of 2,450 warheads on 1,000 missiles. The submarine force included Poseidon submarines with Poseidon C-3 and Trident I (C-4) missiles, and the Ohio-class Trident submarines with Trident I, and some Trident II (D-5) missiles. The total force consisted of 5,216 warheads on around 600 missiles.[15] The bomber force centered on 94 B-52H bombers and 96 B-1 bombers, along with many of the older B-52G bombers and 2 of the new (at the time) B-2 bombers. This force of 260 bombers could carry over 4,648 weapons.

Force Structure and Size After the Cold War

During the 1990s, the United States reduced the numbers and types of weapons in its strategic nuclear arsenal, both as a part of its modernization process and in response to the limits in the 1991 START Treaty. The United States continued to maintain a triad of strategic nuclear forces, however, with warheads deployed on ICBMs, SLBMs, and bombers. According to the Department of Defense, this mix of forces not only offered the United States a range of capabilities and flexibility in nuclear planning and complicated an adversary's attack planning, but also hedged against unexpected problems in any single delivery system. This latter issue became more of a concern in this time period, as the United States retired many of the different types of warheads and missiles that it had deployed over the years, reducing the redundancy in its force.

The 1991 START Treaty limited the United States to a maximum of 6,000 total warheads, and 4,900 warheads on ballistic missiles, deployed on up to 1,600 strategic offensive delivery vehicles. However, the treaty did not count the actual number of warheads deployed on each type of ballistic missile or bomber. Instead, it used "counting rules" to determine how many warheads would count against the treaty's limits. For ICBMs and SLBMs, this number usually equaled the actual number of warheads deployed on the missile. Bombers, however, used a different system. Bombers that were not equipped to carry air-launched cruise missiles (the B-1 and B-2 bombers) counted as one warhead; bombers equipped to carry air-launched cruise missiles (B-52 bombers) could carry 20 missiles, but would only count as 10 warheads against the treaty limits. These rules have led to differing estimates of the numbers of warheads on U.S. strategic nuclear forces during the 1990s; some estimates count only those warheads that count against the treaty while others count all the warheads that could be carried by the deployed delivery systems.

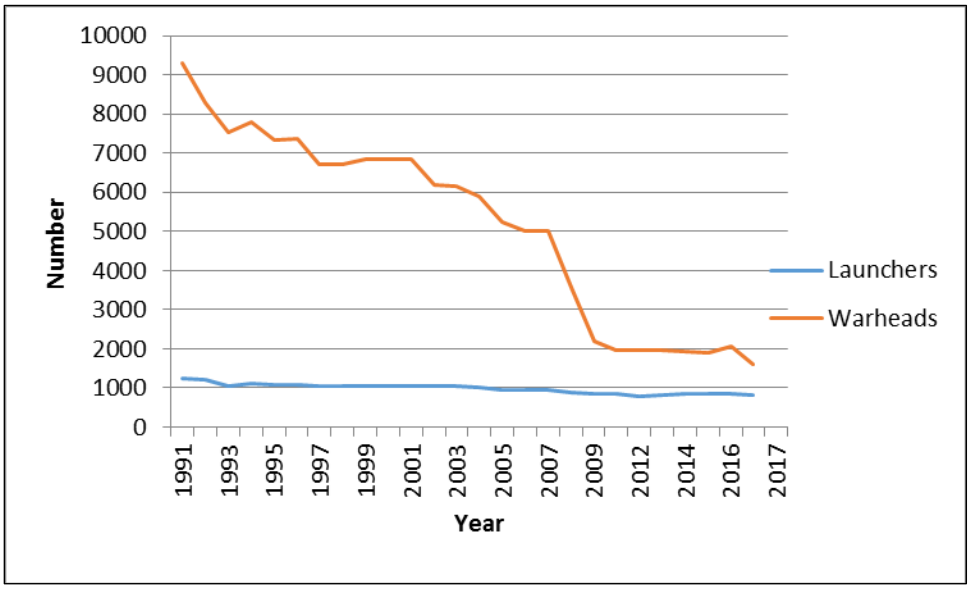
According to the data from the Natural Resources Defense Council, the United States reduced its nuclear weapons from 9,300 warheads on 1,239 delivery vehicles in 1991 to 6,196 warheads on 1,064 delivery vehicles when it completed the implementation of START in 2001. By 2009, the United States had reduced its forces to approximately 2,200 warheads on around 850 delivery vehicles. According to the U.S. Department of State, as of December 2009, the United States had 1,968 operationally deployed warheads on its strategic offensive nuclear forces.[16] NRDC estimated that these numbers held steady in 2010, prior to New START's entry into force, then began to decline again, falling to around 1,900 warheads on around 850 delivery vehicles by early

[15] The older Poseidon submarines were in the process of being retired, and the number of missiles and warheads in the submarine fleet dropped quickly in the early 1990s, to around 2,688 warheads on 336 missiles by 1993. See Natural Resources Defense Council. Table of U.S. Strategic Offensive Force Loadings. Archive of Nuclear Data. http://www.nrdc.org/nuclear/nudb/datab1.asp.

[16] U.S. Department of State, Bureau of Verification, Compliance, and Implementation, *The Legacy of START and Related U.S. Policies*, Fact Sheet, Washington, DC, July 16, 2009, http://www.state.gov/t/avc/rls/126119.htm.

2015, as the United States began to implement New START (this total includes weapons that the U.S. Department of State does not count in the New START force).[17] These numbers appear in **Figure 2**.

Figure 2. U.S. Strategic Nuclear Forces: 1991-2017



Source: Natural Resources Defense Council, Archive of Nuclear Data, Bulletin of Atomic Scientists, Nuclear Notebook.

During the 1990s, the United States continued to add to its Trident fleet, reaching a total of 18 submarines. It retired all of its remaining Poseidon submarines and all of the single-warhead Minuteman II missiles. It continued to deploy B-2 bombers, reaching a total of 21, and removed some of the older B-52G bombers from the nuclear fleet. Consequently, in 2001, its warheads were deployed on 18 Trident submarines with 24 missiles on each submarine and 6 or 8 warheads on each missile; 500 Minuteman III ICBMs, with up to 3 warheads on each missile; 50 Peacekeeper (MX) missiles, with 10 warheads on each missile; 94 B-52H bombers, with up to 20 cruise missiles on each bomber; and 21 B-2 bombers with up to 16 bombs on each aircraft.

The United States and Russia signed a second START Treaty in early 1993. Under this treaty, the United States would have had to reduce its strategic offensive nuclear weapons to between 3,000 and 3,500 accountable warheads. In 1994, the Department of Defense decided that, to meet this limit, it would deploy a force of 500 Minuteman III ICBMs with 1 warhead on each missile, 14 Trident submarines with 24 missiles on each submarine and 5 warheads on each missile, 76 B-52 bombers, and 21 B-2 bombers. The Air Force was to eliminate 50 Peacekeeper ICBMs and reorient the B-1 bombers to nonnuclear missions; the Navy would retire 4 Trident submarines (it later decided to convert these submarines to carry conventional weapons).

The START II Treaty never entered into force, and Congress prevented the Clinton Administration from reducing U.S. forces unilaterally to START II limits. Nevertheless, the Navy and Air Force continued to plan for the forces described above, and eventually implemented those changes. **Table 1** displays the forces the United States had deployed in 2001, after completing the

[17] Hans M. Kristensen and Robert S. Norris, "U.S. Nuclear Forces, 2015," *Bulletin of the Atomic Scientists*, March 2015. http://bos.sagepub.com/content/71/2/107.full.pdf+html.

START I reductions. It also includes those that it would have deployed under START II, in accordance with the 1994 decisions.

Table 1. U.S. Strategic Nuclear Forces Under START I and START II

	Deployed under START I (2001)		Planned for START II	
System	**Launchers**	**Accountable Warheads**[a]	**Launchers**	**Accountable Warheads**
Minuteman III ICBMs	500	1,200	500	500
Peacekeeper ICBMs	50	500	0	0
Trident I Missiles	168	1,008	0	0
Trident II Missiles	264	2,112	336	1,680
B-52 H Bombers (ALCM)	97	970	76	940
B-52 H Bombers (non-ALCM)	47	47	0	0
B-1 Bombers[b]	90	90	0	0
B-2 Bombers	20	20	21	336
Total	**1,237**	**5,948**	**933**	**3,456**

Source: U.S. Department of State and CRS estimates.

a. Under START I, bombers that are not equipped to carry ALCMs count as one warhead, even if they can carry up 16 nuclear bombs; bombers that are equipped to carry ALCMs count as 10 warheads, even if they can carry up to 20 ALCMs.

b. Although they still counted under START I, B-1 bombers are no longer equipped for nuclear missions.

The George W. Bush Administration stated in late 2001 that the United States would reduce its strategic nuclear forces to 1,700-2,200 "operationally deployed warheads" over the next decade.[18] This goal was codified in the 2002 Moscow Treaty. According to the Bush Administration, operationally deployed warheads were those deployed on missiles and stored near bombers on a day-to-day basis. They are the warheads that would be available immediately, or in a matter of days, to meet "immediate and unexpected contingencies."[19] The Administration also indicated that the United States would retain a triad of ICBMs, SLBMs, and heavy bombers for the foreseeable future. It did not, however, offer a rationale for this traditional "triad," although the points raised in the past about the differing and complementary capabilities of the systems probably still pertain. Admiral James Ellis, the former Commander of the U.S. Strategic Command (STRATCOM), highlighted this when he noted in a 2005 interview that the ICBM force provides responsiveness, the SLBM force provides survivability, and bombers provide flexibility and recall capability.[20]

The Bush Administration did not specify how it would reduce the U.S. arsenal from around 6,000 warheads to the lower level of 2,200 operationally deployed warheads, although it did identify some force structure changes that would account for part of the reductions. Specifically, after

[18] President Bush announced the U.S. intention to reduce its forces on November 13, 2001, during a summit with Russia's President Vladimir Putin. The United States and Russia codified these reductions in a Treaty signed in May 2002. See CRS Report RL31448, *Nuclear Arms Control: The Strategic Offensive Reductions Treaty*, by Amy F. Woolf.

[19] U.S. Senate. Committee on Armed Services. Statement of the Honorable Douglas J. Feith, Under Secretary of Defense For Policy. February 14, 2002.

[20] Hebert, Adam. The Future Missile Force. *Air Force Magazine*. October 2005.

Congress removed its restrictions,[21] the United States eliminated the 50 Peacekeeper ICBMs, reducing by 500 the total number of operationally deployed ICBM warheads. It also continued with plans to remove four Trident submarines from service, and converted those ships to carry nonnuclear guided missiles. These submarines would have counted as 476 warheads under the START Treaty's rules. These changes reduced U.S. forces to around 5,000 warheads on 950 delivery vehicles in 2006; this reduction appears in **Figure 2**. The Bush Administration also noted that two of the Trident submarines remaining in the fleet would be in overhaul at any given time. The warheads that could be carried on those submarines would not count against the Moscow Treaty limits because they would not be "operationally deployed." This would further reduce the U.S. deployed force by 200 to 400 warheads.

The Bush Administration, through the 2005 Strategic Capabilities Assessment and 2006 Quadrennial Defense Review, announced additional changes in U.S. ICBMs, SLBMs, and bomber forces; these included the elimination of 50 Minuteman III missiles and several hundred air-launched cruise missiles. (These are discussed in more detail below.) These changes appeared to be sufficient to reduce the number of operationally deployed warheads enough to meet the treaty limit of 2,200 warheads, as the United States announced, in mid-2009, that it had met this limit. Reaching this level, however, also depends on the number of warheads carried by each of the remaining Trident and Minuteman missiles.[22]

Current and Future Force Structure and Size

The Obama Administration indicated in the 2010 NPR that the United States would retain a triad of ICBMs, SLBMs, and heavy bombers as the United States reduced its forces to the limits in the 2010 New START Treaty. The NPR indicated that the unique characteristics of each leg of the triad were important to the goal of maintaining strategic stability at reduced numbers of warheads:

> Each leg of the Triad has advantages that warrant retaining all three legs at this stage of reductions. Strategic nuclear submarines (SSBNs) and the SLBMs they carry represent the most survivable leg of the U.S. nuclear Triad…. Single-warhead ICBMs contribute to stability, and like SLBMs are not vulnerable to air defenses. Unlike ICBMs and SLBMs, bombers can be visibly deployed forward, as a signal in crisis to strengthen deterrence of potential adversaries and assurance of allies and partners.[23]

Moreover, the NPR noted that "retaining sufficient force structure in each leg to allow the ability to hedge effectively by shifting weight from one Triad leg to another if necessary due to unexpected technological problems or operational vulnerabilities."[24]

The Obama Administration continued to support the triad, even as reduced U.S. nuclear forces under New START and considered whether to reduce U.S. nuclear forces further in the coming years. In April 2013, Madelyn Creedon, then the Assistant Secretary of Defense for Global

[21] Beginning in FY1996, and continuing through the end of the Clinton Administration, Congress had prohibited the use of any DOD funds for the elimination of strategic nuclear delivery vehicles, below START I levels, until START II entered into force. See, for example, the FY1998 Defense Authorization Act (P.L. 105-85, §1302). Congress lifted this restriction in the FY2002 Defense Authorization Act (P.L. 107-107, §1031).

[22] "U.S. Meets Moscow Nuclear Reduction Commitment Three Years Early," *Global Security Newswire*, February 11, 2009.

[23] U.S. Department of Defense, *Nuclear Posture Review*, Washington, DC, April 6, 2010, p. 22. http://www.defense.gov/npr/docs/2010%20Nuclear%20Posture%20Review%20Report.pdf.

[24] Ibid., p. 20.

Security Affairs, stated, "The 2010 nuclear posture review concluded that the United States will maintain a triad of ICBMs, SLBMs, and nuclear capable heavy bombers. And the president's F.Y. '14 budget request supports modernization of these nuclear forces."[25] Further, in its report on the Nuclear Employment Strategy of the United States, released in June 2013, DOD states that the United States will maintain a nuclear triad, because this is the best way to "maintain strategic stability at reasonable cost, while hedging against potential technical problems or vulnerabilities."[26]

On April 8, 2014, the Obama Administration released a report detailing the force structure that the United States would deploy under New START.[27] It indicated that, although the reductions would be complete by the treaty deadline of February 5, 2018, most of the reductions would come late in the treaty implementation period so that the plans could change, if necessary. **Table 2** displays this force structure and compares it with estimates of U.S. operational strategic nuclear forces in 2010, prior to New START's entry into force. This force structure is consistent with the statements and adjustments the Administration has made about deploying all Minuteman III missiles with a single warhead, retaining Trident submarines deployed in two oceans, and converting some number of heavy bombers to conventional-only missions.

Table 2. U.S. Strategic Nuclear Forces under New START

(Estimated Current Forces and Potential New START Forces)

	Estimated Forces, 2010		Planned Forces Under New START, 2018[a]		
	Launchers	**Warheads**	**Total Launchers**	**Deployed Launchers**	**Warheads**
Minuteman III	450	500	454	400	400
Trident	336	1,152	280	240	1,090
B-52	76	300	46	42	42
B-2	18	200	20	18	18
Total	**880**	**2,152**	**800**	**700**	**1,550**

Source: U.S. Department of Defense, Report on Plan to Implement the Nuclear Force Reductions, Limitations, and Verification, Washington, DC, April 8, 2014.

a. Under this force the United States will retain 14 Trident submarines with 2 in overhaul. In accordance with the terms of New START, the United States will eliminate 4 launchers on each submarine, so that each counts as only 20 launchers. The United States will also retain all 450 Minuteman III launchers, although only 400 would hold deployed missiles.

The Trump Administration has continued to adjust the U.S. nuclear force to meet this planned force structure. When the treaty reductions were completed in February 2018, the U.S. Department of State reported that the United States had 1,350 warheads on 652 deployed ICBMs, SLBMs, and heavy bombers, within a total of 800 deployed and nondeployed ICBMs, SLBMs,

[25] U.S. Congress, House Armed Forces, Strategic Forces, Hearing on the Proposed Fiscal 2014 Defense Authorization as it Relates to Atomic Energy Defense Activities, 113th Cong., 1st sess., May 9, 2013.

[26] U.S. Department of Defense, *Report on Nuclear Employment Strategy of the United States*, Washington, DC, June 2013, p. 5, http://www.defense.gov/pubs/reporttoCongressonUSNuclearEmploymentStrategy_Section491.pdf.

[27] U.S. Department of Defense, *Report on Plan to Implement the Nuclear Force Reductions, Limitations, and Verification*, Washington, DC, April 8, 2014, http://www.defense.gov/documents/New-START-Implementation-Report.pdf.

and heavy bombers.[28] These totals likely exclude one or two Ohio-class submarines that are completing their conversion from 24 to 20 launch tubes; when these return to the active force, the number of deployed launchers and deployed warheads is likely to reach the New START limits of 700 and 1,550, respectively. Moreover, the 2018 Nuclear Posture Review (NPR) notes that New START will remain in effect through 2021, and that the United States will continue to implement it through that date.[29] The NPR also notes that the treaty can be extended for up to five years, through 2026, but it does not indicate whether or not the United States will pursue such an extension. As a result, it does not offer any indications of how long the United States will retain a force structure consistent with New START after 2021 or whether the United States would seek to increase or reduce its deployed forces when New START expires.

At the same time, the 2018 Nuclear Posture Review reaffirms the U.S. commitment to the nuclear triad and to the modernization programs for each of the components of that force structure. It notes that "the triad's synergy and overlapping attributes help ensure the enduring survivability of our deterrence capabilities against attack and our capacity to hold a range of adversary targets at risk throughout a crisis or conflict. Eliminating any leg of the triad would greatly ease adversary attack planning and allow an adversary to concentrate resources and attention on defeating the remaining two legs."[30]

Strategic Nuclear Delivery Vehicles: Past Reductions and Current Modernization Programs

Intercontinental Ballistic Missiles (ICBMs)

Peacekeeper (MX)

In the late 1980s, the United States deployed 50 Peacekeeper ICBMs, each with 10 warheads, at silos that had held Minuteman missiles at F.E. Warren Air Force Base in Wyoming. The 1993 START II Treaty would have banned multiple warhead ICBMs, so the United States would have had to eliminate these missiles while implementing the treaty. Therefore, the Pentagon began planning for their elimination, and the Air Force added funds to its budget for this purpose in 1994. However, beginning in FY1998, Congress prohibited the Clinton Administration from spending any money on the deactivation or retirement of these missiles until START II entered into force. The Bush Administration requested $14 million in FY2002 to begin the missiles' retirement; Congress lifted the restriction and authorized the funding. The Air Force began to deactivate the missiles in October 2002, and completed the process, having removed all the missiles from their silos, in September 2005. The MK21 reentry vehicles and W87 warheads from these missiles have been placed in storage. As is noted below, the Air Force plans to redeploy some of these warheads and reentry vehicles on Minuteman III missiles, under the Safety Enhanced Reentry Vehicle (SERV) program.

[28] U.S. Department of State, Bureau of State, Bureau of Arms Control, Verification, and Compliance, New START Treaty Aggregate Numbers of Strategic Offensive Forces, Fact Sheet, Washington, DC, https://www.state.gov/t/avc/newstart/278775.htm.

[29] Department of Defense, *Nuclear Posture Review*, Washington, DC, February 2, 2018, p. 73, https://media.defense.gov/2018/Feb/02/2001872886/-1/-1/1/2018-NUCLEAR-POSTURE-REVIEW-FINAL-REPORT.PDF.

[30] Ibid., p. 43.

Under the terms of the original, 1991 START Treaty, the United States would have had to eliminate the Peacekeeper missile silos to remove the warheads on the missiles from accountability under the treaty limits. However, the Air Force retained the silos as it deactivated the missiles. Therefore, the warheads that were deployed on the Peacekeeper missiles still counted under START, even though the missiles were no longer operational, until START expired in December 2009. The United States did not, however, count any of these warheads under the limits in the Moscow Treaty. They also will not count under the limits in the New START Treaty, if the United States eliminates the silos. It will not, however, have to blow up or excavate the silos, as it would have had to do under the original START Treaty. The New START Treaty indicates that the parties can use whatever method they choose to eliminate the silos, as long as they demonstrate that the silos can no longer launch missiles. The Air Force filled the silos with gravel to eliminate them, and completed the process in February 2015.

Minuteman III

The U.S. Minuteman III ICBMs are located at three Air Force bases—F.E. Warren AFB in Wyoming, Malmstrom AFB in Montana, and Minot AFB in North Dakota. Each base houses 150 missiles.

Force Structure Changes

In the 2006 Quadrennial Defense Review (QDR), the Pentagon indicated that it planned to "reduce the number of deployed Minuteman III ballistic missiles from 500 to 450, beginning in Fiscal Year 2007."[31] The Air Force deactivated the missiles in Malmstrom's 564th Missile Squadron, which was known as the "odd squad."[32] This designation reflected that the launch control facilities for these missiles were built and installed by General Electric, while all other Minuteman launch control facilities were built by Boeing; as a result, these missiles used a different communications and launch control system than all the other Minuteman missiles. According to Air Force Space Command, the drawdown began on July 1, 2007. All of the reentry vehicles were removed from the missiles in early 2008, the missiles were all removed from their silos by the end of July 2008, and the squadron was deactivated by the end of August 2008.[33]

In testimony before the Senate Armed Services Committee, General Cartwright stated that the Air Force had decided to retire these missiles so that they could serve as test assets for the remaining force. He noted that the Air Force had to "keep a robust test program all the way through the life of the program."[34] With the test assets available before this decision, the test program would begin to run short around 2017 or 2018. The added test assets would support the program through 2025 or longer. This time line, however, raised questions about why the Air Force pressed to begin retiring the missiles in FY2007, 10 years before it would run out of test assets. Some speculated that the elimination of the 50 missiles was intended to reduce the long-term operations and maintenance costs for the fleet, particularly since the 564th Squadron used different ground control technologies and training systems than the remainder of the fleet. This option was not likely, however, to produce budgetary savings in the near term as the added cost of deactivating the missiles could exceed the reductions in operations and maintenance expenses.[35] In addition, to

[31] U.S. Department of Defense. Report of the 2006 Quadrennial Defense Review. Washington, February 2006. p. 50.

[32] Johnson, Peter. Growth Worries Base Boosters. *Great Falls Tribune*. January 19, 2006.

[33] Global Security Newswire. U.S. Deactivates 50 Strategic Missiles. August 4, 2008.

[34] U.S. Senate, Committee on Armed Services, Hearing on Global Strike Plans and Programs. Testimony of James E. Cartwright, Commander U.S. Strategic Command. March 29, 2006.

[35] Private communication.

use these missiles as test assets, the Air Force has had to include them in the modernization programs described below. This has further limited the budgetary savings.

When the Air Force decided to retire 50 ICBMs at Malmstrom, it indicated that it would retain the silos and would not destroy or eliminate them. However, with the signing of the New START Treaty in 2010, these silos added to the U.S. total of nondeployed ICBM launchers. The Air Force eliminated them in 2014, by filling them with gravel, so that the United States can comply with the New START limits by 2018.

In a pattern that has become common over the years, Congress questioned the Administration's rationale for the plan to retire 50 Minuteman missiles, indicating that it believed that more Minuteman silos increased U.S. security and strengthened deterrence. In the FY2007 Defense Authorization Act (H.R. 5122, §139), Congress stated that DOD could not spend any money to begin the withdrawal of these missiles from the active force until the Secretary of Defense submitted a report that addressed a number of issues, including (1) a detailed justification for the proposal to reduce the force from 500 to 450 missiles; (2) a detailed analysis of the strategic ramifications of continuing to equip a portion of the force with multiple independent warheads rather than single warheads; (3) an assessment of the test assets and spares required to maintain a force of 500 missiles and a force of 450 missiles through 2030; (4) an assessment of whether halting upgrades to the missiles withdrawn from the deployed force would compromise their ability to serve as test assets; and (5) a description of the plan for extending the life of the Minuteman III missile force beyond FY2030. The Secretary of Defense submitted this report to Congress in late March 2007.

Although the retirement of 50 Minuteman III missiles probably did little to reduce the cost of maintaining and operating the Minuteman fleet, this program did allow both STRATCOM and the Air Force to participate in the effort to transform the Pentagon in response to post-Cold War threats. These missiles may still have a role to play in U.S. national security strategy, but they may not be needed in the numbers that were required when the United States faced the Soviet threat.

During 2012 and 2013, Congress sought to prevent the Administration from initiating an environmental assessment that would advise the possible elimination of up to 50 silos under New START. In addition, the House Armed Services Committee included a provision in its version of the FY2015 National Defense Authorization Act (H.R. 4435, §1634) that would require the Air Force to retain all 450 ICBM silos, regardless of future force structure requirements, budgets, or arms control limits, through 2015. The provision states that "it is in the national security interests of the United States to retain the maximum number of land-based strategic missile silos and their associated infrastructure to ensure that billions of dollars in prior taxpayer investments for such silos and infrastructure are not lost through precipitous actions which may be budget-driven, cyclical, and not in the long-term strategic interests of the United States." It requires that the Secretary of Defense "preserve each intercontinental ballistic missile silo ... in warm status that enables such silo to—(1) remain a fully functioning element of the interconnected and redundant command and control system of the missile field; and (2) be made fully operational with a deployed missile."

The Air Force has continued to conduct flight tests of the Minuteman III missiles, with three live launches and several simulated launches in 2016. It conducted the first flight test of 2017 on February 8.[36] The most recent test occurred on August 2, 2017. The live launches used missiles

[36] Air Force Global Strike Command, *Minot tests Minuteman III missile with launch from Vandenberg*, Barksdale Air Force Base, LA, February 9, 2017, http://www.afgsc.af.mil/News/ArticleDisplay/tabid/2612/Article/1077316/minot-

pulled from operational wings at Minot Air Force Base and Malmstrom Air Force Base. Each missile delivered a single unarmed warhead to an impact point 4,200 miles (6,759 km) away in the Kwajalein Atoll in the Pacific Ocean.[37]

In the April 2014 report on its planned force structure under New START, the Obama Administration indicated that it planned to retain 400 deployed Minuteman III ICBMs, within a total force of 450 deployed and nondeployed launchers. According to Air Force officials, this option would allow the Air Force to deactivate missiles in silos that have been damaged by water intrusion, repair those silos, and possibly return missiles to them at a later date while it repaired additional silos. If it had eliminated some of the empty silos, it would have had to do so in complete squadrons, regardless of the silos' conditions, and would not have been able to empty and repair the most degraded silos.[38] Congress has also weighed in on this force structure, again arguing that U.S. security would benefit from the retention of more operational ICBM launchers, even if they did not contain operational missiles.

The Air Force began to implement this plan in 2013 and, according to the data exchanged under the New START Treaty, had completed the reductions by early June 2017. It now has 400 silos loaded with operational missiles.[39]

Warhead Plans

Each Minuteman III missile was initially deployed with 3 warheads, for a total of 1,500 warheads across the force. In 2001, to meet the START limit of 6,000 warheads, the United States removed 2 warheads from each of the 150 Minuteman missiles at F.E. Warren AFB,[40] reducing the Minuteman III force to 1,200 total warheads. In the process, the Air Force also removed and destroyed the "bulkhead," the platform on the reentry vehicle, so that, in accordance with START rules, these missiles can no longer carry three warheads.

Under START II, the United States would have had to download all the Minuteman III missiles to one warhead each. Although the Bush Administration initially endorsed the plan to download all Minuteman ICBMs, this plan apparently changed. In an interview with *Air Force Magazine* in October 2003, General Robert Smolen indicated that the Air Force would maintain the ability to deploy these 500 missiles with up to 800 warheads.[41] Although some analysts interpreted this statement to mean that the Minuteman ICBMs would carry 800 warheads on a day-to-day basis, it seems more likely that this was a reference to the Air Force intent to maintain the ability to reload warheads, and reconstitute the force, if circumstances changed.[42] The 2001 NPR had indicated that the United States would maintain the flexibility to do this. However, in testimony before the Senate Armed Services Committee, General Cartwright also indicated that some Minuteman missiles might carry more than one warhead. Specifically, when discussing the reduction from

tests-minuteman-iii-missile-with-launch-from-vandenberg.aspx#.WJyUFJu-LXc.twitter.

[37] Hans M. Kristensen and Robert S. Norris, "U.S. Nuclear Forces, 2017," *Bulletin of the Atomic Scientists*, January 2017, http://www.tandfonline.com/doi/full/10.1080/00963402.2016.1264213.

[38] Gabe Starosta, "On New START, Timing Begins to Limit Force-Structure Alternatives," *InsideDefense.com*, May 14, 2013.

[39] Captain Esther Willet, 90th Missile Wing Public Affairs, "AF Meets New START Treaty Requirements," June 28, 2017, http://www.afgsc.af.mil/News/Article-Display/Article/1234307/af-meets-new-start-requirements/.

[40] See Robert S. Norris and Hans M. Kristensen. U.S. Nuclear Forces, 2016. Bulletin of the Atomic Scientists. January/February 2006.

[41] Hebert, Adam. The Future Missile Force. *Air Force Magazine*. October 2005.

[42] See, for example, Jeffrey Lewis. STRATCOM Hearts MIRV. ArmsControlWonk.com, January 30, 2006.

500 to 450 missiles, he said, "this is not a reduction in the number of warheads deployed. They will just merely be re-distributed on the missiles."[43] Major General Deppe confirmed that the Air Force would retain some Minuteman III missiles with more than one warhead when he noted, in a speech in mid-April 2007, that the remaining 450 Minuteman III missiles could be deployed with one, two, or three warheads.[44]

In the 2010 NPR, the Obama Administration indicated that, under the New START Treaty, all of the U.S. Minuteman III missiles will carry only one warhead. It indicated that this configuration would "enhance the stability of the nuclear balance by reducing incentives for either side to strike first."[45] The Air Force completed the downloading process, leaving all Minuteman III missiles with a single warhead, on June 16, 2014.[46]

Unlike under START, the United States did not have to alter the front end of the missile or remove the old bulkhead. As a result, the United States could restore warheads to its ICBM force if the international security environment changed. Moreover, this plan could have changed, if, in an effort to reduce the cost of the ICBM force under New START, the Administration had decided to reduce the number of Minuteman III missiles further in the coming years. Reports indicate that the Pentagon may have reviewed such an option as a part of its NPR implementation study, but, as the report released on April 8, 2014, indicated, it did not decide to pursue this approach. As a result, under New START, each of the 400 deployed Minuteman III missiles now carries a single warhead.[47]

Minuteman Modernization Programs

Over the past 20 years, the Air Force pursued several programs that were designed to improve the accuracy and reliability of the Minuteman fleet and to "support the operational capability of the Minuteman ICBM through 2030." According to some estimates, this effort has cost $6 billion-$7 billion.[48] This section describes several of the key programs in this effort.

Propulsion Replacement Program (PRP)

The program began in 1998 and has been replacing the propellant, the solid rocket fuel, in the Minuteman motors to extend the life of the rocket motors. A consortium led by Northrup Grumman poured the new fuel into the first and second stages and remanufactured the third stages of the missiles. According to the Air Force, as of early August, 2007, 325 missiles, or 72% of the fleet, had completed the PRP program; this number increased to around 80% by mid-2008. The Air Force purchased the final 56 booster sets, for a total of 601, with its funding in FY2008.

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[43] See, U.S. Senate, Committee on Armed Services, Hearing on Global Strike Plans and Programs. Testimony of James E. Cartwright, Commander U.S. Strategic Command. March 29, 2006.

[44] Sirak, Michael. Air Force Prepared To Draaw Down Minuteman III Fleet by 50 Missiles. Defense Daily. April 17, 2007.

[45] Single-warhead ICBMs are considered to be stabilizing because it would take two attacking warheads to destroy the silo. If each side has approximately the same number of warheads, than an attack on a single warhead missile would cost more warheads than it would kill, and, therefore, would not be considered to be lucrative.

[46] Jenn Rowell, "Last Malmstron ICBM Reconfigured Under Treaty," *Great Falls Tribune*, June 18, 2014.

[47] Department of Defense, *Nuclear Posture Review*, Washington, DC, February 2, 2018, p. 45, https://media.defense.gov/2018/Feb/02/2001872886/-1/-1/1/2018-NUCLEAR-POSTURE-REVIEW-FINAL-REPORT.PDF.

[48] Robert S. Norris and Hans M. Kristensen. U.S. Nuclear Forces, 2006. Bulletin of the Atomic Scientists. January/February 2006.

Funding in FY2009 supported the assembly of the remaining boosters. The Air Force completed the PRP program in 2013.[49] In the FY2007 Defense Authorization Act (P.L. 109-364) and the FY2007 Defense Appropriations Act (P.L. 109-289), the 109th Congress indicated that it would not support efforts to end this program early. However, in its budget request for FY2010, the Air Force indicated that FY2009 was the last year for funding for the program, as the program was nearing completion.

Guidance Replacement Program (GRP)

The Guidance Replacement Program has extended the service life of the Minuteman missiles' guidance set, and improved the maintainability and reliability of guidance sets. It replaced aging parts with more modern and reliable technologies, while maintaining the accuracy of the missiles.[50] Flight testing for the new system began in 1998, and, at the time, it exceeded its operational requirements. Production began in 2000, and the Air Force purchased 652 of the new guidance units. Press reports indicate that the system had some problems with accuracy during its testing program.[51] The Air Force eventually identified and corrected the problems in 2002 and 2003. According to the Air Force, 425 Minuteman III missiles were upgraded with the new guidance packages as of early August 2007. The Air Force had been taking delivery of 5 to 7 new guidance units each month, for a total of 652 units. Boeing reported that it had delivered the final guidance set in early February 2009. The Air Force did not request any additional funding for this program in FY2010. However, it did request $1.2 million in FY2011 and $0.6 million in FY2012 to complete the program. It has not requested additional funding in subsequent years.

Propulsion System Rocket Engine Program (PSRE)

According to the Air Force, the Propulsion System Rocket Engine (PSRE) program is designed to rebuild and replace Minuteman postboost propulsion system components that were produced in the 1970s. The Air Force has been replacing, rather than repairing this system because original replacement parts, materials, and components are no longer available. This program is designed to reduce the life-cycle costs of the Minuteman missiles and maintain their reliability through 2020. The Air Force plans to purchase a total of 574 units for this program. Through FY2009, the Air Force had purchased 441 units, at a cost of $128 million. It requested an additional $26.2 million to purchase another 96 units in FY2010 and $21.5 million to purchase 37 units in FY2011. This would complete the purchase of the units. As a result, the budget for FY2012 does not support the purchase of any additional units, but does include $26.1 million for continuing work installing the units. The FY2013 budget request contained $10.8 million for the same purpose. The Air Force has not requested additional funding in subsequent years.

Rapid Execution and Combat Targeting (REACT) Service Life Extension Program

The REACT targeting system was first installed in Minuteman launch control centers in the mid-1990s. This technology allowed for a significant reduction in the amount of time it would take to retarget the missiles, automated routine functions to reduce the workload for the crews, and replaced obsolete equipment.[52] In 2006, the Air Force began to deploy a modernized version of

[49] Sirak, Michael. Minuteman Fleet has Life Beyond 2020, Says Senior Air Force Space Official. Defense Daily. June 14, 2006.

[50] LGM Minuteman III Modernization. Globalsecurity.org.

[51] Donnelly, John M. Air Force Defends Spending Half A Billion on Iffy ICBMs. *Defense Week*. September 10, 2001. p. 1.

[52] LGM Minuteman III Modernization. Globalsecurity.org.

this system to extend its service life and to update the command and control capability of the launch control centers. This program will allow for more rapid retargeting of ICBMs, a capability identified in the Nuclear Posture Review as essential to the future nuclear force. The Air Force completed this effort in late 2006.

Safety Enhanced Reentry Vehicle (SERV)

As was noted above, under the SERV program, the Air Force plans to deploy MK21/W-87 reentry vehicles removed from Peacekeeper ICBMs on the Minuteman missiles, replacing the older MK12/W62 and MK12A/W78 reentry vehicles. To do this, the Air Force must modify the software, change the mounting on the missile, and change the support equipment. According to Air Force Space Command, the SERV program conducted three flight tests in 2005 and cancelled a fourth test because the first three were so successful.[53] The Air Force installed 20 of the kits for the new reentry vehicles on the Minuteman missiles at F.E. Warren Air Force Base in 2006. The process began at Malmstrom in July 2007 and at Minot in July 2008. As of early August 2007, 47 missiles had been modified. The Air Force purchase an additional 111 modification kits in FY2009, for a total of 570 kits. This was the last year that it planned to request funding for the program. It completed the installation process by 2012.

This program will likely ensure the reliability and effectiveness of the Minuteman III missiles throughout their planned deployments. The W-87 warheads entered the U.S. arsenal in 1986 and were refurbished in 2005. This process extended their service life past 2025.[54]

Solid Rocket Motor Warm Line Program

In the FY2009 Omnibus Appropriations Bill, Congress approved a new program known as the Solid Rocket Motor Warm Line Program. According to Air Force budget documents, this program was intended to "sustain and maintain the unique manufacturing and engineering infrastructure necessary to preserve the Minuteman III solid rocket motor production capability" by providing funding to maintain a low rate of production of motors each year.[55] The program received $42.9 million in FY2010 and produced motors for four Minuteman ICBMs. DOD requested $44.2 million to produce motors for three additional ICBMs in FY2011. The budget request for FY2012 includes an additional $34 million to complete work on the motors purchased in prior years. The FY2013 budget did not contain any additional funding for this program area, although the Air Force continues to support the solid rocket motor production base with work funded through its Dem/Val program (described below).

ICBM Fuze Modernization

According to DOD budget documents, the ICBM fuze modernization program will replace the current MK21 fuze to "meet warfighter requirements and maintain current capability through 2030." This program is needed because the current fuzes have long exceeded their original 10-year life span and the Strategic Command (STRATCOM) does not have enough fuzes available to meet its requirements. According to DOD, the Air force had initially expected to procure around 700 modernized fuzes for the Minuteman fleet. But the new fuzes will also be deployed on the missile that will eventually replace the Minuteman system—the Ground Based Strategic

[53] Lt. Gen. Frank G. Klotz, Vice Commander, Air Force Space Command. Transcript of Speech to the National Defense University Breakfast. June 13, 2006.

[54] Tom Collina, *Fact Sheet: U.S. Nuclear Modernization*, Arms Control Association, Washington, DC, January 5, 2009, http://www.armscontrol.org/USNuclearModernization.

[55] http://www.saffm.hq.af.mil/shared/media/document/AFD-100128-067.pdf.

Deterrent (GBSD), which is discussed in more detail below—eventually leading to a much larger program as the Air Force plans to acquire nearly 650 new missiles.

According to the Air Force FY2019 budget request, "the ICBM fuze modernization program will leverage technologies, parts, components, and development/production capabilities resulting from extensive fuze modernization work performed by the U.S. Navy and NNSA" in support of the modernization of a fuze used on submarine-launched ballistic missiles. The Air Force and Navy have been seeking to employ common fuze components, in an effort supported by Congress, to increase efficiency and reduce costs. According to the Air Force, some of the common components include the radar module, the thermal battery assembly, and the path length module. Other fuze components may also use common technologies.

Funding for the fuze modernization program has begun to accelerate. The Air Force received $57.9 million for this program in FY2015, $142 million in FY2016, and $189.8 million for FY2017. The Air Force, in its budget for FY2018, has requested $179 million for the fuze modernization program. Congress authorized this funding in the FY2018 National Defense Authorization Act (P.L. 115-91). The Air Force has requested $172.9 million for this program in FY2019. The budget documents show that the program will continue to be funded at more than $130 million per year in FY2020 and FY2021, but will decline to $60 million in FY2022 and only $2 million in FY2023.

ICBM Dem/Val Program

The Air Force has also funded, through its RDT&E budget, a number of programs under the ICBM Dem/Val (demonstration and validation) title that are expected to allow it to mature technologies that might support both the existing Minuteman fleet and the future ICBM program (known as the Ground Based Strategic Deterrent). Congress appropriated $72.9 million for these programs in FY2014, $30.9 million in FY2015, $39.8 million in FY2016, and 108.7 million for FY2017.

With the FY2017 budget request, the Air Force moved this program element into the program element for the ground-based strategic deterrent. Hence, although these projects are designed to support both the Minuteman force and the future force, they will likely begin to focus more specifically on the needs of the new missile. In its FY2018 budget request, the Air Force sought only $10.7 million for the Dem/Val program. This represents a significant reduction from the FY2017 level and from the FY2018 funding anticipated in the FY2017 budget documents. The Air Force notes, in its FY2018budget documents, that the FY2018 funding "reflected a realignment of $61.868M to higher Air Force priorities." When asked about this realignment, Air Force Vice Chief of Staff General Stephen Wilson noted that it was not a sign of waning support for the nuclear weapons modernization programs in the Air Force, but was specific to issues affecting only that program.[56] The Air Force has requested $41.9 million for this program area in the FY2019 budget.

The projects funded through the Dem/Val program area include ICBM guidance applications, ICBM propulsion applications, reentry vehicle applications, and command and control applications. In the area of guidance applications, DOD is seeking to "identify, develop, analyze, and evaluate advanced strategic guidance technologies, such as a new solid-state guidance system, for the ICBM fleet."[57] This new system would increase the accuracy of the ICBM force

[56] Rachal Karas, "Air Force Moving Money From B61, ICBM Upgrades to Fund 'Higher Priorities,'" *Inside Defense*, May 26, 2017.

[57] Elaine Grossman, "Key Targeting Tech for Future U.S. Nuclear Missile has Gone Unfunded," *Nextgov.com*, August

and allow the missiles to destroy hardened targets with a single warhead. However, recent press reports question whether this program is meeting the needs outlined by the Air Force and whether it will produce guidance technologies that can provide the needed increases in ICBM accuracy.[58]

In the area of propulsion applications, DOD is, among other things, "exploring improvements and/or alternatives to current propulsion systems." This program area is specifically seeking to support the solid rocket motor research and development industrial base, so that it will have the capacity to support the ICBM force when the Air Force begins the procurement of its new ground-based strategic deterrent. In the area of reentry vehicle applications, DOD is seeking to both support reentry systems beyond their original design life and develop and test advanced technologies to meet future requirements. The area of command and control applications "evaluates and develops assured, survivable, and secure communications and battlespace awareness." It is focusing on both skills and technologies needed to meet current and future requirements.

Ground-Based Strategic Deterrent (GBSD)

In 2002, the Air Force began to explore its options for a new missile to replace the Minuteman III, with the intent to begin deploying a new missile in 2018. It reportedly produced a "mission needs statement" at that time, and then began an Analysis of Alternatives (AOA) in 2004.[59] In June 2006, General Frank Klotz indicated that, after completing the AOA, Air Force Space Command had decided to recommend "an evolutionary approach to the replacement of the Minuteman III capability,"[60] which would continue to modernize the components of the existing missiles rather than begin from scratch to develop and produce new missiles. He indicated that Space Command supported this approach because it would be less costly than designing a new system "from scratch."

With this plan in place, the Air Force began examining the investments that might be needed to sustain the Minuteman force through 2030. According to General Robert Kehler, then Commander-in-Chief of STRATCOM, the missile should be viable throughout that time.[61] In addition, according to DOD officials, flight tests and surveillance programs should provide the Air Force with "better estimates for component age-out and system end-of-life timelines."[62]

At the same time, the Air Force has begun to consider what a follow-on system to the Minuteman III might look like for the timeframe after 2030. The Air Force began a capabilities-based assessment of its land-based deterrent in early 2011 and began a new Analysis of Alternatives (AOA) for the ICBM force in 2012 with completion expected in mid-2014.[63] According to the Air

19, 2014. http://www.thedailybeast.com/articles/2016/02/17/top-secret-u-s-nuke-war-plans-thwarted.html.

[58] Elaine M. Grossman, "Top Secret U.S., Nuke War Plans Thwarted," *The Daily Beast*, February 17, 2016.

[59] Selinger, Mark. Minuteman Replacement Study Expected to Begin Soon. Aerospace Daily and Defense Report. June 25, 2004.

[60] Lt. Gen. Frank G. Klotz, Vice Commander, Air Force Space Command. Transcript of Speech to the National Defense University Breakfast. June 13, 2006.

[61] Jason Simpson, "Kehler: Air Force Investigating Minuteman III Follow-On System," *Inside the Air Force*, October 8, 2009. See, also, Jason Simpson, "Testers See no Problems With Minuteman III Missiles Lasting to 2030," *Inside the Air Force*, September 4, 2009.

[62] See the prepared statement of Assistant Secretary of Defense Madelyn Creedon, U.S. Congress, House Armed Forces, Strategic Forces, Hearing on the Proposed Fiscal 2014 Defense Authorization as it Relates to Atomic Energy Defense Activities. 113th Cong., 1st sess., May 9. 2013.

[63] U.S. Department of Defense, *November 2010 Update to the National Defense Authorization Act of FY2010*, New START Treaty Framework and Nuclear Force Structure Plans, Washington, DC, November 17, 2010, p. 11. http://www.lasg.org/CMRR/Sect1251_update_17Nov2010.pdf.

Force, it requested $2.6 million to begin the study in the FY2012 budget. The FY2013 budget request included $11.7 million for a new project area known as Ground-based Strategic Deterrence (GBSD). According to the Air Force, this effort, which was previously funded under Long-Range Planning, included funding to begin the Analysis of Alternatives (AOA). The FY2014 budget request included $9.4 million to continue this study.

In early January 2013, the Air Force Nuclear Weapons Center issued a "Broad Agency Announcement (BAA)" seeking white papers for concepts "that address modernization or replacement of the ground-based leg of the nuclear triad." The papers produced as a part of this study served as an early evaluation of alternatives for the future of the ICBM force, and may have helped select those concepts that will be included in the formal Analysis of Alternatives. According to the BAA, the Air Force Nuclear Weapons Center created five possible paths for further analysis. These include one that would continue to use the current Minuteman III baseline until 2075 without seeking to close gaps in the missiles' capabilities, one that would incorporate incremental changes into the current Minuteman III system to close gaps in capabilities, one that would design a new, fixed ICBM system to replace the Minuteman III, one that would design a new mobile ICBM system, and one that would design a new tunnel-based system.

Some analysts expressed surprise at the possibility that the Air Force would consider deploying a new ICBM on mobile launchers or in tunnels. During the Cold War, the Air Force considered these types of deployment concepts as a way to increase the survivability of the ICBM force when faced with possibility of an attack with hundreds, or thousands, of Soviet warheads. Even during the Cold War, these concepts proved to be very expensive and impractical, and they were dropped from consideration after the demise of the Soviet Union and in the face of deep reductions in the numbers of U.S. and Russian warheads. Some analysts saw the Air Force's possible renewed interest in these concepts as a step backward; they argued that the United States should consider retiring its ICBM force, and should not consider new, expensive schemes to increase the missiles' capabilities. Others, however, noted that the presence of these concepts in the study did not mean that the Air Force would move in this direction. They noted that the 2010 NPR mentioned the possibility of mobile basing for ICBMs as a way to increase warning and decision time, so it should not be a surprise to see requests for further study. However, the cost and complexity of mobile ICBM basing has, again, eliminated these concepts from further consideration.

According to press reports, this AOA was completed in 2014 and briefed to industry officials in July 2014. The Air Force had reportedly decided to pursue a "hybrid" plan for the next generation ICBM. It would maintain the basic design of the missile, the current communications system, and the existing launch silos, but would replace the rocket motors, guidance sets, postboost vehicles, and reentry systems. Reports indicated that, although this missile would be deployed in fixed silos, the design would allow the missiles to be deployed on mobile launchers sometime in the future.[64]

However, in recent documents, the Air Force has indicated that the GBSD program "will replace the entire flight system, retaining the silo basing mode while recapitalizing the ground facilities." While this seemed to indicate that there would be a greater level of effort to modernize the silos and launch control facilities, it did not resolve questions about whether the Air Force would continue to retain the option of deploying the missiles on mobile launchers and how much such an option might cost. Nevertheless, there seemed to be some indications that the cost of such an

[64] Elaine Grossman, "Key Targeting Tech for Future U.S. Nuclear Missile has Gone Unfunded," *Nextgov.com*, August 19, 2014.

option might be prohibitive, and that the priority is on designing a new missile that would be deployed in fixed silos, although mobile launch control facilities remain a possibility.

The Air Force received $75 million for the GBSD program in FY2016 and an additional $113 million for FY2017. It requested $215.7 million for FY2018, a reduction from the $294 million for FY2018 expected in the FY2017 budget documents. The Air Force noted that this reduction of $78.2 million occurred to align the program with an Independent Cost Estimate conducted by DOD. Congress authorized $215.7 million for the GBSD in the National Defense Authorization Act for 2018 (P.L. 115-91). The Defense Authorization Act for 2017 (P.L. 114-328) also included a provision stating that none funds available in FY2017 or FY2018 could be "obligated or expended to retain the option for, or develop, a mobile variant of the ground-based strategic deterrent missile." The NDAA for 2018 extended this prohibition through FY2019.

The Air Force has requested $345 million for the GBSD program in FY2019. The budget documents show that the cost of the program will rise rapidly over the next few years, to $570.4 million in FY2020, $1.5 billion in FY2021, $2.5 billion in FY2022, and $3 billion in FY2023. According to DOD budget documents, the Air Force is seeking to deliver "an integrated flight system" beginning in FY2029, with booster production beginning in FY2026. In FY2017, the Air Force awarded two contracts for the Technology Maturation and Risk Reduction (TMRR) phase of the program, which will run through FY2020. The goals of this phase are for the contractors to deliver the preliminary design of a "modular, integrated weapon system" and to "mature technologies related to the major activities and demonstrate performance of sub-system capabilities through prototyping, modeling, and simulation."

According to press reports, the Air Force estimated, in 2015, that the program would cost a total of $62.3 billion, in then-year dollars, over 30 years. This included $48.5 billion for the acquisition of 642 missiles, $6.9 billion for command and control systems, and $6.9 billion to renovate the launch control centers.[65] The 642 missiles would support testing and deployment of a force of 400 missiles. Recent reports indicate that the Pentagon's Cost Analysis and Program Evaluation Office (CAPE) estimated that the program would cost $85 billion over that time, with $22.6 billion for research and development, $61.5 billion for procurement, and $718 million for related military construction.[66] The Air Force has indicated that the $23 billion difference in estimates is due to the fact that CAPE used different assumptions and a different methodology in its analysis, in part, because the United States has not designed and produced long-range missiles in decades.

Normally, DOD would require that the Air Force and CAPE agree on a cost estimate before the program could proceed, but it seems that this will not be the case with the GBSD. Deborah Lee James, the Secretary of the Air Force at the end of the Obama Administration, indicated that it could take a year or more to refine cost estimates, based on the submissions received by defense industry as they bid on the program.[67]

Press reports indicate that the system would reach its initial operational capacity, with 9 missiles on alert, by 2029 and would complete the deployment with 400 missiles on alert in 2036.[68] The Air Force, however, plans to install new command and control systems in all 450 existing launch

[65] Kingston Reif, "Air Force Drafts Plan for Follow-on ICBM," *Arms Control Today*, July/August 2015.

[66] Anthony Carpaccio, "America's New Nuclear Armed Missile Could Cost $85 Billion," *Bloomberg News*, September 6, 2016.

[67] Aaron Mehta, "Planned ICBM Replacement To Move Forward Without Consensus," *Defense News*, September 19, 2016, http://www.defensenews.com/articles/james-new-icbm-cost-question-will-not-impact-next-budget.

[68] Brian Bradley, "GBSD Scheduled to Reach IOC in FY'29," *Nuclear Security and Deterrence Monitor*, August 7, 2015.

silos by 2037. According to recent reports, the missile will employ an "open architecture" so that technologies can be upgraded as needed, through the expected 60-year life of the missile. According to officials at Boeing, this modular, open architecture will help keep down the costs of maintenance and upgrades.[69] Moreover, by designing a completely new system, officials believe the Air Force can acquire a more modern, capable, and flexible system at a lower cost than needed to complete another life extension of the Minuteman III. The new system would be "flexible for a wide range of scenarios" and would have improved performance "against modern, precision-guided missile defenses."[70]

Submarine Launched Ballistic Missiles

The U.S. fleet of ballistic missile submarines consists of 14 Trident (Ohio-class) submarines, each originally equipped to carry 24 Trident missiles. With 2 submarines in overhaul, the operational fleet of 12 submarines currently carries around 1,100 warheads. To comply with the launcher limits in New START, each of the submarines can now carry only 20 missiles. The four empty launch tubes have been removed from accountability under New START after being modified so that they can no longer carry or launch missiles. As a result, the 14 submarines count as a total of 280 deployed and nondeployed launchers, with 240 deployed launchers counting on the 12 operational submarines.

By the early 1990s, the United States had completed the deployment of 18 Trident ballistic missile submarines (SSBNs). Each of these submarines was equipped to carry 24 Trident missiles, and each missile could carry up to 8 warheads (either W-76 warheads or the larger W-88 warheads on the Trident II missile). The Navy initially deployed eight of these submarines at Bangor, WA, and all eight were equipped with the older Trident I missile. It then deployed 10 submarines, all equipped with the Trident II missile, at Kings Bay, GA. During the 1994 Nuclear Posture Review, the Clinton Administration decided that the United States would reduce the size of its Trident fleet to 14 submarines, and that 4 of the older submarines would be "backfit" to carry the Trident II missile.

The Bush Administration's 2001 Nuclear Posture Review endorsed the plan to backfit four of the Trident submarines so that all would carry Trident II missiles. It also indicated that, instead of retiring the remaining four submarines, the Navy would convert them to carry conventional weapons, and designated them "guided missile" submarines (SSGNs). The 2010 NPR also endorsed a force of 14 Trident submarines, although it noted that it might reduce that force to 12 submarines in the latter half of this decade. As was noted above, each submarine will deploy with only 20 missiles to meet the reductions in New START. As a result, the U.S. ballistic missile submarine (SSBN) force may continue to consist of 14 Trident submarines, with 2 in overhaul, through New START implementation.

The SSGN Program

The Navy converted four Trident submarines (the USS *Ohio*, USS *Michigan*, USS *Florida*, and USS *Georgia*) to carry conventional cruise missiles and other conventional weapons. Reports indicate that the conversion process took approximately $1 billion and two years for each of the

[69] Stew Magnuson, "Air Force on a Long Road to Replace Minuteman III," *National Defense*, July 23, 2017.

[70] Sydney Freedberg Jr., "New ICBM Cheaper Than Upgraded Minuteman: Boeing on GBSD," *Breaking Defense*, August 2, 2017.

four submarines. The SSGNs can each carry 154 Tomahawk cruise missiles, along with up to 100 special forces troops and their mini-submarines.[71]

The first two submarines scheduled for this conversion were removed from the nuclear fleet in early 2003. They were slated to receive their engineering overhaul, then to begin the conversion process in 2004.[72] The first to complete the process, the USS *Ohio* returned to service as an SSGN in January 2006[73] and achieved operational status on November 1, 2007. According to the Navy, the *Georgia* was scheduled for deployment in March 2008, and the other submarines were scheduled to reach that status later in the year.[74] According to Admiral Stephen Johnson, the Director of the Navy's Strategic Submarine Program (SSP), all four of the submarines had returned to service by mid-2008, and two were forward-deployed on routine patrols. According to the Navy, these submarines are likely to remain in service through the mid-2020s.

The Backfit Program

As was noted above, both the 1994 and 2001 Nuclear Posture Reviews confirmed that the Navy would backfit four Trident submarines so that they could carry the newer Trident II (D-5) missile. This process not only allowed the Navy to replace the aging C-4 missiles, it also equipped the fleet with a missile that has improved accuracy and a larger payload. With its greater range, it would allow the submarines to operate in a larger area and cover a greater range of targets. These characteristics were valued when the system was designed and the United States sought to enhance its ability to deter the Soviet Union. The Bush Administration believed that the range, payload, and flexibility of the Trident submarines and D-5 missiles remained relevant in an era when the United States may seek to deter or defeat a wider range of adversaries. The Obama Administration has emphasized that, by providing the United States with a secure second strike capability, these submarines enhance strategic stability.

Four of the eight Trident submarines based in Bangor, WA (USS *Alaska*, USS *Nevada*, USS *Henry M. Jackson*, and USS *Alabama*) were a part of the backfit program. The *Alaska* and *Nevada* both began the process in 2001; the *Alaska* completed its backfit and rejoined the fleet in March 2002 and the *Nevada* did the same in August 2002. During the process, the submarines underwent a preplanned engineered refueling overhaul, which accomplishes a number of maintenance objectives, including refueling of the reactor, repairing and upgrading some equipment, replacing obsolete equipment, repairing or upgrading the ballistic missile systems, and other minor alterations.[75] The submarines also are fit with the Trident II missiles and the operating systems that are unique to these missiles. According to the Navy, both of these efforts came in ahead of schedule and under budget. The *Henry M. Jackson* and *Alabama* were completed their engineering overhaul and backfit in FY2006 and reentered the fleet in 2007 and 2008.

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[71] Connolly, Allison. For Four Subs, Its Good-bye Ballistic Missiles, Hello SEALs. Norfolk Virginia Pilot. December 18, 2004.

[72] Ohio Class SSGN Tactical Trident. GlobalSecurity.org http://www.globalsecurity.org/military/systems/ship/ssgn-726.htm.

[73] First Trident Submarine Converted. Associated Press. January 10, 2006.

[74] U.S. Congress. Senate. Armed Services Committee, Subcommittee on Strategic Forces. Fiscal Year 2008 Strategic Forces Program Budget. Hearing. Prepared statement of Mr. Brian R. Green, Deputy Assistant Secretary of Defense, Strategic Capabilities, p. 6. March 28, 2007. See also, Guided Missile Submarine Ohio Ready for Deployment. Inside the Navy, November 5, 2007.

[75] SSBN-726 Ohio-Class FBM Submarines, GlobalSecurity.org, http://www.globalsecurity.org/wmd/systems/ssbn-726-recent.htm.

The last of the Trident I (C-4) missiles was removed from the fleet in October 2004, when the USS *Alabama* off-loaded its missiles and began the overhaul and backfit process. All the Trident submarines currently in the U.S. fleet now carry the Trident II missile.[76]

Basing Changes

When the Navy first decided, in the mid-1990s, to maintain a Trident fleet with 14 submarines, it planned to "balance" the fleet by deploying 7 Trident submarines at each of the 2 Trident bases. The Navy would have transferred three submarines from Kings Bay to Bangor, after four of the submarines from Bangor were removed from the ballistic missile fleet, for a balance of seven submarines at each base. However, these plans changed after the Bush Administration's Nuclear Posture Review. The Navy has transferred five submarines to Bangor, "balancing" the fleet by basing nine submarines at Bangor and five submarines at Kings Bay. Because two submarines would be in overhaul at any given time, this basing plan means that seven submarines would be operational at Bangor and five would be operational at Kings Bay.

According to unclassified reports, the Navy began moving Trident submarines from Kings Bay to Bangor in 2002, and transferred the fifth submarine in September 2005.[77] This change in basing pattern apparently reflected changes in the international security environment, with fewer targets within range of submarines operating in the Atlantic, and a greater number of targets within range of submarines operating in the Pacific. In particular, the shift allows the United States to improve its coverage of targets in China and North Korea.[78] Further, as the United States modifies its nuclear targeting objectives it could alter the patrol routes for the submarines operating in both oceans, so that a greater number of emerging targets would be within range of the submarines in a short amount of time.

Warhead Loadings

The Trident II (D-5) missiles can be equipped to carry up to eight warheads each. Under the terms of the original START Treaty, which was in force from 1994 to 2009, the United States could remove warheads from Trident missiles, and reduce the number listed in the database, a process known as downloading, to comply with the treaty's limit of 6,000 warheads. The United States took advantage of this provision, reducing to six warheads per missile on the eight Trident submarines based at Bangor, WA.[79]

During the George W. Bush Administration, the Navy further reduced the number of warheads on the Trident submarines so that the United States could reduce its forces to the 2,200 deployed warheads permitted under the 2002 Moscow Treaty. The United States did not have to reach this limit until 2012, but it had done so by 2009.

The United States has continued to reduce the total numbers of warheads carried on its Trident missiles to reach the New START Treaty limits. Unlike START, which attributed the same

[76] Morris, Jefferson. Older Trident Missiles to be Phased out by Fall, Admiral Says. Aerospace Daily and Defense Report, June 17, 2005.

[77] Robert S. Norris and Hans M. Kristensen. U.S. Nuclear Forces, 2006. Bulletin of the Atomic Scientists. January/February 2006.

[78] Ibid.

[79] Even though four of these submarines are being converted to SSGNs, they still count under the START Treaty because they still have SLBM launch tubes. Each of those tubes count as six warheads. See U.S. Department of State. Bureau of Verification, Compliance, and Implementation. START Aggregate Number of Strategic Offensive Arms. April 1, 2006.

number of warheads to each missile of a given type, regardless of whether some of the missiles carried fewer warheads, the United States can deploy different numbers of warheads on different missiles, and count only the actual warheads deployed on the force. This will allow each missile to be tailored to meet the mission assigned to that missile.[80] The United States does not need to indicate how many warheads are deployed on each missile at all times; it must simply report the total number of operationally deployed warheads on all of its strategic nuclear delivery vehicles. The United States and Russia can confirm that actual number of warheads on a specific missile, with random, short-notice inspections. Moreover, the United States will not have to alter the platforms in the missiles, so it could restore warheads to its Trident missiles if circumstances changed.

Modernization Plans and Programs

The Navy initially planned to keep Trident submarines in service for 30 years, but then extended that time period to 42 years. This extension reflects the judgment that ballistic missile submarines would have operated with less demanding missions than attack submarines, and could, therefore, be expected to have a much longer operating life than the expected 30-year life of attack submarines. Therefore, since 1998, the Navy has assumed that each Trident submarine would have an expected operating lifetime of at least 42 years, with two 20-year operating cycles separated by a 2-year refueling overhaul.[81] With this schedule, the submarines will begin to retire from the fleet in 2027. The Navy has also pursued a number of programs to ensure that it has enough missiles to support this extended life for the submarines.

Trident Missile Production and Life Extension

The Navy purchased a total force of 533 missiles D-5 missiles through 2012. It continued to produce rocket motors, at a rate of around one per month, and to procure alternation kits (known as SPALTs) needed to meet the extended service life of the submarine. Although the Navy plans to deploy its submarines with only 240 ballistic missiles under New START, it needs the greater number of missiles to support the fleet throughout the their life-cycle. In addition, around 50 of the Trident missiles are available for use by Great Britain in its Trident submarines. The remainder would support the missile's test program throughout the life of the Trident system.

The Navy is also pursuing a life extension program for the Trident II missiles, so that they will remain capable and reliable throughout the 42-year life of the Trident submarines; they will also serve as the initial missile on the new Columbia class submarine. The funding for the Trident II missile supported the purchase of additional solid rocket motors other critical components required to support the missile throughout its service life. Reports indicate the Navy will begin loading the submarines with the new missile in 2017.[82]

The Navy allocated $5.5 billion to the Trident II missile program in FY2008 and FY2009. This funding supported the purchase of an additional 36 Trident II missiles. The Navy spent $1.05 billion on Trident II modifications in FY2010 and requested $1.1 billion in FY2011. In FY2010, $294 million was allocated to the purchase of 24 new missiles, $154.4 million was allocated to missile support costs, and $597.7 million was allocated to the Trident II Life Extension program. In FY2011, the Navy requested $294.9 million for the purchase of 24 new missiles, $156.9

[80] Hans M. Kristensen and Robert S. Norris, "United States Nuclear Forces, 2017," *Bulletin of the Atomic Scientists*, December 2016, p. 52.

[81] SSBN Ohio-Class FBM Submarines. GlobalSecurity.org.

[82] Hans M. Kristensen and Robert S. Norris, "U.S. Nuclear Forces, 2017," *Bulletin of the Atomic Scientists*, January 2017, http://www.tandfonline.com/doi/full/10.1080/00963402.2016.1264213.

million to missile support costs, and $655.4 million to the Trident II Life Extension Program. The FY2012 budget included $1.3 billion for Trident II missile program. Within this total, $191 million was allocated to the purchase of 24 additional new missiles, $137.8 million was allocated to missile support costs, and $980 million was allocated to the Trident II Life Extension Program. This was the last year during which the Navy sought to purchase new Trident II missiles. The FY2013 budget requested $1.2 billion for the Trident II missile program. This total included $524 million for program production and support costs, and $700.5 million for the Trident II life extension program. The Navy requested $1.14 billion for this program area in FY2014. According to the Navy's budget documents, this allowed it to continue to purchase components, such as the alteration kits for the guidance and missile electronics systems and solid rocket motors for these missiles. The Navy received $1.17 billion for FY2015 and $1.1 billion for FY2016 for Trident II modifications.

The Navy requested $1.1 billion for FY2017 and $1.2 billion for FY2018 for Trident II modifications. The Navy's budget for FY2019 includes a request for $1.1 billion for this program. Within this total, $576.5 million is allocated to the life extension program and $502 million is allocated to operating and support costs. The Navy plans to spend $4.9 billion on Trident II modifications between FY2020 and 2023.

W76 Warhead Life Extension

The overwhelming majority of Trident missiles are deployed with the MK4/W76 warhead, which, according to unclassified estimates, has a yield of 100 kilotons.[83] It is currently undergoing a life extension program (LEP) that is designed to enhance its capabilities. According to some reports, the Navy had initially planned to apply this program to around 25% of the W76 warheads, but has increased that plan to cover more than 60% of the stockpile. According to recent estimates, NNSA had completed "80% of the production units through FY2017." It expects to complete production in 2019.[84] The LEP is intended to add 30 years to the warhead life "by refurbishing the nuclear explosive package, the arming, firing, and fusing system, the gas transfer system, and associated cables, elastomers, valves, pads, cushions, foam supports, telemetries, and other miscellaneous parts."

NNSA requested $224.1 million for the W76 LEP in FY2018 and $133.9 million in FY2019. The FY2019 budget documents also introduce a new component to the W76 LEP. NNSA notes that "the 2018 Nuclear Posture Review (NPR) states that the United States will modify a small quantity of existing SLBM warheads to provide a low-yield option in the near-term." The NPR views this capability as a response to the belief that Russia, using what is often referred to as the "escalate to de-escalate" doctrine, might misjudge U.S. willingness to respond to the limited first use of nuclear weapons during a conventional conflict in Europe. The NPR argues that, by deploying a low-yield SLBM warhead, the United States will "ensure that the Russian leadership does not miscalculate regarding the consequences of limited nuclear first use" and will "understand that nuclear first-use, however limited, will fail to achieve its objectives, fundamentally alter the nature of a conflict, and trigger incalculable and intolerable costs for Moscow."[85]

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[83] Robert S. Norris and Hans M. Kristensen. U.S. Nuclear Forces, 2015. Bulletin of the Atomic Scientists. March 2015, http://bos.sagepub.com/content/71/2/107.full.pdf+html.

[84] Hans M. Kristensen and Robert S. Norris, "U.S. Nuclear Forces, 2013," March/April 2013, p. 81.

[85] U.S. Department of Defense, *Nuclear Posture Review*, Washington, DC, February 2, 2018, p. 30, https://media.defense.gov/2018/Feb/02/2001872886/-1/-1/1/2018-NUCLEAR-POSTURE-REVIEW-FINAL-REPORT.PDF.

The low-yield version of the W76 warhead has been referred to as the W76-2. NNSA's FY2019 budget request does not seem to request any funding specifically allocated to this modification, but it does note that "as the Nuclear Weapons Council translates policy into military requirements, the Administration will work with Congress for appropriate authorizations and appropriations to develop options that support the modification." NNSA could either submit a supplemental budget request to fund the program in FY2019 or wait until FY2020 to modify the warheads at the end of the W76 LEP program.

Several questions came up during the life extension program. For example, some weapons experts questioned whether the warhead's design is reliable enough to ensure that the warheads will explode at its intended yield.[86] In addition, in June 2006, an inspector general's report from the Department of Energy questioned the management practices at the National Nuclear Security Administration (NNSA), which is responsible for the LEP, arguing that management problems had led to delays and created cost overruns in the program. This raised questions about whether NNSA would be able to meet the September 2007 delivery date for the warhead,[87] and, when combined with other technical issues, delayed the delivery of the first W76 warhead until August 2008. The Navy accepted the first refurbished warhead into the stockpile in August 2009.[88]

W88 Alteration Program

While most Trident II missiles carry W76 warheads, a portion of the fleet carries the W88 warhead. This warhead, the last to be added to the U.S. nuclear stockpile, entered the force in the late 1980s. According to DOE, this warhead is also in need of work to address concerns with its safety and reliability. In particular, according to recent testimony, the W88 warhead is in the "development engineering phase for Alteration (ALT) 370 to replace the aging arming, fuzing, and firing components." In August 2014, the Nuclear Weapons Council also decided to address potential problems with the warhead's conventional high explosive during the ALT 370 program. This program received $169.5 million in FY2014, $165.4 million in FY2015, and $220.1 million in FY2016. In its FY2016 budget request, NNSA indicated that the additional funding for this program will come from offsets generated by reducing sustainment activities and the quantities of stored warheads for some other types of warheads. In essence, NNSA "identified areas where increased risk could be accepted to produce cost-savings within the current program—without additional funding—and without additional delays to future work."[89] NNSA received $281.1 million for the W88 Alteration in FY2017. It requested $332.3 million for FY2018 and $304.3 million in FY2019. The increase in funding in FY2018 reflects an expanded scope of work on the weapon. According to NNSA budget documents, this program is scheduled to produce its first production unit (FPU) in 2020.

The Ohio Replacement Program (ORP) Program

The Navy is currently conducting development and design work on a new class of ballistic missile submarines, originally known as the SSBN(X) program and the Ohio Replacement Program (ORP). The Navy has recently announced that these submarines will be known as the Columbia class; they will replace the Ohio-class Trident submarines as they reach the end of their

[86] Fleck, John. Flaws Seen in Sub-Launched Nuclear Warhead. Albuquerque Journal. July 8, 2004.

[87] Costa, Keith J. IG: Project Weaknesses put W-76 Warhead Refurbishment Plan at Risk. *InsideDefense.com*, June 8, 2006.

[88] "Navy Receives First Refurbished W-76 Warheads," *Global Security Newswire*, November 6, 2009.

[89] Ibid.

service lives.[90] The Trident submarines will begin to retire in 2027, and the Navy initially indicated that it would need the new submarines to begin to enter the fleet by 2029, before the number of Trident submarines falls below 12.[91] To do this, the Navy would have had to begin construction of its new submarine by 2019 so that it could begin to enter the fleet in 2029.[92] However, in the FY2013 budget request, the Navy delayed the procurement of the new class of submarines by two years. As a result, the first new submarine will enter the fleet in 2031 and the number of SSBNs in the fleet is expected to decline to 10 for most of the 2030s.

Costs and Funding

The SSBN(X) program received $497.4 million in research and development funding in the Navy's FY2010 budget. The Navy requested an additional $672.3 million in research and development funding for the program in its FY2011 budget proposal. The FY2012 budget included $1.07 billion to develop the SSBN(X). It expected to request $927.8 million in FY2013, with the funding of $29.4 billion between 2011 and 2020. However, with the delay of two years in the procurement of the first SSBN(X), the Navy budgeted only $565 million for the program in FY2013. It then budgeted $1.1 billion for FY2014 and $1.2 billion in FY2015. It received an additional $1.39 billion in FY2016, with $971.4 million allocated to submarine development and $419.3 million allocated to power systems.

The Navy requested an additional $1.9 billion for the Ohio-replacement (ORP) in FY2017. Within this total, $700.1 million was allocated to submarine development and $390.3 million was allocated to nuclear power systems. The Navy also requested $773.1 million for advanced procurement; this funding will support detailed design work in preparation for the beginning of construction. Both the House and the Senate authorized the requested levels of funding in their versions of the 2017 Defense Authorization Bill. The House, however, moved the $773.1 million for advanced procurement from the Navy's shipbuilding budget into the congressionally created National Sea-based Deterrent Fund (NSDF), which is described below. Congress approved the full funding requests in the FY2017 National Defense Authorization Act (P.L. 114-328), but did not transfer funding for advanced procurement to the NSDF. The Navy requested $1.9 billion for the Columbia class submarine in FY2018, with $776.2 million for submarine development, $265.5 million for advanced nuclear power systems, and $842.9 million for advanced procurement. Congress approved this request in the National Defense Authorization Act for FY2018 (H.Rept. 115-404).

The Navy has requested $3.8 billion for the Columbia Class submarine in its FY2019 budget. Within this total, $514.8 million is allocated to submarine development, $256.1 million to advanced nuclear power systems, and $3 billion to advanced procurement. According to the Navy's budget documents, the FY2019 request is "predominantly driven by procurement of the two-year long lead time" of equipment needed to begin construction of the first submarine. This equipment includes launcher and fire control subsystem components, nuclear propulsion plant equipment, and hull mechanical and electrical systems. According to the Navy, "these funds are required in October of 2018 to ensure the Columbia Program meets program schedules and the components will meet contractor in yard need dates to support on time construction start and delivery of the lead ship." Moreover, within the $3 billion requested for advanced procurement,

[90] For details on this program, see CRS Report R41129, *Navy Ohio Replacement (SSBN[X]) Ballistic Missile Submarine Program: Background and Issues for Congress*, by Ronald O'Rourke.

[91] Christopher J. Castelli, "Navy Confronts $80 Billion Cost of New Ballistic Missile Submarines," *Inside Defense*, November 3, 2009.

[92] RADM Stephen Johnson, Director, Navy Strategic Programs Office. Speech at the NDU/NDIA Seminar Series, June 23, 2009.

the largest single amount ($1.7 billion) is allocated to the "nuclear propulsion plant equipment"—the nuclear reactor that will power the submarine.

The Navy had planned to begin the detailed design for the submarine and to begin advanced procurement of critical components in FY2015, with the seven-year construction period for the first submarine beginning in FY2019. This timeline changed, in part to reduce near-term costs, but also to reduce risks in the program. With advanced procurement beginning in FY2017, the Navy plans to begin building the first hull in 2021. At the same time, it will continue to support the joint U.S./U.K. development of a common missile compartment, which both nations will use in their new SSBNs.

The Navy initially estimated that each submarine in this program could cost $6 billion to $7 billion in FY2010 dollars. It has worked to redesign the submarine and reduce the costs, with the plan to hold each submarine to around $4.9 billion, in FY2010 dollars. Officials in the Navy and analysts outside government have expressed concerns about the cost of this program, and about the effect that these costs may have on the rest of the Navy's shipbuilding plans. A study by the Congressional Budget Office indicated that the SSBN(X) program could cost a total of $97-$102 billion, in 2010 dollars, with $10-$15 billion for research and development and $87 billion for the procurement of 12 submarines.[93] A March 2015 GAO report assessing estimated the total acquisition cost of the SSBN(X) program at about $95.8 billion, in constant FY2015 dollars, including about $11.8 billion in research and development costs and about $84.0 billion in procurement costs.[94] The Navy has since estimated that, using then-year dollars rather than 2010 dollars, the program will cost $139 billion. It expects the first submarine to cost $14.5 billion, with $8.8 billion in construction costs and $5.7 billion in nonrecurring engineering work. Subsequent submarines are expected to cost $9.8 billion in then-year dollars, which is equivalent to $5.2 billion in FY2010 dollars.[95]

There has been widespread agreement, in the Navy, at the Pentagon, and among defense analysts, that the costs associated with the Columbia class submarine could undermine the rest of the Navy's shipbuilding budget. At one point, Navy officials estimated that, if the Navy funded this program through its current, planned shipbuilding budget, it would have to forgo the acquisition of up to 32 other naval vessels. According to former Navy Secretary Ray Mabus, unless Congress provides extra funding, "the production of 12 new ships to replace the Ohio-class submarines could 'gut' the Navy's shipbuilding budget for more than a decade."[96] In testimony before Congress in February 2015, Navy officials noted that "the Navy continues to need significant increases in our topline beyond the FYDP [Future Years Defense Plan] … in order to afford the OR [Ohio replacement] SSBN procurement costs. Absent a significant increase … OR SSBN construction will seriously impair construction of virtually all other ships in the battle force: attack submarines, destroyers, and amphibious warfare ships."[97]

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[93] Congressional Budget Office, *An Analysis of the Navy's Fiscal Year 2014 Shipbuilding Plan*, Washington, DC, October 2013, p. 24, http://www.cbo.gov/publication/44655.

[94] Government Accountability Office, Defense Acquisitions[:] Assessments of Selected Weapons Programs, GAO-15-342SP, March 2015, p. 148.

[95] Jason Sherman, "Navy Estimates $14.5B Tab for Lead Ohio-Class Replacement Submarine," *Inside Defense*, March 16, 2015.

[96] Yasmin Tadjdeh, "Mabus: Ohio-Class Submarine Replacement Could 'Gut' Navy Shipbuilding Budget," *National Defense*, September 15, 2014, http://www.nationaldefensemagazine.org/blog/Lists/Posts/Post.aspx?List=7c996cd7%2Dcbb4%2D4018%2Dbaf8%2D8825eada7aa2&ID=1601.

[97] Statement of the Honorable Sean J. Stackley, Assistant Secretary of the Navy (Research, Development and Acquisition) and Vice Admiral Joseph P. Mulloy, Deputy Chief of Naval Operations for Integration of Capabilities and

In response to this growing fiscal pressure, Admiral Richard Breckenridge suggested, in testimony offered in 2013, that Congress set up an annual $4 billion supplemental fund outside the Navy's budget to help support this program.[98] Several Members of Congress have supported this proposal.[99] Congress included language in the FY2015 National Defense Authorization Act establishing a National Sea-based Deterrence Fund (P.L. 113-291, §1022). According to the legislation, money placed in the fund will be available for the design, construction, purchase, alteration, and conversion of "national sea-based deterrence vessels," which is a reference to ballistic missile submarines. The legislation also states that the Secretary of Defense has the authority to transfer up to $3.5 billion into the fund from unobligated funds in the DOD budget. Congress did not, however, appropriate increased funding for this effort, and the Secretary of Defense had not identified or transferred any money into this fund. In the FY2016 NDAA, (H.R. 1735, §1051), Congress expanded the authority to transfer funding and included provisions allowing the Secretary of the Navy to enter into "economic order quantity contracts" that might achieve economic efficiencies based on production economies for major components or subsystems. Some analysts estimate that this provision could reduce the procurement costs for the submarine, saving, perhaps, several hundred million dollars per submarine.[100]

Most experts agree that, without increased appropriations, this fund may protect the Navy's shipbuilding budget from the costs of the Columbia class submarine, but that it would not really solve the DOD's problem, because the money for the fund would have to come from other portions of the Pentagon budget.[101] Nevertheless, the Navy continues to support the Columbia class submarine as its highest priority, with Admiral John Richardson, the Chief of Naval Operations, noting that the ballistic missile submarine force is "foundational to our survival."[102]

Force Posture

As a part of its effort to reduce costs, the Navy is designing the new submarines with only 16 ballistic missile launch tubes. The existing Trident submarines have 24 launch tubes, and each has been reduced to 20 missiles as the United States complies with the New START Treaty. Congress questioned the Navy on this plan during hearings in April 2011, with some Members questioning whether the United States would be able to deploy enough warheads if it reduced the numbers of missiles on each submarine. Admiral Terry Benedict, the Director of the Navy's Strategic Systems Program Office, testified that the current international security environment, along with the Navy's ability to "upload" warheads onto Trident missiles, convinced him, along with other

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Resources and Lieutenant General Kenneth J. Glueck Jr., Deputy Commandant, Combat Development and Integration & Commanding General, Marine Corps Combat Development Command, Before the Subcommittee on Seapower and Projection Forces of the House Armed Services Committee on Department of the Navy Seapower and Projection Forces Capabilities, February 25, 2015, p. 8.

[98] Lee Hudson, "Navy Asks Congress To Set Up Supplemental Fund for SSBN(X)," *InsideDefense.com*, September 12, 2013.

[99] "Some U.S. Lawmakers Eye Funding new Submarines Outside Normal Process," *Global Security Newswire*, March 12, 2014. See, also, Lee Hudson, "House Committee Looks to Create Separate Fund for Ohio Replacement," *InsideDefense.com*, May 2, 2014.

[100] Eric Laws, *An Analysis of the Navy's Fiscal Year 2016 Shipbuilding Plan*, Congressional Budget Office, Washington, DC, October 2015, pp. 18-19, https://www.cbo.gov/sites/default/files/114th-congress-2015-2016/reports/50926-Shipbuilding_OneCol-2.pdf.

[101] Kingston Reif, "Hill Denies Money for Submarine Fund," *Arms Control Today*, January 2016. http://www.armscontrol.org/ACT/2016_0102/News/Hill-Denies-Money-for-Submarine-Fund.

[102] Robert Burns, "New Navy Leader: Nukes "Foundational to Our Survival"," *Associated Press*, January 7, 2016.

Navy and STRATCOM officials, that they could be comfortable with this configuration.[103] However, Congress remained unconvinced. In the FY2012 Defense Authorization Act, it called for a new study of the plans for the SSBN(X). Congress indicated that the report should consider the possibility of deploying 10 or 12 submarines with 16 launch tubes on each and 8 or 10 submarines with 20 launch tubes on each. Moreover, the study was to review not only the cost of each option, but also the ability of each option to meet the Navy's at-sea requirements for the SSBN force and the ability of each option to meet the nation's nuclear employment and planning guidance.[104]

A report published in late 2011 indicated that the Office of Management and Budget (OMB) suggested that the Navy reduce the number of SSBNs in the fleet to 10, but increase the number of launch tubes on each submarine to 20.[105] According to the OMB analysis, this could save the Navy $7 billion over the life of the fleet, by reducing acquisition costs and operating costs. It would not, however, undermine the submarines' mission because, with 20 missiles per submarine, the Navy would still be able to cover the full range of targets assigned to the Trident fleet. Analysts outside government have offered similar suggestions, noting that the Navy could save $27 billion over 10 years and $120 billion over the life of the fleet if the Navy built 8, rather than 12 submarines.[106] Moreover, according to this analysis, the Navy would be able to deploy the necessary number of warheads on these submarines, even if it did not increase the number of launch tubes, by deploying more warheads on each of the Trident missiles on the submarine.

Generally, the number of launch tubes on the submarines should not affect the number of warheads carried by each submarine or the ability of the fleet to hold a range of potential targets at risk. Trident missiles can be equipped with 8 warheads each, but, in their current configuration, the missiles likely carry, on average, only 4 or 5 warheads each. This number might drop to 3-4 warheads per missile, on average, as the United States reduces to the levels in New START. If the new submarines carry only 16 missiles, rather than the 20 planned under New START, then they could deploy with 5-6 warheads per missile. In essence, the Navy would put the same number of warheads on each submarine, but would just spread them over a smaller number of missiles.

The Navy has noted that, as the United States reduces its forces to New START levels, the lower number of missiles per submarine will allow the United States to retain a larger number of submarines, without exceeding the treaty's limit of 700 operational delivery vehicles. This will allow the Navy to maintain a fleet of 12 submarines, and to operate those submarines with continuous deployments from 2 bases. The Navy has argued that, if it reduces the numbers of submarines in the fleet, and alters its deployment patterns, it will not be able to meet its requirements, as these cover more than just the total number of warheads on the fleet or total number of warheads at sea at any time. Critics outside the government, however, question this approach, both because a fleet of 12 submarines will cost more to procure and operate than a fleet of only 8 submarines and because this fleet presumes that the United States must retain its current pattern of operations for the SSBN fleet for the next 50-60 years.

With 12 submarines in the fleet, the Navy can maintain 4-5 on station at any time, patrolling in areas where they would need to be to launch their missiles promptly after a presidential order. But critics question whether this pattern, and the "continuous at-sea" deterrent of 4-5 submarines, will

[103] Emelie Rutherford, "Navy Defends Plan for Just 16 Missile Tubes on Next Boomer," *Defense Daily*, April 7, 2011.

[104] Elaine M. Grossman, "U.S. Defense Conference Bill Seeks New Submarine Cost Assessment," *Global Security Newswire*, December 16, 2011.

[105] Colin Clark, "OMB Pushes More Tubes, Fewer Boats for Ohio Replacement Subs," *AOL Defense*, November 4, 2011, http://defense.aol.com/2011/11/04/omb-pushes-more-tubes-fewer-boats-for-ohio-replacement-subs/.

[106] Tom Collina and Kelsey Davenport, "U.S. Must Rethink New Subs, Bombers," *Defense News*, October 24, 2011.

be necessary in the decades ahead. They note that the United States will be able to maintain a secure second strike deterrent on the submarines, even if they cannot launch as many warheads promptly as they can launch today. Others however, continue to support the current operational patterns, and to argue for a fleet of 12 submarines into the future. For example, Congress, in the FY2013 Defense Authorization Bill (P.L. 112-239, §130) stated that "the continuous at-sea deterrence provided by a robust and modern fleet of nuclear-powered ballistic missile submarines is critical to maintaining nuclear deterrence and assurance and therefore is a central pillar of the national security of the United States." The legislation went on to indicate that "a minimum of 12 replacement ballistic missile submarines are necessary to provide continuous at-sea deterrence over the lifetime of such submarines.... "

Bombers

B-1 Bomber

The Air Force began to deploy the B-1 bomber in the mid-1980s and eventually deployed a fleet of 96 aircraft. After several crashes, the Air Force was left with 92 bombers in 2001. It sought to retire 30 of the aircraft, leaving a force of 62 bombers, but that plan met resistance from Congress. The B-1 served exclusively as a nuclear delivery vehicle through 1991, carrying short-range attack missiles and gravity bombs. Because these bombers were not equipped to carry nuclear-armed air-launched cruise missiles, each counted as a single delivery vehicle and a single warhead under START. In 1993, the Air Force began to convert the B-1 bombers to carry conventional weapons. This process was completed in 1997 and the B-1 bomber is no longer equipped to carry nuclear weapons. In 2011, the United States displayed the bomber to the Russians, under the terms of the New START Treaty, to demonstrate that it was no longer equipped to deliver nuclear weapons and to confirm that it would not count under the limits in New START. The bomber has contributed to U.S. conventional operations in Afghanistan and Iraq and contributed to reassurance missions in Asia.

B-2 Bomber

The Air Force has 20 B-2 bombers, which are based at Whiteman AFB in Missouri.[107] The B-2 bomber can carry both B61 and B83 nuclear bombs, but is not equipped to carry cruise missiles. It can also carry conventional weapons and has participated in U.S. military campaigns from Bosnia to Iraq. It is designed as a "low observable" aircraft and was intended to improve the U.S. ability to penetrate Soviet air defenses. It continues to serve as a penetrating bomber, both when flying conventional missions and when supporting the nuclear deterrent mission. The Air Force has indicated that it needs significant maintenance and modernization funding to support the mission.[108]

Weapons

According to unclassified estimates, the United States has around 452 B61 and B83 bombs for use by strategic bombers, and an additional 300 B61 bombs for use by fighter aircraft.[109] The B61

[107] A B-2 bomber crashed on take-off from Anderson Air Force Base on Guam in late February 2008, reducing the number of deployed bombers from 21 to 20.

[108] For details on the ongoing programs supporting this bomber and the B-52 bomber, see CRS Report R43049, *U.S. Air Force Bomber Sustainment and Modernization: Background and Issues for Congress*, by Jeremiah Gertler.

[109] Hans M. Kristensen and Robert S. Norris, "U.S. Nuclear Forces, 2018," *Bulletin of the Atomic Scientists*, March 2018, https://www.tandfonline.com/doi/pdf/10.1080/00963402.2018.1438219?needAccess=true.

contains a number of different versions. The B61-7 serves as a strategic bomb and is carried by B-2 bombers. The B61-3, 4, and 10 are considered nonstrategic bombs, with lower yields, and would be delivered by fighter aircraft like the F-16 and F-35. The B61-11, a modification developed in the 1990s, has a hardened, modified case so that it can penetrate some hardened targets, although probably not those encased in steel and concrete. The B61-Mod 7, along with the Mod-3 and Mod-4, and Mod-10 versions, are a part of an ongoing life extension program (LEP) that will produce a new B61-mod 12 bomb.[110] During the Obama Administration, NNSA announced that it planned to retire the B83, the largest bomb remaining in the U.S. arsenal, around 2025, after the completion of the B61 LEP. The Trump Administration, in the 2018 Nuclear Posture Review, seems to have altered that plan, announcing in the 2018 Nuclear Posture Review that it will sustain "the B83-1 past its currently planned retirement date until a suitable replacement is identified."[111]

Over the years, Congress has raised numerous questions about the need for and the costs of the B61 life extension program. For example, in the FY2010 Energy and Water Appropriations Bills, Congress reduced funding for this program and limited the available funding to modifications of the bombs' nonnuclear components. These restrictions were reportedly designed to slow the program until the Administration reported, through the Nuclear Posture review, on its future plans for U.S. nuclear weapons programs.[112]

The Obama Administration strongly supported the life extension program for the B-61 bomb in the 2010 Nuclear Posture Review. The report indicated that "the Administration will fully fund the full scope LEP study and follow-on activities for the B61 bomb ... to ensure first production begins in FY2017." The NPR noted that the life extension program for the B61 bomb, which would include enhancing safety, security, and use control, would also support U.S. extended deterrence goals by allowing the United States to retain the capability to forward-deploy U.S. nuclear weapons on B-2 bombers and tactical fighter-bombers.[113] In the years since the NPR, however, the costs for the program have risen sharply and the timeline has slipped. Where DOE initially claimed that the program would cost around $4 billion, it now estimates the cost to be over $8 billion.[114] In addition, it now expects the first unit to be available in 2020, rather than 2017. However, according to a recent report by the Government Accountability Office (GAO), NNSA's Independent Office of Cost Estimating and Program Evaluation now believes the program will cost $10 billion and will not deliver the first production unit until 2022.[115]

Some in Congress challenged the Administration's plans for this program, asking whether a less costly and complicated program might be sufficient. The Obama Administration claimed, however, that if it pursued a less complex life extension program now, it would need to initiate a

[110] For a description of ongoing work in the B61 LEP program, see Kevin Robinson-Avila, "Overhauling the nation's nuclear arsenal: Sandia National Labs achieves B61 milestone," *Albuquerque Journal*, May 18, 2014.

[111] *Department of Defense*, Nuclear Posture Review, Washington, DC, February 2, 2018, p. 61, https://media.defense.gov/2018/Feb/02/2001872886/-1/-1/1/2018-NUCLEAR-POSTURE-REVIEW-FINAL-REPORT.PDF.

[112] Elaine M. Grossman, "Nuclear Bomb Update Effort Slowed by Posture Review, Science Studies," *Global Security Newswire*, January 19, 2010.

[113] U.S. Department of Defense, *Nuclear Posture Review*, Washington, DC, April 6, 2010, p. 27, http://www.defense.gov/npr/docs/2010%20Nuclear%20Posture%20Review%20Report.pdf.

[114] Jeff Tolleson, "U.S. warheads to get a facelift," *Nature*, May 7, 2013.

[115] U.S. Government Accountability Office, *National Nuclear Security Administratioin: Action Needed to Address Affordiability of Nuclear Modernization Programs*, GAO-17-341, April 2017, pp. 24-25, http://www.gao.gov/assets/690/684310.pdf.

second program a few years later to complete the remainder of the work. Moreover, the Obama Administration had noted that, after it completed the B61 life extension, DOE would be able to retire the much larger B83 bomb and reduce the number of B61 bombs in the U.S. stockpile. The Trump Administration continues to support the B61 life extension program, but has raised concerns about whether it will be able to replace the B83 in the U.S. stockpile. It noted that "the B83-1 and B61-11 can hold at risk a variety of protected targets," and, therefore, "both will be retained in the stockpile, at least until there is sufficient confidence in the B61-12 gravity bomb that will become available in 2020."[116] There also is no indication, in the 2018 NPR, that the B61 LEP will allow NNSA to reduce the number of nondeployed warheads in the U.S. stockpile.

The Air Force is also designing a new tail kit for the B61 bomb. This tail kit would replace the parachute that the bomb currently uses to slow to its targets, and would improve the accuracy of the weapon. Some analysts claimed that this tail kit would provide the bomb with new capabilities, and would undermine the Obama Administration's pledge that it would not develop new military capabilities as it conducted the warhead life extension programs.[117] Others, however, disputed this conclusion. They noted that the new B61-12 will combine an increase in accuracy with a reduction in yield, allowing it to accomplish the same mission as the current unguided, but higher yield, weapon. As a result, the Air Force has argued that the tail kit will allow the modified B61 bombs to meet operational requirements for the bomber fleet and provide "nuclear assurance to U.S. allies in Europe."

The Air Force and the National Nuclear Security Administration (NNSA) conducted the first development flight test of the B61-12 LEP in July 2015[118] and has conducted a number of qualification flight tests over the past year. The tests integrated the new tail kit with bomb hardware developed by Sandia and Los Alamos National Laboratories. According to NNSA, these qualification flight tests evaluate "both the weapon's non-nuclear bomb functions as well as the aircraft's capability to deliver the weapons." They demonstrate "effective end-to-end system performance in a realistic ballistic flight environment."[119] The qualification flight tests will continue for three years.

Congress appropriated $537 million for the B61 LEP in FY2014, $643 million in FY2015, $643.3 million in FY2016, and an additional $616 million for FY2017. NNSA requested $788.6 million for FY2018 and $794 million for FY2019. The Air Force is supporting the funding for the tailkit program. Congress appropriated $148.2 million in FY2015, $212.1 million in FY2016, $137.9 million for FY2017. The Air Force requested an additional $91.2 million in FY2018, which was a significant reduction from the $151 million the Air Force expected to request for FY2018 when it submitted its FY2017 budget. The FY2018 budget documents note that reduction was not the result of any expected changes in the program and that funds may be used to address higher Air Force priorities. The Air Force also requested $88 million in advanced procurement funding to support the acquisition of 30 tailkit assemblies.

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[116] Department of Defense, Nuclear Posture Review, Washington, DC, February 2, 2018, p. 42, https://media.defense.gov/2018/Feb/02/2001872886/-1/-1/1/2018-NUCLEAR-POSTURE-REVIEW-FINAL-REPORT.PDF.

[117] William J. Broad and David Sanger, "As U.S. Modernizes Nuclear Weapons, "Smaller" Leaves Some Unease," *New York Times*, January 11, 2016. See, also, Kyle Mizokami, "Why the Pentagon's New Nukes Are Under Fire," *Popular Mechanics*, January 12, 2016.

[118] Marina Malenic, "U.S. Completes first B-61 LEP Flight Test," *Janes Defense Weekly*, July 8, 2015.

[119] National Nuclear Security Administration, "NNSA, Air Force complete first B61-12 Life Extension Program qualification flight test at Tonopah Test Range," press release, April 13, 2017, https://nnsa.energy.gov/mediaroom/pressreleases/nnsa-air-force-complete-first-b61-12-life-extension-program-qualification.

The Air Force has requested $92 million for the research and development on the B61 tailkit in FY2019, along with $162 million in procurement funds to support the acquisition of 250 tailkit assemblies. This funding is designed to support the expected integration of the B61-12 into the force in the early 2020s.

B-52 Bomber

The Air Force maintains 66 nuclear capable B-52H aircraft at two bases, Barksdale, LA, and Minot, ND, with only 44 assigned to nuclear missions on a day-to-day basis.[120] The B-52 bomber, which first entered service in 1961, can be equipped to carry nuclear or conventional air-launched cruise missiles. The B-52 bombers can also deliver a wide range of conventional arms, and are currently receiving numerous upgrades to their communications and electronics systems.

The Air Force has proposed cutting the B-52 fleet on many occasions in the past 25 years. For example, when the United States identified the force structure that it would deploy under the START Treaty, it indicated that it would only seek to retain 76 B-52 bombers. Congress, however, rejected the Clinton Administration's proposal, and the United States retained the full fleet of 94 aircraft.

The 2006 Quadrennial Defense Review called for a significant change to the B-52 fleet, reducing it from 94 to 56 aircraft. The budget request for FY2007 indicated that the Air Force planned to retire 18 bombers in FY2007 and 20 in FY2008. At the same time, the QDR called for continuing improvements to the B-1, B-2, and B-52 bombers' conventional capabilities using the funds that were saved by the retirement of the 38 aircraft. The Air Force has argued that it can reduce the number of deployed bombers, without reducing the overall capabilities of the bomber fleet, because these new weapons have "raised the efficiency" of the bomber platform. At hearings before the Senate Armed Services Committee, General James E. Cartwright, the Commander of STRATCOM, noted that "the next generation weapons that we're fielding, these air-launched cruise missiles, the joint direct attack munitions, et cetera, are much more efficient than they were in the past."[121] General Cartwright also indicated that, in spite of the reduced size of the fleet, the Air Force would continue to deploy B-52 bombers at two bases.

During the FY2007 budget cycle, Congress rejected the Pentagon's proposals for at least part of the B-52 fleet. The House, in its version of the FY2007 Defense Authorization Bill, prohibited the Air Force from retiring any of the B-52 aircraft, and mandated that it maintain at least 44 "combat coded" aircraft until the Air Force began to replace the B-52 with a new bomber of equal or greater capability. It stated, as a part of its rationale for this rejection, that it appeared the reduction was based on the reduced need for nuclear-capable bombers and did not take into consideration a growing need for long-range conventional strike capabilities.[122] The Senate agreed to permit the Air Force to retire 18 B-52 aircraft, but stated that it expected no further reduction in the size of the force, noting that a further reductions might "prevent our ability to strike the required conventional target set during times of war."[123] The conference committee (H.R. 5122, §131) combined these two provisions, allowing the retirement of no more than 18

[120] Hans M. Kristensen and Robert S. Norris, "United States Nuclear Forces, 2018," *Bulletin of the Atomic Scientists*, March 5, 2018, p. 127. https://www.tandfonline.com/doi/pdf/10.1080/00963402.2018.1438219?needAccess=true.

[121] U.S. Senate, Committee on Armed Services, Hearing on Global Strike Plans and Programs. Testimony of James E. Cartwright, Commander U.S. Strategic Command. March 29, 2006.

[122] U.S. Congress. House. Committee on Armed Services. National Defense Authorization Act for Fiscal Year 2007. H.Rept. 109-452. May 5, 2006. p. 103.

[123] U.S. Congress Senate. National Defense Authorization Act for Fiscal Year 2007. S.Rept. 109-254. May 9, 2006. p. 94.

aircraft after the submission of a report, and mandating that the Air Force retain at least 44 "combat coded" aircraft. These restrictions are to remain in place until 2018, or until a new long-range strike aircraft "with equal or greater capability than the B-52H model aircraft" attained initial operational capability, if that occurred first. Congress also stated that no funds could be spent to retire any B-52 aircraft until the Secretary of the Air Force submitted a report to Congress that described the Air Force plan for the modernization of the B-52, B-1, and B-2 bomber fleets; how many bombers would be assigned two nuclear and conventional missions if the United States had to execute "two overlapping 'swift defeat' campaigns"; a justification of the cost and projected savings of any reductions to the B-52H bomber aircraft fleet; and the life expectancy of each bomber aircraft to remain in the bomber force structure and the capabilities of the bomber force structure that would be replaced by a new bomber aircraft.

The Air Force indicated that the report on the bomber fleet would be ready in the fall of 2007. Further, in testimony before the Armed Services Committee, the Air Force indicated that it still planned to reduce the B-52 fleet to 56 aircraft, with 32 combat coded aircraft included in the fleet. But, in recognition of the congressional mandate, it was seeking a way to maintain 44 combat coded aircraft, the minimum set by Congress, within the smaller fleet of 56 aircraft. It also stated that it planned to store the 20 aircraft it wanted to retire in FY2008 on ramps at Barksdale Air Force Base; the aircraft would be kept in serviceable condition, but would not receive any capabilities upgrades.[124] Congress once again rejected this proposal. In the FY2008 Defense Authorization Bill (H.R. 1585, §137), Congress mandated that the Air Force maintain a fleet of 74 B-52 bombers, with no less than 63 in the Primary Aircraft inventory and 11 backup aircraft. Two additional aircraft would be designated as "attrition reserve." The conference committee indicated that the members agreed that a fleet of fewer than 76 aircraft would be insufficient to meet long-range strike requirements.

The growing interest in long-range strike capabilities, and the continuing addition of precision conventional weapons to these aircraft, demonstrates that the Pentagon and STRATCOM view the U.S. bomber fleet as essential to U.S. conventional weapons capabilities. Further, the need for long-range strike capabilities, rather than an interest in maintaining the nuclear role for bombers,[125] appeared to be driving decisions about the size and structure of the bomber fleet. There are some indications that, during the discussions on the 2006 QDR, some in the Pentagon argued that the all the B-52 bombers should be removed from the nuclear mission. Moreover, in November 2008, Secretary of the Air Force Michael Donley noted that the role that the bombers play in nuclear deterrence could be reduced in the future, if the United States and Russia negotiate further reductions in their nuclear arsenals.

This focus began to shift, however, in 2008. Studies have noted that a lack of attention paid in the Air Force and, more broadly, in DOD, to the bombers' nuclear mission seems to be one of the factors that led to the episode in August 2007, when a B-52 bomber flew from Minot to Barksdale with six cruise missiles that carried live nuclear warheads.[126] As is discussed in more detail below, the Air Force is pursuing a number of organizational and procedural changes to increase its focus on the nuclear mission and "reinvigorate" its nuclear enterprise. It has "stood-up" a B-52 bomber

[124] U.S. Congress. Senate. Armed Services Committee, Subcommittee on Strategic Forces. Hearing on the Fiscal Year 2008 Strategic Forces Program Budget. Statement of Major General Roger Burg. March 28, 2007. p. 8.

[125] Carlo Munoz, "Donley: Role of Nuclear Bomber Fleet Could Be Curtailed," *Inside the Air Force*, November 14, 2008.

[126] For a detailed review of this incident see, Warrick, Joby and Walter Pincus. The Saga of a Bent Spear. *Washington Post*. September 23, 2007.

squadron that will focus specifically on the nuclear mission.[127] This unit added 10 bombers to the 12 already deployed at Minot. While all the B-52 bomber crews and aircraft will retain their nuclear roles, this added squadron will participate in a greater number of nuclear exercises and training missions. The aircraft in the squadron will rotate from other missions, but will remain designated as the nuclear squadron for full year. The Air Force hopes this construct will improve not only the operational proficiency of the crews, but also their morale and their confidence in the value of the nuclear mission.

With this change, Secretary of Defense Gates stated, in April 2009, that the Air Force planned to retain 76 B-52 bombers. The 2010 Nuclear Posture Review determined that the Air Force would retain nuclear-capable bombers, but it would also convert some B-52s to a conventional-only role. In the report on the New START force structure issued in April 2014, the Obama Administration indicated that the United States would retain 42 deployed and 4 nondeployed nuclear capable B-52 bombers. The remainder of the B-52 bombers would be converted to carry only conventional weapons. In September 2015, the Air Force announced that it had begun to convert a portion of the B-52H bomber force from nuclear to conventional-only capability, thus removing 30 operational bombers from accountability under New START.[128] The database released after the March 2017 New START data exchange shows that the Air Force now has converted 41 bombers conventional-only capability, which removes them from accountability under New START.

Long-Range Standoff (LRSO) Weapons

At the end of the Cold War, the B-52 bomber was equipped to carry both the Air-Launched cruise missile (ALCM) and Advanced Cruise Missile (ACM). The ACM reportedly had a modified design with a lower radar cross-section, making it more "stealthy" than the ALCM. According to Air Force figures, in 2006, the United States had 1,142 ALCMs and 394 ACMs.[129] Although these weapons represented a majority of the weapons that U.S. bombers could carry on nuclear missions, the Department of Defense decided to retire many of these missiles. In his statement to the Senate Armed Services Committee's Subcommittee on Strategic Forces, Major General Roger Burg indicated that this study had concluded, and the Secretary of Defense had directed, that the Air Force retire all the Advanced Cruise Missiles, although some could be converted to carry conventional warheads, and reduce the ALCM fleet to 528 cruise missiles. The excess ALCMs would also be eliminated, with the remaining missiles consolidated at Minot Air Force Base. With all the ALCMs consolidated at Minot Air Force Base, the bombers at Barksdale may no longer be included in the nuclear mission.

The Air Force plans to sustain the ALCM in the fleet through 2030. It is then planning to replace the ALCM with a new advanced long range standoff (LRSO) cruise missile. It completed an analysis of alternatives (AOA) for this system to "define the platform requirements, provide cost-sensitive comparisons, validate threats, and establish measures of effectiveness, and assess candidate systems for eventual procurement and production" of the new missile.[130] The DOD

[127] Marcus Weisgerber, "USAF To Activate Rotational Nuclear Bomber Squadron Next Month," *Inside Defense*, September 26, 2008.

[128] U.S. Department of Defense, Air Force Global Strike Command, AFGSC Completes First New START Bomber Conversion, September 17, 2015.

[129] The Air Force also has 289 ALCMs that have been converted to carry conventional warheads (CALCMs). See Michael Sirak. DOD Studies Future Role of Nuclear-Armed Cruise Missiles. Defense Daily, March 30, 2006.

[130] U.S. Department of Defense, *November 2010 Update to the National Defense Authorization Act of FY2010*, New START Treaty Framework and Nuclear Force Structure Plans, Washington, DC, November 17, 2010, p. 12. http://www.lasg.org/CMRR/Sect1251_update_17Nov2010.pdf.

budget request for FY2014 contained $5 million for the Air Force to begin systems engineering support for the program. The budget also indicated that the technology development phase would begin in FY2014, and that the funding requests could reach a total of $1 billion through FY2014.

In the FY2015 budget request, DOD indicated that the plans for the LRSO missile had slipped by three years. This change was the result of fiscal constraints and the need to fund higher priorities elsewhere in the nuclear force. As a result, although the Air Force requested only $4.9 million for this program in FY2015, it indicated that it would spend $221 million over the next five years. Congress expressed concerns with this plan in the FY2015 National Defense Authorization Act (P.L. 113-291, §143), noting that the existing ALCMs were, on average, over 30 years old and that the capabilities provided by the cruise missile were "critical to maintaining a credible and effective air-delivery leg of the nuclear triad." The legislation requested a report on the status of the current cruise missile and the development of the new LRSO missile.

In its FY2016 budget request, the Air Force added funding for the LRSO to accelerate the program by two years, seeking now to begin deployments in the mid-2020s. According to testimony, the Air Force had placed a higher priority on this program because the existing ALCM has been through several life extension programs and is beginning to show reliability problems. According to Frank Kendall, the Under Secretary of Defense for AT&L, this is making the ALCM more difficult to maintain.[131] Where the Air Force requested only $3.4 million for this program in FY2015, it requested $36.6 million in FY2016. DOD expected this funding to increase rapidly, to a total of nearly $1.8 billion between FY2016 and FY2020.

Congress appropriated only $16.4 million for the LRSO in FY2016, reducing the request by $20.5 million due to delays in the award of the contract that reduced the budget requirements for the program. The Air Force requested $95.6 million for the LRSO in FY2017; Congress approved this amount FY2017 National Defense Authorization Act (P.L. 114-328). When it submitted its FY2017 budget, the Air Force indicated that it would request $419.8 million in FY2018 and a total of $2.1 billion between FY2018 and FY2021. The FY2018 budget request, however, included $451.2 million for the LRSO and indicated that the Air Force plan to request over $2.6 billion between FY2018 and FY2022. Congress approved the FY2018 request in the National Defense Authorization Act for FY2018 (P.L. 115-91).

The Air Force has requested $615 million for the LRSO in FY2019. The budget documents show that it plans to request $722.5 million in FY2020, then reduce its requests to $475.3 million in FY2021, $359.3 million in FY2022, and $396 million in FY2023. The Air Force selected two contractors to execute the LRSO Technology Maturation and Risk Reduction (TMRR) phase in FY2017; this phase will run for 4.5 years. The FY2019 budget documents indicate that the funding increase from FY2018 to FY2019 occurred due to a "ramp up" in TMRR, during which the contractors will "continue to design, develop, integrate and test the LRSO system" to meet "validated requirements prior to the engineering & manufacturing phase."

According to press reports, the Air Force plans to buy a total of 1,000-1,100 new cruise missiles through the LRSO program, at a cost of around $10.8 billion, with the first missile slated for completion in 2026.[132] This total would support the testing program and deployment plans over the life of the missile.

[131] U.S. Congress, Senate Committee on Armed Services, Subcommittee on Strategic Forces, *President Obama's Fiscal 2016 Budget Request for the U.S. Nuclear Weapons Policy, Programs and Strategy*, Hearing, 114th Cong., 1st sess., March 4, 2014.

[132] Kingston Reif, "Air Force Wants 1,000 New Cruise Missiles," *Arms Control Today*, May 2015.

NNSA is also conducting a life-extension program on the W80 warhead to provide a warhead for the new LRSO. Its plans for the W80-4 warhead had also slipped in the FY2015 budget, with the Nuclear Weapons Council delaying the first production unit from 2024 until the 2025-2027 timeframe. Congress, in the FY2015 National Defense Authorization Act, mandated that NNSA deliver the first production unit of this new warhead by 2025 (P.L. 113-291, §3119). In its FY2016 budget request, NNSA indicated that it had allocated the resources necessary to meet this requirement, and to align the warhead life extension program with the plan to field the first LRSO missile in FY2026. Congress appropriated $195 million for the W80-4 life extension program in FY2016 and $220 million in FY2017. NNSA requested $399 million for FY2018 and $666.4 million in FY2019. NNSA has begun to "the ramp up engineering activities for development and design on the W80-4," leading to the significant increase in the budget request for FY2019.

The LRSO program has attracted attention, and significant debate among analysts outside government and several Members of Congress. Some have questioned whether the Air Force needed to accelerate the LRSO program and whether the United States needs and can afford to develop and produce a new cruise missile in the coming decade. They questioned whether the capabilities provided by the LRSO may be redundant, as the Air Force is also developing a new penetrating bomber and proceeding with the life extension program for the B61 bomb. Moreover, they noted that the Air Force also has conventional cruise missiles that could destroy critical targets from beyond the reach of an adversary's air defenses.[133]

During testimony before both the House and Senate Armed Services Committees in 2015, Admiral Haney, the Commander of Strategic Command (STRATCOM), noted that the LRSO is "important from a deterrence and warfighting requirement" because it will provide Air Force bombers with a "standoff capability" now and into the future. He noted that this standoff capability will remain important because as more countries develop advanced air defenses, those defenses will provide them with "anti-access/access denial" capabilities. Admiral Haney and others have responded by noting that the capabilities are not redundant, but are complementary, because they provide the President with more flexibility and more options in the event of a crisis. In a letter to Senator Sanders in February 2016, Brian McKeon, the Principal Deputy Under Secretary of Defense, elaborated on this point, noting that

> Cruise missiles provide capabilities that complement rather than duplicate that of a stealth bomber. Standoff capability improves the survivability of our bomber fleet, extends its effective range, and multiplies the type and number of penetrating targets each bomber presents to the adversary. This complicates the air defense problem facing any country seeking to negate this portion of our deterrent.

Lt. Gen. (retired) David Deptula made a similar point in a recent interview. He noted that "LRSO will act as a force multiplier augmenting the long-range bomber force and appreciably complicating an adversary's ability to defend its airspace." He indicated that the weapons could "significantly increase the reach and target coverage" of U.S. bombers and "amplify" the challenge to enemy air defenses "posed by a combined force of stealth bombers and LRSO." This would make "countermeasures both more costly and problematical for the adversary and thus enhances deterrence."[134]

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[133] Council for a Liveable World. The Center for Arms Control and Non-Proliferation, *Is a New Cruise Missile Necessary?*, Fact Sheet, Washington, DC, February 2, 2016, http://armscontrolcenter.org/is-a-new-nuclear-cruise-missile-necessary/.

[134] Lt. Gen. Dave Deptula, "Stealthy New Nuclear Cruise Missile Aims to Deter the Enemy," *The Cipher Brief*, August 8, 2017, https://www.thecipherbrief.com/article/north-america/stealthy-new-nuclear-cruise-missile-aims-deter-enemy?utm_source=Join+the+Community+Subscribers&utm_campaign=a20baac8c6-EMAIL_CAMPAIGN_2017_08_08&utm_medium=email&utm_term=0_02cbee778d-a20baac8c6-122497273.

B-21 Bomber

As the preceding discussion noted, the United States currently deploys two types of heavy bombers—the B-2 and B-52—that can deliver both nuclear and conventional weapons. A third bomber, the B-1, was initially equipped to deliver nuclear weapons but is now exclusively dedicated to conventional missions. The Air Force has employed all three aircraft in conventional conflicts over the past two decades, and all have received upgrades to sustain their capabilities, but all three are aging and, according to many in the Air Force, may not be sufficient to meet emerging challenges.

As a result, the Air Force has also begun develop a new strategic bomber, now known as the B-21 Raider. When it began this effort more than a decade ago, it hoped to introduce the new bomber into the fleet around 2018. At the time, it was seeking a bomber with not only stealth capabilities and long range, but also one with "persistence," one that could "stay airborne and on call for very long periods."[135] However, the start of the study on a new bomber, known as an Analysis of Alternatives (AOA), was delayed by a dispute over whether the study should stand alone or be merged with another AOA on prompt global strike (PGS) capabilities, such as hypersonic technologies and missiles.[136] General James Cartwright, the former head of STRATCOM, reportedly supported a plan to merge the two efforts, so that the considerations of capabilities for a new bomber would be measured alongside other systems, both to balance the force and avoid redundancy across the force.[137] On the other hand, the former Air Force Chief of Staff, General T. Michael Moseley, reportedly preferred to keep the two studies separate. He argued that a bomber with long-range strike capabilities must have "persistent, survivable, and penetrating capabilities" while a platform with PGS capabilities could be a "standoff weapon that is very, very fast."[138] This position reportedly prevailed, with the Air Force deciding, in May 2006, to keep the two studies separate.[139]

This dispute revealed wide-ranging differences, within the Air Force and Pentagon, about the goals for and capabilities that should be sought in a new bomber program.[140] The dispute focused, however, on conventional capabilities; it seemed to be almost a foregone conclusion that nuclear capabilities, or the need for a bomber leg of the nuclear triad, would not drive the discussion or analysis. This position remains true today, with the Air Force seeking a new bomber to meet conventional challenges, and considering delaying the introduction of nuclear capabilities to save money. But disagreements over the capabilities needed, even for the conventional mission, served to delay the new bomber program by several years.

In May 2007, the Air Force indicated that it had decided that the next generation bomber would be manned and subsonic, although it would incorporate some stealth characteristics.[141] It decided

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[135] Christie, Rebecca. Air Force To Step Up New Bomber Search in Next Budget. *Wall Street Journal*. June 29, 2006.

[136] For details on these types of systems, see CRS Report R41464, *Conventional Prompt Global Strike and Long-Range Ballistic Missiles: Background and Issues*, by Amy F. Woolf.

[137] Grossman, Elaine M. Cartwright Wants to See Strike Studies Await "Discovery" Process. *InsideDefense.com*, April 6, 2006.

[138] Bennet, John T. Internal Squabbles Holding Up Bomber Study, USAF Official Says. *InsideDefense.com*, April 21, 2006.

[139] Matishak, Martin. Long-Range, Prompt Global Strike Studies Will Remain Separate. *InsideDefense.com*, June 16, 2006.

[140] For more details on the proposed bomber, see CRS Report RL34406, *Air Force Next-Generation Bomber: Background and Issues for Congress*, by Jeremiah Gertler.

[141] Sirak, Michael. Air Force Identifies Manned, Subsonic Bomber as Most Promising 2018 Option. Defense Today.

that it would not pursue supersonic capabilities, or an unmanned option, to contain costs and maintain the capabilities of the future aircraft. However, on April 6, 2009, in a briefing describing the FY2010 defense budget, Secretary of Defense Robert Gates delayed the program and indicated that the Air Force would not proceed until it had "a better understanding of the need, the requirement and the technology."[142] He suspended the program until DOD completed the QDR and 2010 Nuclear Posture Review.

The 2010 Quadrennial Defense Review, published in February 2010, indicated that the Air Force was "reviewing options for fielding survivable, long-range surveillance and strike aircraft as part of a comprehensive, phased plan to modernize the bomber force."[143] The report also noted that Secretary of Defense Gates ordered a follow-on study to the QDR to determine "what combination of joint persistent surveillance, electronic warfare, and precision-attack capabilities, including both penetrating platforms and stand-off weapons, will best support U.S. power projection operations over the next two to three decades." Although the study was just beginning, the DOD budget request for 2011 included $200 million for the new bomber, and DOD documents indicated that expenditures on the bomber could total $1.74 billion through 2015.[144] Secretary Gates indicated that he expected the Air Force to field the next generation bomber in the late 2020s.[145]

The update to the 1251 Report, submitted to the Senate before its vote on the New START Treaty in late 2010, emphasized that the United States would maintain the bomber leg of the strategic triad and that DOD was committed to modernizing the bomber force. The report noted that the long-range strike study was not questioning whether the United States would pursue a new heavy bomber, but "the appropriate type of bomber and the timelines for development, production, and deployment."[146] The report indicated that this study would advise the President's budget submission for FY2012. Air Force officials echoed this, noting that Secretary Gates seemed inclined to accept the Air Force's recommendations on the building of a new long-range bomber.[147] Secretary Gates confirmed this approach in January 2011, when he announced the Air Force would develop a new bomber "using proven technologies," and that this bomber would be nuclear-capable.[148] The Pentagon requested $197 million in the FY2012 budget on a new bomber. The budget documents indicate that the bomber will be nuclear-capable, and that the Air Force was planning to spend $3.7 billion on its development over the next five years.

Air Force officials indicate that they hope to field between 80 and 100 of the new bombers, now known as the B-21, in the future, with the first to enter service around 2025. It indicated that it

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May 2, 2007.

[142] U.S. Department of Defense, *Briefing by Defense Secretary Robert Gates and Marine Corps Gen. James Cartwright, Vice Chairman of the Joint Chiefs of Staff*, Washington, DC, April 6, 2009, http://insidedefense.com/secure/data_extra/html3/dplus2009_0893_3.htm.

[143] U.S. Department of Defense, *Quadrennial Defense Review Report*, Washington, DC, February 2010, p. 33, http://www.defense.gov/qdr/images/QDR_as_of_12Feb10_1000.pdf.

[144] Elaine M. Grossman, "Pentagon Eyes More than $800 Million for New Nuclear Cruise Missile," *Global Security Newswire*, March 9, 2010.

[145] Andrea Shalal-Esa, "Gates Sees New U.S. Bomber Fielded in 2020s," *Reuters*, February 2, 2010.

[146] U.S. Department of Defense, *November 2010 Update to the National Defense Authorization Act of FY2010*, New START Treaty Framework and Nuclear Force Structure Plans, Washington, DC, November 17, 2010, p. 11. http://www.lasg.org/CMRR/Sect1251_update_17Nov2010.pdf.

[147] Emelie Rutherford, "Schwartz Hopeful About Long-Range Strike Funding," *Defense Daily*, November 29, 2010.

[148] Marcus Weisgerber, "Air Force To Develop New Long-Range, Optionally Manned Bomber," *Inside the Air Force*, January 6, 2011.

planned to hold the procurement cost for each bomber to $550 million, with the total cost of the program to reach $36 billion-$56 billion. However, it acknowledged, in 2014, that this cost did not include research and development funding,[149] which, according to some estimates, could amount to between $20 billion and $45 billion if the program follows the trends set by previous bomber programs.[150] The per-unit cost would also rise if the Air Force were to buy fewer than the planned 80-100 bombers. As a result, many analysts agree that the final cost of the bomber could reach $60-$80 billion.

The Air Force expects funding requests for the new bomber to rise sharply in the coming years. Congress appropriated $259 million for R&D on this aircraft in FY2013, $359.4 million in FY2014, and $913.7 million in FY2015. These requests were sufficient to keep the bomber program on track but led to Air Force spending levels that exceeded the levels set by the 2011 Budget Control Act. According to one analysis at the time, the Air Force would likely need to reduce its other acquisition programs to find the "budget headroom" for this program.[151] The Air Force requested $1.3 billion for FY2016, but Congress appropriated only $736 million. According to Air Force budget documents, this reduction reflected schedule delays in the program and the awarding of the contract.

The Air Force announced on October 27, 2015, that it had awarded the initial contract, which includes the production of 21 bombers, to Northrup Grumman. Analysts believe this contract is worth more than $20 billion, but that the total cost of the program could reach $80 billion for 100 aircraft.[152] This total includes development costs and the expected cost of $511 million (in 2010 dollars) for each of the 100 bombers. This represents a small reduction from the target cost of $550 million per bomber. The lower expected cost of the bombers is reflected in the Air Force budget request for FY2017. The Air Force has requested $1.4 billion for the B-21 in FY2017, which is lower than the $2.2 billion that it had expected for its FY2017 request as noted in the FY2016 budget documents. Congress further reduced this amount, authorizing $1.05 billion in the FY2017 National Defense Authorization Act (P.L. 114-328). The FY2017 Air Force budget also noted that the Air Force planned to request $12.1 billion between FY2017 and FY2021, as opposed to the $15.6 billion expected over five years in the FY2016 budget request. The Air Force indicated that these reductions reflected revised cost estimates following the award of the B-21 contract in late 2015.[153]

The Air Force has requested $2 billion for the B-21 bomber in its FY2018 budget and $2.3 billion in FY2019. Most of the information about the costs and progress of the B-21 bomber remain classified. As a result, the Air Force budget documents do not contain any details about the status of the program or the reason for the increase in funding for FY2019.

Sustaining the Nuclear Weapons Enterprise

In late August 2007, a B-52 bomber based in Minot, ND, took off on a flight to Barksdale Air Force Base in Louisiana. The bomber carried 12 air-launched cruise missiles that were slated for

[149] Aaron Mehta, "USAF General: "Of Course" Bomber Will Be More Than $550M per Copy," *Defense News*, March 5, 2014.

[150] Jon B. Wolfsthal, Jeffrey Lewis, and Marc Quint, *The Trillion Dollar Nuclear Triad*, James Martin Center for Nonproliferation Studies, Monterey, CA, January 2014, pp. 18-19. http://cns.miis.edu/opapers/pdfs/140107_trillion_dollar_nuclear_triad.pdf.

[151] Colin Clark, "LRS-B, Next Boomer May Force Weapons Cuts," *Breaking Defense*, September 4, 2014.

[152] Doug Cameron, "Northrop Grumman Wins Long-Range Bomber Deal," *Wall Street Journal*, October 27, 2015.

[153] Kingston Reif, "Budget Would Raise Nuclear Spending," *Arms Control Today*, March 2016.

retirement at Barksdale. As a result of a series of errors and missteps in the process of removing the missiles from storage and loading them on the bombers, six of the missiles carried live nuclear warheads, instead of the dummy warheads that were installed on missiles heading for retirement. This episode was the first of many that have led to questions about the capabilities management of the U.S. nuclear weapons enterprise. It led to a series of studies and reviews by the Air Force that identified the source of the episode and identified a number of steps the Air Force should take to improve its handling of nuclear weapons.[154] These studies were followed, in 2014, by additional studies and a number of changes designed to raise morale and the quality of life for servicemembers in the nuclear enterprise.

In early June 2008, Secretary of Defense Robert Gates requested the resignations of the Secretary of the Air Force, Michael Wynne, and the Chief of Staff of the Air Force, General Michael Mosely, from their positions, at least in part, due to concerns that shortcomings in the Air Force's handling of nuclear weapons "resulted from an erosion of performance standards within the involved commands and a lack of effective Air Force leadership oversight."[155] Secretary Gates appointed a task force, led by former Secretary of Defense and Energy James Schlesinger, to provide "independent advice on the organizational, procedural and policy improvements necessary to ensure that the highest levels of accountability and control are maintained in the department's stewardship of nuclear weapons, delivery vehicles, sensitive components and basing procedures."[156]

Several of the studies that reviewed this event concluded that the Air Force leadership had lost its focus on the nuclear mission as it diverted resources to more pressing missions related to the ongoing conflicts in Iraq and Afghanistan. As a result, the "nuclear enterprise" had been allowed to atrophy, with evident declines in morale, cohesion, and capability.[157] These reports suggested that the United States restore its focus on the nuclear mission and repair long-standing and often-identified deficiencies in manpower and training programs for crews that maintain and service nuclear weapons and operate nuclear-capable bombers. The studies identified a number of organizational changes to achieve these goals. For example, the Air Force has created a new Global Strike Command, based at Barksdale Air Force Base, that is responsible for both the ICBM force and the nuclear-capable bombers. This organization began its operations in early 2009. The Air Force has also established a new headquarters office in the Pentagon that will monitor and manage the resources and policies dedicated to the nuclear mission. The Air Force also altered its inspection program and its expectations for achievement during these inspections.

In a study published in April 2011, the Defense Science Board reviewed and evaluated the changes Air Force had made in its nuclear weapons enterprise.[158] The report noted that Air Force leadership "has taken decisive action to correct deficiencies, reinvigorate, and further strengthen

[154] See, for example, The Defense Science Board Permanent Task Force on Nuclear Weapons Surety. Report on the Unauthorized Movement of Nuclear Weapons. February 2008.

[155] Nuclear Lapses Trigger Ouster of Top U.S. Air Force Officials. Global Security Newswire. June 6, 2008.

[156] U.S. Department of Defense. Office of the Assistant Secretary of Defense (Public Affairs). Department of Defense Announces Task Force on Nuclear Weapons Management. June 12, 2008.

[157] See, for example, United States Air Force, *Reinvigorating the Air Force Nuclear Enterprise*, Prepared by the Air Force Nuclear Task Force, Washington, DC, October 24, 2008, http://www.af.mil/shared/media/document/AFD-081024-073.pdf. See also, Report of the Secretary of Defense Task Force on DOD Nuclear Weapons Management (the Schlesinger Commission), *Phase I: The Air Force's Nuclear Mission,* Washington, DC September 2008. http://www.defenselink.mil/pubs/Phase_I_Report_Sept_10.pdf.

[158] Defense Science Board Permanent Task Force on Nuclear Weapons Surety, *Independent Assessment of The Air force Nuclear Enterprise*, Washington, DC, April 2011. http://www.acq.osd.mil/dsb/reports/NWS_2010.pdf.

the Air Force Nuclear Enterprise."[159] At the same time, though, the study noted that some of the "extraordinary measures" taken in response to the earlier lapses could have negative impacts if they are extended beyond the "period of urgent need." This problem was particularly evident in the areas of oversight and inspection. The study reported that there has been "intense attention to the issue of accountability and control of nuclear weapons-related materials." But the numerous and overlapping inspections have become so frequent and invasive that the units may not have the time or resources to correct deficiencies found during the many inspections. As a result, the task force concluded that the intense level of inspections and exercises had become counterproductive by interfering with the normal rhythm of operations at the wings.[160]

Several incidents that occurred in 2013 and early 2014 raised new concerns about the capabilities and morale of ICBM launch officers. For example, press reports from May 2013 noted that the Air Force had removed 17 launch officers from duty at Minot Air Force Base and had sent them for additional training after they earned low scores on an inspection in March.[161] In August, a missile unit at Malmstrom Air Force Base also received a failing grade on an inspection. Air Force officials expressed concern about these results, but noted that they remained confident in the capabilities of Air Force nuclear officers. After the incident in Minot, some saw the commander's response, and the remedial action, as a sign of progress in the force, because problems were identified and corrected on site. Others have noted that unsatisfactory results in inspections may be the result of higher expectations, and do not necessarily indicate deeper problems. Others, however, view the low scores on inspections as a symptom of continuing problems in the force.

Two other incidents in September and October 2013 also raised concerns about the U.S. nuclear enterprise, even though they did not affect the safety or security of the nuclear force. In September, Vice Admiral Timothy Giardina, the second-in-command at STRATCOM, was suspended after an investigation into the use of counterfeit gambling chips. In October, Major General Michael Carey, the Commander of 20th Air Force, which is responsible for the entire ICBM fleet, was reassigned following an investigation into "personal misbehavior."[162]

In January 2014, press reports indicated that nuclear launch officers at Malmstrom Air Force Base had been implicated in a drug investigation. While investigating this charge, the Air Force discovered that 34 of launch officers may have been cheating on their monthly proficiency exams. In response to this event, Secretary of Defense Hagel ordered an internal review of nuclear weapons personnel issues and commissioned another outside study of morale and effectiveness in the nuclear enterprise. As this review has proceeded, the Air Force has questioned whether some officers in the nuclear force may be experiencing "burnout" and boredom in a mission that seems connected to an earlier time and whether the tense atmosphere created by the frequent testing and inspection regimes has created incentives to cheat to produce perfect scores.[163]

The Air Force responded to these problems with plans to increase funding by nearly $8 billion over five years, beginning in FY2015, to raise pay levels, introduce new management positions, modify the testing process, and raise morale among Air Force ICBM officers. In its FY2018

[159] Ibid., p. 16.

[160] Ibid., pp. 22-23.

[161] Robert Burns, "Air Force Sidelines 17 ICBM launch officers: commander cites 'rot' within system," *Associated Press*, May 8, 2013.

[162] "Air Force Fires General In Charge Of Nuclear Missiles," *Los Angeles Times*, October 11, 2013.

[163] R. Jeffrey Smith, "Aiming High: Boredom, Drugs, Low Morale. The millennials of the U.S. nuclear missile corps are struggling to stay on high alert for a nuclear Armageddon," *Slate*, April 2014.

budget request, the Air Force has indicated that it now plans to spend an additional $3 billion over the next five years. Many of these plans are designed to highlight the high value that Air Force places on the ICBM mission and to convince airmen that their leaders value their effort and accomplishment. At the same time, though, the changes will require additional funding, and the Air Force will need to request increases in its budget in an era of fiscal restraint to follow through on these initiatives.

While the Air Force has worked to increase the level of attention and accountability for its nuclear weapons after these incidents, other analysts found different lessons in the lapses. Some saw the decline of the Air Force nuclear enterprise as an inevitable part of the declining role of nuclear weapons in U.S. national security strategy and argued that the United States should extend the process by further reducing its nuclear arsenal and removing greater numbers of weapons from the operational force. For example, some suggested that the evident weaknesses in the Air Force's procedures argued for removing nuclear weapons from the whole of the bomber fleet.[164] Congress may address concerns about these issues, and review possible changes in command structures and security procedures, as it reviews nuclear weapons policies and programs.

Issues for Congress

This report focuses on the numbers and types of weapons in the U.S. strategic nuclear force structure. It does not address the broader question of why the United States chooses to deploy these numbers and types of weapons, or more generally, the role that U.S. nuclear weapons play in U.S. national security strategy. This question is addressed in other CRS reports.[165] However, as the new Trump Administration reviews and possibly revises the plans for U.S. nuclear force structure, Congress could address broader questions about the relationship between these forces and the role of nuclear weapons.

Force Size

In 2001, the Bush Administration argued that, because the United States and Russia were no longer enemies, the United States would not size or structure its nuclear forces simply to deter the "Russian threat." Instead, nuclear weapons would play a broader role in U.S. national security strategy. The Obama Administration, in contrast, noted that there is a relationship between the size of the U.S. arsenal and the size of the Russian arsenal. The 2010 NPR states that

> Russia's nuclear force will remain a significant factor in determining how much and how fast we are prepared to reduce U.S. forces. Because of our improved relations, the need for strict numerical parity between the two countries is no longer as compelling as it was during the Cold War. But large disparities in nuclear capabilities could raise concerns on both sides and among U.S. allies and partners, and may not be conducive to maintaining a stable, long-term strategic relationship, especially as nuclear forces are significantly reduced.[166]

The Trump Administration, in the 2018 Nuclear Posture Review, states that the "global threat conditions have worsened markedly since the most recent, 2010 NPR." It emphasizes that

[164] Kristensen, Hans. Nuclear Safety and the Saga of the Missing Bent Spear. Federation of the American Scientists. February 22, 2008. http://www.fas.org/blog/ssp/2008/02/nuclear_safety_and_the_saga_ab.php.

[165] See, for example, CRS Report RL31623, *U.S. Nuclear Weapons: Changes in Policy and Force Structure*, by Amy F. Woolf.

[166] U.S. Department of Defense, *Nuclear Posture Review*, Washington, DC, April 6, 2010, p. 30, http://www.defense.gov/npr/docs/2010%20Nuclear%20Posture%20Review%20Report.pdf.

"Russia and China are contesting the international norms" and that "Russia and North Korea have increased the salience of nuclear forces in their strategies and plans and have engaged in increasingly explicit nuclear threats." As a result, it states that the 2018 NPR is "strategy driven and provides guidance for the nuclear force structure and policy requirements needed now and in the future to maintain peace and stability in a rapidly shifting environment with significant future uncertainty."[167]

The Bush Administration's 2001 Nuclear Posture Review determined that the United States would need to maintain between 1,700 and 2,200 operationally deployed nuclear warheads. The Bush Administration also indicated that the United States would maintain in storage many of the warheads removed from deployed forces, and would maintain the capability to restore some of these warheads to the deployed forces to meet unexpected contingencies. The Obama Administration concluded, in its NPR, that the United States could reduce its forces to 1,550 deployed warheads, and agreed to do so under the New START Treaty, but it also planned to retain the capability to restore warheads to its deployed forces. It also plans to retain many warheads in storage, although it has indicated that the size of the total stockpile could decline as the United States reduces its deployed forces to the New START limits.[168]

The Obama Administration also indicated that the United States could reduce its numbers of deployed and nondeployed warheads further, but that it should do so in parallel with Russia. It indicated, in the 2010 NPR, that "large disparities in nuclear capabilities could raise concerns on both sides and among U.S. allies and partners, and may not be conducive to maintaining a stable, long-term strategic relationship."[169] In June 2013, the Department of Defense completed a new study, as a follow-up to the NPR, to determine how deeply the United States might reduce its forces, and how it should deploy the remaining forces. Press reports indicate the Pentagon reviewed a number of alternatives in this study, with some contemplating reductions as low as 300 warheads,[170] but the Administration concluded that the United States could reduce U.S. deployed strategic forces by about one-third, to a level of 1,000-1,100 warheads, if it did so along with Russia. They United States would not proceed with unilateral cuts in the U.S. arsenal.[171]

The Trump Administration did not directly address questions about the size of the U.S. nuclear arsenal in the 2018 Nuclear Posture Review. It indicated that it would continue to support the implementation of New START, at least through 2021, and that it would continue to pursue the nuclear modernization programs that began during the Obama Administration. It stated that, as a part of this modernization program, the United States would deploy a minimum of 12 Columbia class submarines and 400 missiles within 450 launch facilities under the GBSD program.[172] It did

[167] Department of Defense, *Nuclear Posture Review*, Washington, DC, February 2, 2018, pp. 2-3, https://media.defense.gov/2018/Feb/02/2001872886/-1/-1/1/2018-NUCLEAR-POSTURE-REVIEW-FINAL-REPORT.PDF.

[168] On May 3, 2010, the Obama Administration announced that the United States has 5,113 warheads in its stockpile of nuclear weapons. This number includes the deployed warheads, active nondeployed warheads and inactive nondeployed warheads. For more information, see http://www.defense.gov/npr/docs/10-05-03_Fact_Sheet_US_Nuclear_Transparency__FINAL_w_Date.pdf.

[169] U.S. Department of Defense, *Nuclear Posture Review*, Washington, DC, April 6, 2010, p. 30, http://www.defense.gov/npr/docs/2010%20Nuclear%20Posture%20Review%20Report.pdf.

[170] R. Jeffrey Smith, "Obama Embraces Big Nuke Cuts," *Foreign Policy*, February 8, 2013.

[171] U.S. Department of Defense, *Report on Nuclear Employment Strategy of the United States*, Washington, DC, June 12, 2013, p. 6, http://www.defense.gov/pubs/reporttoCongressonUSNuclearEmploymentStrategy_Section491.pdf.

[172] Department of Defense, *Nuclear Posture Review*, Washington, DC, February 2, 2018, pp. 49-50, https://media.defense.gov/2018/Feb/02/2001872886/-1/-1/1/2018-NUCLEAR-POSTURE-REVIEW-FINAL-REPORT.PDF.

not, however offer recommendations on the numbers of warheads that would be deployed on these missiles or indicate whether the United States would remain within the limits established by New START after the treaty expired.

Over the years, analysts have questioned why the United States must maintain such a large force of nuclear weapons. They have questioned whether the United States would attack with such a large number of weapons if its own national survival were not at risk, and they note that only Russia currently has the capability to threaten U.S. national survival. They assert that the United States could likely meet any other potential contingency with a far smaller force of nuclear weapons. Some have concluded, instead, that the United States could maintain its security with a force of between 500 and 1,000 warheads.[173] Others, however, dispute this view and note that the United States has other potential adversaries, and, even if these nations do not possess thousands of nuclear warheads, some may expand their nuclear forces or chemical and biological capabilities in the future. Some have argued that the United States also needs to assure its allies of its commitment to their security, and this goal could require a force of significant size, regardless of the number of potential targets an adversary nation might possess. They also argue that a "minimum deterrent" of only a few hundred warheads would require a strategy of targeting an adversary's cities and population centers, rather than military capabilities. They note that this strategy has been rejected by both Republican and Democratic Administrations throughout the nuclear age.[174]

Force Structure

When the Bush Administration announced the results of the 2001 Nuclear Posture Review, it indicated that the United States would retain a triad of ICBMs, SLBMs, and heavy bombers for the foreseeable future. The Obama Administration also offered continuing support for the retention of the strategic triad. In recent testimony, Robert Scher, the Assistant Secretary of Defense for Strategy, Plans, and Capabilities, reiterated the Administration's support for the nuclear triad. He argued that the United States needed to "maintain a deterrent that is inherently robust and stable," even though the United States did not need "to mirror every potential adversary, system-for-system or yield-for-yield." He indicated that the Obama Administration believed that the triad continued to "provide the credibility, flexibility, and survivability to meet and adapt to the challenges of a dynamic 21st century security environment."[175]

The 2018 Nuclear Posture Review offers a similar justification for retaining the nuclear triad. It notes that "the triad's synergy and overlapping attributes help ensure the enduring survivability of our deterrence capabilities against attack and our capacity to hold a range of adversary targets at risk throughout a crisis or conflict. Eliminating any leg of the triad would greatly ease adversary attack planning and allow an adversary to concentrate resources and attention on defeating the remaining two legs." It also lists additional capabilities and attributes that it views as essential to meeting U.S. deterrence needs, and argues that "the multiplicity of platforms, weapons, and

[173] See, for example, Sidney D. Drell and James E. Goodby. What Are Nuclear Weapons For? Recommendations for Restructuring U.S. Strategic Nuclear Forces. Arms Control Association, Updated October 2007.

[174] Dr. Keith B. Payne, *Why Do US Nuclear Force Numbers Matter for Deterrence?*, National Insititue for Public Policy, Information Series, Washington, DC, March 9, 2016, http://www.nipp.org/wp-content/uploads/2016/03/IS-404.pdf.

[175] U.S. Congress, Senate Committee on Armed Services, Subcommittee on Strategic Forces, *Nuclear Acquisition Programs and the Nuclear Doctrine*, Hearing, 114th Cong., 2nd sess., February 9, 2016.

modes of operation inherent in the triad and U.S. non-strategic nuclear forces, provide a significant margin of flexibility and resilience."[176]

Congress has also offered its support for the retention of the nuclear triad. The FY2017 National Defense Authorization Act (P.L. 114-328, Section 1671) states the modernization of the nuclear triad is a key element "in support of a strong and credible nuclear deterrent." The Trump Administration is also likely to continue to support the nuclear triad. Although, as a candidate, President Trump seemed unfamiliar with the concept of the triad, Secretary of Defense Mattis offered his support during his confirmation hearings in January 2017.

As the Obama Administration outlined plans to modernize and replace the delivery vehicles in all three legs of the strategic triad, many analysts began to question whether the United States could afford to retain the triad and whether it could retain a robust deterrent without one of the current types of strategic delivery vehicles.[177] Specifically, some called for reductions in or even the elimination of the U.S. ICBM force. Others have noted that, under the current financial pressures, the Air Force may not be able to afford a new ICBM after 2030. Moreover, even if the financial pressures did not exist, some argued the Air Force should eliminate the ICBM force because it no longer serves U.S. national security needs. For example, in a study published in May 2012,[178] the Global Zero Organization argued for the elimination of the ICBM force because it views these missiles as dangerous and destabilizing in the current security environment. It noted that "ICBMs can only support nuclear wartime operations against Russia" and that current-generation ICBMs "fired from the existing bases, on their minimum energy trajectories," have to overfly Russia and China or fly near Russia to reach targets in potentially adversarial countries. It contends that, if U.S. missiles fly over or near Russia on their way to more southerly targets in Iran or Syria, Russia might be confused by ambiguous attack indications and might then launch its own retaliatory attack against the United States. Second, the report asserted that, because ICBMs are based in fixed silos that are vulnerable to destruction in an attack, they must depend heavily upon "launch on warning" to survive and retaliate in some scenarios. As a result, according to the report, ICBMs exacerbate the risk that the United States might launch its weapons on false warning.

Former Secretary of Defense William Perry has also questioned the future need for the ICBM force. He noted that ICBMs are not an essential part of the U.S. nuclear deterrent because the bomber force and SSBN force are sufficient to promise an overwhelming response if the United States is attacked. Specifically, he said that "any sane nation would be deterred by the incredible striking power of our submarine force."[179] He suggested that the United States could keep its ICBM force for a number of years, but that he would not recapitalize it through the GBSD program.

Analysts who support the continued deployment of U.S. ICBMs dispute many of these assertions. First, they noted that, although each individual ICBM silo may be vulnerable to destruction if

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[176] Department of Defense, *Nuclear Posture Review*, Washington, DC, February 2, 2018, p. 43, https://media.defense.gov/2018/Feb/02/2001872886/-1/-1/1/2018-NUCLEAR-POSTURE-REVIEW-FINAL-REPORT.PDF.

[177] Mark Thompson, "Nuclear Triad Warfare," *Time Magazine*, October 18, 2011.

[178] Global Zero U.S. Nuclear Policy Commission, *Modernizing U.S. Nuclear Strategy, Force Structure, and Posture*, Global Zero, Washington, DC, May 2012, herein after referred to as the Global Zero Report. http://dl.dropbox.com/u/6395109/GZ%20US%20Nuclear%20Policy%20Commission%20Report.pdf.

[179] Daniel Horner and Kingston Reif, "Lowering Nuclear Risks: An Interview with Former Secretary of Defense William Perry," *Arms Control Today*, January/February 2016, http://www.armscontrol.org/ACT/2016_0102/Features/Interviews/Lowering-Nuclear-Risks-An-Interview-With-Former-Defense-Secretary-William-Perry.

targeted by several incoming warheads, an attack that threatened to destroy the entire U.S. ICBM force would have to consist of hundreds, if not thousands of attacking warheads.[180] This is because the United States maintains nearly 450 ICBM silos hardened against nuclear blast, and an attacker would have to target two or three warheads against each silo to ensure their destruction. Further, because the United States now deploys each Minuteman missile with only a single warhead, the attacker would have to expend two to three times as many warheads as he could hope to destroy. This calculation underpins the conclusion, which is widespread among nuclear policy analysts, that single-warhead ICBMs enhance stability and discourage attack because they are not lucrative targets.[181]

Some analysts have also argued that the United States could reduce the size of its SLBM fleet and retain only 8 or 10 submarines. They argued that this reduction now, and the future acquisition of fewer replacement submarines, could save the Navy $6 billion-$7 billion over the next 10 years.[182] They also noted that this change need not reduce the number of operational warheads on SLBMs, because the United States would deploy each submarine with 24 missiles, rather than the 20 planned under New START, and could increase the number of warheads on each missile. However, with so few submarines, the United States might have to eliminate one of its submarine bases, leaving it with submarines based only in the Atlantic or only in the Pacific Ocean. Or the United States might have to reduce the number of submarines on station, and, therefore, the number of warheads available to the President promptly, at the start of a conflict. These changes may not be consistent with current submarine operations and employment plans. President Obama and the U.S. military may want to consider the implications of these basing, operational, and policy changes, *before* deciding whether or not to reduce to 1,000 warheads, as opposed to choosing the warhead number first *then* deciding later how to base and operate the remaining nuclear forces.

Analysts outside government have also questioned the Administration's plans to replace the air-launched cruise missile (ALCM) with the new long-range strike missile (LRSO) in the 2020s. As noted above, some argue that this missile will be redundant, as the Air Force is already planning to deploy a new penetrating bomber. They note that, during the 1980s, the United States deployed cruise missiles both to extend the service life of the B-52 bombers, which could no longer penetrate Soviet air defenses, and to provide a means to attack and destroy those air defenses prior to follow-on attacks with penetrating bombers.[183] But, according to the program's critics, if the Air Force deploys 100 new bombers that can penetrate advanced air defenses, it will not need cruise missiles to destroy those defenses. Moreover, even if the United States does plan to attack an adversary's air defenses, it could do so with existing conventional cruise missiles, such as the extended range version of the Joint Air-to-Surface Standoff Missile (JASSM) missile.[184]

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[180] See, for example, Senate ICBM Coalition, *The Long Pole of the Nuclear Umbrella*, A White Paper on the Criticality of the Intercontinental Ballistic Missile to the United States Security, Washington, DC, November 2009. See also, Peter Huessy, "In Defense of the Nuclear Triad." Defense One, October 18, 2013, http://www.defenseone.com/ideas/2013/10/defense-nuclear-triad/72242/?oref=search_Huessy.

[181] See, for example, the comments of General Larry Welch, before the NDIA and ROA Congressional Breakfast Seminar Series, May 25, 2012, http://www.afa.org/hbs/transcripts/5-25-2012%20Gen%20Larry%20Welch%20v2.pdf.

[182] Daryl G. Kimball, "Defuse the Exploding Costs of Nuclear Weapons," *Arms Control Today*, December 2012, p. 4.

[183] William J. Perry and Andy Weber, "Mr. President, kill the new cruise missile," *Washington Post*, October 15, 2015. See, also, Tom Nichols, "The 1980s Called. "They Don't Need Their Cruise Missile Back." *The National Interest*, November, 3, 2015.

[184] Hans Kristensen, "LRSO—The Nuclear Cruise Missile Mission," *Strategic Security Blog, Federation of American Scientists*, October 20, 2015. http://fas.org/blogs/security/2015/10/lrso-mission/.

The Air Force has disputed the assertion that the bomber and cruise missile capabilities are redundant. Air Force officials have noted that the two systems are complementary, with each providing different capabilities for the United States and different profiles that would complicate an adversary's attempts to defend against a U.S. attack.[185] Some analysts also note that advanced air defense systems have proliferated among potential U.S. adversaries, and that these capabilities "make it harder for our forces to reach their targets." Deploying both penetrating bombers and long-range cruise missiles, therefore, will strengthen the U.S. nuclear deterrent.[186]

In addition to debating the value of each of the legs of the nuclear triad, some analysts have addressed questions about whether the United States should develop and deploy new types of nuclear weapons in response to the challenges posed by emerging nuclear adversaries. Attention has focused, in particular, on lower-yield weapons. Some argue that these weapons would strengthen deterrence by giving the United States more limited, tailored, and, therefore, credible options for nuclear use than are currently available with higher-yield weapons.[187] Others, however, argue that the deployment of low-yield nuclear weapons could undermine deterrence and make nuclear war more likely, because they might be seen as a more "usable" nuclear weapons.

Press reports indicate that a Defense Science Board study completed in December 2016 called for the Pentagon to consider the deployment of lower-yield nuclear weapons and the development of options for the limited use of nuclear weapons.[188] In early February 2017, General David Goldfein, the Chief of Staff of the Air Force, indicated that he also thought the nuclear posture review should consider the development of lower-yield warheads, as a part of a new look at "what constitutes deterrence in the 21st century.[189]

The Trump Administration addressed this issue during its nuclear posture review and concluded that "in the near-term, the United States will modify a small number of existing SLBM warheads to provide a low-yield option." The report notes that the United States has long maintained cruise missile warheads and B61 bombs that provide a low-yield option, but it also argues that, a low-yield SLBM warhead will "ensure a prompt response option that is able to penetrate adversary defenses."[190] The report asserts that this "supplement" to the U.S. nuclear force posture will enhance deterrence by "by denying potential adversaries any mistaken confidence that limited nuclear employment can provide a useful advantage over the United States and its allies."

The NPR's rationale for a new low-yield SLBM warhead differs, in some respects, from the debate evident in the literature over the past few years. Where the previous debate focused on the possible need for a low-yield warhead in regional scenarios, the NPR specifically points to Russia's nuclear doctrine, and Russia's purported "escalate to de-escalate strategy" as the

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[185] Bryan Bender, "Air Force Questions Call to Cancel new Nuclear-Armed Cruise Missile," *Politico*, October 25, 2015.

[186] Mel Deaile and Al Mauroni, "Why We Still Need a Nuclear-Armed Cruise Missile," *War on the Rocks*, October 26, 2015. http://warontherocks.com/2015/10/why-we-still-need-a-nuclear-armed-cruise-missile/.

[187] Clark Murdock et al., "Project Atom: A Competitive Strategies Approach to Defining U.S. Nuclear Strategy and Posture for 2025-2050," CSIS, May 2015, https://csis-prod.s3.amazonaws.com/s3fs-public/legacy_files/files/publication/150716_Murdock_ProjectAtom_Web_Rev2.pdf.

[188] John M. Donnelly, "Pentagon Panel Urges Trump Team to Expand Nuclear Options," *CQ Roll Call*, February 2, 2017.

[189] John M. Donnelly, "Top Air Force General Open to Changes in Nuclear Arms," *CQ Roll Call*, February 7, 2017.

[190] Department of Defense, *Nuclear Posture Review*, Washington, DC, February 2, 2018, pp. 54-55, https://media.defense.gov/2018/Feb/02/2001872886/-1/-1/1/2018-NUCLEAR-POSTURE-REVIEW-FINAL-REPORT.PDF.

justification for this warhead. The NPR argues that Russia "mistakenly assesses that the threat of nuclear escalation or actual first use of nuclear weapons would serve to 'de-escalate' a conflict on terms favorable to Russia."[191] The NPR, therefore, "concluded that a new capability was required to ensure the Russian leadership does not miscalculate regarding the consequences of limited nuclear first use.... Russia must instead understand that nuclear first use, however limited, will fail to achieve its objectives, fundamentally alter the nature of a conflict, and trigger incalculable and intolerable costs for Moscow." According to one analyst, by modifying a small number of W-76 warheads, the United States will "strengthen Russian perceptions of U.S. credibility and will."[192]

Analysts outside government have raised a number of concerns about the possible deployment of a low-yield version of the W76 warhead. Some have argued that, because the United States already has warheads with low-yield options on cruise missiles and B61 bombs, it already has the flexibility and means to deter Russia's escalation to low-yield nuclear weapons during a conventional conflict. Others argue that the new warhead will add little to the U.S. deterrent capability because Russia would be unable to determine the yield of an attacking warhead until it had detonated. Moreover, if Russia could not determine the yield of the warhead, and chose to retaliate before assessing the yield, the U.S. use of a low-yield warhead could lead Russia to escalate to a much broader and more destructive nuclear conflict.

Those who support the NPR's recommendation have responded to these concerns by noting that Russia is not likely to escalate to full-scale nuclear war before confirming the nature of the U.S. attack. In addition, some have pointed out that because the U.S. goal is to deter Russian nuclear use in the first place, concerns about how the war might unfold if deterrence failed are highly speculative. They believe that a U.S. low-yield warhead would raise the nuclear threshold because the United States would be more likely to respond to Russia's use of low-yield nuclear weapons if it had a low-yield option of its own. Because Russia would know that the United States had this option, Russia would be less likely to escalate to nuclear use during a conventional conflict.

The Cost of Nuclear Weapons

When the Obama Administration submitted the 1251 report to the Senate during the New START ratification process, it indicated that it expected to spend around $210 billion over the next 10 years (2011-2021) to maintain and modernize the U.S. nuclear arsenal. This total, however, did not include most of the costs of producing and procuring the next generation of submarines, bombers, and missiles, as these activities would occur after the timeframe contained in the report. Moreover, it became evident, as Congress reviewed the Administration's plans to modernize the nuclear enterprise, that it was difficult, if not impossible, to determine how much the United States spent each year on nuclear weapons, as the funding was divided between the Department of Defense and the Department of Energy, and, in many cases, was combined with funding for other, nonnuclear activities. In other words, the United States does not maintain a single, unified budget for nuclear weapons and other nuclear activities.

In response to both the growing concerns about the pending costs of nuclear weapons modernization programs and the confusion about how to calculate the annual costs of the nuclear enterprise, Congress directed the Congressional Budget Office (CBO) to estimate the costs of

[191] Ibid., p. 8.

[192] Frank Miller, "Addressing Fears About the Nuclear Posture Review and Limited Nuclear Use," *War on the Rocks*, February 28, 2018. https://warontherocks.com/2018/02/addressing-fears-nuclear-posture-review-limited-nuclear-use/?utm_content=buffer7699f&utm_medium=social&utm_source=twitter.com&utm_campaign=buffer.

U.S. plans for operating, maintaining and modernizing nuclear weapons, the delivery systems, and the DOE nuclear weapons complex over the next 10 years. CBO issued its report in late 2013.[193] It found that the United States was likely to spend $355 billion over the next 10 years on its nuclear weapons enterprise. This total included $56 billion for command, control, communications, and early warning activities and $59 billion for additional costs based on historical cost growth of similar programs. Neither of these categories had been included in the Administration's estimate in 2010. When CBO considered the same categories as the Administration, it estimated 10-year spending of $241 billion, a number close to the estimate provided by the Administration. CBO updated its estimate in January 2015, and reported that it calculated that the United States would spend $348 billion between 2015 and 2024; excluding command and control and cost growth, the total that was comparable to the Administration's 2010 estimate was now $247 billion. CBO updated its report again in February 2017, estimating that the United States would spend $400 billion on nuclear weapons between 2017 and 2026.

Congress also mandated that the DOD and DOE provide 10-year cost estimates of the expected costs of nuclear weapons programs, and that GAO evaluate the cost estimates. In July 2017, GAO released its review of the DOD and DOE combined report for FY2017. The combined report estimates that the costs of sustaining and modernizing nuclear delivery systems, the nuclear command and control system, the nuclear stockpile, and the nuclear security enterprise will total $342 billion between FY2017 and FY2026.

Both the CBO studies and the DOD/DOE reports indicate that the United States is on track to spend, on average, $35-$40 billion per year as it sustains and modernizes its nuclear weapons programs. This indicates that the United States could spend at least $1-$1.2 trillion on nuclear weapons programs and modernization over the next 30 years. This estimate is consistent with others that have been presented by organizations outside government. For example, in January 2014, analysts at the James Martin Center for Nonproliferation Studies estimated that the United States might spend $1 trillion, or an average of just over $30 billion per year, over the next 30 years, to modernize its nuclear enterprise.[194] In addition, in a briefing prepared in May 2013, the Air Force estimated that the investments in nuclear modernization programs would peak in between 2025 and 2035, at approximately $30 billion per year.[195]

While there appears to be a broad base of agreement about the magnitude of the costs that the United States is likely to incur as it modernizes its nuclear arsenal, there has been less agreement about whether the United States can, or should, proceed with all of these programs. Many analysts have noted that, with the passage of the Budget Control Act in 2011, the amount of funding available for defense spending will be nearly $1 trillion lower than expected when the Obama Administration first outlined the nuclear modernization program. In this environment, rising costs for nuclear weapons programs could to cut into funding for other Pentagon priorities.

Moreover, this problem may not disappear after the Budget Control Act expires in 2021. Frank Kendall, the Under Secretary of Defense for AT&L, noted in a hearing before the Senate Armed Services Committee in 2015 that "the funding that we have requested from both departments, through the 5-year plan that we've submitted, is adequate to execute our plan during that period.

[193] Congressional Budget Office, *Projected Costs of U.S. Nuclear Forces, 2014-2023*, Washington, DC, December 2013, http://www.cbo.gov/sites/default/files/cbofiles/attachments/12-19-2013-NuclearForces.pdf.

[194] Jon B. Wolfsthal, Jeffrey Lewis, and Marc Quint, *The Trillion Dollar Nuclear Triad*, James Martin Center for Nonproliferation Studies, Monterey, CA, January 2014, http://cns.miis.edu/opapers/pdfs/140107_trillion_dollar_nuclear_triad.pdf.

[195] For a copy of General Kowalski's briefing slides, see http://www.fas.org/programs/ssp/nukes/nuclearweapons/AFGSC-CommandBrief-May2013.pdf.

After the end of that period, as we start to actually produce the systems I talked about, we're going to have an affordability problem that we have to deal with." He went on to say, "In 2021, we're going to start to have a problem finding ways to afford these systems."[196]

Others, however, argue that the United States not only can afford to bear the costs of these systems, but cannot afford the costs of failing to modernize its nuclear arsenal. Admiral Haney, the Commander of Strategic Command, made this point in a hearing before the House Armed Services Committee, when he said that "achieving strategic deterrence in the 21st century requires continued investment in strategic capabilities and renewed multigenerational commitment of intellectual capital." He argued that "any cuts to that budget, including those imposed by sequestration, will hamper our ability to sustain and modernize our military forces." He noted that, as the modernization programs progressed, spending on nuclear weapons was likely to rise from around 2.5%-3% of DOD's budget to around 5%-6% of that budget in the late 2020s to 2030s. When asked whether the United States could afford to make this investment, he noted that other nations have been modernizing their forces and continued to pose an "existential threat" to the United States. He noted that "in order to maintain and sustain its strategic stability, it's very important that we have that kind of balance" with these nations. And he asked, "Quite frankly, the question really is, can we afford not to" proceed with the modernization programs.[197]

The 2018 Nuclear Posture Review offered a similar response to concerns about the cost of the nuclear modernization programs. It noted that DOD currently spends 2%-3% of its budget to maintain and operate the nuclear force; this will rise to about 6.4% of its budget at the "highpoint" of the modernization program.[198] This total does not include the costs associated with NNSA's life extension programs or the recommended investment in recapitalization of NNSA's infrastructure. Moreover, although Congress has raised the caps in the Budget Control Act to allow for additional spending on defense, the analysis in the NPR does not address questions about whether the nuclear modernization will compete with other DOD priorities for scarce funding.

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[196] U.S. Congress, Senate Committee on Armed Services, Subcommittee on Strategic Forces, *President Obama's Fiscal 2016 Budget Request for the U.S. Nuclear Weapons Policy, Programs and Strategy*, Hearing, 114th Cong., 1st sess., March 4, 2014.

[197] U.S. Congress, House Committee on Armed Services, Subcommittee on Strategic Forces, *President Obama's Fiscal 2016 Budget Request on Strategic Forces*, Hearing, 114th Cong., 1st sess., February 26, 2015.

[198] Department of Defense, *Nuclear Posture Review*, Washington, DC, February 2, 2018, p. 51, https://media.defense.gov/2018/Feb/02/2001872886/-1/-1/1/2018-NUCLEAR-POSTURE-REVIEW-FINAL-REPORT.PDF.

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