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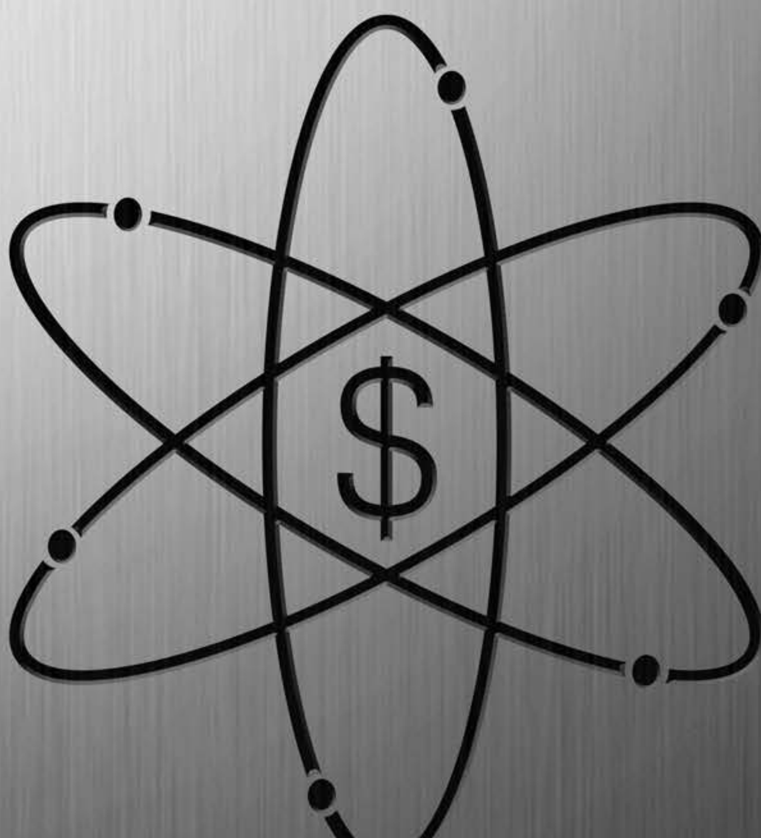
THE COST OF U.S. NUCLEAR FORCES
FROM BCA TO BOW WAVE AND BEYOND



TODD HARRISON
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ABOUT THE CENTER FOR STRATEGIC AND BUDGETARY ASSESSMENTS

The Center for Strategic and Budgetary Assessments (CSBA) is an independent, nonpartisan policy research institute established to promote innovative thinking and debate about national security strategy and investment options. CSBA's analysis focuses on key questions related to existing and emerging threats to U.S. national security, and its goal is to enable policymakers to make informed decisions on matters of strategy, security policy, and resource allocation.

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Evan Braden Montgomery is a Senior Fellow at the Center for Strategic and Budgetary Assessments. At CSBA, his research addresses two broad questions. First, how should the United States adapt its military strategy, capabilities, posture, and alliance relationships in response to changes in the balance of power as well as trends in future warfare? Second, how should we think about the role of nuclear weapons, including the size and shape of the U.S. arsenal as well as the impact of proliferation on regional security competitions? His current academic work focuses on how established powers respond to emerging powers and the relationship between grand strategy and military strategy. Dr. Montgomery is the author of numerous CSBA reports and policy briefs, most recently *The Future of America’s Strategic Nuclear Deterrent*. He has also published articles in *Foreign Affairs*, *International Security*, *Security Studies*, and *Journal of Strategic Studies*, and his commentary has appeared in *Defense News*, *The Diplomat*, *The National Interest*, and *Real Clear Defense*. He is a member of the International Institute for Strategic Studies.

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CHAPTER 1

Introduction

Nuclear weapons have underpinned U.S. national security strategy since the early days of the Cold War. For more than half a century, the United States has relied on its nuclear arsenal to deter attacks against its territory, extend deterrence to its allies, and limit the amount of damage that an adversary could inflict if deterrence were to fail. Because of their enormous destructive potential, however, nuclear weapons have also been one of the most controversial elements of U.S. military power. As a result, the size and shape of the U.S. nuclear arsenal, along with the core tenets of U.S. nuclear strategy and doctrine, have been continuously debated for decades.

Today, the United States has far fewer nuclear weapons than it did during the Cold War. It also relies on these weapons far less than it did in the past.[1] Nevertheless, the controversy surrounding them has not gone away. Critics of the status quo maintain that U.S. nuclear forces are ill suited to address many of the challenges that concern policymakers most, such as the threat from non-state actors, the proliferation of sophisticated military technology, and, most worrisome of all, the interaction between the two. They argue, therefore, that the United States should make a number of modifications to its existing policies, programs, and posture. Some potential changes include, for example, fielding a somewhat smaller arsenal than the 2011 New START Treaty allows, abandoning the triad of strategic delivery systems that has been in place for more than half a century, withdrawing the last tactical nuclear warheads that remain stationed in Europe, and perhaps even adopting a minimum deterrence strategy that would require no more than a few hundred operational weapons.[2] In theory, these measures or others like them could allow Washington to shed unnecessary capabilities and set an example that others might follow.[3]

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1 Department of Defense (DoD), *Nuclear Posture Review Report* (Washington, DC: DoD, April 2010), p. 15.

2 According to the New START Treaty between the United States and the Russian Federation, both sides will be limited to 700 deployed strategic delivery vehicles, 800 deployed and non-deployed delivery vehicles, and 1,550 deployed strategic warheads by February 2018.

3 For recent studies that advocate some of these positions, see Global Zero, *Modernizing U.S. Nuclear Strategy, Force Structure, and Posture*, Global Zero U.S. Nuclear Policy Commission Report (Washington, DC: Global Zero, May 2012); Benjamin Freedman, Christopher Preble, and Matt Fay, *The End of Overkill: Reassessing U.S. Nuclear Weapons Policy* (Washington, DC: Cato Institute, 2013); Tom M. Nichols, *No Use: Nuclear Weapons and U.S. National Security* (Philadelphia, PA: University of Pennsylvania Press, 2013); and Barry Blechman and Russell Rumbaugh, *Protecting U.S. Security by Minimizing the Role of Nuclear Weapons* (Washington, DC: Stimson Center, May 2015). Although the measures outlined in these and other reports could be taken unilaterally, most proponents suggest that

Notably, though, the main rationale for many of these recommendations has been shifting over the past several years from the realm of strategy to the world of resources. Simply put, several studies have suggested that one reason to cut back U.S. nuclear force structure or scale back modernization efforts would be to save money, and that reason is arguably overshadowing most others. As one recent report argues, "The Departments of Defense and Energy are in the process of making long-term, multi-billion dollar decisions about how many new missiles, submarines, bombers and nuclear warheads the nation will build and deploy over the next 30 years. These plans should be reevaluated before major budget decisions are locked in."[4]

Why are resource-based arguments for nuclear reductions receiving more emphasis? Three reasons stand out. First, changes in the security environment are beginning to cast doubt on the decreasing relevance of nuclear weapons. With the decline of great power competition and the rise of non-state threats, the complex dynamics of nuclear deterrence appeared anachronistic during the early part of the post-Cold War era. Consequently, the United States has been able to substantially reduce its nuclear stockpile, defer the introduction of new delivery systems, and maintain a prohibition on the development of new warheads. Yet nuclear dangers now appear to be increasing in many corners of the world. In Europe, for example, Russia has been placing greater emphasis on nuclear weapons as tools of political intimidation and potentially warfighting as well.[5] Not only have Russian officials recently been making a series of nuclear threats against neighboring nations, but Moscow has also been violating its obligations under the 1987 Intermediate-Range Nuclear Forces (INF) Treaty.[6] In Northeast Asia, China is still far from becoming a nuclear peer competitor of the United States or Russia, but is steadily working to improve its arsenal, to include developing new nuclear-powered ballistic missile submarines (SSBNs) and equipping some of its existing intercontinental ballistic missiles (ICBMs) with multiple independently targetable reentry vehicles (MIRVs). Meanwhile, North Korea might have the ability to field much larger and more capable nuclear forces than many observers had anticipated.[7] In South Asia, both India and Pakistan are pursuing a variety of new nuclear capabilities, some of which—such as Islamabad's short-range nuclear delivery systems—are heightening the risk of a regional war.[8] Finally, in the Middle East, questions remain about the

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they should be implemented as part of negotiated reductions if possible, especially with Russia, which remains the world's other nuclear "superpower."

4 Tom Z. Collina and the Arms Control Association Research Staff, *The Unaffordable Arsenal: Reducing the Costs of the Bloated U.S. Nuclear Stockpile* (Washington, DC: Arms Control Association, October 2014), p. 6. See also Steven Pifer, "Nukes, Dollars, and Sense," *The National Interest*, March 10, 2014; and Angela Canterbury and Kingston Reif, "It's Time to Rein in Nuclear Spending," *Defense One*, September 25, 2014.

5 See, for example, Jacob W. Kipp, "Russia as a Nuclear Power in the Eurasian Context," in Ashley J. Tellis, Abraham M. Denmark, and Travis Tanner, eds., *Strategic Asia 2013–14: Asia in the Second Nuclear Age* (Seattle, WA: National Bureau of Asian Research, 2014); and Dmitry (Dima) Adamsky, "Nuclear Incoherence: Deterrence Theory and Non-Strategic Nuclear Weapons in Russia," *Journal of Strategic Studies*, 37, No. 1, 2014.

6 Paul Sonne, "As Tensions Rise with West, Russia Increasingly Rattles Nuclear Saber," *Wall Street Journal*, April 5, 2015; and Michael R. Gordon, "U.S. Says Russia Tested Cruise Missile, Violating Treaty," *New York Times*, July 28, 2014.

7 Office of the Secretary of Defense (OSD), *Military and Security Developments Involving the People's Republic of China 2015*, Annual Report to Congress (Washington, DC: DoD, April 2015); and David Albright, *Future Directions in the DPRK's Nuclear Weapons Program: Three Scenarios for 2020* (Washington, DC: Institute for Science and International Security, February 2015).

8 Evan Braden Montgomery and Eric S. Edelman, "Rethinking Stability in South Asia: India, Pakistan, and the Competition for Escalation Dominance," *Journal of Strategic Studies*, 38, Nos. 1–2, 2015.

longer-term impact of the recent agreement between Iran and the so-called "P5+1" on regional stability and the likelihood of additional proliferation.[9]

Second, just as the security environment is growing more complex, particularly when it comes to the nuclear dimension, the fiscal constraints on the United States are becoming more severe. In August of 2011, Congress passed the Budget Control Act (BCA), which put in place budget caps for the defense and non-defense portions of the federal discretionary budget. For the Pentagon, these budget caps are roughly $1 trillion less than it had been planning to spend from Fiscal Year (FY) 2012 to FY 2021. Since the BCA was enacted, Congress has twice modified the level of the budget caps, raising the defense and non-defense budget caps for Fiscal Years 2013 to 2015. But the budget caps remain at their original level for FY 2016 and beyond. As a result, the United States is being forced to make difficult decisions when it comes to the types of capabilities it fields and its capacity to respond to threats. This has also created a "zero-sum game" when it comes to defense spending; that is, any funding allocated for maintaining, upgrading, or replacing nuclear forces will come at the expense of the funds needed to sustain or improve conventional forces, and vice versa.[10]

Third, limits on national security spending are occurring at a time when virtually every component of the U.S. nuclear arsenal is due for modernization. For instance, the backbone of the U.S. nuclear deterrent is the strategic triad of bombers, land-based ICBMs, and SSBNs.[11] At present, the United States maintains two types of nuclear-capable bombers: B-52H bombers that can release air-launched cruise missiles (ALCMs) from outside the range of enemy air defenses and stealthy B-2 bombers that can drop gravity bombs directly over targets in well-defended areas. Both the standoff and penetrating components of the bomber leg will need to be recapitalized if they are going to be retained, however, given the age of the platforms and the weapons they carry. The United States also has nearly 450 Minuteman III ICBMs in hardened silos that are scattered across five states. Yet the Minuteman III was first deployed over four decades ago, and while the missiles have been preserved and upgraded, current plans call for their replacement by 2031 due to a combination of age and a reduced ability to conduct test launches as the inventory continues to decline in size. Lastly, the United States has a fleet of 14 Ohio-class SSBNs, which were each built to carry 24 Trident-II D5 submarine-launched ballistic missiles (SLBMs). These SSBNs are reaching the end of their service life, however, which has already been extended from 30 to 42 years, and the Navy cannot delay a replacement any longer without abandoning its current requirement of having 10 boats operationally available at all times. Along with rebuilding the triad, the Departments of Defense and Energy are also planning to field dual-capable F-35s that can deliver tactical nuclear weapons, upgrade communications networks that allow the national command authority to exercise command-and-control over nuclear forces, conduct life extension programs to replace critical components on existing warheads, consolidate many of those warheads into a smaller number of interoperable weapons, and revitalize the aging physical infrastructure that is needed to monitor and maintain the nuclear arsenal.[12]

The goal of modernizing U.S. nuclear forces has been reaffirmed by the Obama administration on multiple occasions, including the 2010 Nuclear Posture Review, the 2013 Report on Nuclear

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9 Henry Kissinger and George P. Shultz, "The Iran Deal and its Consequences," *Wall Street Journal*, April 7, 2015.

10 See Todd Harrison, *Analysis of the FY 2015 Defense Budget* (Washington, DC: Center for Strategic and Budgetary Assessments, 2014).

11 For an overview of the U.S. strategic triad and planned modernization programs, see Evan Braden Montgomery, *The Future of America's Strategic Nuclear Deterrent* (Washington, DC: Center for Strategic and Budgetary Assessments, 2013).

12 Maintaining the physical infrastructure to monitor and maintain the nuclear arsenal is of particular concern because the United States has not fielded a new nuclear weapon since the late 1980s and has not tested a nuclear weapon since 1992.

Employment Strategy, the 2014 Quadrennial Defense Review, and, most recently, the 2015 National Security Strategy, which declared that the United States "will protect our investment in foundational capabilities like the nuclear deterrent."[13] Yet there are widespread doubts that it will be able to pay the bills that are now starting to come due—and those doubts will only grow larger in the decade ahead. As the independent National Defense Panel noted in its final report, "The Department of Defense is committed to a recapitalization of the triad, which under current budget constraints is unaffordable, especially considering that the nuclear deterrent's supporting infrastructure, command and control systems, and other enabling capabilities also require expensive renovations."[14] According to Frank Kendall, the Undersecretary of Defense for Acquisition, Technology, and Logistics, the Pentagon would require an additional $10–12 billion per year beginning in FY 2021 to support its planned nuclear modernization efforts.[15]

In sum, the claim that nuclear weapons are becoming obsolete is starting to appear less credible given events around the globe. At the same time, arguments for nuclear reductions based on their cost seem more compelling at first glance, particularly as the Pentagon is asked to do more with less and is finding it increasingly difficult to fund all its other priorities. Yet the notion that nuclear weapons represent a major burden on national security spending stands in stark contradiction to the longstanding assumption that these weapons provide "more bang for the buck." As then Deputy Secretary of Defense (now Secretary of Defense) Ashton Carter explained to an audience several years go, "nuclear weapons don't actually cost that much."[16]

This apparent inconsistency stems in part from the fact that the actual cost of U.S. nuclear weapons has long been shrouded in ambiguity. For instance, in his seminal volume on nuclear weapons spending before and during the Cold War, Stephen Schwartz observed that "the United States spent vast amounts on nuclear weapons without the kind of careful and sustained debate or oversight that are essential both to democratic practice and to sound public policy."[17] Over the past several years, however, several studies by non-governmental and governmental organizations have been released, all of which have tried to put a price tag on the U.S. nuclear arsenal. Yet these studies vary widely in the assumptions they use, the costs they include, and the timeframes they assess. As a result, they reach very different conclusions.

Given the complexity of the nuclear enterprise as well as the speculative nature of some modernization programs, this lack of consensus is hardly surprising. Nor is it particularly helpful when it comes to answering the central—albeit sometimes implicit—question at the heart of these studies: how much money could the United States actually save through nuclear reductions? The purpose of this report, therefore, is to provide an in-depth accounting of what U.S. nuclear forces cost and to explicitly address how much could potentially be saved by cutting those forces. To do so, the remainder of the report is divided into three main chapters. Chapter 2 reviews a number of existing cost estimates and explains why they reach such different conclusions. Chapter 3

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13 DoD, *Nuclear Posture Review Report*; DoD, *Report on Nuclear Employment Strategy of the United States Specified in Section 491 of 10 U.S.C.* (Washington, DC: DoD, June 2013); OSD, *Quadrennial Defense Review 2014* (Washington, DC: DoD, 2014); and *National Security Strategy* (Washington, DC: The White House, February 2015), p. 8.

14 William J. Perry and John P. Abizaid, Co-Chairs, *Ensuring a Strong U.S. Defense for the Future: The National Defense Panel Review of the 2014 Quadrennial Defense Review* (Washington, DC: United States Institute of Peace, 2014), p. 50.

15 Marcus Weisgerber, "Pentagon: We Can't Afford to Replace Aging ICBMs, Bombers, Subs," *Defense One*, April 14, 2015, available at http://www.defenseone.com/management/2015/04/pentagon-we-cant-afford-replace-aging-icbms-bombers-subs/110134/.

16 Remarks by Deputy Secretary of Defense Carter at the Aspen Security Forum at Aspen, Colorado, July 18, 2013, available at http://www.defense.gov/Transcripts/Transcript.aspx?TranscriptID=5277.

17 Stephen I. Schwartz, "Introduction," in Schwartz, ed., *Atomic Audit: The Costs and Consequences of U.S. Nuclear Weapons Since 1940* (Washington, DC: The Brookings Institution, 1998), p. 1.

presents detailed cost estimates for U.S. forces looking out over the next two and half decades. Chapter 4 outlines and assesses a number of potential cost-savings options.

Ultimately, this report finds that the Pentagon will indeed require as much as $12–13 billion per year in additional funding to support nuclear maintenance and modernization during the 2020s, when spending on U.S. nuclear forces will peak. At most, however, nuclear spending will still account for only 5 percent of total defense spending, even if the BCA budget caps are extended indefinitely. Moreover, plausible options to reduce spending levels within the next five years—when the budget caps are slated to remain in effect—would only account for a small fraction of the difference between the president's current budget proposal and existing spending caps. In other words, nuclear reductions would not provide much savings when those savings are needed most.

CHAPTER 2

Framing the Nuclear Cost Debate

Since the BCA was enacted, every area of the defense budget has come under increased scrutiny. The cost of nuclear forces in particular has received considerable attention because nearly every component of the triad is due for modernization. To execute these programs as currently planned, DoD will need to increase funding for U.S. nuclear forces well above recent levels, which will create additional pressure on an already-strained defense budget. Not surprisingly, with nuclear costs now in the spotlight, a number of reports have been published that attempt to estimate just how much the U.S. government currently spends on nuclear forces and how much it plans to spend in the years ahead. Congress has also directed DoD to produce a ten-year cost projection for nuclear forces, known as the 1251 Report. The details and methodology used to produce this report remain classified, however.

Table 1 summarizes four of the most frequently cited estimates for the cost of nuclear forces. Their projections range from $73 billion over five years to more than a trillion dollars over thirty years. To compare these projections, though, it is necessary to understand what forces they include, what they exclude, and how they account for the cost of dual-use capabilities (i.e., weapon systems and supporting infrastructure with both nuclear and conventional missions). This chapter summarizes each study to provide a basis of comparison.

TABLE 1: COMPARISON OF NUCLEAR FORCES COST PROJECTIONS

SOURCE	TOTAL COST *(IN THEN-YEAR DOLLARS)*	TIME PERIOD	YEARS INCLUDED
DoD's Major Force Program 1: Strategic Forces (April 2014)	$73B	5 years	FY 2016 to 2020
CBO's *Projected Costs of U.S. Nuclear Forces* (January 2015)	$348B	10 years	FY 2015 to 2024
Stimson's *Resolving Ambiguity: Costing Nuclear Weapons* (June 2012)	$352–392B	10 years	FY 2013 to 2022
CNS's *The Trillion Dollar Nuclear Triad* (January 2014)	$872–1,082B	30 years	FY 2014 to 2043

DoD's Major Force Program 1: Strategic Forces

One of the most commonly used estimates for the cost of U.S. nuclear forces is the Major Force Program (MFP) for strategic forces. In each budget request, DoD includes a summary of the overall budget split between 11 different MFPs, with costs projected five years into the future through the end of the Future Years Defense Program (FYDP). Dating back to Robert McNamara's tenure as Secretary of Defense during the 1960s, every program element in the budget is assigned to only one MFP, a structure that cannot easily account for dual-use systems whose costs should be split among categories. The first category, MFP-1, is designated for strategic forces, which are often treated as synonymous with nuclear forces. In the FY 2016 President's Budget, MFP-1 costs total $73 billion for FY 2016 to FY 2020.[18]

As Russell Rumbaugh and Nathan Cohn have noted, however, "the elements that make up the major force programs have not been managed to ensure the MFPs reflect an accurate and comprehensive account of the categories they were originally intended to represent."[19] DoD defines the strategic forces MFP to include "organizations and associated weapon systems whose force missions encompass intercontinental or transoceanic inter-theater responsibilities."[20] On the one hand, this definition is much broader than nuclear forces. For example, MFP-1 includes all operating costs for Air Force bombers, which qualify as intercontinental strategic forces. The B-1 bomber is no longer nuclear-capable, though, and the B-2 and B-52 bomber fleets are used for both conventional and nuclear missions. Yet MFP-1 includes all costs related to these aircraft. On the other hand, MFP-1 omits significant nuclear-related costs. Current development funding for the Ohio Replacement submarine, for example, is included in MFP-6: Research and Development. Likewise, funding for the development and procurement of some command, control, and communications systems used to support nuclear forces is included in MFP 3: Command, Control, Communications, and Intelligence. Additionally, MFP-1 does not include Department of Energy funding for nuclear weapons, such as the cost of maintaining the nuclear weapons stockpile, warhead modernization programs, and nuclear weapons research laboratories. For all of these reasons, MFP-1 is not a particularly useful or accurate indicator of the total cost of U.S. nuclear forces.

CBO's *Projected Costs of U.S. Nuclear Forces*

In January 2015, the Congressional Budget Office (CBO) published its latest report on the cost of U.S. nuclear forces, which projected a total cost of $348 billion over ten years (FY 2015 to FY 2024).[21] This estimate includes the cost of nuclear weapons (primarily funded through DoE) and associated delivery systems (both strategic and tactical), as well as command, control, communications, and early warning systems. CBO also includes projected cost growth for these programs based on historical data, which accounts for some $49 billion of its total estimate.[22] The estimate does not include the legacy costs of nuclear weapons, threat reduction and arms control, or missile defense, which CBO previously estimated would add $215 billion over ten years.[23]

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18 Office of the Undersecretary of Defense, Comptroller, *National Defense Budget Estimates for FY 2016* (Washington, DC: DoD, March 2015), p. 104.

19 Russell Rumbaugh and Nathan Cohn, *Resolving Ambiguity: Costing Nuclear Weapons* (Washington, DC: The Henry L. Stimson Center, June 2012), p. 19.

20 DoD, *Future Years Defense Program (FYDP) Structure*, DoD 7045.7-H (Washington, DC: DoD, April 2004), available at: http://www.acqnotes.com/Attachments/DoD%2070450.7H%20FYDP%20Structure.pdf.

21 Congressional Budget Office (CBO), *Projected Costs of U.S. Nuclear Forces, 2015 to 2024* (Washington, DC: Government Printing Office [GPO], January 2015), p. 1.

22 Ibid. p. 3.

23 CBO, *Projected Costs of U.S. Nuclear Forces, 2014 to 2023* (Washington, DC: GPO, December 2013).

Because the sea-based and land-based legs of the nuclear triad (the Navy's SSBNs and the Air Force's ICBMs) are dedicated to the nuclear mission, CBO includes all of the costs associated with these weapon systems, including their modernization costs. For the air leg of the triad, however, the delivery systems are used for both nuclear and conventional missions. To account for this, CBO allocates 25 percent of the costs for the B-52 bomber, 100 percent of the B-2 bomber, and 25 percent of the new Long-Range Strike Bomber (LRS-B) program to the nuclear mission.[24] It also assumes that 10 percent of the operation and maintenance and military personnel costs associated with the dual-use F-16 and F-15E fleets can be attributed to the nuclear mission, since these aircraft and their aircrews must maintain nuclear certification.

CBO does not attempt to estimate the fraction of command, control, communications, and early-warning systems attributable to the nuclear mission. Instead, it includes all of the costs for systems deemed to be "the most critical to the use of nuclear forces" and none of the costs associated with other systems. It includes 100 percent of the costs of protected military satellite communications systems, specifically Milstar, Advanced Extremely High Frequency (AEHF), and Polar MILSATCOM, since these systems are designed to be survivable in the event of a nuclear attack. It also includes all costs associated with early-warning systems, such as the Space-Based Infrared System (SBIRS).[25] CBO's estimates of these costs may be high given that protected MILSATCOM systems and SBIRS are also used for conventional missions. And because the CBO projection only extends through FY 2024, it does not capture most of the costs for the Ohio Replacement and LRS-B programs, as well as the peak funding years for the Minuteman III and Trident D5 replacement programs.

Stimson's *Resolving Ambiguity: Costing Nuclear Weapons*

The Stimson Center's 2012 report on the cost of U.S. nuclear forces provides one the most detailed and documented cost estimates available. Although much of the report focuses on establishing a single-year cost estimate, it also extrapolates these costs over a ten-year period, and concludes that U.S. nuclear forces will account for $352–$392 billion in spending for the period between FY 2013 to FY 2022.[26] Like the CBO report, the Stimson report does not include the legacy costs of nuclear weapons, threat reduction and arms control, or missile defense in its estimate.[27]

Perhaps the most notable aspect of the report, though, is its methodology. It takes a broad view of nuclear costs by estimating the costs of "what would remain if DoD's only responsibility were to operate and maintain strategic nuclear offensive forces."[28] In other words, it estimates what an all-nuclear force would cost. Given this premise, the report allocates 100 percent of the costs of dual-use systems and a proportionate share of supporting capabilities needed for nuclear missions to the cost of nuclear forces, even though these systems support other missions as well.

The report primarily bases its estimates on two sections of the budget, the Weapons Activities funding line in DoE's budget and MPF-1 funding in DoD's budget. It also includes a share of support costs from other MPFs in DoD's budget. These support costs include: RDT&E funding for the Ohio Replacement and LRS-B programs and other related technologies; RDT&E, procurement, and O&M costs of nuclear-related command and control systems; and a proportionate share of other operational and support costs, such as aerial refueling tankers, training and recruiting, medical costs, family housing, and administrative costs. While the

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24 Ibid., p. 11.

25 Ibid., pp. 17–18.

26 Rumbaugh and Cohn, *Resolving Ambiguity: Costing Nuclear Weapons,* p. 61.

27 Ibid., pp. 11–12.

28 Ibid., p. 31.

Stimson report takes a broad view of what costs should be included, it does not include any costs for tactical nuclear delivery platforms, specifically the dual-use F-16 and F-15E fleets.

Beyond MFP-1 in DoD's budget, the Stimson report also includes nuclear weapons-related costs in the Department of Energy's budget. It includes DoE's National Nuclear Security Administration's (NNSA) Weapons Activity funding, which supports the maintenance and modernization of nuclear warheads and a proportionate share of NNSA's Office of the Administrator funding. The NNSA also designs and builds nuclear reactors for the Navy's fleets of aircraft carriers, attack submarines, and ballistic missile submarines. While only the Navy's ballistic missile submarines are part of the nuclear force, Stimson includes all of NNSA's Naval Reactor funding in its cost estimate. This is in keeping with its broad methodological approach, which seeks to estimate what costs would remain if DoD's only mission "were to operate and maintain strategic nuclear offensive forces."[29] As the report notes, all Naval Reactor funding is included because "most of their work would require much of the same infrastructure," even if all other nuclear-powered naval platforms were eliminated.[30]

CNS's *The Trillion Dollar Nuclear Triad*

The James Martin Center for Nonproliferation Studies (CNS) issued a report in January 2014 that, true to its title, estimates the cost of U.S. nuclear forces at somewhere between $872 billion to $1.082 trillion—although this estimate covers a 30-year period (FY 2014 to FY 2043) that is three times longer than the time periods covered by the Stimson and CBO reports.[31] Specifically, the CNS report attempts to "reverse engineer the administration's 1251 Report" from November 2010.[32] The 1251 Report, mandated by Congress in section 1251 of the National Defense Authorization Act for Fiscal Year 2010, provides detailed plans for the nuclear weapons stockpile, weapons complex, and delivery systems.[33] Because the 1251 Report only projects costs through 2020, which does not include the bulk of U.S. nuclear modernization programs, the CNS report estimates what these programs will cost over the next three decades. Specifically, it appears to include the full costs of nuclear delivery platforms dedicated to the nuclear mission, including the Ohio-class SSBN, the Ohio Replacement Program, the Trident II D5 missile modernization program, the Minuteman III ICBM, and a notional Minuteman follow-on program. For dual-use programs, CNS includes the full costs of the B-52 bomber, B-2 bomber, and LRS-B program, but it does not include any costs for dual-capable F-16s and F-15Es.

The report includes all costs contained in the NNSA's Weapons Activities account, including NNSA's long-range projections of life extension programs for nuclear warheads extending through FY 2039. It also includes a projection for command, control, and communications costs over the next thirty years, as well as the cost of the Air Force's Long Range Standoff (LRSO) program, which will replace the ALCM that is currently scheduled for decommissioning around 2030. Like CBO and Stimson, the CNS report does not include the legacy costs of nuclear weapons, threat reduction and arms control, or missile defense in its estimates.

Summary

Each of the estimates discussed above have significant limitations. For instance, MFP-1 does not accurately represent the cost of U.S. nuclear forces because it includes some programs and

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29 Rumbaugh and Cohn, *Resolving Ambiguity: Costing Nuclear Weapons,* p. 31.

30 Ibid., p. 50.

31 Jon B. Wolfsthal, Jeffrey Lewis, and Marc Quint, *The Trillion Dollar Nuclear Triad* (Monterey, CA: CNS, January 2014), p. 11.

32 Ibid., p. 10.

33 *National Defense Authorization Act for Fiscal Year 2010*, Public Law 11-84, 111th Congress, October 28, 2009, available at http://www.gpo.gov/fdsys/pkg/PLAW-111publ84/pdf/PLAW-111publ84.pdf.

platforms that do not contribute to the nuclear mission (such as the B-1 bomber) while it omits others that do (such as nuclear weapons modernization programs in DoE's budget). Both the CBO study and the Stimson study only look ten years into the future and therefore miss many significant nuclear modernization costs. Moreover, the Stimson study employs a methodology that estimates the cost of an all-nuclear force rather than the additional costs of maintaining nuclear forces alongside conventional forces. Finally, while the CNS study does capture long-term modernization costs given its much longer timeframe, it does not provide a sufficient granularity of detail to determine what could potentially be saved by altering nuclear force structure and modernization plans. The next chapter presents CSBA's estimate, which addresses many of these limitations.

CHAPTER 3

Estimating the Costs of U.S. Nuclear Forces

As the previous chapter indicated, there are three major issues that account for much of the variation across different cost estimates for U.S. nuclear forces: the timeframe of an estimate, what expenses it includes or omits, and how it accounts for dual-use capabilities. First, the estimate in this report covers 25 years beginning in FY 2015 and extending until FY 2039, a period that includes five FYDPs and is sufficient to capture near-term expenses that will be incurred while the BCA budget caps remain in effect, medium-term expenses that will be incurred during the 2020s "bow wave" when a number of nuclear and conventional modernization programs are scheduled to reach their peak costs, and longer-term expenses beyond the "bow wave" in the 2030s.

Second, decisions about what platforms and programs to include are based on what is needed for nuclear forces above and beyond the needs of conventional forces. In other words, what capabilities could be eliminated and what expenses could be avoided if the Pentagon shed all of its nuclear missions? This represents a major difference from the Stimson study, which takes the opposite approach and estimates what would remain if DoD shed all of its conventional missions and became an all-nuclear force. The difference between these two approaches is shown in Figure 1, with the scope of the Stimson methodology shown in the purple dashed outline and the scope of the CSBA methodology shown in the yellow dashed outline.

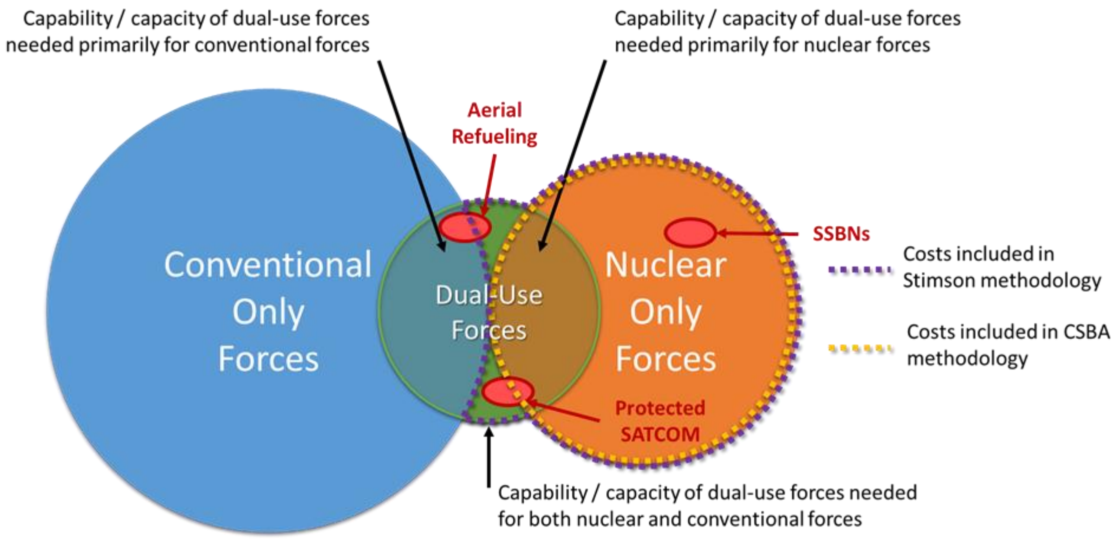
An example that highlights the differences between these two approaches is how aerial refueling tankers are treated. According to the Stimson report, the bomber force needs roughly 1.5 tankers per nuclear-capable bomber, for a peak tanker demand of 144 aircraft.[34] If all conventional missions that require tankers are assumed to no longer exist, then U.S. nuclear forces would still need 144 tankers. Thus, the cost of 144 tankers is attributed to nuclear forces in the Stimson methodology.

However, the all-nuclear force that the Stimson report postulates is not an option under consideration. A more practical consideration for policy makers is how much nuclear forces add to military costs on top of the conventional forces it would procure and maintain anyway. From this perspective, none of the costs of aerial refueling tankers should be attributed to nuclear forces

34 Rumbaugh and Cohn, *Resolving Ambiguity: Costing Nuclear Weapons*, p. 40.

because the Air Force is not sizing its tanker fleet based on the nuclear mission. In fact, the Air Force has already determined that its tanker inventory is not sufficient to meet its conventional mission requirements alone.[35] Thus, the CSBA methodology does not attribute any of the costs of tankers to the nuclear mission.

FIGURE 1: COMPARISON OF STIMSON AND CSBA METHODOLOGIES



A third consideration when estimating the costs of nuclear forces is how the costs of dual-use systems are allocated. The four cost estimates described in the previous chapter vary considerably in how they treat dual-use systems. The MFP-1, Stimson, and CNS reports generally apply a binary approach, counting all or none of the costs for each dual-use system. This report, like the CBO report, allocates partial costs for dual-use systems. The fraction of a system's costs due to the nuclear mission is estimated by asking the same question as before: how would costs change if the nuclear mission is reduced or eliminated? In the case of dual-use aircraft, such as the F-16s and F-15Es that can carry nuclear weapons, some of the O&M costs would be avoided if the aircraft and flight crews did not have to maintain nuclear certification and training. Thus, in keeping with CBO's estimate, 10 percent of the O&M costs of dual-capable fighter aircraft are counted toward the cost of nuclear forces.[36]

Just as important as what costs are included is what costs are not included. Like many other studies, this report does not include costs associated with cleanup and disposal of nuclear waste, threat reduction and arms control, and missile defense. However, the costs of these activities could increase if nuclear weapons were eliminated from the U.S. arsenal. For example, legacy costs for cleaning up and disposing of nuclear materials would increase in the near-term if more weapons are taken out of the inventory. And since nuclear weapons help deter a massive conventional or nuclear attack on the United States and its allies, a reduction or elimination of nuclear forces could increase the need for both theater and national missile defense systems. This report also does not include the cost of missile warning systems, such as SBIRS-High, because these systems would still be needed for missile defense even if the United States had no nuclear forces.

35 Ibid., p. 39.

36 CBO, *Projected Costs of U.S. Nuclear Forces, 2014 to 2023*, p. 16.

Given these parameters, the remainder of this chapter uses a bottom-up approach that begins with estimates of the RDT&E, procurement, O&M, military personnel (MILPERS), and military construction (MILCON) costs for each major component of the nuclear enterprise and associated modernization programs. It provides these estimates on a year-by-year basis for FY 2015 to FY 2039. This is important because the annual costs associated with nuclear forces varies considerably over that time period, and a key consideration in planning modernization programs is whether their peak costs will overlap. The first three sections cover airborne, sea-based, and land-based nuclear delivery systems. The fourth section includes the cost of nuclear warheads and bombs, which are separated from delivery vehicles since most of their costs are funded by DoE, in contrast to the delivery systems, which are funded almost entirely within the DoD budget. The final section includes cross-cutting command, control, and communications systems that support U.S. nuclear forces. As with any cost estimate, assumptions must be made about how to allocate costs and how costs may vary in the future. These assumptions are noted in the text, footnotes, and appendix, as appropriate.[37]

Airborne Delivery Systems

In general, airborne delivery systems have a number of unique attributes: they are visible enough that they can be used to send signals during crises; they can be recalled before they reach their targets or release their weapons; and they can be forward-stationed as a symbol of extended deterrence.[38] In addition, airborne delivery systems can be armed with the only low-yield weapons that remain in the U.S. nuclear arsenal, which might be a more effective deterrent in some scenarios than the much higher-yield warheads carried by ICBMs and SLBMs.[39] For the purpose of estimating costs, these systems can be divided into three broad categories. First, the Air Force currently fields a pair of nuclear-capable bombers, namely the standoff B-52 and the stealthy B-2. It also plans to begin procuring a third bomber sometime in the next decade, referred to as the LRS-B, which will be a penetrating platform like the B-2. Second, the Air Force maintains an inventory of nuclear-capable ALCMs, which can be carried by the B-52 and delivered from outside enemy air defenses. The ALCM is due for retirement by 2030, however, and will be replaced by the LRSO missile, which will be compatible with the B-52, B-2, and LRS-B. Finally, the Air Force has a fleet of dual-capable F-16 and F-15E fighter aircraft, and will eventually field dual-capable F-35As as well.

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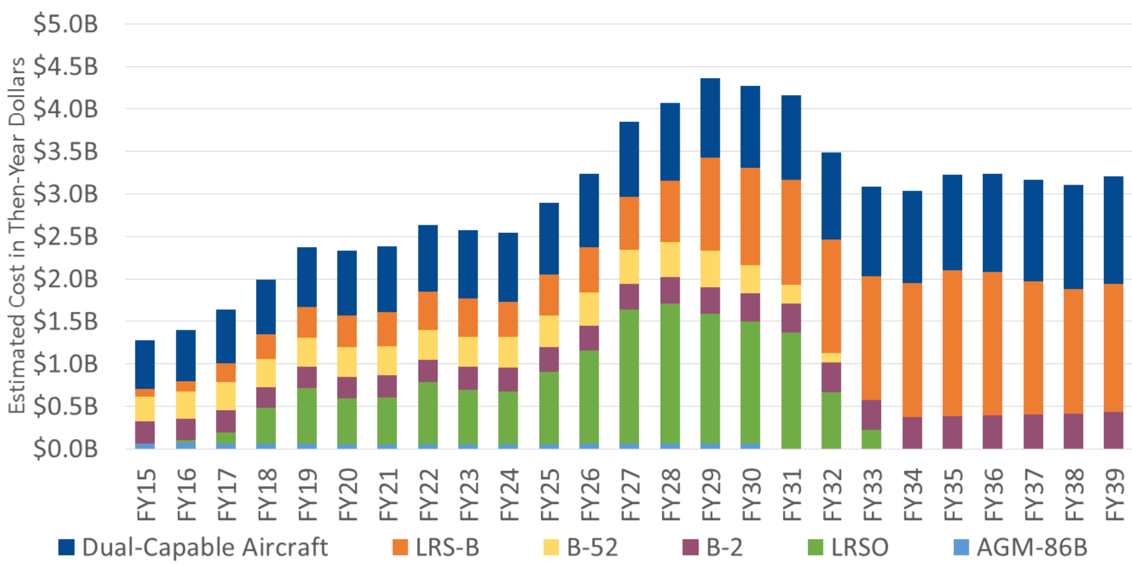
37 Unless otherwise noted, costs are shown in then-year dollars and O&M and personnel costs are assumed to grow at a nominal annual rate of 3 percent, which is in line with long-term trends and above the projected rate of inflation.

38 The cost of the bombs and warheads carried by airborne platforms are covered in the weapons section below.

39 On this point, see the discussion in Keir A. Lieber and Daryl G. Press, "The Nukes We Need: Preserving the American Deterrent," *Foreign Affairs*, 88, No. 6, November/December 2009; and Keir A. Lieber and Daryl G. Press, "The New Era of Nuclear Weapons, Deterrence, and Conflict," *Strategic Studies Quarterly*, 7, No. 1, Spring 2013.

FIGURE 2: ESTIMATED NUCLEAR-RELATED COSTS OF AIRBORNE DELIVERY SYSTEMS



Bombers

The current inventory of nuclear-capable bombers includes 76 B-52s and 20 B-2s.[40] The Air Force also plans to procure up to 100 LRS-Bs beginning in the mid-2020s, which will be nuclear-capable as well.[41] Because all three of these bombers will support conventional missions, it would not be accurate to attribute all of their costs to the nuclear mission. Applying the logic described previously for dual-use systems, the nuclear-related cost of bombers is assumed to be the additional cost incurred due to the nuclear mission. This analysis assumes that 25 percent of O&M and MILPERS costs for existing nuclear-capable bombers are needed to maintain nuclear certification and training for the aircraft and flight crews.[42] It further assumes that the B-52s are gradually phased out of the nuclear mission in the 2030s as the LRS-B becomes operational, because the New START Treaty limits the total number of deployed nuclear delivery systems. On-going procurement and RDT&E costs for the B-52 and B-2 are not included, because they are needed for general aircraft maintenance and upgrades irrespective of the nuclear mission. However, part of the development costs for communications upgrades to the B-2 is included, because some of the communications features are unique to the nuclear mission.[43]

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40 See U.S. Air Force, "B-52 Stratofortress," Fact Sheets, September 20, 2005 , available at http://www.af.mil/AboutUs/FactSheets/Display/tabid/224/Article/104465/b-52-stratofortress.aspx; and U.S. Air Force, "B-2 Spirit," Fact Sheets, April 1, 2005, available at http://www.af.mil/AboutUs/FactSheets/Display/tabid/224/Article/104482/b-2-spirit.aspx.

41 Ed Gullick, "AF Moves Forward with Future Bomber," Air Force press release, July 12, 2014, available at http://www.af.mil/News/ArticleDisplay/tabid/223/Article/486167/af-moves-forward-with-future-bomber.aspx.

42 CBO makes a similar assumption for the B-52 and LRS-B based in part on the fact that the Air Force currently keeps one squadron of B-52s (a quarter of the force) assigned to the nuclear mission. CBO assumes 100 percent of B-2 O&M costs are due to the nuclear mission, which seems excessive since B-2s routinely train for and conduct a variety of conventional missions.

43 See DoD, *Department of Defense Fiscal Year (FY) 2016 President's Budget Submission*, Air Force Justification Book Volume 3a, *Research, Development, Test & Evaluation, Air Force*, Volume-III part 1 (Washington, DC: DoD, 2015), R-1 Line #124, pp. 1–17, available at http://www.dtic.mil/descriptivesum/Y2016/AirForce/0101127F_7_PB_2016.pdf.

The next-generation bomber—LRS-B—is being procured to maintain the United States' ability to penetrate enemy air defenses and attack mobile or time-sensitive targets.[44] The number of aircraft the Air Force plans to procure is unlikely to change if the bomber is made conventional only, and the Air Force has indicated that the LRS-B may not initially be certified to deliver nuclear weapons. However, the acquisition cost of the LRS-B would arguably be less if it were designed without any nuclear-related requirements, such as hardened electronics that can withstand an electromagnetic pulse (EMP), as well as the additional integration and testing needed to carry nuclear weapons. Therefore, this analysis attributes 10 percent of the LRS-B acquisition costs to the nuclear mission, along with 25 percent of its future O&M and MILPERS costs. Allocating 10 percent of LRS-B acquisition costs to the nuclear mission is less than the 25 percent allocated by CBO but more than the 3 to 8 percent of the cost others have estimated is necessary to make LRS-B nuclear-capable.[45]

Acquisition costs for the LRS-B are based on the Air Force's public statements that the average procurement cost per bomber will be $550 million in constant 2010 dollars. Including development and test costs (based in part on the Air Force's FY 2016 budget request) and the effects of inflation, the total acquisition cost of the LRS-B program is estimated to be $111 billion through FY 2039 (in then-year dollars), assuming no cost overruns and procurement of 100 aircraft.[46] O&M and MILPERS costs for LRS-B on a per plane basis are assumed to be 75 percent of the B-2, since the new bomber is expected to be smaller, less expensive, and operated in larger numbers, but the total O&M and MILPERS costs are higher than the B-2 because five times as many LRS-Bs are expected to be in the inventory by the end of the 2030s, according to Air Force plans.

Air-Launched Missiles

The Air Force also maintains the AGM-86B nuclear-capable air-launched cruise missile. The AGM-86B is currently undergoing a life extension program, and the Air Force plans to keep it in the inventory until at least 2030, by which time the LRSO missile should be fielded. While the LRSO could be designed and used for conventional missions, it is solely a nuclear delivery system at present and might not be developed or fielded absent the requirement for an AGM-86B replacement. Accordingly, this analysis attributes the full costs of the AGM-86B and the LRSO to the nuclear mission and assumes a total of 1000 LRSOs will be acquired.[47]

Dual-Capable Fighters

Part of the Air Force's tactical fighter force is also capable of carrying nuclear weapons. F-16s and F-15Es can carry versions of the B61 nuclear gravity bomb. The Air Force also plans to make the F-35A nuclear-capable in the future, which would eventually replace the nuclear-capable F-16s and F-15Es. Since the F-16, F-15E, and F-35A are primarily used for conventional missions, it is unlikely that eliminating the nuclear mission would change the number of aircraft in the

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[44] Gullick, "AF Moves Forward with Future Bomber."

[45] See Mark A. Gunzinger and Christopher Dougherty, *Sustaining America's Advantage in Long-Range Strike* (Washington, DC: Center for Strategic and Budgetary Assessments, 2010), pp. 76–78; and Undersecretary of Defense for Policy Jim Miller, "Nuclear Deterrence: New Guidance and Constant Commitment," Transcript, Reserve Officers Association, National Defense Industrial Association, and Air Force Association Capitol Hill Breakfast Forum, July 17, 2013, available at http://secure.afa.org/HBS/transcripts/2013/July%2017%20-%20Miller2.pdf.

[46] This is admittedly a major assumption, since DoD acquisition programs, and stealthy aircraft programs in particular, routinely experience cost overruns and reductions in quantity. It does not have a significant effect on this analysis, however, because only 10 percent of the acquisition costs are counted toward nuclear forces. The overall effects of cost overruns are addressed at the conclusion of this chapter.

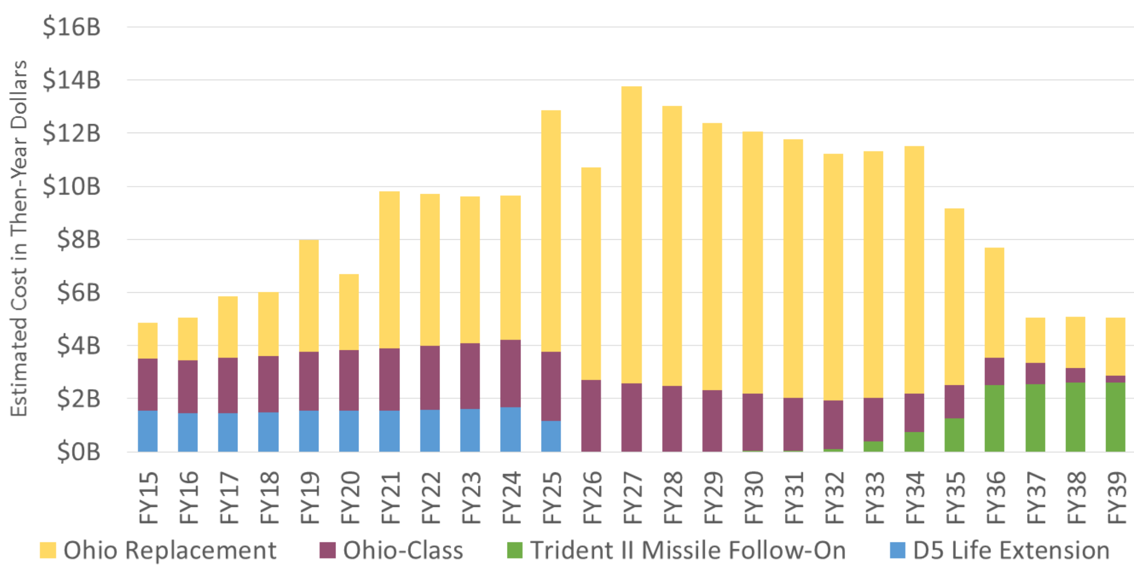
[47] Kingston Reif, "Air Force Wants 1,000 New Cruise Missiles," *Arms Control Association*, updated May 7, 2015, available at http://www.armscontrol.org/ACT/2015_05/News/Air-Force-Wants-Thousand-New-Cruise-Missiles.

inventory. However, the O&M and MILPERS costs of these aircraft would decline if the nuclear mission were eliminated, because the aircraft and flight crews would not need to maintain nuclear certification and training. This analysis attributes 10 percent of F-16 and F-15E O&M and MILPERS costs to the nuclear mission, consistent with CBO's assumption.[48] It further assumes that as the F-35A begins to replace these aircraft, 10 percent of the F-35A's O&M and MILPERS costs will also be due to the nuclear mission, along with the full cost of making the F-35A dual-capable.[49]

Sea-Based Delivery Systems

The sea-based leg of the triad is valued most for its survivability. Given the inherent difficulty of detecting targets under water, the advanced quieting technology that masks the signature of these submarines, and the ability to conduct extended deterrent patrols in two oceans, it would be extremely difficult for an adversary to neutralize U.S. SSBNs and the weapons they carry. As a result, they provide an assured and massive retaliatory capability and are widely regarded as the most important leg of the U.S. strategic triad. Sea-based delivery systems can be broken down into two broad categories. The first category is the submarine fleet that carries nuclear-armed missiles. This includes the Navy's existing fleet of Ohio-class SSBNs, which are due to begin retiring in 2027, and the Ohio Replacement Program, which is scheduled to begin fielding the next generation of SSBNs in 2030. The second category is the sub-launched missiles that carry nuclear warheads. This includes the existing inventory of Trident II D5 SLBMs, which are expected to remain in service until the 2040-timeframe, and an unspecified replacement missile that will need to enter the force as the current inventory of D5s begin to reach the end of their useful life.

FIGURE 3: ESTIMATED NUCLEAR-RELATED COSTS OF SEA-BASED DELIVERY SYSTEMS



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48 CBO, *Projected Costs of U.S. Nuclear Forces, 2014 to 2023*, p. 16.

49 The F-35A's dual capable aircraft costs can be found at DoD, *Department of Defense Fiscal Year (FY) 2016 President's Budget Submission*, Air Force Justification Book Volume 3a, *Research, Development, Test & Evaluation, Air Force*, Volume-III part 1 (Washington, DC: DoD, 2015), R-1 Line #139, pp. 1–20, available at: http://www.dtic.mil/descriptivesum/Y2016/AirForce/0207142F_7_PB_2016.pdf.

Ballistic Missile Submarines

The U.S. Navy currently maintains a fleet of 14 Ohio-class ballistic missile submarines. Each of these submarines can carry up to 24 submarine-launched ballistic missiles (SLBMs). Due to treaty restrictions, however, each boat will be limited to only 20 missiles by 2018. Ohio-class submarines were designed for a 30-year lifespan that has since been extended to 42 years. The oldest SSBN in the fleet (SSBN-730) will reach the end of its 42-year projected life in 2027, and the other ships will reach the end of their service lives at a rate of approximately one per year thereafter.[50]

As the Ohio-class submarines are retired, the Navy plans to replace them with a new boat, currently known as Ohio Replacement. The Navy's stated requirement is to have ten SSBNs operationally available at any given time to provide continuous two-ocean coverage. The Ohio-class submarines required an extensive mid-life refueling and overhaul, which meant that in some years three or four boats were out of service at the same time. This required a total of 14 boats in the fleet to meet the requirement of ten operationally available at any given moment. The Ohio Replacement, however, is being designed so that it will not require a refueling during its mid-life overhaul. This shortens the amount of time each boat will be out of service, thus only 12 Ohio Replacement submarines will need to be procured to have ten boats operationally available at all times.[51] The initial stages of the Ohio Replacement Program are currently underway. Each Ohio Replacement submarine will carry only 16 SLBMs. The Navy plans to begin procuring the first boat in 2021, but it will not be operationally available until 2030.[52]

Because both the Ohio-class and Ohio Replacement submarines are primarily used for their nuclear capabilities, all of the costs associated with these platforms are assigned to the nuclear mission in this analysis. The cost of the existing fleet of Ohio-class submarines includes O&M for fleet ballistic missile submarines, MILPERS for the associated crews and support personnel, a proportionate share of the DoE naval reactors budget, and minor procurement and RDT&E costs for ongoing upgrades. The Ohio Replacement costs within the FYDP are based on the budget justification documents provided to Congress in the FY 2016 request, including naval reactor costs for the Ohio Replacement in the DoE request. Estimated acquisition costs for the Ohio Replacement Program beyond the FYDP are based on the Navy's most recent statements that the total cost of the program will be $139 billion and the lead ship will cost $14.5 billion (in then-year dollars).[53] Future O&M and MILPERS costs for the Ohio Replacement are assumed to be similar to the Ohio-class submarines on a per ship basis, and incremental procurement funding is assumed to smooth spikes in annual funding requirements.[54]

Sub-Launched Ballistic Missiles

The current fleet of Ohio-class SSBNs and the future fleet of Ohio Replacement SSBNs carry the Trident II D5 SLBM, which has a range of approximately 4,600 miles with a full payload of eight warheads, and a longer range with lower payloads. The Trident II D5 is currently undergoing a modernization program that will extend its life through at least 2042.[55] The current inventory of

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50 Ronald O'Rourke, *Navy Ohio Replacement (SSBN[X]) Ballistic Missile Submarine Program: Background and Issues for Congress* (Washington, DC: CRS, March 24, 2015) p. 3.

51 Ibid., p. 10.

52 Ibid., p. 12.

53 "Navy Estimates $14.5B Tab for Lead Ohio-Class Replacement Submarine," *Inside Defense*, March 18, 2015, available at http://insidedefense.com/inside-pentagon/navy-estimates-145b-tab-lead-ohio-class-replacement-submarine.

54 OMB has stated that the Ohio Replacement does not meet the criteria for incremental funding. This analysis, however, assumes that three-year incremental funding will be allowed.

55 DoD, *Selected Acquisition Report: Trident II (D-5) Sea-Launched Ballistic Missile UGM 133A* (Washington, DC: DoD, April 2014), p. 45.

approximately 533 missiles exceeds the missile capacity of current Ohio-class SSBNs (280 total allowable missile tubes) and the future missile capacity of the Ohio Replacement (192 total missile tubes). The extra missiles are needed for periodic test firings, and the D5 missile has averaged 6.2 successful test firings per year over the past 25 years.[56] The current inventory can support continued testing at this rate through 2070 before the number of missiles drops below the 192 needed to fully load the Ohio Replacement fleet.

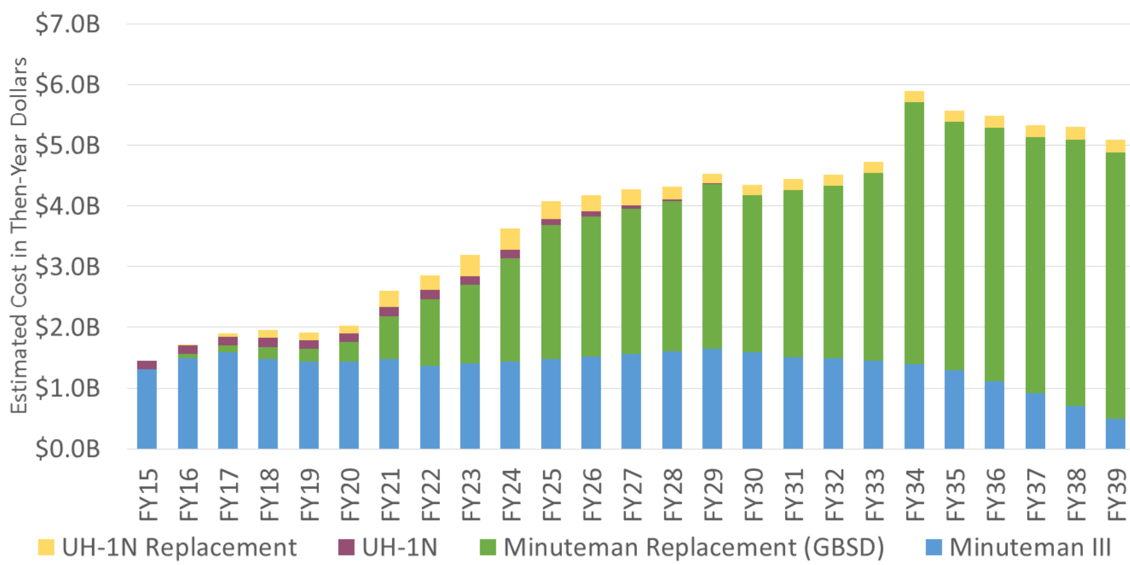
Before the missile inventory is exhausted, however, key components on the missile will reach the end of their useful life or become obsolete. As a result, the Navy will likely need to initiate a Trident II D5 modernization program starting around 2030 for a missile that could be fielded in the 2040s. Because the D5 missile is only equipped to carry nuclear warheads, this analysis allocates the full cost of the current life extension program and the projected cost of a future modernization program in the 2030s to the nuclear mission. The acquisition cost of the follow-on missile assumes a new missile design, based by analogy on the cost of the Trident II (adjusted for inflation), and that procurement does not begin until FY 2040 or later.

Land-Based Delivery Systems

Land-based delivery systems include Minuteman III (LGM-30G) ICBMs stored in hardened underground silos. The missile force is divided into three wings, which are based at F.E. Warren Air Force Base in Wyoming, Minot Air Force Base in North Dakota, and Malmstrom Air Force Base in Montana (the Air Force also operates three squadrons of UH-1N helicopters to support these geographically dispersed missile forces). ICBMs have traditionally contributed to deterrence in a number of ways: they provide a prompt launch capability, because more than 90 percent of the force is on alert at all times; they increase the likelihood of retaliation for an attack, because an adversary contemplating a disarming or damage-limiting first strike would have to target U.S. territory; and they increase the requirements of a first strike, because an adversary would need to devote at least one nuclear warhead, and possibly more, to hundreds of discrete targets.

56 "Navy's Trident II D5 Missile Marks 155 Successful Test Flights," Lockheed Martin press release, February 23, 2015, available at http://www.lockheedmartin.com/us/news/press-releases/2015/february/ssc-space-trident.html.

FIGURE 4: ESTIMATED NUCLEAR-RELATED COSTS OF LAND-BASED DELIVERY SYSTEMS



Intercontinental Ballistic Missiles (ICBMs)

The Minuteman III has an approximate range of more than 6,000 miles. The U.S. military currently has nearly 450 operationally deployed Minuteman III missiles and about 40 additional non-deployed missiles in reserve. Due to the parameters of the New START treaty, the size of the ICBM force will be cut to 400 operational missiles by 2018.[57] The Air Force plans to use the excess inventory of non-deployed missiles for testing. As a 2014 RAND report notes, if the Air Force increases the test rate to four launches per year as it has proposed, it will eventually deplete the inventory of available missiles below the 400 needed under current plans.[58]

The Air Force has initiated early development work for a follow-on ICBM, requesting $946 million over the next five years (FY 2016 to FY 2020) for early research and development efforts to replace the Minuteman III.[59] The estimated future cost of the Minuteman replacement in this analysis assumes a new missile design, based by analogy on previous ICBM programs, and assumes new missiles are operationally available beginning in FY 2031. Because the current and future ICBM force can only carry nuclear weapons, the full cost of the existing and future missiles is assigned to the nuclear mission.

Helicopter Support for ICBMs

The U.S. ICBM force is geographically dispersed, with silos located across five states (Colorado, Montana, Nebraska, North Dakota, and Wyoming). To maintain access and security for these facilities, the Air Force operates a fleet of UH-1N "Huey" helicopters organized into three

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57 Amy F. Woolf, *U.S. Strategic Nuclear Forces: Background, Developments, and Issues* (Washington, DC: CRS, 2015), p. 11, available at https://fas.org/sgp/crs/nuke/RL33640.pdf.

58 The RAND study assumed 420 deployed missiles instead of the 400 currently planned. At a test rate of four per year, the Air Force would drop below 400 missiles in the available inventory by 2036. See Lauren Caston et al., *The Future of the U.S. Intercontinental Ballistic Missile Force* (Santa Monica, CA: RAND, 2014), p. 84.

59 DoD, *Department of Defense Fiscal Year (FY) 2016 President's Budget Submission*, Air Force Justification Book Volume 2, *Research, Development, Test & Evaluation, Air Force*, Volume-II (Washington, DC: DoD, 2015), R-1 Line #46, pp. 1–7, available at http://www.dtic.mil/descriptivesum/Y2016/AirForce/0605230F_4_PB_2016.pdf.

squadrons, primarily to support ICBM forces.[60] DoD has determined that these helicopters do not meet its requirements for survivability, speed, endurance, and capacity, and the Air Force has begun an effort to replace the UH-1N.[61] The UH-1N Replacement is a new start program in the FY 2016 budget request with $437 million over the next five years (FY 2016 to FY 2020) included as a placeholder. The current acquisition plan calls for procuring an existing helicopter off-the-shelf, such as the Army's UH-60A, and installing mission-specific equipment to meet the needs of Air Force Global Strike Command and other stakeholders.[62] Based on these requirements, this analysis estimates the replacement helicopters will cost an average of $20 million each, with procurement beginning in FY 2021 and extending through FY 2028. Since the Air Force would not likely keep or replace these helicopters if the nuclear mission was eliminated, this analysis allocates all of the costs associated with the Air Force's fleet of UH-1Ns and its replacement program to the nuclear mission.

Nuclear Warheads

The sustainment, management, and modernization of nuclear warheads are primarily funded through the Department of Energy. The United States currently maintains 12 different warhead variants, as shown in Figure 5 below, but under the "3+2 Strategy," the stockpile is being narrowed to five main warhead variants. More specifically, five bomb and cruise missile warhead variants (W80-1, B61-3, B61-4, B61-7, and B61-10) are being consolidated into two replacement warhead designs, and five ballistic missile warheads (W76-0, W76-1, W88, W78, and W87) are being consolidated into three new interoperable warhead designs (IW-1, IW-2, and IW-3). The B83-1 megaton-class weapon—and perhaps the B61-11 ground-penetrating weapon as well—will eventually be eliminated from the arsenal.[63] DoE also funds other nuclear weapons-related activities, such as research labs, security programs, and other stockpile management activities. All nuclear weapons activity funding is included in this analysis. Funding for nuclear nonproliferation activities and environmental cleanup is not included since these activities would continue (or even increase) if the United States reduced or eliminated its stockpile of nuclear weapons.

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60 DoD, *Department of Defense Fiscal Year (FY) 2016 President's Budget Submission*, Air Force Justification Book Volume 1 of 2, *Aircraft Procurement, Air Force*, Volume-2 (Washington, DC: DoD, 2015), P-1 Line #55, pp. 1–5, available at http://www.dtic.mil/procurement/Y2016/AirForce/P40_H0106O_BSA-5_BA-5_APP-3010F_PB_2016.pdf.

61 Air Force Global Strike Command, *Air Force Global Strike Command 2014 Strategic Master Plan* (Barksdale AFB, LA: Department of the Air Force, 2014), p. 11, available at http://www.defenseinnovationmarketplace.mil/resources/AFGS-2014StrategicPlan.pdf.

62 DoD, *Department of Defense Fiscal Year (FY) 2016 President's Budget Submission*, Air Force Justification Book Volume 1 of 2, *Aircraft Procurement, Air Force*, Volume-2 (Washington, DC: DoD, 2015), P-1 Line #55, pp. 1–5, available at http://www.dtic.mil/procurement/Y2016/AirForce/P40_H0106O_BSA-5_BA-5_APP-3010F_PB_2016.pdf.

63 Statement of the Honorable Madelyn R. Creedon, Assistant Secretary of Defense, Global Strategic Affairs, Before the House Armed Services Strategic Forces Subcommittee, October 29, 2013, Page 2, available at http://docs.house.gov/meetings/AS/AS29/20131029/101355/HHRG-113-AS29-Wstate-CreedonM-20131029.pdf.

FIGURE 5: U.S. NUCLEAR WEAPONS MODERNIZATION PLANS

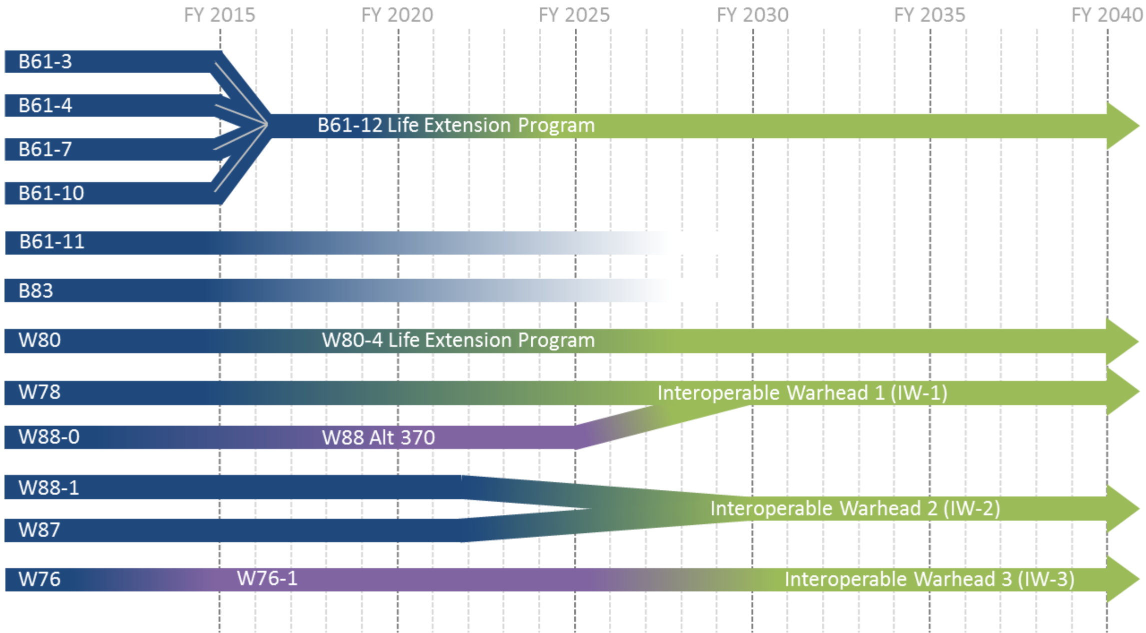
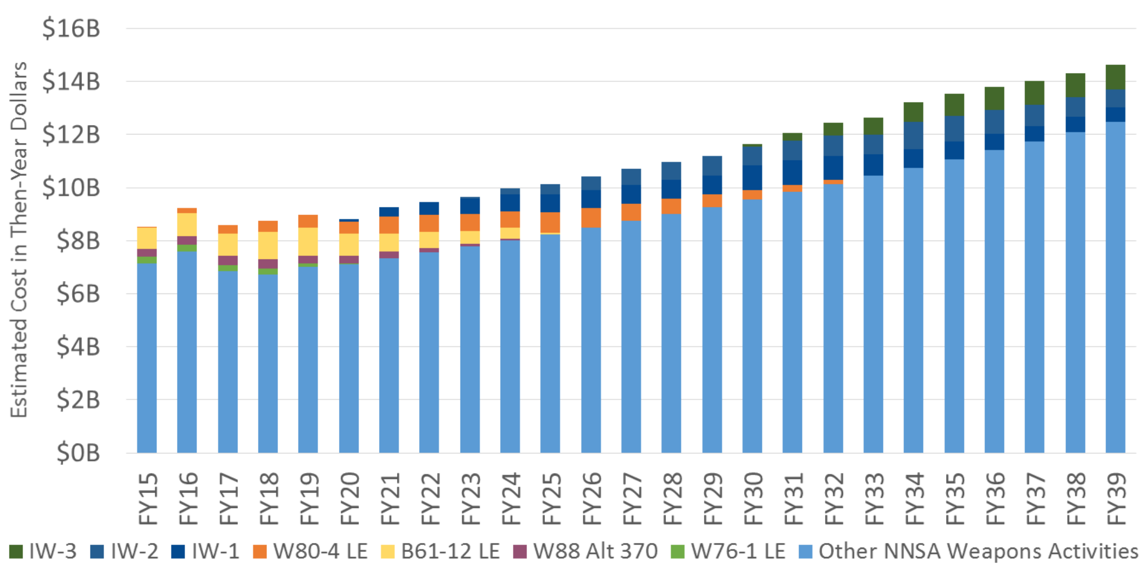


FIGURE 6: ESTIMATED COSTS OF NUCLEAR WEAPONS ACTIVITIES



B61-12 Life Extension

The B61 is the oldest nuclear weapon in the U.S. arsenal. The B61 life extension program will consolidate four existing variants of the B61 (-3, -4, -7, and -10) into a single variant, the B61-12.[64] The B61-12 will be used on the B-2, F-15, F-16, and NATO certified tactical aircraft, as well as on the F-35A and LRS-B in the future.[65] The B61-11 ground penetrating variant of the bomb is not part of the consolidation program. The first production unit B61-12 is scheduled for FY20.[66] The program is being funded by both DoE and DoD. Cost estimates for this program are from the December 2014 Selected Acquisition Reports (SARs) for both the Air Force and DoE B61 programs.

W76-1 Life Extension

The W76, the most numerous warhead in the U.S. arsenal, is currently used on the Trident II D5 ballistic missile. The W76-1 life extension program will extend the life of the warhead an additional 30 years by addressing aging issues and refurbishing key components. Production began in 2008 and is scheduled to be completed by 2019.[67] The program is funded by DoE, and the estimated cost for this program is from the December 2014 SAR.

W88 Alt 370

The W88 warhead is also used on the Trident II D5 missile. The W88 Alt 370 program is addressing near-term aging and readiness issues for the warhead to extend its life until it can undergo a more comprehensive life extension process as part of the Interoperable Warhead-1 (IW-1) program. The program plans to begin production in 2019.[68] The program is funded by DoE, and the estimated cost is from the December 2014 SAR.

W80-4 Life Extension

Another component of the "3+2" modernization strategy is the cruise missile warhead life extension program. This program recently designated the W80-1 as the warhead to be reused and refurbished under a new designator, W80-4, for use on the Air Force's LRSO cruise missile. Previous versions of this warhead have been used on the Tomahawk cruise missile and the current ALCM.[69] The first production unit of the W80-4 is projected for FY 2025.[70] The program is jointly funded by DoE and DoD. The combined estimated cost is from the DoE *FY 2016 Stockpile Stewardship and Management Plan*.[71]

W78/88-1 (IW-1)

The first ballistic missile warhead to be developed under the "3+2" strategy is intended to replace the W78 on the Minuteman III and W88-1 on the Trident II D5 missile with a single interoperable warhead, known as IW-1. Due to budget constraints, the Nuclear Weapons Council decided to prioritize the W80-4 life extension program for the cruise missile warhead and defer the IW-1 program. DoE plans to restart the program in FY 2020 with the first production unit planned for

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64 NNSA, DoE, *Fiscal Year 2016 Stockpile Stewardship and Management Plan*, Report to Congress (Washington, DC: DoE, March 2015), p. 1-4, available at http://nnsa.energy.gov/sites/default/files/FY16SSMP_FINAL%203_16_2015_reducedsize.pdf.

65 Ibid., p. 1-7.

66 NNSA, DoE, *Fiscal Year 2016 Stockpile Stewardship and Management Plan*, p. 1-7.

67 Ibid., p. 2-19.

68 Ibid., p. 2-20.

69 Hans M. Kristensen, "W80-1 Warhead Selected For New Nuclear Cruise Missile," *FAS Strategic Security Blog*, October 10, 2014, available at https://fas.org/blogs/security/2014/10/w80-1_lrso/.

70 NNSA, DoE, *Fiscal Year 2016 Stockpile Stewardship and Management Plan*, p. 2-25

71 Ibid., p. 8-15.

FY 2030. Because the W78 warheads are older, the program will initially focus on replacing these warheads in the ICBM fleet before it begins replacing W88 warheads.[72] The program will be jointly funded by DoE and DoD, and the combined estimated cost is from the DoE *FY 2016 Stockpile Stewardship and Management Plan*.[73]

IW-2 and IW-3

The second and third interoperable warheads for ballistic missiles are not planned to begin until the mid-2020s. IW-2 is intended to replace the W87 and W88 warheads. The W87 warhead was originally intended for the Peacekeeper ICBM but was later fitted to the Minuteman III. It has an estimated yield similar to the W88 warhead used on the Trident II D5. The IW-2 program is expected to begin in FY 2023 with the first production unit planned for FY 2034. The IW-3 warhead is intended to replace the W76-1, which is currently undergoing a life extension program. The IW-3 program is not expected to begin until FY 2030, and the first production unit will not be delivered until after FY 2039. The cost projections for these programs are from the DoE *FY 2016 Stockpile Stewardship and Management Plan*.[74]

Other NNSA Weapon Activities

NNSA's Weapons Activities budget also supports a number of other activities that are essential to the ability of NNSA to execute the modernization, alteration, and life extension programs listed above. Much of this funding is used to support relatively fixed costs (i.e., costs that do not vary significantly with the size of the arsenal), such as nuclear research laboratories and production facilities, secure transportation, and overall security for nuclear materials, infrastructure, and personnel. Weapons activities funding is also used to monitor and assess the existing stockpile of weapons and conduct regular maintenance of weapons.

Command and Control Systems

Command and control systems are used to ensure the National Command Authority (NCA) remains in control of U.S. nuclear forces before, during, and after a conflict. Multiple layers of redundancy are built into nuclear command and control systems so that the force is not critically dependent on any one system. Nuclear command and control systems can be categorized into three layers: terrestrial systems, airborne systems, and space-based systems.

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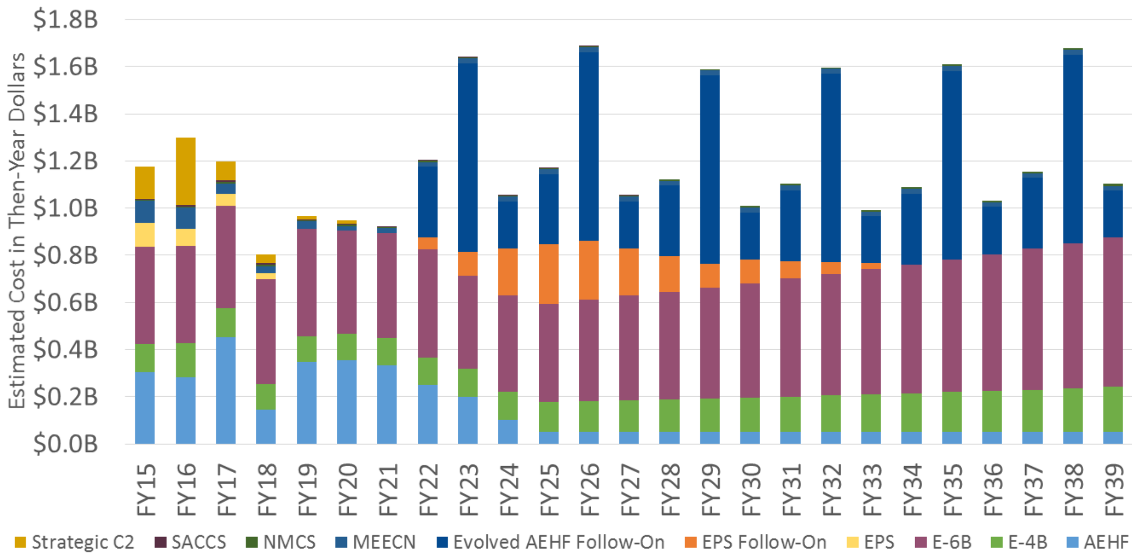
72 Ibid., pp. 2-25 to 2-26.

73 Ibid., p. 8-16.

74 Ibid., pp. 8-16 to 8-17.

FIGURE 7: ESTIMATED NUCLEAR-RELATED COSTS OF COMMAND, CONTROL, AND COMMUNICATIONS



Terrestrial Command and Control

The terrestrial component of nuclear command and control includes a number of systems that are undergoing modernization or replacement, to include: the Minimum Essential Emergency Communications Network (MEECN), the National Military Command System (NMCS), and the Strategic Automated Command and Control System (SACCS). These systems allow the President and other commanders to send orders to nuclear forces and maintain situational awareness in a crisis. The Air Force is planning an on-going system improvement program for MEECN that will extend into the 2020s,[75] and the Defense Information Systems Agency (DISA) is currently upgrading NMCS.[76] The FY 2016 budget requests a new start program to replace SACCS that will also extend into the 2020s.[77] While some of these systems have conventional mission uses as well, the vast majority of the costs can be attributed to the nuclear mission due to nuclear survivability requirements.

Airborne Command and Control

The airborne layer of nuclear command and control includes the Air Force's E-4B and the Navy's E-6B flying command posts. The E-4B, a Boeing 747 derivative, is a survivable mobile command

75 See DoD, *Department of Defense Fiscal Year (FY) 2016 President's Budget Submission*, Air Force Justification Book Volume 3b, *Research, Development, Test & Evaluation, Air Force*, Volume-III part 2 (Washington, DC: DoD, 2015), R-1 Line #180, pp. 1–14, available at http://www.dtic.mil/descriptivesum/Y2016/AirForce/0303131F_7_PB_2016.pdf; and DoD, *Department of Defense Fiscal Year (FY) 2016 President's Budget Submission*, Defense Wide Justification Book Volume 5, *Research, Development, Test & Evaluation, Defense-Wide* (Washington, DC: DoD, 2015), R-1 Line #196, pp. 1–12, available at http://www.dtic.mil/descriptivesum/Y2016/Other/DISA/0303131K_7_PB_2016.pdf.

76 See DoD, *Department of Defense Fiscal Year (FY) 2016 President's Budget Submission*, Defense Wide Justification Book Volume 5, *Research, Development, Test & Evaluation, Defense-Wide* (Washington, DC: DoD, 2015), R-1 Line #193, pp. 1–8, available at http://www.dtic.mil/descriptivesum/Y2016/Other/DISA/0302016K_7_PB_2016.pdf.

77 See DoD, *Department of Defense Fiscal Year (FY) 2016 President's Budget Submission*, Air Force Justification Book Volume 3b, *Research, Development, Test & Evaluation, Air Force*, Volume-III part 2 (Washington, DC: DoD, 2015), R-1 Line #128, pp. 1–7, available at http://www.dtic.mil/descriptivesum/Y2016/AirForce/0101316F_7_PB_2016.pdf.

post that can be used by the President, the Secretary of Defense, and the Joint Chiefs of Staff in the event that terrestrial command and control centers are unusable.[78] The E-6B is a Boeing 707 derivative also used for airborne command and control of nuclear forces. The E-6B carries a very low frequency communication system for communicating with ballistic missile submarines and is also capable of sending launch codes to land-based ICBMs.[79] Because the E-4B and E-6B are dual-use systems that support both nuclear and conventional military operations, 50 percent of their on-going costs, including O&M and MILPERS, are allocated to the nuclear mission.

Satellite Communications

Nuclear command and control is also supported by satellite communications, specifically Milstar, Advanced Extremely High Frequency (AEHF), Interim Polar System (IPS), and Enhanced Polar System (EPS). These systems provide protected, survivable satellite communications to support voice and data links between the National Command Authority and nuclear forces during a crisis. The waveforms used on these satellites are designed to resist jamming and nuclear scintillation effects so that communications can be maintained during and after a nuclear attack. The Milstar and AEHF satellites provide worldwide coverage between latitudes 65 degrees North and 65 degrees South. These satellites are hardened against EMP attack and use crosslinks to pass data directly between satellites to reduce their dependence on ground stations.[80] IPS and EPS are protected communications payloads (derived from Milstar and AEHF, respectively) hosted on classified satellites operating in highly elliptical polar orbits. This allows the IPS and EPS payloads to provide continuous coverage of the northern polar region.

AEHF and EPS are the current generation satellites replacing the legacy Milstar and IPS constellations. Three AEHF satellites are already in orbit, and the Air Force plans to launch three more over the coming years to complete the constellation.[81] EPS is a two-satellite constellation that is replacing IPS. The Air Force has not yet committed to a follow-on program for AEHF and EPS. AEHF satellites have a design life of roughly 14 years, which means the Air Force will need to begin launching replacements in the mid-2020s and continue launching replacements at a rate of roughly one every three years in order to maintain a minimum constellation size of five satellites. Similarly, the Air Force will need to begin an EPS follow-on program in the mid-2020s to ensure additional polar orbiting payloads are available when the EPS host satellites reach the end of their design life.

Milstar and AEHF are dual-use systems that many conventional forces use on a daily basis. Applying the same standard as used for other nuclear forces, if the nuclear mission did not exist, DoD would likely continue to build and operate these protected SATCOM systems to provide jam-resistant communications for conventional forces. However, without the nuclear mission requirements, such as EMP hardening of the satellites, these systems could be procured at a significantly lower cost.[82] To account for this, half of the cost of AEHF and its follow-on are allocated to the nuclear mission. In contrast, IPS and EPS are primarily for nuclear forces. These systems only provide coverage in the northern polar region, and DoD would not likely field these systems were it not for the nuclear mission. Accordingly, all of the cost of EPS and its follow-on are assigned to the nuclear mission.

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78 See U.S. Air Force, "E-4B," Fact Sheets, March 15, 2005, available at http://www.af.mil/AboutUs/FactSheets/Display/tabid/224/Article/104503/e-4b.aspx.

79 STRATCOM Factsheet, available at http://www.stratcom.mil/factsheets/1/Airborne_Command_Post/.

80 Todd Harrison, *The Future of MILSATCOM* (Washington, DC: Center for Strategic and Budgetary Assessments, 2013).

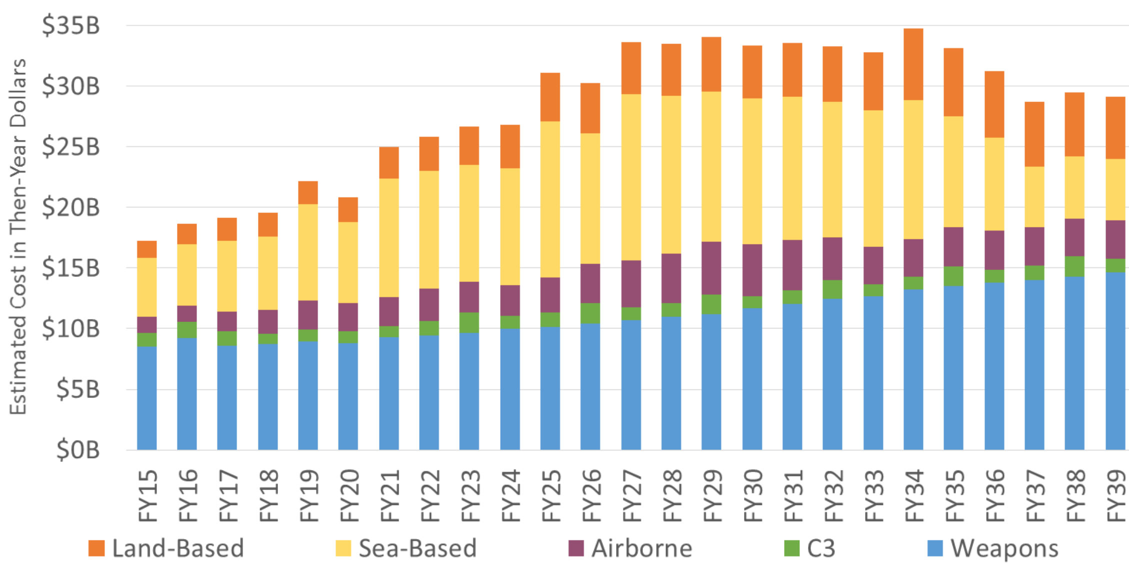
81 See U.S. Air Force Space Command, "Advanced Extremely High Frequency System," Fact Sheets, March 25, 2015, available at http://www.afspc.af.mil/library/factsheets/factsheet.asp?id=7758.

82 For more explanation of the potential cost savings of disaggregating the nuclear and convention missions for protected SATCOM, see Harrison, *The Future of MILSATCOM*.

Summary of Costs

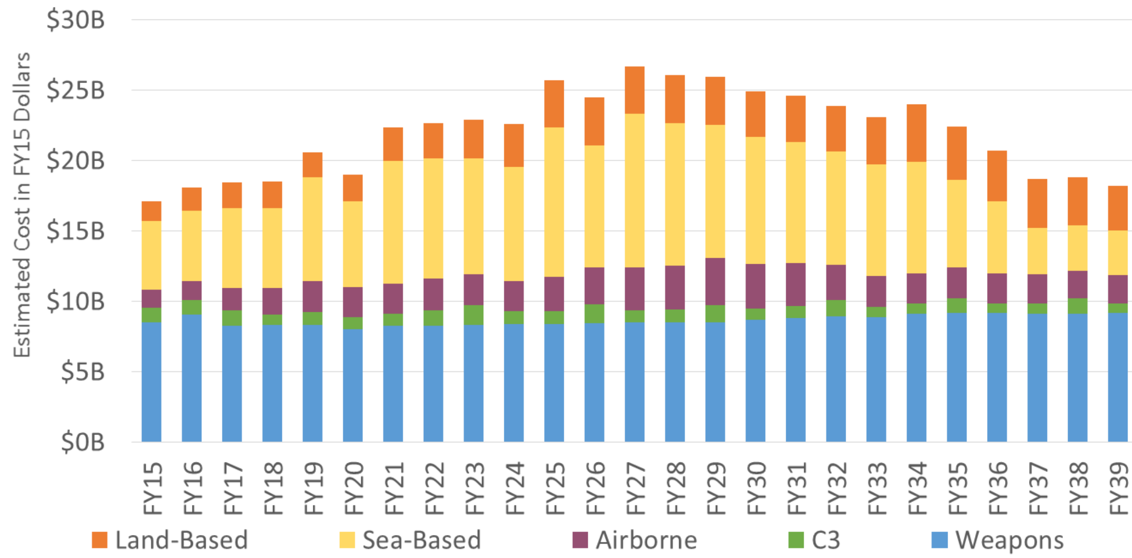
Based on the above analysis, the total projected cost of nuclear forces from FY 2015 to FY 2039 is $704 billion in then-year dollars. The annual cost, shown in Figure 8, is projected to grow significantly in the coming years from $17 billion in FY 2015 to over $34 billion by FY 2029. Adjusting for inflation, however, the peak year of funding occurs in FY 2027 at $27 billion in FY 2015 dollars, as shown in Figure 9.[83] This means the annual cost of nuclear forces will grow by 56 percent in real terms over the next 12 years before declining to near today's level in the late 2030s. The two largest cost components are weapons and sea-launched delivery systems, which together constitute an average of 72 percent of the annual funding for nuclear forces over the next 25 years.

FIGURE 8: TOTAL ESTIMATED COST OF NUCLEAR FORCES IN THEN-YEAR DOLLARS



83 This analysis uses the GDP price index to adjust for inflation, as published by OMB in the FY 2016 budget request. For years beyond the OMB projection period, an annual inflation rate of 2.0 percent is assumed.

FIGURE 9: TOTAL ESTIMATED COST OF NUCLEAR FORCES IN FY 2015 DOLLARS



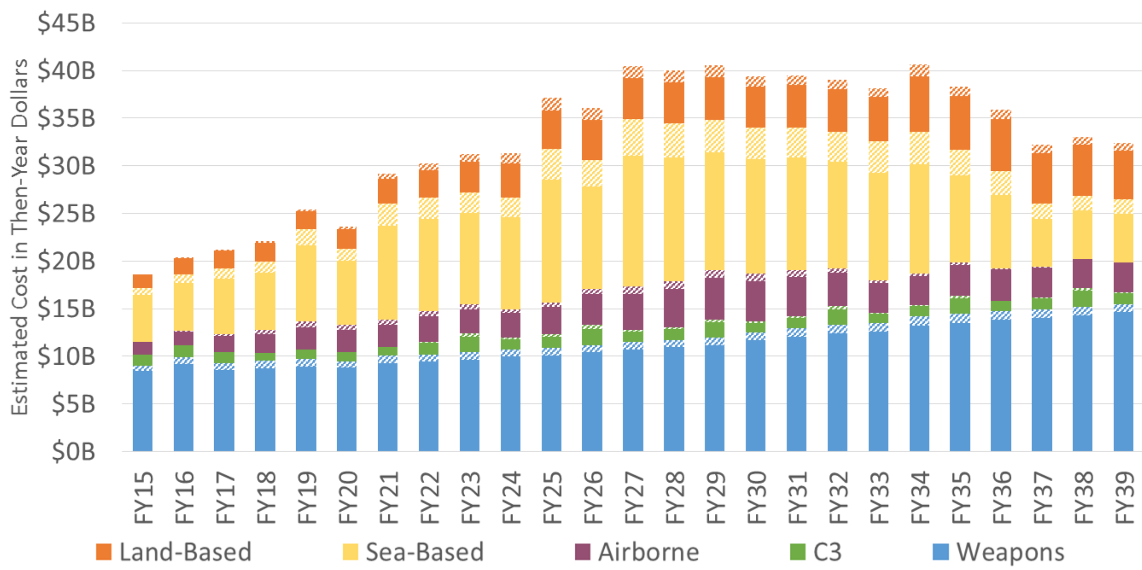
Potential Cost Growth in Modernization Programs

Much of the projected increase in the cost of nuclear forces over the coming years is due to modernization programs, and an overarching concern for these modernization programs is the potential for cost overruns. DoD and DoE modernization programs have a long and well-documented history of experiencing cost growth due to a variety of factors, but the cost estimates above do not account for unanticipated cost growth. A 2008 RAND report quantified cost overruns for major DoD acquisition programs, dividing the overruns into development and procurement. The RAND study found that for the 35 major acquisition programs it examined, the average cost growth in development was 57 percent, due primarily to errors in the original cost estimate and requirements changes. The study also found that the average growth in procurement costs (excluding quantity changes) was 34 percent, due primarily to requirements and schedule changes.[84]

To account for unanticipated cost growth in nuclear modernization programs, aggregate cost growth is estimated using the RAND study's findings. For major acquisitions programs early in the development phase (Milestone B or earlier) a cost growth factor of 57 percent is added to projected RDT&E costs, and a factor of 34 percent is added to projected procurement costs. While it is unlikely any specific program's costs would grow by these precise amounts, it provides an aggregate view of the risks cost growth may pose to nuclear modernization programs and the overall cost of nuclear forces.

84 Joseph G. Bolten et al., *Sources of Weapon System Cost Growth: Analysis of 35 Major Defense Acquisition Programs* (Santa Monica, CA: RAND, 2008) pp. 28–29 available at http://www.rand.org/content/dam/rand/pubs/monographs/2008/RAND_MG670.pdf.

FIGURE 10: TOTAL ESTIMATED COST OF NUCLEAR FORCES WITH COST OVERRUNS IN THEN-YEAR DOLLARS



The hashed sections of the bars in Figure 10 show the additional costs due to overruns using the assumptions stated above. This suggests that cost growth could add an average of $5 billion per year to the overall cost of nuclear forces in the 2020s, when the costs of many nuclear modernization programs are scheduled to peak. In total, cost growth could add some $112 billion to the cost of nuclear forces over the next 25 years. In comparison, CBO estimated cost growth would be slightly higher, totaling $49 billion for FY 2015 to FY 2024, compared to $31 billion over the same time period in CSBA's estimate.

Sensitivity to Other Assumptions

This estimate is sensitive to a number of assumptions that are necessary to calculate the cost of nuclear forces. For example, cost estimates for the airborne leg of the triad and command and control systems are highly sensitive to assumptions regarding the allocation of costs for dual-use systems since many airborne platforms and command and control systems are dual-use. The analysis is also sensitive to assumptions regarding cost growth for O&M and MILPERS, which is assumed to grow at an average annual rate of 3 percent in future years. Increasing O&M and MILPERS cost growth to 3.5 percent annually, for example, would increase the estimated total annual cost of nuclear forces in FY 2039 by more than 7 percent. Costs would also change significantly if DoD and DoE requirements, force levels, and modernization schedules differ from assumptions used in this analysis.

Putting Nuclear Costs in Perspective

Table 2 compares the CSBA estimates to the other estimates discussed in Chapter 2.[85] When adjusted for the various time periods used in other studies, the CSBA baseline and cost growth estimates are higher than DoD's MFP-1, lower than the CBO and Stimson estimates, and overlapping with the CNS estimate. The CSBA estimates are higher than the DoD MFP-1 category included in the FY 2016 budget request primarily because the CSBA estimates include DoE costs for weapons programs whereas MFP-1 does not. Additionally, some of the costs included in MFP-1 are excluded from the CSBA estimates because they are not nuclear-related, such as the B-1B

85 Where the time periods of the other estimates exceeded the range of the CSBA estimates, the CSBA estimates were extrapolated accordingly.

bomber. Other costs, such as modernization programs in development like the Ohio Replacement and satellite communications programs, are included in the CSBA estimates but are not part of MFP-1.

The CBO estimate is higher due primarily to differences in the assumptions used for dual-use systems, particularly bombers and command and control systems. CBO includes 100 percent of the B-2's costs (mainly O&M and MILPERS) and 25 percent of the acquisition cost for LRS-B, whereas the CSBA estimate includes 25 percent of the B-2's O&M and MILPERS costs and 10 percent of the LRS-B's acquisition costs.[86] Similarly, CBO includes 100 percent of the cost of protected satellite communications systems (e.g., AEHF and EPS) and early warning satellites (e.g., SBIRS-High), whereas CSBA includes 50 percent of the cost of protected satellite communications systems and none of the costs of early warning satellites.

As previously discussed, the Stimson study's methodology differs significantly from the methodology used in this study. The Stimson study estimates the total stand-alone cost of a nuclear-only force. In contrast, this study estimates the additional cost due to nuclear forces above and beyond the cost of conventional forces—i.e., the difference between the cost of a combined nuclear and conventional force and a conventional-only force. The Stimson and CNS studies also do not include the cost of tactical airborne delivery systems (F-16s, F-15Es, and F-35As).

TABLE 2: COMPARISON TO OTHER ESTIMATES

SOURCE	TOTAL COST (IN THEN-YEAR DOLLARS)	YEARS INCLUDED	CSBA ESTIMATE OVER SAME PERIOD (IN THEN-YEAR DOLLARS)	
			WITHOUT COST GROWTH	WITH COST GROWTH
DoD's Major Force Program 1: Strategic Forces	$73B	FY 2016 to 2020	$100B	$113B
CBO's *Projected Costs of U.S. Nuclear Forces*	$348B	FY 2015 to 2024	$222B	$253B
Stimson's *Resolving Ambiguity: Costing Nuclear Weapons*	$352–392B	FY 2013 to 2022	$199B	$224B
CNS's *The Trillion Dollar Nuclear Triad*	$872–1,082B	FY 2014 to 2043	$836B	$963B

To help put these costs in perspective, Figure 11 compares the total cost of nuclear forces as a percentage of the overall national defense base discretionary budget under three different scenarios: the BCA budget caps currently in effect, the President's FY 2016 budget request, and the President's FY 2012 budget request (often referred to as the "Gates Budget"). In each case, the top-line budget scenarios use a straight-line extrapolation to extend through FY 2039.[87] The cost of nuclear forces remains below five percent in all years under all three scenarios. Nuclear forces are projected to peak as a share of the overall national defense budget in the 2020s, averaging 4.3 percent of the budget during this decade under the President's FY 2016 budget request scenario. This compares to an average of 3.4 percent in FY 2015 to FY 2019.

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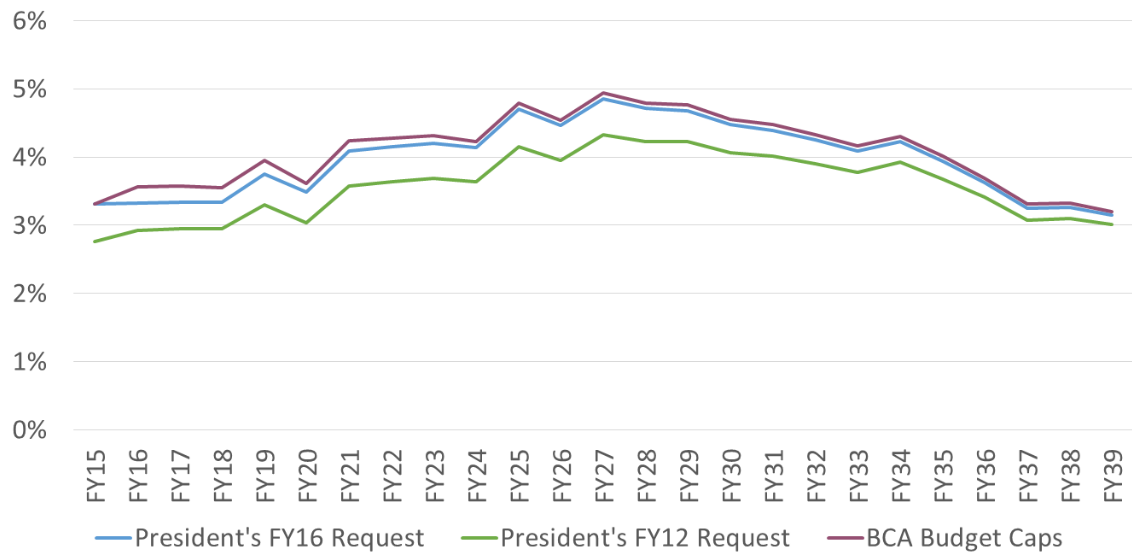
86 The CSBA estimate also includes 25 percent of the LRS-B's O&M and MILPERS costs, but these costs do not occur within the window of the CBO estimate.

87 The overall national defense budget, also known as the "050" budget function for national defense, includes the entire DoD budget, the portion of DoE's budget used for national defense, and relatively small budgets from other government agencies that support national defense activities. DoD typically constitutes around 95.5 percent of the total national defense base budget.

FIGURE 11: NUCLEAR FORCES AS A PERCENTAGE OF THE TOTAL NATIONAL DEFENSE BUDGET UNDER THREE BUDGET SCENARIOS



CHAPTER 4

Estimating Savings from Nuclear Reductions

Understanding how much the United States will likely spend on its nuclear forces over the next two and a half decades is important in its own right. Not only has this issue received considerable attention over the past several years, particularly as fiscal pressures have forced DoD to consider difficult tradeoffs and "do more with less," but it has also been the subject of several recent studies, which have all reached very different conclusions. An accurate estimate of nuclear spending is important for another reason as well: it is a necessary first step toward assessing potential savings from nuclear forces, whether those savings are achieved by making reductions to the existing U.S. nuclear arsenal, making changes to planned modernization programs, or both.

This chapter considers a number of hypothetical savings options and places them in a broader budgetary context. The bottom line—which should not be surprising given the previous chapter's conclusion that nuclear weapons will continue to account for a very small share of overall defense spending—is that these options would not provide much relief for the Pentagon. In fact, an assessment of possible cuts to U.S. nuclear forces highlights the underappreciated distinction between near-term savings and long-term savings, which is especially significant given the near-term budget constraints imposed by the BCA. Simply put, any plausible cuts would only save a very small amount of money over the next five years, when those savings are needed most.

How to Think about Nuclear Savings

Although nuclear costs and nuclear savings are obviously interrelated, they are not synonymous.[88] The amount of money the United States could save by cutting its nuclear forces is considerably less than the amount of money it spends on those forces, for a number of reasons. Perhaps most importantly, there are certain "fixed" costs that are largely insensitive to the size of the U.S. nuclear arsenal or that would only decline markedly if Washington implemented radical changes in nuclear strategy and force structure. This includes the cost of laboratories that maintain nuclear weapons and the cost of communications systems that ensure these weapons will be available if they ever need to be used. Writing in 2001, for example, David Mosher explained that, "the United States has cut its long- and short-range nuclear forces so steeply over the past decade that the cost of having nuclear weapons and delivery platforms has become dominated by the high

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88 This point is also made in Jeffrey Lewis, "The Nuclear Weapons Budget," *Arms Control Wonk,* December 5, 2011, available at http://lewis.armscontrolwonk.com/archive/4759/the-nuclear-weapons-budget.

fixed cost of staying in the nuclear business."[89] Therefore, "as long as the United States continues to be a nuclear power, keep submarine-launched ballistic missiles at sea, maintain a robust early-warning network and command and control system, and pursue a science-based stockpile stewardship program, the price tag for nuclear forces will not fall much below where it is today."[90] This observation has only become more relevant as the size of the U.S. nuclear arsenal has declined even further, and fixed costs have become a larger share of the nuclear enterprise.

Of course, not all nuclear costs are insensitive to the size of the arsenal. In particular, the costs of warhead modernization programs, delivery system acquisitions, operation and maintenance, and personnel costs all vary to some degree with the size and shape of the U.S. arsenal. Each type of warhead or delivery system (either existing or planned) that is eliminated would reduce the cost of U.S. nuclear forces in the future. The question, then, is: by how much?

Before answering that question, however, it is necessary to note that the options explored below are not exhaustive. Some may view these options as relatively minor changes to the status quo and wonder why more dramatic alternatives were not considered, while others will undoubtedly consider them radical changes and ask why more modest alternatives were not included. The options presented here are intended to be a middle ground between the two extremes and therefore provide a useful way of gauging how much money that the United States could realistically save from nuclear reductions.

Specifically, wholesale changes to the U.S. nuclear arsenal, such as eliminating an entire leg of the triad or adopting a "minimum deterrent" posture are not considered here because there appears to be no consensus in Washington for such changes. It is notable, for example, that the Obama administration has remained committed to pursuing a wide range of nuclear modernization programs across all three legs of the triad despite significant fiscal constraints, growing conventional military challenges in multiple regions of the world, and the president's stated goal of working towards a nuclear-weapons free world. If policymakers are not seriously considering major changes today under these conditions, it seems unlikely they will consider them in the near future. Likewise, minor adjustments in force structure are not included because they would result in negligible savings, and therefore would not be worth consideration from a budgetary perspective.

Given these factors, the following sections outline various options for reductions in nuclear force structure across the airborne, sea-based, and land-based components of the force. These savings are presented in then-year dollars and cannot be added across all options because some options include part or all of the savings included in others. Moreover, each of these options could have significant strategic consequences, which are not assessed in detail in this report.

Potential Reductions to Airborne Nuclear Forces

At present, the largest program associated with airborne nuclear forces is the acquisition of the new bomber, the LRS-B. As described above, however, this platform will be a conventional weapons system first and foremost, and only ten percent of its acquisition cost is allocated to the nuclear mission. It is also a program that the Air Force would almost certainly pursue even if it were not required for nuclear deterrence. The LRS-B is an important conventional weapons system given the growing vulnerability of non-stealthy aircraft to advanced air defenses and the growing vulnerability of close-in air bases to ballistic and cruise missile attacks, both of which are making power-projection more difficult. The new bomber is also likely to retain its nuclear role for the simple reason that the added expense of making the LRS-B nuclear-capable from the

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89 David Mosher, "The Hunt for Small Potatoes: Savings in Nuclear Deterrence Forces," in Cindy Williams, ed., *Holding the Line: U.S. Defense Alternatives for the 21st Century* (Cambridge, MA: MIT Press, 2001), p. 130.

90 Ibid., p. 134.

outset is a small fraction of its total price tag, while retrofitting platforms to make them nuclear-capable should circumstances warrant it in the future would be prohibitively expensive.[91] Consequently, potential options to reduce the costs of airborne nuclear forces would likely have to be found elsewhere.

One option to reduce airborne nuclear forces is to eliminate the Air Force's standoff nuclear delivery capability. This would entail converting nuclear-capable B-52Hs to a conventional-only role, retiring the existing inventory of ALCMs, cancelling the LRSO program, and cancelling the W80-4 cruise missile warhead modernization. The net savings from these changes would total some $4 billion from FY 2015 to FY 2019, $20 billion in the 2020s, and $5 billion in the 2030s.

Another option is to scale back direct attack nuclear weapons (i.e., gravity bombs) rather than standoff cruise missiles. This option would include cancelling the B61-12 program, which is consolidating all nuclear gravity bombs except the B61-11 and the B83 into a single variant, eliminating the certification and training of dual-capable tactical aircraft and flight crews for nuclear missions, and cancelling the upgrades required to make the F-35A dual-capable.[92] Under this option, therefore, bombers would still be able to carry standoff weapons, as well as the B61-11 and B83 gravity bombs that remain in the arsenal. The savings from this option total approximately $6 billion from FY 2015 to FY 2019, $11 billion in the 2020s, and $11 billion in the 2030s.

Potential Reductions to Undersea Nuclear Forces

The Navy's SSBNs are generally regarded as the most survivable nuclear capability in the U.S. arsenal and therefore should remain the core component of its deterrent force. Given that the Navy's 14 Ohio-class boats are due to begin retiring in just over a decade, the question is how many Ohio Replacement boats need to be procured and when they should enter service. At present, the Navy intends to buy 12 Ohio Replacements in total. Moreover, its current acquisition schedule would ensure that 10 boats are always available for deployment, which remains its chief operational requirement. In theory, however, the Navy could maintain a two-ocean capability with a smaller fleet of 10 total SSBNs (which would allow it to retain approximately eight boats available at any time), but this would require a new patrol plan and introduce additional strategic risk.

One option, for example, is to reduce the fleet to 10 boats by 2020 through the early retirement of the oldest four Ohio-class SSBNs. This would incur some near-term expenses, particularly for deactivating nuclear reactors ahead of schedule, but it would also begin to save money from the reduction in O&M and MILPERS costs, assuming all associated military and civilian positions are eliminated. Reducing the overall size of the fleet would also allow the Navy to delay the Ohio Replacement Program by three years and cut the final two SSBNs from its production run. The net savings from these changes would total some $8 billion from FY 2015 to FY 2019 and $29 billion in the 2020s. Savings would be -$9 billion (a net cost) in the 2030s because delaying the Ohio Replacement shifts peak years of funding into that decade.

An alternative option is to cut the fleet to 10 boats without retiring any Ohio-class subs early, which would postpone a reduction in the size of the fleet until 2030. By delaying the Ohio Replacement Program three years and cutting the last two SSBNs from production, this option would generate savings of just under $8 billion from FY 2015 to FY 2019 and $23 billion in the 2020s. It would also increase costs by $9 billion in the 2030s, however, by shifting peak funding years.

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91 Montgomery, *The Future of America's Strategic Nuclear*, p. 17.

92 This assumes that penetrating bombers rather than tactical fighters would be used to deliver the B61-11, and therefore that fighters would no longer have any nuclear missions.

A final option is to maintain the current procurement and retirement plans but simply cut the final two Ohio Replacement boats from the end of the production run. This would result in a fleet of 10 total SSBNs by 2040 and would not generate any savings in from FY 2015 to FY 2019 or in the 2020s. The estimated savings in the 2030s would be roughly $17 billion.

Potential Reductions in Land-Based Nuclear Forces

ICBMs are also a frequently discussed target for budget cuts for several reasons. First, they have been in service for decades and will soon need to be recapitalized or replaced. They also contribute most to deterring a massive first strike on U.S. nuclear forces, which is an extremely consequential but unlikely scenario. And finally, ICBMs have relatively little utility in other contingencies, due mainly to their high-yield warheads and flight paths that would carry them over the territory of one nuclear power (Russia) if they were to be used against targets in other nations. Like the other two legs of the triad, though, ICBMs have their own unique virtues, including the fact that they are based on U.S. territory, which means that any first strike against them would undoubtedly trigger a massive retaliation. In fact, even some proponents of major nuclear reductions have highlighted these virtues and argued for retaining ICBMs.[93]

One option for cutting land-based nuclear forces while retaining this leg of the triad would be to remove an entire wing of ICBMs (approximately 150 missiles) and delaying the Ground-Based Strategic Deterrent (GBSD) program by five years. This would yield approximately $1 billion in net savings from FY 2015 to FY 2019, $16 billion in the 2020s, and $14 billion in the 2030s. Importantly, these figures assume that the facilities and personnel associated with one missile wing would be reduced as well, which is hardly guaranteed, particularly because closing bases within the United States requires approval by Congress.[94] The projected net savings account for the upfront costs of such closures, which reduces the potential for near-term savings.

An alternative option is to delay the GBSD program by five years without making any force structure reductions, which would mean that a successor to the Minuteman III would not be operational until around 2036. Notably, this option would assume some risk with the existing fleet of missiles, not only by extending their projected lifespan by an additional five years, but also because a five-year extension would require slowing the current rate of testing so that the missile inventory is not exhausted. The estimated savings from this option are $0.6 billion from FY 2015 to FY 2019, $11 billion in the 2020s, and $9 billion 2030s.

Savings When You Need Them?

Thanks in large part to the budget caps on national defense spending established by the BCA, many proponents of shrinking the U.S. nuclear arsenal have highlighted the costs of these weapons as one of the main rationales for shedding current systems and shrinking, deferring, or cancelling planned modernization programs. To alleviate these near-term fiscal pressures, however, any cuts in nuclear forces would need to produce significant savings between now and FY 2021, when the BCA's budget caps are set to expire. Yet barring a major change in U.S. nuclear force posture, the force structure options described above suggest that cutting nuclear weapons is not likely to have a significant near-term budget impact. Rather, most of the savings from these options—which are not so large that they are wildly implausible but not so small that they are financially insignificant—would accrue *after* the expiration of the BCA.

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93 See, for example, Tom Nichols, "If America Could Rebuild Its Nuclear-Weapons Force from Scratch…" *The National Interest*, September 14, 2014.

94 Given current opposition in Congress to another Base Realignment and Closure (BRAC) round, the likelihood of cutting an ICBM wing and shuttering an entire base is quite low. A more plausible alternative would entail cutting a proportionate number of missiles from each of the three ICBM wings and leaving their bases largely untouched. The savings from this option would be much smaller, however, and thus are not considered here.

For instance, the most substantial savings over the FYDP come from eliminating the Air Force's standoff nuclear capability ($4.3 billion); cancelling the B61-12 program[95] and eliminating dual-capable fighters entirely ($6.3 billion); reducing the size of the Navy's SSBN fleet to 10 boats by 2020 ($8.1 billion); and closing an entire wing of ICBMs while delaying the GBSD program ($1.0 billion).[96] Collectively, these changes in force structure would substantially reduce U.S. nuclear forces, with significant near-term and long-term strategic consequences, yet would only produce less than $20 billion in savings through the end of the decade. Put differently, the $20 billion in savings from these options is just 14 percent of the projected $140 billion shortfall between the President's FY 2016 budget request and the BCA budget caps over the FYDP.

In the 2020s, the long-term savings from reductions in nuclear forces can help smooth the projected "bow wave" of nuclear modernization programs. The same four options listed above that would yield $20 billion in savings over the next five years would produce an estimated $77 billion in savings during the 2020s, when the cost of nuclear forces are projected to peak. However, the projected bow wave of nuclear modernization programs may not be a problem in the 2020s if offsetting cuts are made to conventional modernization programs and forces, or if the overall national defense budget is higher than straight-line projections at the BCA budget cap level. In fact, an increase of only two percent in overall national defense spending above the BCA level would be sufficient to fund the higher cost of nuclear forces in the 2020s, even without any offsetting cuts elsewhere in the defense budget. Moreover, historical data shows that defense spending is highly cyclic, rising and falling by up to 50 percent within a decade, so an increase of two percent would not be unusual.

Ultimately, these findings cast significant doubt on the notion that nuclear weapons are too expensive to maintain, or that cutting nuclear weapons can help the Pentagon manage its near-term fiscal challenges in a major way. In other words, the search for budgetary savings in nuclear forces continues to be, as David Mosher wrote in 2001, a "hunt for small potatoes."[97]

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95 This would also limit the nuclear gravity bombs available for long-range penetrating aircraft to the megaton B83 and ground-penetrating B61-11 bombs that would presumably remain in the arsenal if the B61-12 was cancelled.

96 While it is technically possible to simultaneously cut the standoff strike, dual-capable aircraft, and B-61 program, it is highly unlikely such reductions would be implemented together because they would nearly eliminate the airborne leg of the triad. Given this consideration, therefore, the aggregate potential savings of $20 billion may be unrealistically high.

97 Mosher, "The Hunt for Small Potatoes."

TABLE 3: SUMMARY OF OPTIONS TO REDUCE NUCLEAR FORCES (IN THEN-YEAR DOLLARS)

OPTION	PROGRAMMATIC CHANGE	NET SAVINGS FY15–19	NET SAVINGS FY20–29	NET SAVINGS FY30–39	TOTAL NET SAVINGS FY15–39
Eliminate B61-12 and dual capable aircraft	Cancel B61-12 program effective FY16	$3.8B	$3.1B	$0B	$6.8B
	Cancel dual capable aircraft modifications for F-35A and eliminate nuclear mission certification and associated training for dual-capable fighters	$2.6B	$8.4B	$11.1B	$22.0B
	Total	***$6.3B***	***$11.4B***	***$11.1B***	***$28.8B***
Eliminate nuclear-capable standoff weapons and delivery systems	Cancel LRSO program	$1.2B	$9.8B	$3.7B	$14.7B
	Cancel W80-4 cruise missile warhead modernization	$1.4B	$6.2B	$0.8B	$8.3B
	Eliminate nuclear capability, certification, and training for B-52s	$1.3B	$3.8B	$0.7B	$5.8B
	Retire existing AGM-86B ALCMs	$0.3B	$0.6B	$0.1B	$0.9B
	Total	***$4.3B***	***$20.3B***	***$5.2B***	***$29.7B***
Reduce SSBN fleet to 10 boats by FY20	Retire the oldest Ohio-class subs at a rate of 1 per year beginning in FY17	$0.2B	$6.0B	$0.1B	$6.2B
	Delay Ohio Replacement Program by 3 years and stop production at 10 boats	$7.9B	$22.9B	-$9.4B	$21.4B
	Total	***$8.1B***	***$28.8B***	***-$9.3B***	***$27.6B***
Reduce SSBN fleet to 10 boats in FY30	Delay Ohio Replacement Program by 3 years and end production at 10 boats	$7.9B	$22.9B	-$9.4B	$21.4B
	Total	***$7.9B***	***$22.9B***	***-$9.4B***	***$21.4B***
Reduce SSBN fleet to 10 boats in FY40	End production of Ohio Replacement at 10 boats	$0	$0	$16.5B	$16.5B
	Total	***$0***	***$0***	***$16.5B***	***$16.5B***
Cut one wing of ICBMs and delay follow-on GBSD program by 5 years	Eliminate one wing of existing Minuteman III missiles (150), close associated facilities, and eliminate associated positions over 5 years	$0.4B	$4.8B	$4.5B	$9.6B
	Delay follow-on GBSD program by 5 years	$0.6B	$11.5B	$9.2B	$21.2B
	Total	***$1.0B***	***$16.3B***	***$13.6B***	***$30.9B***
Reduce Minuteman III Test Rate	Reduce Minuteman III test rate from 4 to 3 per year to enable delay of follow-on program (GBSD) by 5 years	$0.6B	$11.5B	$9.2B	$21.2B
	Total	***$0.6B***	***$11.5B***	***$9.2B***	***$21.2B***

CHAPTER 5

Conclusion

Debates over the future of U.S. nuclear forces are no longer dominated by questions such as whether the United States should retain a triad of strategic delivery systems, whether it needs new warheads in addition to those that are already in its arsenal, and whether it should continue to base tactical weapons abroad in support of its extended deterrence commitments. Instead, they are frequently characterized by arguments over affordability. Unfortunately, this is not a very useful perspective. One does not need to accept the old adage that nuclear weapons provide more "bang for the buck" to dismiss the notion that they are unaffordable.

At present, the Pentagon's spending plans exceed its available resources, a situation that is likely to persist for the next five years while the budget caps in the BCA remain in effect. That means that any aspect of the defense budget—from sustaining and modernizing conventional forces, to maintaining adequate levels of readiness, to providing compensation for current personnel—could be described as "unaffordable." This description appears to be particularly ill fitting for nuclear forces, however. Although the costs of sustaining and modernizing U.S. nuclear forces are projected to grow in the years ahead, due mainly to the confluence of modernization programs now being undertaken at once, this report has shown that those costs will still account for a small fraction of total defense spending, even at their peak. Once the peak of these modernization programs is reached, funding for nuclear forces will gradually decline to roughly the level it is today (adjusting for inflation) by the late 2030s. Moreover, cutting nuclear weapons is unlikely to provide enough savings to help manage the near-term resource constraints, unless the United States were to make wholesale changes in nuclear strategy and force structure—changes that are not only unlikely but could not be easily undone. In the end, what the United States can or cannot afford depends on the priorities set by policymakers. Will they make reductions to nuclear forces, find offsetting reductions elsewhere, or expand the resources available to avoid making these choices? The answer to these questions is ultimately a matter of strategy rather than cost.

Appendix: Detailed Cost Estimates

The detailed cost data used in this analysis is available as a downloadable spreadsheet at:

http://csbaonline.org/?p=6515

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