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CBO

Approaches for Managing the Costs of U.S. Nuclear Forces, 2017 to 2046

OCTOBER 2017

Notes

Unless otherwise indicated, all dollars are expressed in constant 2017 dollars, and all years are federal fiscal years, which run from October 1 to September 30 and are designated by the calendar year in which they end.

Numbers in the text and tables may not add up to totals because of rounding.

Data underlying the figures are posted along with this report on CBO's website.

On the cover (clockwise from top right): A maintenance team works on an intercontinental ballistic missile (photo provided courtesy of the U.S. Air Force); an Air-Launched Cruise Missile is released from a B-52H Stratofortress (photo by U.S. Air Force Staff Sgt. Roidan Carlson); the nose assembly of a mock B61-12 awaits movement to Sandia National Laboratories (photo by Randy Montoya); and a graphic representation of the future USS *Columbia* (U.S. Navy photo illustration by Petty Officer 1st Class Armando Gonzales).

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www.cbo.gov/publication/53211

Contents

Summary

To continue to field a nuclear force roughly the same size as it is today, the United States plans to modernize virtually every element of that force over the coming decades. The Congressional Budget Office estimates that the most recent detailed plans for nuclear forces, which were incorporated in the Obama Administration's 2017 budget request, would cost $1.2 trillion in 2017 dollars over the 2017–2046 period: more than $800 billion to operate and sustain (that is, incrementally upgrade) nuclear forces and about $400 billion to modernize them.[1]

That planned nuclear modernization would boost the total costs of nuclear forces over 30 years by roughly 50 percent over what they would be to only operate and sustain fielded forces, CBO estimates. During the peak years of modernization, annual costs of nuclear forces would be roughly double the current amount. That increase would occur at a time when total defense spending may be constrained by long-term fiscal pressures, and nuclear forces would have to compete with other defense priorities for funding.

In its first few months, the Trump Administration began a new Nuclear Posture Review to determine a nuclear policy and force structure "appropriately tailored to deter 21st century threats."[2] That review may recommend changing modernization plans and force sizes inherited from the Obama Administration to reflect the Trump Administration's priorities for nuclear forces or to shift resources to address other defense priorities in the face of long-term budgetary pressures.

To assist policymakers, CBO examined nine options that could be pursued to lower or delay the costs of planned modernization. Some options would keep forces at or near the limit of 1,550 deployed warheads permitted under the New START treaty; others would reduce forces to around 1,000 deployed warheads. Those cuts to the forces would, to varying degrees, reduce the capability of future nuclear forces relative to those of forces as planned in 2017, although all components that would be retained in the options would be modernized.

What Are the 30-Year Costs of Planned Nuclear Forces?

CBO projects that the 2017 plan for nuclear forces would cost a total of $1.2 trillion from 2017 to 2046. Of that amount:

- $772 billion would be allocated for the operation, sustainment, and modernization of strategic nuclear delivery systems and weapons—the long-range aircraft, missiles, and submarines that launch nuclear weapons; the nuclear weapons they carry; and the nuclear reactors that power the submarines (see Summary Table 1).
- $25 billion would be allocated for the operation, sustainment, and modernization of tactical nuclear delivery systems—the aircraft capable of delivering nuclear weapons over shorter ranges—and the weapons they carry.
- $445 billion would be allocated for the complex of laboratories and production facilities that support nuclear weapons activities and the command, control, communications, and early-warning systems that enable the safe and secure operation of nuclear forces.

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[1] The scope of this estimate differs in several ways from CBO's previously published estimates of the costs of nuclear forces. For the most recent estimate, see Congressional Budget Office, *Projected Costs of U.S. Nuclear Forces, 2017 to 2026* (February 2017), www.cbo.gov/publication/52401. In this analysis, to better assess the budgetary effects of decisions about the entire set of nuclear systems, CBO includes the full cost of bombers rather than allocating only a portion of their costs to nuclear missions. In addition, previous estimates of costs covered a 10-year period and were calculated in nominal dollars, so they were not adjusted to remove the effects of inflation.

[2] See the White House, Office of the Press Secretary, "Presidential Memorandum on Rebuilding the U.S. Armed Forces" (press release, January 27, 2017), https://go.usa.gov/xN8fU. The Nuclear Posture Review is the Administration's most complete statement about its nuclear priorities. The last one was conducted in 2010.

Summary Table 1.

Projected Costs of U.S. Nuclear Forces, by Function, 2017 to 2046

Billions of 2017 Dollars

	30-Year Costs
Strategic Nuclear Delivery Systems and Weapons	
Ballistic missile submarines	313
Intercontinental ballistic missiles	149
Bombers[a]	266
Other nuclear activities[b]	44
Subtotal	772
Tactical Nuclear Delivery Systems and Weapons	25
Nuclear Weapons Laboratories and Supporting Activities	261
Command, Control, Communications, and Early-Warning Systems[c]	184
Total Estimated Costs of Nuclear Forces	**1,242**

Source: Congressional Budget Office, using information from the Department of Defense and the Department of Energy.

Total estimated costs are the costs to field, operate, and sustain the current generation of nuclear forces, as well as the costs to develop, field, operate, and sustain the next generation of systems. The costs reflect CBO's projections of the Department of Defense's and the Department of Energy's budgets plus CBO's estimates of cost growth based on historical experience with similar programs.

a. Cost estimates are based on 100 percent of the costs of all nuclear-capable bombers, which include their conventional (nonnuclear) mission. In previous studies, CBO attempted to capture the nuclear portion of the mission by counting only 25 percent of the costs of the B-52 and B-21 bombers. Using that accounting, the total cost of bombers would be $127 billion and the total costs of nuclear forces would be $1.1 trillion.

b. This category includes the Department of Defense's nuclear-related research and operation and support activities that CBO was not able to associate with a specific type of delivery system or weapon.

c. Estimates for modernization plans for this category are based on programs already delineated in budget documents. If additional modernization programs were needed, actual costs would be higher.

Any changes that the Trump Administration or the Congress makes to modernization plans or the size of nuclear forces could affect those costs. In the Department of Defense's (DoD's) parlance, sustainment means providing a series of incremental upgrades over time to a system, often by developing and inserting components that are easier to maintain or that add capability, whereas modernization means performing a complete refurbishment of an entire system or developing and producing new versions of a system.

To estimate costs, CBO projected agencies' budgets of the costs to operate and sustain the nuclear forces that exist today and combined those projections with CBO's independent estimates of the costs of major new nuclear systems. Those calculations also include CBO's estimates of cost growth beyond projected budgeted amounts for other modernization programs and for operation and sustainment of current and next-generation nuclear forces. (Those estimates are based on historical experience; see Appendix A for more details on CBO's approach to estimating costs.)

Many of today's nuclear weapon systems were designed and built decades ago and are nearing the end of their service life. According to DoD, if the United States wishes to continue to field nuclear forces, it will need to refurbish or replace essentially all elements of the forces that it decides to retain. Overall, CBO estimates that planned modernization would cost $399 billion through 2046 and include these programs:

- A new ballistic missile submarine (SSBN), designated the Columbia class;
- A new silo-based intercontinental ballistic missile (ICBM) and refurbished silos and other supporting infrastructure for ICBMs through the Ground-Based Strategic Deterrent (GBSD) program;
- A new long-range stealthy bomber, designated the B-21;
- Refurbishment of the current-generation D5 submarine-launched ballistic missile (SLBM);

- A new SLBM to eventually replace the D5;
- A new air-launched nuclear cruise missile, the Long-Range Standoff (LRSO) weapon;
- A life-extension program (LEP) for the B61 nuclear bomb that would combine several different varieties of that bomb into a single type, the B61-12;
- A LEP for the B61-12 bomb when it reaches the end of its service life, referred to as the Next B61;
- LEPs for the SSBN-related W76 and W88 warheads;
- A LEP to refurbish the W80 warhead that would be used on the LRSO; and
- A series of LEPs that would produce three interoperable warheads (called IW-1 through IW-3), each of which would be compatible with both ICBMs and SLBMs.

The rising costs of modernization would drive the total annual costs of nuclear forces, including operation and sustainment, from $29 billion in 2017 to about $50 billion through the early 2030s, CBO estimates. As most modernization programs reach completion, costs would gradually fall to around $30 billion a year in the 2040s (see Summary Figure 1).

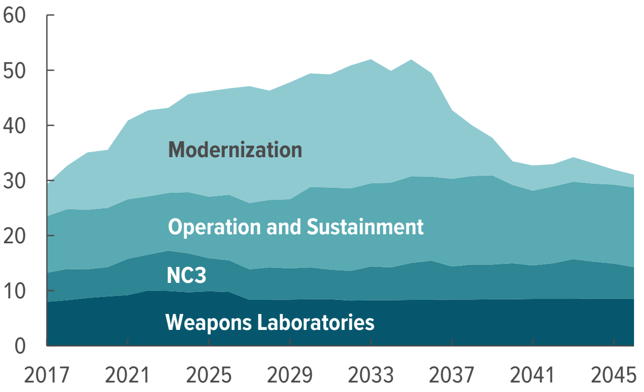
What Are Some Options for Managing the Costs of Nuclear Forces?

Some policymakers have raised concerns about the rising costs of nuclear forces. CBO analyzed three broad approaches that the United States could take to manage those costs. The first approach offers one option that would delay some modernization programs but would eventually achieve the currently planned force structure. The second approach offers five options that would reduce force structure but keep the number of warheads at New START limits. The third offers three options that would reduce the size of forces and the number of warheads below New START limits. The latter two approaches would affect both the costs and capabilities of modernized forces (see Summary Table 2).

Summary Figure 1.

Costs of Nuclear Forces Under the 2017 Plan, 2017 to 2046

Billions of 2017 Dollars



Source: Congressional Budget Office, using data from the Department of Defense and the Department of Energy.

NC3 = Nuclear command, control, communications, and early-warning systems.

If those options were implemented for the next generation of systems, savings through 2046 would range from $27 billion to $139 billion, or from 2 percent to 11 percent of the total 30-year costs of nuclear forces (see Summary Figure 2 on page 6).[3] Although the options would make substantial, or even complete, cuts to specific strategic and tactical nuclear weapons and delivery systems, the percentage reduction in overall costs would be limited because no single segment of the strategic nuclear triad (SSBNs, ICBMs, and bombers) would represent more than 25 percent of the total costs. Moreover, there are substantial fixed costs involved in maintaining the capability to safely and reliably field nuclear weapons. CBO assumed that the nuclear command-and-control systems and the complex of nuclear laboratories, which together constitute about 36 percent of the total costs of nuclear forces, would not change under any of the options.[4]

One Option That Would Delay Modernization but Still Achieve the Planned Force Structure

CBO analyzed an option that would delay development of three programs: the new ICBM portion of the

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[3] If the options were implemented now, savings would be greater—ranging from 2 percent to 14 percent of the 30-year costs of the 2017 plan.

[4] Substantial reductions to nuclear forces could make possible cuts to nuclear command-and-control systems or to the complex of laboratories and production facilities, but that analysis is beyond the scope of this report.

Summary Table 2.

Savings and Effects on Capability of CBO's Options for U.S. Nuclear Forces

Billions of 2017 Dollars

	Number of Platforms in 2046			30-Year Savings Relative to Costs of the 2017 Plan[a]		
Option	SSBNs	ICBMs	Nuclear Bombers	Savings in Modernization Programs Only	Total Savings[b]	Effects on Capability Under Nuclear-Use Scenarios[c]
Option That Would Delay Modernization						
Option 1: Delay New ICBM, New Bomber, and Interoperable Warheads	12	450	100 [d]	17 [e]	63 (5%) [e]	n.a.
Options That Would Reduce Delivery Systems but Maintain New START Weapon Limits (1,550 deployed warheads)						
Option 2: Forgo Nuclear Cruise Missiles	12	450	120	23	28 (2%)	Reduced somewhat for limited nuclear strikes
Option 3: Forgo Nuclear Bombs[f]	12	450	120	15	27 (2%)	Reduced slightly for limited nuclear strikes
Option 4: Field a Triad With 10 SSBNs and 300 ICBMs	10	300	120	25	30 (2%)	Reduced somewhat for large-scale nuclear exchange
Option 5: Field a Dyad Without Bombers[f,g]	12	450	None [h]	50	71 (6%)	Reduced for crisis management and limited nuclear strikes
Option 6: Field a Dyad Without ICBMs	12	None	120	88	120 (10%)	Reduced for large-scale nuclear exchange

Continued

GBSD program, the B-21 bomber, and the interoperable warheads. Delaying those programs would reduce the peak costs of modernization by pushing some costs into later years without changing the final modernized force structure. Under Option 1, average annual costs would be $5 billion lower than costs of the 2017 plan over the first 20 years. Over the following 10 years, however, as the delayed programs ramped up activity, average annual costs would rise to $4 billion higher than the costs of the 2017 plan. Some costs would be pushed beyond the 30-year time frame considered in this report, so annual costs under Option 1 would exceed annual costs of the 2017 plan for some time after 2046.

Five Options That Would Reduce Delivery Systems but Maintain the Number of Warheads at New START Limits

CBO analyzed five alternative force structures that would cancel or scale back selected modernization programs but retain the number of deployed warheads at (or near) the limit of 1,550 set by New START. Those options would reduce costs relative to those of the 2017 plan, but they would also decrease capability and could have implications for strategic stability, escalation management, and the survivability of strategic forces. To illustrate the operational impact of the options, CBO assessed the capability of alternative force structures, relative to the capability of nuclear forces under the 2017 plan, in three types of operational scenarios: crisis management (that is, raising the alert status of nuclear forces or operating them in a way intended to forestall escalation in a crisis situation), limited nuclear strikes, and large-scale nuclear exchanges.

Options 2, 3, and 4 would each retain the nuclear triad. Two of those would forgo one of the bomber weapons (the LRSO in Option 2 and the B61-12 bomb in Option 3); Option 4 would field fewer SSBNs and ICBMs. If those options were implemented for the next generation of systems, they would save between

Summary Table 2. Continued

Savings and Effects on Capability of CBO's Options for U.S. Nuclear Forces

Billions of 2017 Dollars

	Number of Platforms in 2046			30-Year Savings Relative to Costs of the 2017 Plan[a]		
Option	SSBNs	ICBMs	Nuclear Bombers	Savings in Modernization Programs Only	Total Savings[b]	Effects on Capability Under Nuclear-Use Scenarios[c]
Options That Would Reduce Delivery Systems and Have Fewer Weapons (1,000 deployed warheads)						
Option 7: Field a 1,000-Warhead Triad	8	150	120	55	66 (5%)	Reduced moderately for large-scale nuclear exchange
Option 8: Field a 1,000-Warhead Dyad Without Bombers[f,g]	10	300	None[h]	81	107 (9%)	Reduced for all scenarios
Option 9: Field a 1,000-Warhead Dyad Without ICBMs	10	None	120	106	139 (11%)	Reduced for large-scale nuclear exchange
Memorandum:						
2017 Plan	12	450	120	n.a.	n.a.	n.a.

Source: Congressional Budget Office, using information from the Department of Defense and the Department of Energy.

ICBM = intercontinental ballistic missile; SSBN = ballistic missile submarine; n.a. = not applicable.

a. These savings reflect the assumption that the options would be implemented for the next generation of systems. The savings would be greater if the options were implemented for the current generation of systems.

b. Total savings include savings from modernization and savings from operation and sustainment.

c. CBO used three illustrative scenarios—crisis management, limited nuclear strike, and large-scale nuclear exchange—to measure the qualitative effects of the options on capability. The effects are measured relative to capabilities under the 2017 plan.

d. Procurement of the last 20 new bombers would occur after 2046 under this option, when the total would reach 120 bombers.

e. Most of the 30-year savings would result from forgoing 10 years of operations for the new bomber. For the acquisition programs, savings would come from delaying costs until after 2046; if the estimation period was extended far enough, the costs of Option 1 would exceed those of current plans for those acquisition programs.

f. If the United States was to continue fielding tactical nuclear weapons, the savings from these options would be smaller.

g. Cost estimates include 100 percent of the costs of all nuclear-capable bombers, although they also have a conventional (nonnuclear) mission. In previous studies, CBO attempted to capture the nuclear portion of the mission by counting only 25 percent of the costs of the B-52 and B-21 bombers.

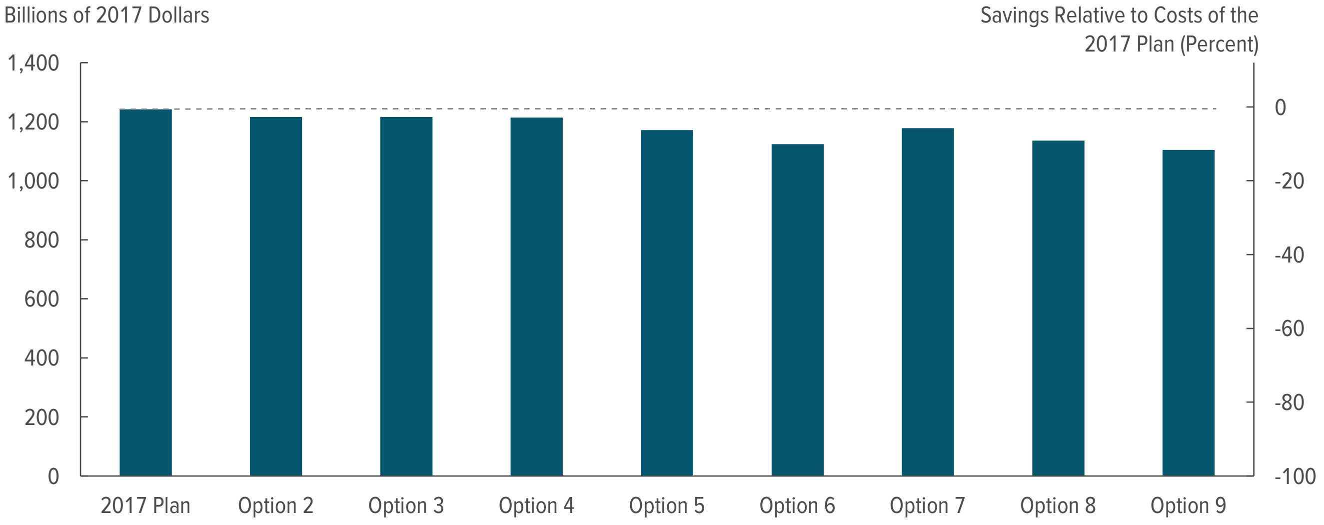
h. No bombers would carry nuclear weapons. The number of B-21s purchased would decline from 100 to 80 to continue their conventional mission.

$27 billion and $30 billion over 30 years relative to the costs of the 2017 plan, CBO estimates. All of those options would result in a capability similar to or somewhat less than that of planned forces for crisis management and limited strike scenarios, and the option with fewer ICBMs would have somewhat less capability than that of planned forces under a scenario that involved a large-scale exchange of nuclear weapons.

CBO also considered two options that would eliminate one of the segments of the triad: Option 5 would remove the nuclear mission from strategic bombers and tactical aircraft (leaving a dyad of SSBNs and ICBMs), and Option 6 would eliminate ICBMs (leaving a dyad of SSBNs and bombers). CBO estimates that—if it was implemented for the next generation of systems—Option 5 would save $71 billion over 30 years relative to the costs of the 2017 plan, although a substantial fraction of those savings would depend on DoD's choosing to purchase 20 fewer B-21 aircraft because the nuclear mission had ceased. Option 6 would save $120 billion—or 10 percent of projected costs—over 30 years, CBO estimates.

Summary Figure 2.

Total Costs of CBO's Options for Future Nuclear Forces If Changes Were Implemented for the Next Generation of Systems, 2017 to 2046



Source: Congressional Budget Office.

Option 1 is not included in this figure. Although that option would have net savings over the 2017–2046 period, they would be realized largely by delaying costs until after 2046.

Both dyad options would reduce capability substantially. Option 5, with no nuclear bombers, would provide significantly less capability in crisis management and in a limited nuclear strike, CBO estimates. Some analysts argue that such a change in capability would have serious implications for U.S. strategy and extended deterrence; other analysts contend that having less capability for limited strikes is a benefit because the risk of escalation to a large-scale nuclear exchange makes even limited nuclear strikes dangerous. Option 6, with no ICBMs, would lessen U.S. capability in large-scale nuclear exchanges by significantly reducing the number of targets an adversary would need to destroy to neutralize U.S. nuclear forces. According to some analysts, that possibility could significantly undermine deterrence; other analysts contend that deterrence would remain strong as long as enough warheads on SSBNs would survive any adversary's first nuclear strike to guarantee a substantial retaliatory strike.

Three Options That Would Reduce the Number of Delivery Systems and Warheads Below New START Limits

CBO analyzed three options that would reduce the number of warheads and delivery systems below New START limits. Under those options, deployed warheads would be limited to 1,000 and delivery systems would be reduced in proportion to similar CBO options that would retain 1,550 warheads. Option 7 would maintain the nuclear triad, Option 8 would field a dyad with no strategic bombers, and Option 9 would field a dyad with no ICBMs.

If they were implemented for the next generation of systems, the 1,000-warhead options would save between $66 billion and $139 billion over 30 years relative to the costs of the 2017 plan, CBO estimates. Those savings are about $20 billion to $40 billion larger than the savings under Options 4, 5, and 6 (which would maintain weapons and delivery systems at New START levels). Among all the options CBO examined, Option 9 would save the most: $139 billion (or 11 percent). In general, the capability under each option that is limited to 1,000 warheads would be similar to that under the 1,550-warhead option it resembles, except that the capability for large-scale nuclear exchanges would be diminished for Options 7 and 8 because of their smaller ICBM forces.

CHAPTER

1

Current Plans for Nuclear Forces

Throughout the Cold War, nuclear weapons were central to U.S. national security strategy. During those years, the nuclear arsenal grew to tens of thousands of weapons as the United States routinely developed new nuclear systems and retired old ones. However, the end of the Cold War and the collapse of the Soviet Union, as well as substantial improvement in U.S. conventional forces, led to dramatic reductions in the U.S. nuclear arsenal and to a significantly reduced role for nuclear weapons in U.S. defense and deterrence strategy. The most recent arms control treaty with Russia, known as New START, will result in a U.S. stockpile that has fewer than 15 percent of the peak number of warheads during the Cold War (see Box 1-1). The pace of innovation in nuclear forces has also slowed—the United States has not fielded any newly designed nuclear systems since the dissolution of the Soviet Union 25 years ago.

Nevertheless, the need to "maintain a secure and effective nuclear deterrent" still tops the list of priorities in U.S. national security strategy.[1] Yet many of the existing nuclear weapons and the specialized systems that deliver them were developed and built in the 1970s and 1980s (or even earlier) and are nearing the end of their operational lifetime. In a speech last year, then Secretary of Defense Ashton Carter said, regarding the planned modernization, "It's not a choice between replacing these platforms or keeping them; it's really a choice between replacing them or losing them."[2] Those modernization efforts are beginning now, and they will extend over the next three decades.

Current Nuclear Forces and Planned Modernization

From its beginnings in the Manhattan Project, the U.S. nuclear enterprise has involved the cooperative efforts of military and civilian agencies. Today, the Department of Defense (DoD) is responsible for developing, fielding, and operating all delivery systems for nuclear weapons. The primary components of those forces make up the strategic nuclear triad: intercontinental ballistic missiles (ICBMs); strategic bomber aircraft and their nuclear armaments; and ballistic missile submarines (SSBNs) and the missiles they carry. In addition, DoD fields shorter-range aircraft capable of carrying nuclear weapons, which are often referred to as tactical (or nonstrategic) nuclear forces. DoD also is responsible for the command, control, communications, and early-warning systems that enable secure and reliable control of nuclear forces.

The Department of Energy (DOE) is responsible for developing and sustaining nuclear weapons. DOE maintains a complex of laboratories and production facilities to perform and support nuclear weapons work, including production and handling of the special materials (like uranium and plutonium) used in nuclear weapons. DOE's effort includes research into the dynamics of nuclear explosions and the properties of nuclear materials. That research allows the agency to continue to certify that the weapons are safe and reliable without exploding them in underground tests.

To preserve U.S. nuclear forces, DoD and DOE have nearly 20 major life-extension programs (LEPs) and new system developments planned for the upcoming decades (see Figure 1-1 on page 10). Some of those efforts are already under way or are slated to begin in the next few years—in particular:

- Development of a new SSBN, referred to as the Columbia class program;
- Development of a new ICBM as part of the Ground-Based Strategic Deterrent (GBSD) program, which

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[1] Department of Defense, Joint Chiefs of Staff, *The National Military Strategy of the United States of America 2015: The United States Military's Contribution to National Security* (June 2015), pp. 10–11.

[2] Ashton Carter, Secretary, Department of Defense, "Sustaining Nuclear Deterrence" (speech, Minot Air Force Base, Minot, North Dakota, September 26, 2016), https://go.usa.gov/xN9kG.

Box 1-1.

Details About the New START Treaty

The New START treaty is the most recent in a series of bilateral agreements between the United States and Russia (or the Soviet Union before it) to reduce the size of the nuclear arsenals of both countries.[1] That treaty, known formally as the Treaty between the United States of America and the Russian Federation on Measures for the Further Reduction and Limitation of Strategic Offensive Arms, was signed by President Obama and President Medvedev in April 2010 and entered into force in February 2011 after approval by each country's legislature. The United States and Russia are required to meet the treaty's limits by 2018, seven years after it went into force. The treaty expires in 2021 but can be extended by five years if both countries agree to do so.

Under New START, the strategic nuclear forces of each country are limited to 700 deployed launchers, 800 deployed and nondeployed launchers, and 1,550 deployed warheads (see the table). The limits apply to strategic nuclear forces as a whole, with no restriction on the composition of those forces. There are no limits on the number of nondeployed warheads or on tactical nuclear forces. The treaty defines all technical terms. Roughly speaking, though, a single launcher can be either a silo for an intercontinental ballistic missile (ICBM), a tube for containing a submarine-launched ballistic missile (SLBM) on a ballistic missile submarine (SSBN), or a strategic bomber. To be considered deployed, an ICBM silo needs to contain an ICBM, an SLBM tube needs to contain an SLBM, and a bomber must not be based at a maintenance facility. A warhead is considered deployed if it is on a deployed launcher. The treaty counts the actual number of warheads deployed on any missile that is able to carry multiple warheads—not a fixed number of warheads for each missile type, as in some earlier treaties. Each deployed strategic bomber counts as a single warhead, regardless of the total number of bombs or missiles it can carry. Similarly, each warhead counts as a single warhead regardless of its explosive yield.

To meet the limits under New START, the United States will need to reduce its total number of strategic launchers by about

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[1] For a brief history, see Arms Control Association, "U.S.–Russian Nuclear Arms Control Agreements at a Glance" (June 2017), http://tinyurl.com/844jvhv.

Strategic Nuclear Forces Before and After Implementation of New START

	Forces in 2014	Forces Under New START (Deployed/Total	Warheads Under New START	Operational Characteristics Relevant to Deterrence
Ballistic Missile Submarines				This segment would be most likely to survive a large nuclear strike; mobility of submarines would allow some flexibility in launch points so that missiles do not fly over sensitive regions.
Submarines	14	12/14	n.a.	
Submarine-launched ballistic missiles	336	240/280	1,090	
Intercontinental Ballistic Missiles (Land-based)	454	400/454	400	This segment would provide capability for prompt response to an adversary's first nuclear strike and would present many hardened targets to a nuclear adversary.
Bombers (B-2A and B-52H)	96	60/66	60	This segment's alert level or operational status could be varied to signal intent to an adversary; bombers could be recalled after launch if a crisis situation changed.

Source: Congressional Budget Office, using information from the Department of Defense and the Department of Energy, including Department of Defense, *Report on Plan to Implement the Nuclear Force Reductions, Limitations, and Verification and Transparency Measures Contained in the New START Treaty Specified in Section 1042 of the National Defense Authorization Act for Fiscal Year 2012 (U)* (undated), https://go.usa.gov/xRDzf.

n.a. = not applicable.

Continued

Box 1-1. Continued

Details About the New START Treaty

10 percent relative to levels before the treaty's entry into force. To do that, the Department of Defense is deactivating four of the SLBM tubes on each SSBN, removing 50 ICBMs from silos, and converting some B-52H aircraft from both nuclear and conventional missions to conventional-only missions.

To observe and verify compliance with New START, each country is allowed to visit nuclear bases in the other country on short notice, a practice that had begun under the original START treaty in the 1990s but had lapsed for several months after that treaty expired and before New START took effect. In addition, each country is required to notify the other whenever a launcher changes status or is moved and must periodically provide access to other technical performance data on ICBMs and SLBMs.

also includes refurbishment of all ICBM silos and infrastructure;

- Development of a new nuclear-capable bomber, the Long-Range Strike Bomber (designated the B-21);
- Refurbishment of the current-generation submarine-launched ballistic missile (SLBM), the D5;
- Development of a new nuclear cruise missile, the Long-Range Standoff (LRSO) weapon; and
- LEPs for the W76 warhead for SLBMs, the W88 warhead for SLBMs, the W80-4 warhead for the new cruise missile, and the B61-12 bomb (including development of a new back end, called a tailkit, for the B61 to improve its accuracy).

Several other programs are slated to begin over the next 20 years. The two largest are development of a new SLBM (to replace the D5) and development of three interoperable warhead types, each of which would be compatible with both ICBMs and SLBMs.

Challenges for Nuclear Modernization Plans

The United States will face several challenges as it begins its extensive nuclear modernization program. One of the largest is likely to be budgetary—those modernization efforts would drive up annual costs for the nuclear enterprise substantially above the amounts DoD and DOE spend currently. At a time when modernization of other conventional systems is planned and defense spending is likely to be constrained by long-term fiscal pressures, nuclear modernization will compete for funding with other defense priorities. The United States also will face policy, diplomatic, programmatic, and management challenges as it develops new systems.

Budgetary Challenges

Civilian and uniformed leadership at DoD have stated that modernizing the nuclear enterprise is the department's top priority. Nonetheless, even supporters of that effort within DoD have expressed concern about the cost. For example, in 2015, Robert Work, who was then Deputy Secretary of Defense, said that modernization of the nuclear enterprise, when added to the cost of continuing to operate current systems until the new ones were available, would "roughly double the share of the defense budget allocated to the nuclear mission" and would "require very hard choices and increased risk in some missions without additional funding above current defense budget levels."[3]

Pursuing nuclear modernization will be challenging in the current environment. National defense budgets are subject to the limits established in the Budget Control Act of 2011, which set budget caps through 2021; total funding for defense under those limits is lower than the amounts incorporated in agencies' five-year plans in the 2017 budget, so if the budget caps remained in place, funding would be tighter than envisioned under the 2017 plan. Even if the funding caps were lifted, nuclear modernization would compete with other defense priorities in those years, including proposals to increase the number of warships in the Navy's fleet, modernize DoD's fleet of aircraft, and expand the size of the Army. Beyond 2021, budgetary pressures may continue: Appropriations

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3. Testimony of Robert Work, Deputy Secretary of Defense, and Admiral James Winnefeld, Vice Chairman of the Joint Chiefs of Staff, before the House Committee on Armed Services (June 25, 2015).

Figure 1-1.

Approximate Timelines for Modernization of Nuclear Forces, 2015 to 2046

Source: Congressional Budget Office, using data from the Department of Defense and the Department of Energy.

GBSD = Ground-Based Strategic Deterrent; ICBM = intercontinental ballistic missile; SLBM = submarine-launched ballistic missile; SSBN = ballistic missile submarine; * = program continues beyond 2046.

for both defense and nondefense programs may be constrained in the longer term because of rising spending on the aging population (for Social Security and Medicare benefits), health care, and interest on the national debt.[4]

Many arms control advocates argue that the United States could reduce its nuclear costs by scaling back modernization programs and shrinking and reshaping the arsenal. For example, one recent study listed programs that it suggested should be reduced or canceled; the authors estimated that the savings would total about $70 billion over 10 years.[5] However, another recent study concluded that, in the short run, cuts to nuclear forces would not aid in addressing budgetary pressures from the Budget Control Act because "any plausible cuts would only save a very small amount of money over the next five years, when those savings are needed most."[6]

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[4] See Congressional Budget Office, *The 2017 Long-Term Budget Outlook* (March 2017), www.cbo.gov/publication/52480.

[5] Savings estimates were not adjusted for the effects of inflation. See Tom Collina and others, *The Unaffordable Arsenal: Reducing the Costs of the Bloated U.S. Nuclear Stockpile* (Arms Control Association, October 2014).

[6] Todd Harrison and Evan Braden Montgomery, *The Cost of U.S. Nuclear Forces: From BCA to Bow Wave and Beyond* (Center for Strategic and Budgetary Assessments, July 2015), p. 35.

The call for constraints on nuclear budgets would probably intensify if the modernization programs experienced cost growth and schedule delays. Historically, development programs in both DoD and DOE have often run into technical difficulties that led to higher costs. Often cost growth has caused programs to be canceled; one recent study found that over a 10-year span in the early 2000s, DoD spent $46 billion on development programs that experienced difficulties and were canceled before any operational systems were fielded.[7] Some analysts have argued that the United States would be better served by scaling back nuclear modernization plans to increase the chances that the plans could be fully executed in the expected tight budget environment, even if the programs experienced cost growth. In that way, they argue, the United States could avoid a situation in which "cost overruns and schedule delays … result in deep reductions in the number of forces—reductions that … lack any strategic rationale."[8]

Policy and Diplomatic Challenges

The most recent official statement of U.S. nuclear policy, the 2010 *Nuclear Posture Review Report*, confirmed the United States' commitment to maintaining its nuclear deterrent "for as long as nuclear weapons exist" but also set a long-term goal of a "world without nuclear weapons."[9] A more recent White House statement indicated that President Obama had determined that the nuclear mission could be achieved with one-third fewer deployed strategic nuclear weapons than New START allows.[10]

In January 2017, the Trump Administration announced that it would be undertaking a new Nuclear Posture Review. That review, which will consider whether changes to U.S. nuclear policy and forces are desirable, will take place at a watershed moment for U.S. nuclear forces: Essentially every piece of the nuclear arsenal is due for replacement or refurbishment, and there has been considerable debate about the direction that the rebuilding should take.

Some strategists argue that all of the planned modernization efforts must be fully completed, which would essentially replicate the existing forces in modern form. They contend that reductions in the modernization programs that resulted in forces that were below the limits in New START would be unwise because new arms control agreements with Russia seem very unlikely given current tensions; furthermore, unilateral reductions below treaty limits would put the United States at a disadvantage if a conflict arose and could harm security relationships with its allies and partners. For many years, the United States has pursued a policy of extended deterrence, providing security assurances (backed by U.S. nuclear weapons) to its allies and partners. That policy has deterred potential aggressors and reassured allied nations that they do not need to develop their own nuclear arsenals. Reductions to U.S. nuclear forces, particularly in the current environment of North Korean nuclear and missile tests and Russian and Chinese efforts to change the territorial status quo in their regions, could embolden those countries and lead allies of the United States to question its commitment to extended deterrence and to take unwelcome steps in response.

Other strategists have argued that the need to rebuild essentially all U.S. nuclear forces provides an opportunity to reshape those forces for the post–Cold War nuclear future rather than simply replicate existing forces. Cuts to particular systems could be tailored to a change in nuclear strategy. For example, one recent analysis argued for reducing the role of nuclear weapons by trimming the size of the triad and phasing out tactical nuclear weapons.[11] Other analysts have called for expanding capabilities in some areas to provide forces more suited for a world with multiple nuclear powers.[12] In many

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[7] Todd Harrison, *Analysis of the FY2012 Defense Budget* (Center for Strategic and Budgetary Assessments, 2011), p. viii, http://tinyurl.com/l5bhlso (PDF, 2.6 MB).

[8] Jeffrey Lewis, "Into Thin Air," *Foreign Policy (*May 23, 2014), http://foreignpolicy.com/2014/05/23/into-thin-air.

[9] Department of Defense, *Nuclear Posture Review Report* (April 2010), https://go.usa.gov/xN95h (PDF, 2.8 MB).

[10] The White House, Office of the Press Secretary, "Fact Sheet: Nuclear Weapons Employment Strategy of the United States" (press release, June 19, 2013), https://go.usa.gov/xN9NC.

[11] Barry Blechman and Russell Rumbaugh, "Protecting U.S. Security by Minimizing the Role of Nuclear Weapons: A New U.S. Nuclear Policy," in Clark Murdock and others, *Project Atom: A Competitive Strategies Approach to Defining U.S. Nuclear Strategy and Posture for 2025–2050* (Center for Strategic and International Studies, 2015), pp. 28-49, http://tinyurl.com/levk7zg (PDF, 3.2 MB).

[12] Thomas Karako, "Characteristics of a Future Nuclear Force: Smaller, Lower, Newer, More Diverse, and More Integrated," in Clark Murdock and others, *Project Atom: A Competitive Strategies Approach to Defining U.S. Nuclear Strategy and Posture for 2025–2050* (Center for Strategic and International Studies, 2015), pp. 97–115, http://tinyurl.com/levk7zg (PDF, 3.2 MB).

cases, those analysts have argued for changes that would, in their view, increase flexibility (see Box 1-2).[13]

Many arms control advocates argue that now is the correct time to pursue further cuts in the U.S. nuclear arsenal—through bilateral agreements with Russia (if possible) or unilateral reductions—before the next generation of nuclear systems is developed. Reductions would save money, they argue, and U.S. leadership on reductions would move everyone closer to the goal of a world without nuclear weapons. Reductions also would support the goals of the Nuclear Non-Proliferation Treaty, under which nuclear powers pursue arms control and disarmament while nations that do not have nuclear weapons continue to forgo their development.

Programmatic and Management Challenges

Development and production of new versions of nearly all components of U.S. nuclear forces would be technically challenging, for several reasons. Nuclear weapons and their delivery systems are some of the most complex machines ever built; they must meet the highest standards for safety, security, and reliability; and the United States has not produced any newly designed nuclear systems for more than 25 years. DoD is addressing those issues by using technology and manufacturing techniques borrowed from newer systems. For DOE, experience from the LEP for the W76 warhead—which had some technical difficulties early on but is now more than halfway through production—is expected to help with development of future warhead LEPs.

Some modernization plans are more ambitious than simple replacement, which would create additional challenges. For DOE, development of the B61 LEP (which would combine multiple warhead types into a single type) and interoperable warheads (which would be compatible with both SSBN and ICBM missions) is complicated by the need to certify the weapons without underground explosive testing and to comply with a policy established by the Obama Administration that the United States will develop no new nuclear warheads.[14] For DoD, designs for new delivery systems could be complicated by the desire to include the ability to add capabilities in the future—for example, to adapt the new bomber for remotely piloted operation or to adapt the new ICBM for mobile operation.

Historically, technically challenging development programs have often encountered cost growth, schedule delays, or both. Substantial cost growth in a program could lead DoD or the Congress to reduce its scope—specifically, the number of items purchased, the capability of the systems, or both. If an existing system reaches the end of its service life before a new system is fielded, capability gaps could result. Since the Cold War ended, modernization of nuclear forces has been pushed off when possible. As a result, some systems have very little margin to accommodate schedule slips, which may lead to higher costs if problems are encountered.

Finally, these modernization efforts come at a time when the nuclear enterprise faces other management challenges. At DoD, several high-profile incidents of ethical lapses and lax control of nuclear systems have occurred in recent years. Many analysts have attributed those incidents to morale issues that stem from a perception among workers that the reduced role of nuclear weapons in national security has led to fewer opportunities for career advancement. DoD has taken steps to address those issues—in November 2014, the Secretary of Defense announced a series of reforms intended to remedy those problems, and recent statements from DoD indicate that progress has been made—but if more steps need to be taken, they may require additional resources associated with operating the forces.[15] At DOE, persistent managerial problems, particularly with security and with the execution of construction projects, have led to a debate about management structure for the weapons laboratories. Resolving those issues is likely to add to the costs of nuclear weapons.

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13. Because this report focuses on ways to manage costs and because there are no detailed plans for new nuclear capabilities, CBO has not estimated the costs of such capabilities.

14. Department of Defense, *Nuclear Posture Review Report* (April 2010), p. xiv, https://go.usa.gov/xN95h (PDF, 2.8 MB).

15. Jim Garamone, "Hagel Announces Changes to U.S. Nuclear Deterrent Enterprise," *DoD News* (November 14, 2014), https://go.usa.gov/xN9f7.

Box 1-2.

Increasing the Capability of Nuclear Forces

As part of its effort to strengthen U.S. armed forces, the Trump Administration has directed the Secretary of Defense to perform a Nuclear Posture Review to ensure that nuclear forces are "modern, robust, flexible, resilient, ready, and appropriately tailored to deter 21st-century threats and reassure our allies."[1] As a result of that review, the Administration could conclude that the United States needs to change its nuclear force structure, perhaps by pursuing new nuclear capabilities, increasing or reducing planned modernization programs, or combining those approaches in some way.

Several studies have suggested new nuclear capabilities that the United States could pursue. Those capabilities are intended to provide decisionmakers with more options to address regional crises or conflicts. One factor driving the push for new capabilities is a view among many strategic analysts that the likelihood that regional conflicts could involve nuclear weapons is increasing. Analysts do not agree, however, about whether new nuclear capabilities are needed.

Some analysts have argued that the United States should boost the numbers and types of tactical weapons it fields. Because those weapons can be forward-deployed to a crisis location, proponents argue, they can deter nuclear escalation.[2] Historically, the United States has had a wide variety of tactical nuclear weapons deployed in Europe and Asia; currently, it has only about 200 bombs deployed in Europe, which shorter-range aircraft would carry in support of the North Atlantic Treaty Organization. (Additional tactical weapons are stored at domestic bases.) Russia, by contrast, is estimated to have about 2,000 tactical nuclear weapons for delivery from both sea and air.[3]

Some ideas that have been suggested to increase the capability of U.S. nuclear forces include these:

- Provide nuclear capability to the Navy's version of the F-35 aircraft, which would allow deployment of nuclear weapons on aircraft carriers;
- Deploy a nuclear cruise missile on tactical aircraft, by adapting either the Long-Range Standoff (LRSO) weapon or an existing cruise missile, like the Joint Air-to-Surface Standoff Missile, for the nuclear mission; and
- Return nuclear cruise missile capability to the Navy's surface ships by adapting an existing conventional missile or by adapting the LRSO weapon for that mission.[4]

In addition, some analysts argue that increasing the types of weapons with relatively low explosive yield would give decisionmakers more flexibility. Currently, only the air-delivered nuclear weapons (bombs and air-launched cruise missiles) have that capability. But any of the new tactical capabilities listed above could have low-yield capability, and some analysts have asserted that low-yield versions of existing warheads on intercontinental ballistic missiles or submarine-launched ballistic missiles could be produced through simple modifications.[5] Opponents are concerned that low-yield weapons would make nuclear weapons easier to use, however, because, in their view, such weapons could blur the threshold between nuclear and conventional weapons.

The United States could also choose to expand its strategic nuclear forces by producing more of the currently planned modernized systems. Such an expansion would not violate any treaties if New START was allowed to expire in 2021. Even if the United States and Russia chose to extend that treaty to 2026, production of new systems would just be starting in earnest then, and it would be years before enough systems were produced to expand forces beyond the treaty's limits. However, even without explicitly violating a treaty, a decision to expand strategic forces would reverse a multidecade trend of negotiated and unilateral reductions in the size of nuclear forces, running counter to the U.S. commitment as part of the Non-Proliferation Treaty to work toward eventual total nuclear disarmament and perhaps triggering another nuclear arms race.

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1. See the White House, Office of the Press Secretary, "Presidential Memorandum on Rebuilding the U.S. Armed Forces" (press release, January 27, 2017), https://go.usa.gov/xN8fU.

2. See, for example, Angela Weaver, "Project Atom Key Points of Comparison," in Clark Murdock and others, *Project Atom: A Competitive Strategies Approach to Defining U.S. Nuclear Strategy and Posture for 2025–2050* (Center for Strategic and International Studies, 2015), pp. 89–96, http://tinyurl.com/levk7zg (PDF, 3.2 MB).

3. That figure comes from unclassified sources. Reports indicate that Russia has fielded a ground-launched nuclear cruise missile, which would violate the Intermediate Nuclear Forces Treaty between the United States and Russia. See Hans Kristensen and Robert Norris, "Russian Nuclear Forces, 2017," *Bulletin of the Atomic Scientists*, vol. 73, no. 2 (February 2017), pp. 115–126, http://tinyurl.com/y93n67hu.

4. Surface ships and submarines used to carry a nuclear version of the Tomahawk missile, but it was retired from service.

5. Keith B. Payne and others, *Nuclear Force Adaptability for Deterrence and Assurance: A Prudent Alternative to Minimum Deterrence* (National Institute for Public Policy, 2014), p. 34.

CHAPTER

2

Costs of Planned Nuclear Forces Over 30 Years

To estimate the costs of planned nuclear forces, the Congressional Budget Office grouped the wide range of programs and activities of the Department of Defense and the Department of Energy into four categories:

- Strategic nuclear forces, which are composed of long-range bombers and their nuclear armaments, intercontinental ballistic missiles and their warheads, and ballistic missile submarines and their missiles carrying nuclear warheads;

- Tactical nuclear forces, which are composed of shorter-range aircraft and their nuclear armaments;

- Nuclear laboratories and the production complex for nuclear weapons and components; and

- Command, control, communications, and early-warning systems that enable nuclear operations.

CBO's estimates of costs—the amounts that would need to be appropriated—cover the period from 2017 to 2046. By the end of that 30-year period, most of the major modernization programs would have finished production and the current-generation forces that are scheduled to be retired would have been.

To construct its estimates, CBO used the budget plans for nuclear forces submitted by DoD and DOE for fiscal year 2017, which are the most recent detailed plans available. Those plans provide budget projections for 5 years for most programs, although in some cases projections are available for as many as 30 years. For major modernization programs for which plans are still being formulated, CBO based its estimates on historical costs of analogous programs. CBO also estimated the cost growth that nuclear forces could encounter beyond the projected budgeted amounts; it based those estimates on historical growth experienced by similar programs. (See Appendix A for more details on how CBO estimated costs.)

The estimates in this report do not include costs that some analysts consider relevant, such as the costs of cleaning up the nuclear weapons complex, missile defense, and nonproliferation activities (including compliance with nuclear arms control agreements). Those costs would be incurred regardless of whether the United States modernized its nuclear forces. CBO examined those costs in an earlier report.[1]

Projecting costs over 30 years entails substantial uncertainty. Most nuclear modernization programs are in their early stages, and the exact specifications for the systems are unclear. Historically, even when the designs of weapon systems have been determined, the costs of producing them are uncertain. For this report, CBO generated independent estimates of the costs of major modernization programs. For all other components of nuclear forces, CBO's cost estimates are based on projections of DoD's and DOE's budgets combined with CBO's estimates of potential cost growth, which come from DoD's and DOE's historical experiences involving weapon systems and facilities of that type. (Actual cost growth for a specific program could be higher or lower than the historical averages that CBO used.) However, because this analysis is primarily intended to quantify the differences in costs among various options, the effects of some of the uncertainties would essentially cancel out. Thus, CBO's estimates of savings for alternative options relative to costs of the 2017 plan might be considered less uncertain than its estimates of the total costs of that plan or of any given option.

Total Costs of the 2017 Plan

Over the 2017–2046 period, the costs of the plan for nuclear forces described in DoD's and DOE's 2017 budget documents would total about $1.2 trillion in 2017 dollars (that is, adjusted to remove the effects of inflation), CBO estimates. Of that total, about one-third ($399 billion) would be allocated for modernization

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[1] Congressional Budget Office, *Projected Costs of U.S. Nuclear Forces, 2014 to 2023* (December 2013), www.cbo.gov/publication/44968.

activities—developing and producing new systems and conducting major life-extension programs. The remaining two-thirds ($843 billion) would be allocated to operate, sustain, and support both the current generation of forces and the modernized forces once they entered service. Allocating that $1.2 trillion by department, $890 billion would be for DoD's activities and $352 billion would be for DOE's (see Table 2-1). Those estimates include expected cost growth.

Annual costs would rise substantially over the next decade, CBO estimates, primarily because DoD and DOE would be developing several systems at the same time. Costs would rise from $29 billion in 2017 to $47 billion in 2027, CBO estimates, before peaking at around $50 billion a year through the early 2030s. In the 2040s, by which point most of the modernization programs would have been completed, annual costs would drop back to roughly $30 billion.[2]

In percentage terms, the total cost of nuclear forces would represent about 6 percent of all spending on national defense over the 2017–2046 period, in CBO's estimation, if DoD implemented its 2017 plan for defense.[3] On an annual basis, that percentage would vary substantially, rising from about 5.5 percent in 2017 to a peak of around 8 percent in the late 2020s and early 2030s before declining to about 4.5 percent in the 2040s.[4] The increase in the share of DoD's annual acquisition costs dedicated to nuclear forces would be larger: The combined annual costs of modernization and sustainment of current forces would peak at about 15 percent of DoD's total acquisition costs in the early 2030s, more than triple the current share, CBO estimates.

How This Estimate Differs From CBO's Previous Estimates of the Costs of Nuclear Forces

The scope of this estimate differs in several important ways from CBO's previously published estimates of the costs of nuclear forces, the most recent of which covered the period from 2017 to 2026.[5] The most significant difference is how the analyses address the costs of systems that have both nuclear and nonnuclear missions, particularly strategic bombers. This study analyzes the budgetary impacts of trade-offs among systems, particularly trade-offs entailing substantial reductions in the number of systems purchased (including bombers). To more accurately evaluate those trade-offs, CBO has accounted for the full costs of nuclear-capable bombers, which necessarily include the costs of their conventional missions. In its previous estimates of the costs of nuclear forces, CBO attempted to capture only the nuclear-related portion of the bombers' costs by counting only 25 percent of the costs of the B-52H and B-21 bombers. (CBO included 100 percent of the costs of the B-2A.) If that same accounting was applied in this study, the total 30-year cost to execute the nuclear mission would be about $1.1 trillion, CBO estimates, instead of $1.2 trillion.

Another significant difference between these estimates and previous ones is how potential growth in the costs of programs is presented. For this study, CBO relied heavily on its independent estimates of the costs of programs that include the effects of cost growth. In CBO's earlier 10-year estimates, the projected costs of budgets for nuclear forces were presented separately from estimates of potential cost growth, which were based on historical experience; those figures were then added together to arrive at CBO's total estimate of the costs of nuclear forces. Therefore, for consistency across analyses, the estimates in this study should be compared with the summed totals in CBO's previous estimates.

Other differences are that the estimates in this study cover 30 years rather than 10 and that this study

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[2] That cost profile reflects the assumption that the Congress would allow funding for building the new SSBNs to be spread over multiple years. The Navy currently has the authority to split the costs of constructing large ships, like aircraft carriers, over several years rather than purchasing them in a single year, as it does for other ships.

[3] The projection of total defense spending from 2017 through 2032 under DoD's 2017 plan is based on the methodology in Congressional Budget Office, *An Analysis of the Obama Administration's Final Future Years Defense Program* (April 2017), www.cbo.gov/publication/52450. For the calculation after 2032, annual defense costs were projected to increase by about 0.7 percentage points faster than inflation, which is the average annual growth rate in CBO's projection for 2028 through 2032.

[4] Those values use the discretionary portion of budget function 050 to represent total national defense spending. That budget function comprises all of DoD's funding, DOE's funding for Atomic Energy Defense Activities only, and some national defense activities by other agencies.

[5] Congressional Budget Office, *Projected Costs of U.S. Nuclear Forces, 2017 to 2026* (February 2017), www.cbo.gov/publication/52401.

Table 2-1.

Projected Costs of U.S. Nuclear Forces, by Department and Function, 2017 to 2046

Billions of 2017 Dollars

	DoD	DOE	Total
Nuclear Delivery Systems and Weapons			
Strategic nuclear delivery systems and weapons			
Ballistic missile submarines	275	38	313
Intercontinental ballistic missiles	124	25	149
Bombers[a]	245	20	266
Other nuclear activities[b]	44	n.a.	44
Subtotal	688	84	772
Tactical nuclear delivery systems and weapons	18	7	25
Nuclear weapons laboratories and supporting activities	n.a.	261	261
Total, Nuclear Delivery Systems and Weapons	**706**	**352**	**1,058**
Command, Control, Communications, and Early-Warning Systems[c]	184	n.a.	184
Total Estimated Costs of Nuclear Forces	**890**	**352**	**1,242**

Source: Congressional Budget Office, using information from the Department of Defense and the Department of Energy.

Total estimated costs are the costs to field, operate, and sustain the current generation of nuclear forces, as well as the costs to develop, field, operate, and sustain the next generation of systems. The costs reflect CBO's projections of the Department of Defense's and the Department of Energy's budgets, CBO's estimates of cost growth based on historical experience with similar programs, and CBO's estimates of the costs of major modernization programs.

DoD = Department of Defense; DOE = Department of Energy; n.a. = not applicable.

a. Cost estimates include 100 percent of the costs of all nuclear-capable bombers, although they also have a conventional (nonnuclear) mission. In previous studies, CBO attempted to capture the nuclear portion of the mission by counting only 25 percent of the costs of the B-52 and B-21 bombers. Using that accounting, the total cost of bombers would be $127 billion and the total costs of nuclear forces would be $1.1 trillion.

b. This category includes DoD's nuclear-related research and operation and support activities that CBO was not able to associate with a specific type of delivery system or weapon.

c. Estimates for modernization plans for this category are based on programs already delineated in budget documents. If additional modernization programs were needed, actual costs would be higher.

expresses costs in 2017 dollars rather than in nominal dollars.

Costs of Components of Nuclear Forces

Because the alternative approaches considered in this study would affect only strategic and tactical nuclear forces, CBO focused on those costs separately and combined the other two categories—nuclear weapons laboratories and the production complex, and nuclear command, control, communications, and early-warning systems—together. Strategic forces account for about 60 percent of the projected costs.

Strategic Nuclear Forces

Strategic nuclear forces comprise long-range nuclear delivery systems (bomber aircraft, submarines and the missiles they launch, and ICBMs) and the nuclear warheads they carry. Those forces are also known as the nuclear triad. To capture the full cost of each component, CBO combined the costs for DoD and DOE that are specific to that portion of the forces. For DoD, the estimate includes the costs to operate and sustain the current generation of delivery systems, develop and produce next-generation systems, and operate and sustain those systems once they are fielded. For DOE, the estimate includes the cost to sustain current-generation nuclear weapons, perform LEPs to produce the next generation of nuclear weapons, and sustain the next generation of weapons once they are fielded.

Under the most recently articulated plans, DoD and DOE would spend $772 billion overall on strategic nuclear forces over the 2017–2046 period, CBO estimates.[6] Of that total, $235 billion would fund continued operation and sustainment of the current generation of systems until they are retired, and $537 billion would fund development and procurement of new systems and their operation and sustainment once they are fielded.[7] SSBN submarines and nuclear-capable bombers account for three-quarters of those estimated costs.

SSBNs. Over the 2017–2046 period, DoD's and DOE's costs to field, operate, and modernize the fleet of SSBN submarines, the SLBM missiles they carry, and the warheads on those missiles are projected to be $313 billion under the current plan. Of that total, $79 billion would be for operating and sustaining the current generation of systems. The remaining $234 billion would be for the next generation of systems, including operation and sustainment of those systems once they are fielded.

DoD operates 14 Ohio class SSBNs from two bases, one in Georgia and the other in Washington. Those submarines were developed in the 1970s and came into the fleet in the 1980s and 1990s. Twelve of those submarines are considered to be deployed at any given time under the counting rules of New START; the other two are in long-term maintenance and are not available for use. Each Ohio class SSBN can carry a maximum of 24 current-generation D5 SLBMs, and each SLBM carries as many as 8 warheads. To meet New START limits, 4 of the 24 SLBM launchers (that is, missile tubes) on each boat will be disabled by 2018. DOE maintains two types of warheads for SLBMs, the W76 and the W88. Designing and building the nuclear reactors that power the SSBNs are also DOE's responsibility. CBO estimates that DoD and DOE currently spend about $4 billion per year to operate and sustain the current generation of systems in the SSBN fleet.

Essentially all parts of the SSBN fleet would be replaced through planned or ongoing modernization programs over the coming decades. The most visible of those programs is the Columbia class program (previously referred to as the Ohio Replacement program), which would produce a total of 12 new SSBNs. DoD will begin to retire the current Ohio class of SSBNs before the first of the new boats is operational, primarily because the fuel for their nuclear reactors will be exhausted. Development of the Columbia class SSBN is now under way; the first submarine is slated to be formally authorized in 2021 and to enter the fleet in 2030. The current generation SLBM, the Trident II D5, is in the midst of an extensive LEP that is expected to continue into the 2020s. That missile is expected to be replaced by a new SLBM around the early 2040s; for this study, CBO assumed that DoD would begin development of the new SLBM in the mid-2020s and start production around 2035.

Both warheads now carried by the D5 are in the midst of LEPs: The W76 is more than halfway through production, and the W88 is being developed and would begin production in 2020. Those refurbished warheads are slated to be replaced starting in the 2030s with interoperable warheads (IWs), which would be compatible with both SLBMs and ICBMs. Three varieties of interoperable warheads, IW-1 through IW-3, are planned. For this study, CBO has split the cost of IWs evenly between the SSBN and ICBM segments of the triad. The IW-2 and IW-3 modernization programs are expected to continue beyond 2046, the end point for this analysis.

Annual costs for SSBN modernization programs would peak at $12 billion in the first half of the 2030s, when the construction of new SSBNs, development of a new SLBM, and efforts on all three IW programs would overlap. Modernization costs would average $8 billion per year during the 2020–2035 period under the 2017 plan, CBO estimates. After 2046, annual operation and sustainment costs for SSBN systems would average $4 billion.

ICBMs. Under the current plan, the costs to DoD and DOE to field, operate, and modernize the fleet of ICBM missiles, the warheads they carry, and the associated infrastructure are projected to be $149 billion over the 2017–2046 period. Of that total, $37 billion would be spent to operate and sustain the current generation of systems, and $112 billion would fund the next

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[6] That total includes $44 billion for other strategic nuclear costs that CBO was not able to associate with a particular segment of the triad. If only 25 percent of the costs of the B-21 and B-52H bombers were included, CBO's estimate of the costs for strategic nuclear forces would be $633 billion: $212 billion for current-generation systems and $420 billion for next-generation systems.

[7] Sustainment includes all of DoD's acquisition costs—that is, all costs under the appropriation titles for procurement and for research, development, test, and evaluation—for existing weapon delivery systems (except for major LEPs for those systems) as well as DOE's costs for sustaining the relevant warhead types and supporting naval reactors on current SSBNs.

generation of systems (including operation and sustainment of those systems once they are fielded).

DoD currently fields about 400 Minuteman III ICBMs, distributed among 450 silos at three bases.[8] The Minuteman III was designed in the 1960s and entered into service throughout the 1960s and 1970s. To meet New START limits on deployed launchers, DoD plans to field 400 ICBMs starting in 2018. (Individual silos do not have personnel stationed on site; instead, for every 10 silos, one launch control center is manned around the clock, and the facilities are connected by a set of extensive and robust command-and-control systems.) Although each missile can carry up to three nuclear warheads, all ICBMs carry a single warhead—either a W78 or W87—under current policy. Together, DoD and DOE currently spend $2 billion per year to operate the current generation of ICBM systems.

DoD plans to modernize the full ICBM enterprise through its Ground-Based Strategic Deterrent program, which would design and construct a new ICBM and would refurbish and modernize all silos and infrastructure. That program is in its early stages, and the Air Force expects to begin fielding the new ICBMs in the late 2020s. Existing ICBM warheads would be replaced with interoperable warheads starting in the 2030s.

Costs of modernizing the ICBM system peak at $7 billion per year in the early 2030s and average $4 billion per year from 2020 to 2035 in CBO's estimates. Costs for ongoing operation and sustainment of the new ICBM systems are projected to drop to an average of $2 billion per year after 2046.

Bombers. Through 2046, the costs to DoD and DOE to operate, sustain, and modernize the fleet of nuclear-capable bombers and their nuclear armaments under the 2017 plan are projected to be $266 billion. Of that total, $75 billion would be for operation and sustainment of the current generation of systems—the B-52H and the B-2A and their armaments—and $191 billion would be for the next generation of systems (including operation and sustainment of those systems once they are fielded).

To meet New START limits, the 2017 plan calls for the fleet of deployed, nuclear-capable bombers to consist of 41 B-52H aircraft and 19 B-2A aircraft.[9] The nuclear armaments used by those bombers are the Air-Launched Cruise Missile (ALCM) with its W80 warhead (carried by the B-52H) and the B61-7, B61-11, and B83 nuclear bombs (carried by the B-2A). Operating the current generation of nuclear-capable bombers and their nuclear weapons is estimated to currently cost DoD and DOE $3 billion a year.

Several modernization programs are ongoing or planned for the bomber force. The largest is the B-21 program, which is intended to develop and build 80 to 100 stealthy aircraft for initial delivery in the mid-2020s (see Figure 1-1 on page 10). That new bomber is being developed and procured not only to perform the strategic (long-range nuclear) mission but also to maintain a highly capable, credible conventional bomber. For this study, CBO's estimates reflect the assumption that 100 B-21 aircraft would be built. In addition, DoD plans to develop a new nuclear cruise missile, the Long-Range Standoff weapon, and to produce about 1,000 of those missiles starting in the late 2020s. The LRSO is intended to replace the ALCM as that missile becomes unusable because of age; the ALCM was fielded in the 1980s and has had three life extensions already. The LRSO would carry warheads of an existing type that would be refurbished to extend their service life; the schedule for refurbishment is aligned with that for production of the new missile.

Furthermore, DOE has launched a major LEP, currently in the design stages, that would combine four varieties of the B61 bomb into a single design, the B61-12. That warhead would serve both strategic and tactical missions; for this analysis, CBO has split the cost of the B61-12 evenly between the two types of missions. Also under development is a new tailkit that would increase the accuracy of the B61-12. In total, CBO estimates, annual costs for the bomber modernization programs would peak at about $9 billion in the mid-2020s and average $6 billion a year between 2020 and 2035. Operation and sustainment of the modernized bomber force would

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8. That total does not include four silos at a fourth base that are used for regular test flights, which count toward the New START limit on nondeployed launchers.

9. To meet that limit, some of the B-52Hs that are currently nuclear capable will have that capability removed.

cost an average of $6 billion per year after 2046, CBO estimates.[10]

Tactical Nuclear Forces

The United States reportedly maintains about 200 tactical nuclear weapons—all of which are nuclear variants of the B61 bomb—at sites in Europe as part of its support to the North Atlantic Treaty Organization (NATO).[11] Those weapons, if used, would be delivered either by U.S. aircraft or by aircraft operated by NATO allies. Currently, the United States uses the F-15E and the F-16 as its delivery systems for tactical nuclear weapons. In the future, DoD plans to make the F-35A (the Air Force's version of that aircraft) nuclear capable. The current variants of the B61 bomb used by tactical aircraft would be replaced by the B61-12, which would serve both tactical and strategic roles (and the cost of which is split in this analysis between the two categories).

CBO estimates that the cost of tactical nuclear forces over the 2017–2046 period would be $25 billion, or an average of about $1 billion per year, under the 2017 plan.

Other Components of Nuclear Forces

The other two categories of nuclear forces are the weapons laboratories and production complex, and the command, control, communications, and early-warning systems. Over the 2017–2046 period, those two components together are estimated to cost $445 billion, or about 36 percent of the total costs of nuclear forces over that period.

None of the options that CBO has analyzed for managing the costs of nuclear forces include changes to DoD's 2017 plans for those two components. Although savings might be realized by changing the plans for those components or by improving efficiency in their operations, analysis of such changes is beyond the scope of this report.

Nuclear Weapons Laboratories and the Production Complex. DOE operates a complex of design laboratories and production facilities that provide the engineering and scientific capabilities required to sustain the stockpile of nuclear weapons. Those capabilities include the following:

- Facilities to produce and process the nuclear materials and other specialized components used in nuclear weapons and weapons research;
- Basic scientific research and high-speed computer simulations to improve understanding of the dynamics of nuclear explosions and the aging of weapons;
- Research to develop and certify the processes used in maintaining nuclear weapons; and
- The infrastructure required to support those efforts.

In CBO's estimation, the costs to DOE of those efforts would be $261 billion over the 2017–2046 period, or an average of about $9 billion per year, under the 2017 plan. Those costs do not include sustainment and LEP activities specific to particular weapon types; in CBO's accounting, those costs have been included with the costs of their associated delivery systems. Projected costs also exclude DOE's other nuclear-related activities, like nonproliferation efforts and environmental cleanup.

Command, Control, Communications, and Early-Warning Systems. DoD operates a collection of systems that support the nuclear weapons enterprise by allowing operators to communicate with nuclear forces, issue commands that control their use, and detect incoming attacks or confirm that no attacks are under way. According to DoD, many of those systems need to be modernized. However, plans to do so are generally not yet well defined. For that reason, they have not been included in CBO's estimates of costs (except to the extent that they are included in DoD's existing budgets). The costs of those systems over the 2017–2046 period are projected to be $184 billion—or an average of about $6 billion per year—under the 2017 plan. Additional modernization programs, if included, would increase those costs.

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[10] That total includes operation of the B-2A, which is slated to be active into the 2050s.

[11] Amy F. Woolf, *Nonstrategic Nuclear Weapons*, Report for Congress RL32572 (Congressional Research Service, February 23, 2015).

CHAPTER

3

Factors to Consider in Evaluating Changes to the Force Structure

Under the 2017 plan for nuclear forces, annual costs are expected to rise sharply between 2017 and the mid-2020s and then to continue to rise more slowly well into the 2030s. The Congressional Budget Office analyzed various measures that the United States could take to manage or reduce the costs of nuclear forces. But nuclear weapons are central to U.S. national security strategy, so cost is only one factor to weigh when considering changes to the force structure. Nuclear forces must be capable of deterring adversaries from attacking the United States or its allies. However, because deterrence is as much psychological as operational, analysts have a range of views on what capabilities are required to accomplish it.

To assess the capability of alternative force structure options, CBO considered two ways to measure capability. The first is the number of warheads that meet certain criteria. The second is the characteristics that enable nuclear forces to perform certain functions under scenarios in which the United States might use nuclear weapons to deter attacks or to prevent further use if an adversary had already used them.

Number of Warheads

Under each force structure that CBO examined in this analysis, the Department of Defense would field a certain number of warheads, and CBO estimated how many would fall into three (nonexclusive) categories—deployed, on alert, and survivable (see Table 3-1). CBO's calculation of the number of deployed warheads counts warheads on delivery systems that are considered available for missions. (That calculation is consistent with the terms of New START.) Generally, a delivery system is available if it is not undergoing long-term maintenance (which occurs periodically and could last from several months to several years).

The estimated number of warheads on alert encompasses those deployed on delivery systems that are ready to launch their weapons promptly; those systems include all intercontinental ballistic missiles and the submarine-launched ballistic missiles on those ballistic missile submarines that are at sea and located in their assigned launch region (as opposed to those in transit to their launch region or in port).

The estimated number of survivable warheads includes those that would probably survive a large all-out nuclear attack by an adversary, primarily warheads deployed on submarines at sea but also some warheads on ICBMs.[1] (Most, if not all, warheads would survive an attack by a small nuclear power because such an adversary would not have enough warheads or the accuracy to threaten most U.S. nuclear forces, particularly ICBMs, which are scattered across wide areas and housed in hardened silos.)

CBO estimated warhead counts in each category under two conditions—during day-to-day operations and during a crisis. Day-to-day operations are those at the typical operating tempo of the system during normal conditions, which can be maintained indefinitely. During a crisis, more forces could be made available (typically for a limited time), either by sending out to sea SSBNs that would normally be in training or short-term maintenance or by loading bombers with nuclear weapons and placing them on alert (which can be one of several stages, up to maintaining patrols with some bombers in the air at all times.)[2]

Judgments about the appropriate number of warheads depend on one's view of what force would be sufficient to deter the country's adversaries. The prospect of having a few dozen of their own cities (or even just a few of their cities) destroyed by a small survivable U.S. retaliatory

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1. For this analysis, CBO used a previous estimate that 10 percent of ICBM warheads would survive a large-scale nuclear attack. See Congressional Budget Office, *The START Treaty and Beyond* (October 1991), Appendix B, www.cbo.gov/publication/20563.

2. In extreme cases, the number of available warheads could be increased by more involved measures, such as loading spare ICBMs into silos that are normally empty and increasing the number of warheads carried on missiles. CBO did not consider those measures in this analysis.

Table 3-1.

Metrics Used to Assess Numbers of Nuclear Warheads

		Applicability to Segment of Triad		
Metric[a]	Description	SSBNs	ICBMs	Bombers
Deployed	Deployed warheads as defined by New START counting rules, which does not necessarily mean that they could be launched quickly	Except for two SSBNs typically in maintenance, all others considered deployed	All deployed at all times	All deployed except those at designated maintenance facilities
On Alert	Number available for "prompt" response	A few SSBNs are at sea and located for prompt launch	All on alert at all times	Only in crisis mode and only those in the air
Survivable[b]	Number likely to survive a first strike and provide assured response to that strike	All SSBNs that are at sea	Ten percent survivable in large-scale nuclear exchange[c]	Only in crisis mode and only those in the air

Source: Congressional Budget Office.

ICBM = intercontinental ballistic missile; SSBN = ballistic missile submarine.

a. CBO calculated the number of warheads for each metric under day-to-day conditions and under crisis conditions, when more forces could be made available for a limited time.

b. Assumes an attack against U.S. forces that is large enough to target all fixed sites, probably with multiple warheads. This would require many hundreds of warheads—at least two for each ICBM silo and several for every bomber base, submarine base, and command-and-control facility.

c. Counts of survivable warheads are based on CBO's previous analyses and reflect the assumption that forces would "ride out" an attack by an adversary before launching. That strategy differs from ones in which forces could be launched after an incoming attack was detected but had not yet arrived (launch on warning) or after the first phases of the attack had arrived (launch under attack). In those cases, many more ICBMs could be used. An adversary would not know which approach the United States might use.

force might be enough to deter any country from attacking the United States, according to people who adhere to the punishment school of deterrence (see Box 3-1 on page 24). Adherents of the denial school of deterrence might want a larger force, one that would be sufficient to deny an adversary any military advantage. People who believe that deterrence requires limiting damage to the United States and its military forces might want a larger force still, the size and makeup of which would be very sensitive to the size and characteristics of an adversary's nuclear forces.

Force Characteristics

CBO evaluated the characteristics of each force structure under three scenarios: crisis management (before any exchange of nuclear weapons), limited nuclear strike, and large-scale nuclear exchange. For each of those scenarios, CBO defined one or more measures of capability (see Table 3-2 on page 26). Using those metrics, CBO evaluated the capability of alternative force structures relative to that of DoD's planned forces on a five-level scale: full (that is, roughly the same capability as that of planned forces), high (about 2/3 or more of planned capability), intermediate (between 1/3 and 2/3 of planned capability), low (below 1/3 of planned capability but above zero), and none (zero capability).

Crisis Management

To evaluate each force structure's usefulness to leaders as they manage a potential crisis, CBO used one measure of capability: the ability to signal intent. In this analysis, that measure refers to the ability of U.S. forces to be used to signal to an adversary the willingness of the United States to escalate a conflict (in the hopes of deterring that adversary from attacking). Signaling is complicated and can take various forms. It can be done through deployments, such as boosting the number of forces on alert, deploying forces near the adversary, or operating forces near the adversary. (For example, the United States flew B-2A bombers near North Korea in 2013.) In that context, bombers are arguably more effective at signaling intent because ICBMs are always on alert and SSBNs are intended to remain unseen when at sea. (SSBNs could be more effective for signaling intent against some larger adversaries, who have sophisticated surveillance capabilities and would be able to see that the United States had deployed more submarines.)[3] Signaling can also be done by making declarations and statements, by deploying or using conventional forces, or by attacking particular targets thought to be important to the adversary.

In extreme cases, signaling could involve using a small number of nuclear weapons against targets that U.S. planners believed would convince an adversary that the United States would escalate the conflict if that adversary continued to engage in aggressive behaviors. In theory, any force structure with more than a few weapons could be used to engage in that type of signaling, although forces with some low-yield nuclear weapons might increase the signaling options available to the President.

Signaling is complicated, and its effectiveness has been debated for decades. During the Cold War, some theorists developed detailed steps that the United States could use for signaling and preventing a conflict from escalating further; those approaches could still apply today.[4] Others have argued that signaling is likely to be ineffective because what one side might view as a clear signal of intent or a demarcation of a line that must not be crossed might not be perceived as such by an adversary, particularly during the stress of a crisis.[5] History is replete, they argue, with examples of the failures of signaling.

Limited Nuclear Strike

For a scenario involving a limited nuclear strike by the United States, flexibility and the ability to manage escalation of the conflict are important. The concept of limited nuclear war—a "conflict in which nuclear weapons are used in small numbers and in a constrained manner in pursuit of limited objectives"—is not new, but some analysts argue that it is more important now than it was during the Cold War.[6] That is because the stakes for the United States are more limited than they were during the standoff between the United States and the Soviet Union (when national survival was at stake and the possibility of a strike seemed imminent) and because nuclear weapons play a less prominent role in the military balance between the United States and its larger potential adversaries (which could suggest that a large-scale nuclear exchange is less likely even if a conflict crossed the nuclear threshold). Other analysts argue that the concept is misguided and dangerous because escalation cannot be reliably controlled and, if the adversary is a larger nuclear power like Russia or China, could easily lead to a large-scale nuclear exchange.

CBO used three measures of capability to evaluate each force structure's ability to execute a limited nuclear strike. The existence of that capability in any amount is generally more important than the total number of delivery systems that meet the criteria.

- *Low-yield capability* indicates the fraction of warheads that can be detonated at a reduced explosive yield. (The explosive yield of a nuclear weapon is the amount of energy released when it is detonated.) Low-yield nuclear weapons are controversial. Some analysts view the availability of nuclear warheads with relatively low explosive yield as valuable because they provide U.S. leaders with more options during a crisis. Other analysts worry that low-yield weapons make nuclear war more probable because such weapons may be more likely to be used. The lower the yield, the greater their concern. Analysts who favor low-yield weapons argue that the increased plausibility of their use strengthens deterrence, particularly extended deterrence. Currently, only weapons carried by bombers have low-yield capability.

- *Trajectory flexibility* indicates the ability to choose a missile trajectory or aircraft route that avoids having the missile or aircraft fly over other countries on the way to the target nation. That ability is thought to be useful in avoiding misinterpretation of U.S. actions by those flyover countries. SSBNs and bombers have the ability, in at least some cases, to choose a

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3. The ability to absorb a nuclear strike and respond with nuclear weapons can also bolster deterrence during a crisis. Thus, survivability of nuclear forces, which CBO has grouped with the large-scale nuclear exchange scenario, can also apply to crisis management scenarios.

4. See, for example, Herman Kahn, *On Escalation: Metaphors and Scenarios* (Praeger, 1965).

5. See, for example, Robert Jervis and others, *Psychology and Deterrence* (JHU Press, 1989).

6. The definition is from Jeffrey A. Larsen, "Limited War and the Advent of Nuclear Weapons," in Jeffrey A. Larsen and Kerry M. Kartchner, eds., *On Limited Nuclear War in the 21st Century* (Stanford University Press, 2014), p. 6.

Box 3-1.

Theories of Nuclear Deterrence

The 2010 report on the Nuclear Posture Review states that the “fundamental role of U.S. nuclear weapons … is to deter nuclear attack on the United States, our allies, and partners.”[1] That emphasis on nuclear deterrence is similar to the policies of other Administrations over the past 30 years. But even with the same ultimate goal in mind, different theories have been developed about which nuclear posture most effectively deters adversaries.

During the Cold War, a large intellectual effort was under way in the United States, both inside and outside government, to determine how to think about nuclear weapons and the ways in which they deter adversaries, particularly the Soviet Union, from attacking the United States and its allies or engaging in other aggressive behavior. Although views vary widely, they can be broadly grouped into three schools of deterrence.[2]

- *Deterrence by threat of punitive retaliation* holds that the threat of a highly destructive nuclear retaliatory strike is sufficient to deter adversaries. In this case, the size of the U.S. nuclear force could be relatively small as long as enough of those forces were capable of surviving a nuclear attack to execute a retaliatory strike. That strike could be against an adversary’s military forces, particularly its nuclear forces (referred to as *counterforce*) or, more likely if the number of weapons was limited, against cities or economic targets (referred to as *countervalue*). Some analysts in this school also believe that the ability to execute limited nuclear strikes might enhance the credibility of the U.S. deterrent force, although that ability is not held as central to deterrence.
- *Deterrence by military denial* holds that deterrence by threat of punishment is necessary but insufficient to fully deter adversaries, particularly if they feel they have an advantage at some level of conflict. According to this school, U.S. forces need to deny an adversary an advantage at any level of nuclear conflict, from limited nuclear strikes through a large-scale nuclear exchange. Adherents to the denial school argue that countervalue strikes are immoral, so they emphasize counterforce strikes. This school aligns most closely with the approach that the United States pursued in formulating its force posture during the Cold War.
- *Deterrence by damage limitation* holds that deterrence requires nuclear superiority over any adversary across the full range of potential levels of conflict so as to limit the damage to the United States. This school is similar to the military denial school but calls for greater nuclear capabilities. Limits to damage would come from the ability to execute large counterforce strikes against an adversary’s nuclear forces (perhaps even as the first, preemptive nuclear strike if crisis conditions warranted), as well as from ballistic missile and air defenses.

Each school has its own views about the type, size, and posture of nuclear forces necessary for deterrence.

Analysts also differ about the situations in which nuclear deterrence would be effective. Most agree that the most credible use of nuclear deterrence occurs when national survival is at stake. (Deterring nuclear strikes against the homeland is referred to as central deterrence.) In those cases, the potential attacker is more likely to believe threats of retaliation. The further away the threats get from national survival, the more complicated deterrence becomes. For example, the United States provided security guarantees to the North Atlantic Treaty Organization (called extended deterrence) during the Cold War by threatening retaliation, including the use of nuclear weapons, against Soviet attack. But the United States also took many steps to convince the Soviet Union that it would be willing to use nuclear weapons to defend Western Europe, even if such a response would invite Soviet nuclear strikes against the United States.

Now, decades after the end of the Cold War, the geopolitical context has changed. Because Russia and the United States still have several thousand nuclear weapons, some of the Cold War deterrence thinking, particularly the need to avoid escalation to an all-out nuclear exchange, still applies. However, despite recent increases in tension between the United States and Russia, the likelihood of a “bolt from the blue” massive disarming nuclear strike, the threat of which underpinned much of Cold War deterrence theory in the United States, is widely considered to have been substantially reduced. Moreover, U.S. strategy in the Cold War was formulated when the United States was in a position of inferiority in conventional (that is,

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[1] The Nuclear Posture Review is the Administration’s most complete statement about its nuclear priorities. See Department of Defense, *Nuclear Posture Review Report* (April 2010), p. vii, https://go.usa.gov/xN95h (PDF, 2.8 MB).

[2] That taxonomy is drawn from Charles L. Glaser, *Analyzing Strategic Nuclear Policy* (Princeton University Press, 1990), pp. 44–60.

Continued

Box 3-1. Continued

Theories of Nuclear Deterrence

nonnuclear) forces in Europe and was trying to find ways to use nuclear forces to deter conventional aggression by the Soviet Union. Now Russia finds itself in a position of conventional inferiority. To counter that, Russia has reportedly adopted an "escalate to de-escalate" strategy in which it might use a limited first nuclear strike in a regional conflict to deter the United States from pursuing the conflict further.[3] Despite much recent discussion, no consensus has emerged about the best nuclear posture for the United States to take to deter Russian nuclear use in a nonnuclear scenario.

Although the United States and Russia still have substantially larger arsenals than any other nation, considerable current thinking about nuclear strategy concerns the dynamics of deterring smaller nuclear powers in regional conflicts. As one analyst put it, nuclear risks are heightened with new nuclear states in the mix because the motivations for those states to acquire nuclear weapons vary and because "such regimes are likely to engage in risk-taking behavior ... both in conflicts with regional nuclear rivals where the risks of escalation may be discounted ... and in conflicts with more powerful states where regime survival is seen to be at stake."[4] Providing nuclear guarantees to allies in Asia and the Middle East would be challenging because the United States must convince new nuclear states that it would be willing to respond to a nuclear attack on an ally even if that response might lead to a nuclear attack on the United States. Thus, deterrence and stability in a multipolar world are much more complicated, and debate is likely to continue as the United States seeks to determine the best strategy and nuclear posture to deal with the bipolar legacy of the Cold War as well as the dynamics of emerging regional nuclear threats.

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[3] John M. Donnelly, "Pentagon Panel Urges Trump Team to Expand Nuclear Options," *Roll Call* (February 2, 2017), http://tinyurl.com/znu8nfq.

[4] Paul I. Bernstein, "The Emerging Nuclear Landscape," in Jeffrey A. Larsen and Kerry M. Kartchner, eds., *On Limited Nuclear War in the 21st Century* (Stanford University Press, 2014), p. 105.

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trajectory that would avoid other countries. ICBMs do not have that flexibility because they would fly from fixed U.S. bases; for example, a U.S. ICBM targeting North Korea would fly over both Russia and China before reaching its destination.

- *The ability to penetrate defenses* indicates U.S. forces' ability to operate in the presence of an adversary's defenses. It is primarily a strength of ballistic and cruise missiles because the ability of any U.S. adversary to defend against those missiles, particularly long-range ones like ICBMs and SLBMs, is very limited. (Bombers do not have that same capability. Highly capable defenses against aircraft are quite common and can present challenges to bombers, in some cases increasingly even to stealthy bombers, which is one of the key rationales the Air Force gives for developing the B-21, which would have more advanced stealth technology.) Cruise missiles are more difficult for air defenses to detect and track than bombers because they are small and fly close to the ground. Stealthy cruise missiles are even more difficult to defend against, which is why the Air Force wants to develop the LRSO cruise missile.

Large-Scale Nuclear Exchange

For a scenario with a large-scale nuclear exchange, the ability to absorb a large nuclear strike (or to launch weapons upon warning that such a strike is under way) and respond in kind is central for deterring an attack. In addition to estimating the number of warheads that would survive such an attack, CBO evaluated two measures of capability for this scenario: prompt response and the number of aim points that U.S. forces present to an adversary.[7] The prompt-response metric is a measure of the number of warheads available within about an hour of a decision to use them, and it primarily applies to ICBMs and to SSBNs that are on alert and positioned in their launch areas.

The metric for the number of aim points presented to an adversary relates to how many targets an adversary would need to destroy in a large-scale strike to neutralize all the U.S. nuclear forces that are not movable. (Presumably the SSBNs on alert or in transit and the hundreds of warheads that they carry would still survive.) The

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[7] The metric for the ability to penetrate defenses, which CBO has grouped with the limited nuclear strike scenario, also applies to large-scale nuclear exchanges.

Table 3-2.

Metrics Used to Assess Force Characteristics

		Applicability to Segment of Triad			Scenario With Greatest Applicability
Metric	**Description**	**SSBNs**	**ICBMs**	**Bombers**	
Ability to Signal Intent	Ability to demonstrate intent to an adversary by visibly increasing alert level or by forward-deploying forces	Limited (can send extra boats to sea)	No (on alert all the time)	Yes	Crisis management
Low-Yield Capability	Ability to lower the explosive yield of some warheads	No	No	Yes	Limited nuclear strike
Trajectory Flexibility	Ability to avoid flying over sensitive countries by adjusting launch point or missile trajectory	Yes	No	Yes	Limited nuclear strike
Capability Against Defenses	Ability to reach target in the presence of local air defenses	Yes	Yes	Only if stealthy or using standoff weapons	Limited nuclear strike
Prompt Response	Ability to launch quickly after receiving order to do so. This is related to alert level, so it is primarily a strength of ICBMs. Useful only if U.S. nuclear response must be within a few hours.	Applies to boats at sea on alert	Yes	Only in crisis, and then limited by flying time	Large-scale nuclear exchange
Number of Aim Points for Adversary	Number of sites an adversary would need to destroy to remove U.S. nuclear capability (only the "nonsurvivable" part). This is primarily a strength of ICBMs because each must be destroyed individually (whereas each bomber and submarine base houses multiple weapons but is only a single target).[a]	2 bases	450 silos	2 bases, more if bombers are dispersed to additional bases during a crisis	Large-scale nuclear exchange

Source: Congressional Budget Office.

ICBM = intercontinental ballistic missile; SSBN = ballistic missile submarine.

a. Attacks on submarine bases and bomber bases would not destroy submarines already at sea or bombers that had been dispersed to other bases or were in the air when the attack occurred.

aim-point metric primarily depends on ICBMs: Because ICBM silos are well separated from each other geographically and hardened against damage from nuclear weapons, an adversary would need to destroy each ICBM silo individually and would have to assign at least one warhead, but probably two or more, to each targeted silo to ensure destruction. Thus, fielding a large ICBM force raises the threshold for the number of warheads required for an adversary to execute a debilitating first strike against U.S. nuclear forces and leaves fewer of its warheads available to attack more vulnerable (perhaps civilian) targets.

Other Considerations

One aspect of deterrence that is not captured in CBO's assessment of nuclear capability is crisis stability. According to one analysis, crisis stability is "a measure of the countries' incentives … not to attack first in order to beat the attack of the enemy."[8] Often that aspect of deterrence is used in the negative to describe nuclear postures that reduce stability (or are destabilizing). One example of a nuclear force posture that is often considered destabilizing is placing many warheads on ICBMs in fixed silos. (During the Cold War, the United States and the Soviet Union deployed ICBMs that carried 3 to 10 warheads each.) Such a structure is commonly thought to create an incentive for a preemptive attack because the attacker could expect to use only one or two warheads to destroy all the warheads on a targeted ICBM, thus gaining an advantage by striking first. Conversely, the side fielding ICBMs with multiple warheads may fear losing them in a preemptive attack, which may increase the likelihood that they would launch those ICBMs early in a crisis in a "use them or lose them" scenario. Whether any given force structure is destabilizing is subject to debate, so for this analysis CBO notes force structure options that might be considered destabilizing, but it has not assigned a value for stability.[9]

Other aspects of stability also relate to nuclear forces. In particular, arms race stability refers to a situation in which none of the sides in a nuclear deterrence relationship has an incentive to increase the size of its nuclear forces. Arms race stability depends in part on the deterrence strategies of the parties, and it is more complicated when more than two nuclear-armed nations are involved. CBO did not assess that aspect of stability.

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[8] Charles L. Glaser, *Analyzing Strategic Nuclear Policy* (Princeton University Press, 1990), p. 45.

[9] For an example of work done on quantifying stability, see Glenn A. Kent, Randall J. DeValk, and David E. Thaler, *A Calculus of First-Strike Stability (A Criterion for Evaluating Strategic Forces)*, (RAND Corporation, June 1988), www.rand.org/pubs/notes/N2526.html.

CHAPTER

4

Options That Would Reduce the Costs of Nuclear Forces

Starting with its estimate of the costs of planned nuclear forces over the 2017–2046 period, the Congressional Budget Office looked at how those costs might change under a range of alternative options. Those options fall into three categories:

- One option that would manage costs without changing the force structure by delaying some modernization programs;
- Five options that would decrease costs by changing the force structure but would preserve the numbers of weapons at New START levels (1,550 weapons, under the treaty's counting rules); and
- Three options that would lessen costs by further reducing the force structure and by decreasing the number of weapons to 1,000.

CBO looked at the cost savings for each option under two scenarios: if the option was implemented for the next generation of systems (that is, by forgoing or reducing the number of systems for selected modernization programs) with no change to current forces, and if the option was implemented now by not only reducing quantities for the next generation of systems but also retiring current systems earlier. Cost savings for each option are assessed independently from those for other options, so the savings from combining options may be different than a simple sum of the savings of the individual options might suggest. (See Appendix B for a discussion of how savings might change if more than one option was implemented.) For the second and third categories of options, CBO also made a qualitative comparison of the capability of alternative nuclear force structures with that of planned forces.

One Option That Would Delay Modernization but Still Achieve the Planned Force Structure

Option 1 combines three actions that the United States could take to reduce the costs of nuclear forces over the next 20 years without changing the final force structure currently planned. It would lower average annual costs during the peak periods by delaying programs (and thus pushing their costs beyond those periods). It also would lessen total costs during the 30-year estimation period by shifting some modernization costs after 2046 (see Figure 4-1).

Option 1: Delay the New ICBM, New Bomber, and Interoperable Warheads

Option 1 would delay development of the new intercontinental ballistic missile (part of the Ground-Based Strategic Deterrent program) and, in the interim, refurbish the current-generation ICBM. It would also delay development of the B-21 bomber. Finally, it would delay the interoperable warheads and instead perform individual life extensions on the current generation of warheads (which the interoperable warheads would have replaced). Each of those actions, to varying degrees, would affect the capability of nuclear forces.

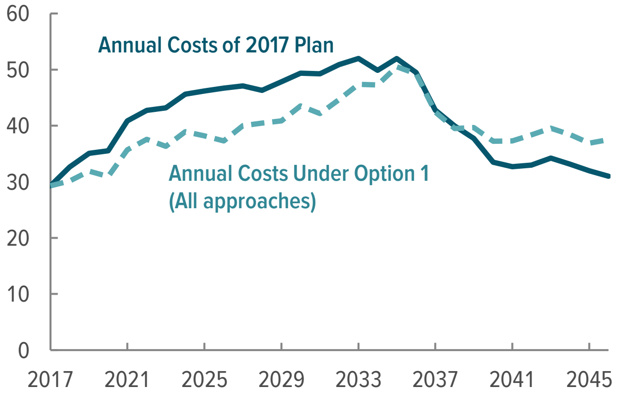
If all three actions in Option 1 were implemented, CBO estimates, the averages of annual spending for nuclear forces over the 2017–2026 and 2027–2036 periods would each be about $5 billion less than under the 2017 plan (see Table 4-1). For the last 10 years of the estimation period, however, costs would increase relative to those of the 2017 plan. (After 2046, costs would continue to exceed those of the 2017 plan until the delayed modernization plans were completed.)

Overall, implementing all three actions would reduce costs over the 2017–2046 period by $63 billion (or about 15 percent), of which $37 billion would come from 10 years of not operating a larger bomber fleet. Because the costs of development programs have historically grown faster than inflation, delaying modernization would probably raise the costs of those modernization programs in the long run, but probably not enough to offset the savings from not operating the bombers.

Figure 4-1.

Costs of Nuclear Forces Under the 2017 Plan and Under Option 1, 2017 to 2046

Billions of 2017 Dollars



Source: Congressional Budget Office.

Option 1 would delay development of the new intercontinental ballistic missile, the B-21 bomber, and interoperable warheads.

Delay the New ICBM and Refurbish the Minuteman III. The Department of Defense's decision to design and build a new ICBM through the GBSD program, announced in January 2015, was the result of a years-long analysis of alternatives for the future of the ICBM force. One of the primary alternatives that DoD considered (and rejected) was to delay building a new ICBM and to instead refurbish the current-generation Minuteman III ICBM.[1] However, a recent major study by RAND concluded that refurbishing the Minuteman IIIs would be a cost-effective path for maintaining the ICBM force.[2] The Minuteman III has already been refurbished several times since it was fielded in the 1970s; presumably, at some point updating the system will no longer be technically feasible. Moreover, the number of missiles available for testing is running low. Thus, choosing to delay the new ICBM might involve some technical risk and may require scaling back the test program. Additionally, DoD has stated that a new ICBM is needed to address shortcomings in the capability of the Minuteman III.

Under this approach, DoD would delay development of the new ICBM for 20 years. The new ICBM would be developed beginning in 2036, produced beginning in 2044, and in service until around 2080. To extend the life of Minuteman IIIs until the new ICBM was ready to deploy, DoD would buy new engines and new guidance systems for the existing missiles. The refurbishment of silos and the command-and-control infrastructure would proceed as planned.

This approach would decrease costs by an average of about $300 million per year over the next 10 years (because CBO assumed that refurbishment activity could ramp up quickly), but savings would increase to an average of about $3 billion per year from 2027 through 2036, CBO estimates. During the late 2030s and early 2040s, costs would exceed those of the 2017 plan by about $2 billion per year, on average, as work on the new ICBM began. Overall, costs would fall by about$18 billion over the 2017–2046 period under this approach, and about $42 billion of the costs of building the new ICBM would be pushed beyond 2046. The apparent net increase of about $24 billion in the total costs of the program under this approach does not account for the likelihood that, under the 2017 plan, the new ICBM in the GBSD program would need to be refurbished around the 2050s to provide ICBM capability into the 2080s.

Delay the B-21. DoD is ramping up the program to develop the B-21 bomber. The contract to develop the aircraft was awarded in October 2015, and the first production units are expected to be available in the mid-2020s. Under this option, the B-21 would be delayed by 10 years, so the first production aircraft would not be available until the mid-2030s.

The two existing types of nuclear bombers—the B52-H and the B-2A—have been in the fleet for many years and have received periodic upgrades. They are slated to remain in the fleet for decades to come, with retirement expected around 2040 and in the 2050s, respectively.

According to the Air Force, the B-21 is one of its highest priority programs because a bomber with modern stealth technology is critical if the aircraft is to be used against adversaries with sophisticated air defenses. Delaying the B-21 could require changes in strategy for both the conventional and nuclear missions.

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1. Amy F. Woolf, *U.S. Strategic Nuclear Forces: Background, Developments, and Issues*, Report for Congress RL33620 (Congressional Research Service, September 27, 2016), p. 17.

2. Lauren Caston and others, *The Future of the U.S. Intercontinental Ballistic Missile Force* (RAND Corporation, 2014), p. xviii.

Table 4-1.

The Budgetary Effects of an Option Delaying Modernization While Still Achieving the Planned Force Structure

Billions of 2017 Dollars

	Average Annual Cost			Total Change in Costs, 2017–2046	Remaining Costs of Delayed or Substituted Modernization After 2046[a]
	2017–2026	2027–2036	2037–2046		
2017 Plan	39.8	49.4	35.0	n.a.	n.a.
Alternative Approaches Under Option 1 (Change in average cost)					
Delay new ICBM	-0.3	-3.4	1.9	-17.5	41.6
Delay new bomber	-4.7	-0.9	2.1	-34.5	8.9
Delay interoperable warheads	-0.2	-0.6	-0.3	-10.5	3.9
Option Incorporating All Approaches	34.6	44.6	38.7	-62.5	50.5

Source: Congressional Budget Office, using information from the Department of Defense and the Department of Energy.

ICBM = intercontinental ballistic missile; n.a. = not applicable.

a. Values in this column represent the total costs of a delayed or substituted modernization program remaining after 2046 and do not necessarily represent a change in costs relative to the 2017 plan. In particular, by delaying the new ICBM, the alternative approach would enable missile operations through about 2080. Under the 2017 plan, the new ICBM would probably need to be refurbished sometime in the 2050s to enable missile operations that far into the future; the cost of that refurbishment is not reflected in CBO's estimate. Similarly, the interoperable warhead program under the 2017 plan would have about $6 billion in costs remaining after 2046.

This approach would shift peak spending on the B-21 to the 2030s. CBO estimates that delaying the B-21 would reduce the average annual costs of nuclear forces by about $4 billion per year relative to the costs of the 2017 plan over the next 15 years. However, once production began, annual costs would exceed those of the 2017 plan—in the 2040s, the additional amount would be more than $2 billion per year, on average. Overall, this approach would reduce costs over the 2017–2046 period by about $34 billion—a combination of $37 billion in savings from not operating the new bomber for 10 years and an increase of more than $2 billion in added costs from delaying development of the B-21. However, costs would increase after 2046 (by about $9 billion).

Delay the Interoperable Warhead Programs. Current plans call for the Department of Energy to develop three versions of interoperable warheads, which would be designed to be compatible with both ICBMs and SLBMs. The IWs are part of a larger effort, designated the "3+2 plan," to reduce the number and types of warheads in the stockpile. Advocates contend that having warheads that could work on more than one type of system would allow the United States to reduce its total number of warheads in the stockpile by keeping fewer spares to guard against technical problems and might also reduce the cost of sustaining warheads over the long run. Critics argue that the plan is expensive and technically risky.

The three IWs, designated IW-1 through IW-3, are slated to enter development in 2022, 2026, and 2033, respectively. Collectively, the three IWs would replace a total of four types of warheads—two for ICBMs (the W78 and W87) and two for SLBMs (the W76 and W88). This option would delay the IWs beyond 2046 and instead perform life-extension programs on the existing warheads under the following schedule: The W78 LEP would enter development in 2022, the W87 in 2026, the W88 in 2029, and the W76 in 2033.

The savings under this approach are difficult to estimate. DOE has based its estimates of costs for LEPs and IWs on the costs of the W76 LEP, which it adjusted to account for the degree to which the complexity of the particular LEP being modeled differs from that for the W76. CBO has taken a similar analytical approach. LEPs for individual warheads would probably be less complex than developing the new IWs, but quantifying that difference is difficult. CBO's estimates reflect the assumption that individual LEPs would be about 20 percent more complex than the W76 LEP but roughly half as complex as developing the IWs.

Under this approach, annual costs would be $300 million to $800 million lower than the cost of the 2017 plan starting in the early 2020s. Before 2046, costs would be about $10 billion lower because individual warhead LEPs are less expensive. After 2046, savings would continue for several years, amounting to about $2 billion, the difference between the $4 billion in costs remaining on individual LEPs after 2046 and the planned $6 billion in costs that would have remained on the IW programs. Whether this approach would result in savings in the long run depends on whether DOE chose to pursue the IW concept or to continue with individual LEPs in the next modernization cycle.

Five Options That Would Reduce Delivery Systems but Maintain Warheads at New START Limits

CBO analyzed five options that would change the nuclear force structure but keep the number of warheads that the United States deployed at or near the New START limit of 1,550 (see Table 4-2). For each option, CBO estimated total costs over the 2017–2046 period, annual operation and support costs after 30 years, and effects on the capability of nuclear forces brought about by changes in the force structure.

The options are grouped into two categories:

- Options 2 and 3 would discontinue some capabilities for delivering nuclear weapons but maintain the number of warheads and delivery systems at the New START limits.
- Options 4, 5, and 6 would maintain the number of warheads at the New START limits but reduce the number of delivery systems.

Options 2 and 3 would retain all segments of the strategic triad and fully maintain the number of warheads and delivery systems allowed under New START. However, they would discontinue some capabilities, forgoing cruise missiles with nuclear warheads (Option 2) or nuclear bombs on strategic bombers and tactical aircraft (Option 3).

Options 4, 5, and 6 would maintain the number of deployed warheads at (or near) the New START limit of 1,550 but would field fewer nuclear delivery systems than the treaty allows. Option 4 would retain the triad structure but would reduce the size of each of the segments, whereas Options 5 and 6 would each eliminate one of the segments of the triad entirely, resulting in a dyad structure. Specifically, Option 5 would eliminate the nuclear mission from strategic bombers and tactical aircraft, and Option 6 would eliminate ICBMs. In general, those two options would result in greater savings than Option 4 (which would maintain the triad), but they would lessen capability in some areas. (For a discussion of the implications of a dyad that would not include ballistic missile submarines, see Box 4-1.)

The three options that would maintain the number of deployed warheads at the New START limit of 1,550 while fielding fewer nuclear delivery systems would do so by increasing the number of warheads loaded on individual SLBMs or ICBMs (or both).[3] Under plans to meet New START limits, SLBMs will carry an average of about four and a half warheads each, but they are capable of carrying up to eight warheads; current-generation ICBMs carry a single warhead each as a matter of policy, but they are capable of carrying up to three warheads.[4] Because the number of warheads carried by each missile would increase under the options, the number of warheads on alert would exceed currently planned levels in some instances. The number of survivable warheads would be reduced in some cases but would remain above 800.

Loading more warheads on SLBMs could affect operations negatively in some cases—the missiles' range could be reduced because of the extra weight they must carry, which might constrain the set of options available for SSBN missions. For ICBMs, placing multiple warheads on a missile reverses a policy decision to limit all ICBMs to a single warhead. Many analysts argue that ICBMs in fixed silos with multiple warheads are strategically

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[3] U.S. missiles use multiple independent reentry vehicles (MIRVs), a technology developed in the 1960s, to carry multiple warheads on each missile. Because each warhead can be aimed at a different target, MIRVs allow a single missile to attack widely separated targets and thus can help overcome an adversary's defenses.

[4] The average number of warheads per SLBM is expected to rise to about five each by 2018 as the number of SLBMs carried on Ohio class SSBNs drops to 20 from 24 to meet New START limits on the number of launchers. If the United States continues to field the same number of warheads on SLBMs, the average loading would increase further, to about six warheads per SLBM, in the next generation of SSBNs because plans call for those boats to carry only 16 SLBMs each.

Table 4-2.

Details of Options That Would Reduce the Number of Delivery Systems but Maintain Warheads at New START Limits in 2046

	Delivery Systems				
		Launchers[a]		Deployed Warheads[a]	
Options	Platforms	Deployed	Total, Deployed and Nondeployed	Notional Loading[b]	Range of Possible Loadings[c]
Option 2: Forgo Nuclear Cruise Missiles					
SSBNs	12 submarines	176	192	1,041	176 to 1,408
ICBMs	450 missiles and silos	400	450	400	400 to 1,200
Bombers[d]	20 B-2, 100 B-21	109	120	109	Up to 1,500
Total		**685**	**762**	**1,550**	**576 to 4,108**
Option 3: Forgo Nuclear Bombs					
SSBNs	12 submarines	176	192	1,041	176 to 1,408
ICBMs	450 missiles and silos	400	450	400	400 to 1,200
Bombers[d]	20 B-2, 100 B-21	109	120	109	Up to 1,500
Total		**685**	**762**	**1,550**	**576 to 4,108**
Option 4: Field a Triad With 10 SSBNs and 300 ICBMs					
SSBNs	10 submarines	144	160	881	144 to 1,152
ICBMs	300 missiles and silos	280	300	560	280 to 840
Bombers	20 B-2, 100 B-21	109	120	109	Up to 1,500
Total		**533**	**580**	**1,550**	**424 to 3,492**
Option 5: Field a Dyad Without Bombers					
SSBNs	12 submarines	176	192	1,150	176 to 1,408
ICBMs	450 missiles and silos	400	450	400	400 to 1,200
Bombers	No nuclear bombers[e]	0	0	0	0
Total		**456**	**492**	**1,550**	**576 to 2,608**
Option 6: Field a Dyad Without ICBMs					
SSBNs	12 submarines	176	192	1,408	176 to 1,408
ICBMs	None	0	0	0	0
Bombers	20 B-2, 100 B-21	109	120	109	Up to 1,500
Total		**285**	**312**	**1,517**	**176 to 2,908**
Memorandum:					
2017 Plan					
SSBNs	12 submarines	176	192	1,041	176 to 1,408
ICBMs	450 missiles and silos	400	450	400	400 to 1,200
Bombers	20 B-2, 100 B-21	109	120	109	Up to 1,500
Total		**685**	**762**	**1,550**	**576 to 4,108**

Source: Congressional Budget Office.

ICBM = intercontinental ballistic missile; SSBN = ballistic missile submarine; TBD = to be determined.

a. The numbers of launchers and warheads were calculated under the assumption that New START counting rules were used for all options.

b. Notional loadings for each option represent an approach to keeping warheads at New START limits that is largely consistent with current U.S. policies for warhead loadings for each segment of the triad under the treaty.

c. The range is based on the assumption that warheads of the appropriate types would be available; it does not take into account the actual size of the stockpile. It also reflects the assumption that each B-21 bomber could carry up to 12 nuclear weapons.

d. In options that would cancel cruise missiles or bombs, bombers would still be able to carry the other type of nuclear weapon.

e. The size of the bomber force would be reduced under this option, and none of the bombers would carry nuclear weapons. The number of B-21s purchased would decline from 100 to 80 to continue their conventional mission.

Box 4-1.

Fielding a Dyad Without SSBNs

From their initial deployments in the 1960s, ballistic missile submarines (SSBNs) have been widely considered the most survivable component of the United States' nuclear forces, and their ability to thereby ensure a retaliatory nuclear strike against any aggressor became a central feature of U.S. nuclear strategy during the Cold War. Even today, very few of the many analyses of potential U.S. nuclear force structures that have been published over the past decade have suggested abandoning the use of SSBNs completely. Accordingly, the Congressional Budget Office has not focused on an option for a dyad with only intercontinental ballistic missiles (ICBMs) and bombers.

Nevertheless, some arguments would support discontinuing the use of SSBNs. Of the three segments of the nuclear triad, SSBNs and their submarine-launched ballistic missiles (SLBMs) are currently the most expensive to operate and sustain, and CBO estimates that they will be the most expensive to modernize. One study that did analyze (but did not recommend) a dyad without SSBNs concluded that it would satisfy "the majority of the current triad attributes" for deterrence.[1] A second study, which considered force structure changes with the goal of moving to a posture of minimal deterrence, concluded that although SSBNs are generally considered as retaliatory forces, they also play a key role in "the earliest phases" of a nuclear war and thus "drive defensive and offensive planning in Russia and China." On the basis of that argument, the authors of that study concluded that SSBNs are "incompatible with a minimal deterrence posture and an obstacle to transparency and verification" and should be retired.[2] On a more operational level, survivability of SSBNs is not necessarily guaranteed forever. On any given day, most of the SSBNs not at sea are located in the two SSBN bases (one in Georgia and the other in Washington State) and thus could be destroyed by nuclear or even conventional attack. Additionally, a recent technical study concluded that advancements in detection techniques might jeopardize the survivability of SSBNs at sea.[3] That threat is probably years away, however, and would be credible only if the ability to detect SSBNs was coupled with enough forces worldwide to destroy them, too.

An approach under which the United States pursued a dyad of ICBMs and bombers at New START levels would save $222 billion over 30 years, relative to the costs of the 2017 plan, if it was implemented for the next generation of systems, CBO estimates.[4] Annual operating and support costs of nuclear forces under such an approach would be $25 billion after 2046, a savings of $4 billion per year relative to the costs of the 2017 plan. Those savings would come from canceling development and procurement of the Ohio Replacement submarine and the new SLBM, forgoing operations of those systems, and replacing the interoperable warhead programs with simpler life extensions of the ICBM warheads only. If such an approach was implemented for the current generation of systems, the savings would increase to $293 billion over 30 years, CBO estimates. The extra savings would come from retiring Ohio class SSBNs early (at a rate of two per year starting in 2018), curtailing the life extension of the current D5 SLBM, and retiring the W88 and W76 warheads as they were removed from retiring SSBNs.

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[1] Dana J. Johnson, Christopher J. Bowie, and Robert P. Haffa, *Triad, Dyad, Monad? Shaping the U.S. Nuclear Force for the Future* (Mitchell Institute for Airpower Studies, 2009), pp. 23–25.

[2] Hans M. Kristensen, Robert S. Norris, and Ivan Oelrich, *From Counterforce to Minimal Deterrence: A New Nuclear Policy on the Path Toward Eliminating Nuclear Weapons* (Federation of American Scientists and Natural Resources Defense Council, 2009), pp. 20 and 44.

[3] See, for example, Henry J. Kazianis, "Are Submarines About to Become Obsolete?" *National Interest* (February 14, 2015), http://tinyurl.com/kpmq8e3.

[4] That estimate reflects the assumption that the numbers of ICBMs and bombers would remain at planned levels. If SSBNs were discontinued, however, those numbers could be increased or other survivable nuclear platforms (like mobile ICBMs) could be pursued, which would decrease the savings from forgoing SSBNs.

destabilizing because they present a more attractive target to an adversary. (Nevertheless, Russia continues to rely heavily on that configuration.)

Option 2: Forgo Nuclear Cruise Missiles

Under this option, the United States would cease fielding air-launched cruise missiles with nuclear warheads.[5] The nuclear armaments now used by bombers are the Air-Launched Cruise Missile and its W80 warhead carried by the B-52H, and the B61-7, B61-11, and B83 nuclear bombs carried by the B-2A. A new nuclear air-launched cruise missile, the Long-Range Standoff weapon, is under development. Plans call for the LRSO, which is designed to be compatible with all U.S. nuclear-capable bombers (including the B-21), to be produced in the 2020s. If Option 2 was implemented for the next generation of systems, the LRSO and its associated nuclear warhead would be canceled, but the ALCM would continue to be fielded until it reached the end of its lifetime (around 2030). If Option 2 was implemented now, the ALCM and its associated warhead would be retired immediately, and the LRSO would be canceled.

Some analysts have argued that the combination of a stealthy cruise missile (the LRSO) on a stealthy bomber (the B-21) would be destabilizing because it could reduce the amount of warning time between when an adversary became aware an attack was under way and when the missiles struck their targets. That fear of a surprise attack could spur a preemptive strike by an adversary during a crisis. Former Secretary of Defense William Perry recently called for the cancellation of the LRSO because "they can be launched without warning and come in both nuclear and conventional variants," which makes "cruise missiles … uniquely destabilizing."[6]

DoD would field the same number of bombers under Option 2 as it would under the 2017 plan. For that reason, the number of deployed warheads in 2046 would not be affected, and neither would the numbers of on-alert and survivable warheads (see Table 4-3).[7] If Option 2 was implemented now, the B-52H would no longer carry nuclear weapons.[8] In that case, DoD could place more warheads on SSBNs or ICBMs to keep the number of deployed warheads at New START limits until the B-21 was fielded.

Forgoing air-launched cruise missiles would diminish the capability of U.S. nuclear forces, particularly for limited nuclear strikes. Cruise missiles offer flexibility to operational planners because they can travel for extended distances (the unclassified range for the ALCM is more than 1,500 miles) along complicated flight paths, allowing bombers to avoid dangerous or sensitive areas in many cases. Additionally, bombers can carry multiple cruise missiles (for the B-52H, up to 20 ALCMs at a time), so a single bomber can strike a geographically diverse set of targets without having to take the time to fly over each target. CBO assigned the intermediate rating for Option 2's diminished capability (between one-third and two-thirds of the planned 2046 force) in the areas of trajectory flexibility and ability to penetrate an adversary's defenses.

If Option 2 was implemented for the next generation of systems, it would save about $28 billion through 2046 (relative to the costs of planned forces), reducing total costs to $1,214 billion (see Table 4-4 and Figure 4-2). Those savings include about $23 billion from forgoing the development and production of the LRSO and its associated warhead, the W80-4. (CBO's estimate reflects the assumption that forgoing the LRSO would not change operating costs for bombers.) The remaining savings would arise because DoD and DOE would not have to operate and sustain the LRSO and its warhead. After 2046, the average annual operation and support costs of nuclear forces would be about $200 million less than the costs of currently planned forces, CBO estimates. If Option 2 was implemented now, the 30-year savings would increase to about $30 billion because the ALCM

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[5] Ground-launched nuclear cruise missiles with ranges between 500 kilometers and 5500 kilometers are prohibited by the terms of the Intermediate-Range Nuclear Forces Treaty. The United States has also retired the nuclear-capable version of the sea-launched Tomahawk cruise missile.

[6] William J. Perry and Andy Weber, "Mr. President, Kill the New Cruise Missile," *Washington Post* (October 15, 2015), http://tinyurl.com/zvo4dsn.

[7] To determine the numbers of deployed warheads, CBO used the counting rules in effect for the New START treaty. Under those rules, each deployed bomber counts as one deployed warhead, even though bombers can carry more than one nuclear weapon.

[8] DoD could choose to field the B61 bomb on the B-52H bomber, although that configuration might require modifications to the aircraft. That choice is unlikely, however, because the B-52H is not stealthy and is thus vulnerable to the air defenses that it might have to traverse on its way to drop bombs on enemy targets.

Table 4-3.

Characteristics of CBO's Force Structure Options That Would Reduce Delivery Systems but Maintain Warheads at New START Limits

				Capability of Option Relative to Planned Forces					
	Number of Warheads[a]			Crisis Mgmt.	Limited Nuclear Strike			Large-Scale Nuclear Exchange	
	Deployed	On Alert	Survivable	Ability to Signal Intent	Low-Yield Capability	Trajectory Flexibility	Capability Against Air Defenses	Prompt Response	Aim Points for Adversary
Option 2: Forgo Nuclear Cruise Missiles	●	●	●	●	●	◒	◒	●	●
Option 3: Forgo Nuclear Bombs	●	●	●	●	◕	◕	◕	●	●
Option 4: Field a Triad With 10 SSBNs and 300 ICBMs	●	●	◕	●	●	●	●	●	◒
Option 5: Field a Dyad Without Bombers	●	●	●	◔	○	◔	◒	●	●
Option 6: Field a Dyad Without ICBMs	◕	◒[b]	●	●	●	●	●	◒	◔

● Equal to or Greater Than Planned Forces
◕ Greater Than ⅔ of Planned Forces
◒ Between ⅓ and ⅔ of Planned Forces
◔ Less Than ⅓ of Planned Forces
○ No Capability

Source: Congressional Budget Office.

ICBM = intercontinental ballistic missile; SSBN = ballistic missile submarine.

a. For quantitative values of the number of warheads, see Appendix C.

b. The value is for day-to-day operations. During a crisis, the number of warheads on alert under Option 6 would be higher and would meet the criteria for the "greater than ⅔ of planned forces" capability.

and its warhead would be retired early, eliminating the costs to operate and sustain those systems.

Option 3: Forgo Nuclear Bombs

Under Option 3, the United States would cease fielding nuclear bombs on strategic bombers and tactical aircraft but would continue to use cruise missiles. Currently, the B83 bomb and two versions of the B61 bomb are carried on the B-2A bomber; if Option 3 was implemented now, the B-2A would not carry nuclear weapons until the LRSO cruise missile became available.[9]

Several versions of the B61 bomb are also carried on nuclear-capable tactical fighter aircraft. A LEP now under development would combine all but one of the existing varieties of the B61 into a single design, the B61-12. That warhead would be compatible with the B-2A bomber, the B-21 bomber, and tactical aircraft. The B83 bomb is slated to be retired after the B61-12 enters service. If Option 3 was implemented now, the B83 and all versions of the B61 would be retired immediately, and the B61-12 LEP would be canceled. If Option 3 was implemented for the next generation of weapons, the B61-12 LEP would be canceled, but the B-2A and B-21 would continue to carry the existing B61 bombs (including versions that are not being consolidated into the B61-12) until they were retired from the stockpile.

CBO assumed that DoD would field the same number of bombers under Option 3 as currently planned (and as in Option 2), so the number of warheads in all categories

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[9] The B-2A does not carry the currently fielded ALCM.

Table 4-4.

Savings Under Options That Would Reduce Delivery Systems but Maintain Warheads at New START Limits

Billions of 2017 Dollars

	Savings in Acquisition Costs for Modernization Programs, 2017–2046			Savings in Costs of Nuclear Forces[a]				
				Average Annual Savings			Total Savings, 2017–2046	Savings in Annual Operating and Sustainment Costs After 2046
	Research and Development	Production	Total	2017–2026	2027–2036	2037–2046		
Option 2: Forgo Nuclear Cruise Missiles								
Implement for Next Generation of Systems	9	15	23	1.1	1.4	0.3	28	0.2
Implement for Current Generation of Systems	9	15	23	1.3	1.5	0.3	30	0.2
Option 3: Forgo Nuclear Bombs								
Implement for Next Generation of Systems	8	7	15	0.8	0.6	1.2	27	0.6
Implement for Current Generation of Systems	8	7	15	1.3	0.7	1.2	32	0.6
Option 4: Field a Triad With 10 SSBNs and 300 ICBMs								
Implement for Next Generation of Systems	0	25	25	0.5	1.8	0.7	30	0.6
Implement for Current Generation of Systems	0	26	26	1.2	2.1	0.7	40	0.6
Option 5: Field a Dyad Without Bombers								
Implement for Next Generation of Systems	17	33	50	2.2	2.0	2.9	71	1.5
Implement for Current Generation of Systems	17	33	50	2.9	2.2	2.9	80	1.5
Option 6: Field a Dyad Without ICBMs								
Implement for Next Generation of Systems	29	59	88	2.3	6.9	2.8	120	2.1
Implement for Current Generation of Systems	30	60	90	3.8	8.2	3.0	149	2.2
Memorandum:								
Costs of 2017 Plan	107	292	399	40	49	35	1,242	29

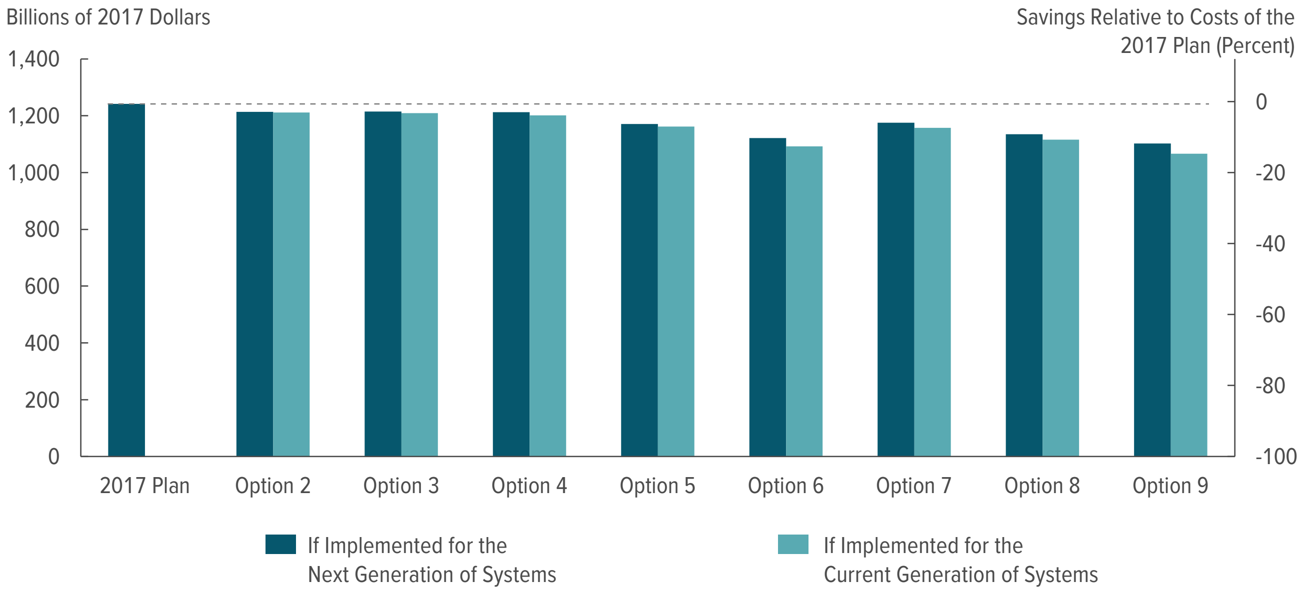
Source: Congressional Budget Office.

ICBM = intercontinental ballistic missile; SSBN = ballistic missile submarine.

a. Total costs of nuclear forces include costs to operate and sustain current and modernized forces, develop and procure modernized forces, and perform other support activities.

Figure 4-2.

Total Costs of CBO's Options for Future Nuclear Forces, 2017 to 2046



Source: Congressional Budget Office.

Option 1 is not included in this figure. Although that option would have net savings over the 2017–2046 period, they would be realized largely by delaying costs until after 2046.

(deployed, on-alert, and survivable) in 2046 would be the same under Option 3 as under the current plan. DoD could load more warheads on SSBNs or ICBMs or deploy more ICBMs to bring the number of deployed warheads up to New START limits until the LRSO was fielded.

Without nuclear bombs, the capability of U.S. strategic nuclear forces would be diminished, but to a lesser extent than under Option 2. Nuclear bombs must be dropped close to their target, so removing them from the fleet would decrease trajectory flexibility and the ability to penetrate defenses—but the effects would be less than what would occur by forgoing nuclear cruise missiles. Therefore, CBO assigned a high rating for the capability of Option 3 in the areas of trajectory flexibility and ability to penetrate defenses. But CBO assigned only the intermediate rating for low-yield capability because Option 3 would eliminate the option of deploying warheads with a reduced explosive yield that the B61-12 would have provided in future years. (The LRSO cruise missile would still be available with low-yield capability, but that missile would be carried only on bombers, not tactical aircraft.)

Option 3 would save about $27 billion through 2046 relative to the costs of planned forces if the option was implemented for the next generation of systems, CBO estimates. The largest savings ($6 billion) would come from canceling the B61-12 LEP. (See Box 4-2 for a discussion of how costs might change if the United States chose to forgo strategic nuclear bombs but continued the tactical nuclear mission.) The remaining $21 billion in savings would come from canceling improved tailkits for the B61-12, forgoing making the F-35 nuclear capable, forgoing costs of nuclear operations for the F-35, not having to sustain B61-12 bombs, and forgoing a LEP to refurbish the B61-12 (slated for the late 2030s). CBO's estimates reflect the assumption that operating costs for bombers would not change. After 2046, average annual operation and support costs of nuclear forces would be about $600 million less than such costs for currently planned forces, CBO estimates. If Option 3 was implemented now, the 30-year savings would increase to about $32 billion because the B83 and B61 bombs would be retired early.

Option 4: Field a Triad With Fewer SSBNs and ICBMs

Option 4 would reduce the number of ballistic missile submarines to 10 and the number of intercontinental

Box 4-2.

Arguments for Keeping Tactical Nuclear Weapons

As part of its support of the North Atlantic Treaty Organization (NATO), the United States deploys about 200 nuclear weapons at bases in Europe.[1] Those nonstrategic weapons are carried on short-range aircraft operated by U.S. personnel or by NATO allies. Both U.S. and allied aircraft carry B61 nuclear bombs supplied by the United States and maintained by U.S. personnel. Three versions of the B61 are carried by tactical aircraft, but plans call for those versions to be combined with a version of the B61 that is carried by strategic aircraft into a new hybrid variant—the B61-12—which would be used for both tactical and strategic missions. The United States also retains the capability to forward-deploy nuclear weapons quickly in support of allies and partners worldwide in response to regional conflicts or crises.[2]

In two of the options analyzed in this report (Options 5 and 8), the Congressional Budget Office estimated the reduction in the costs of nuclear forces if the United States stopped fielding nuclear weapons on strategic bombers and tactical aircraft and canceled the B61-12 program. Alternatively, policymakers could decide to forgo the use of nuclear weapons (both bombs and cruise missiles) on *strategic* bombers but retain the ability to field nuclear bombs on *tactical* aircraft. If that approach was adopted, the costs of retaining tactical nuclear weapons as currently planned would reduce the 30-year savings under Options 5 and 8 by $29 billion, CBO estimates.

The United States may want to continue fielding tactical nuclear weapons, for several reasons. First, those weapons are seen to be a visible symbol of the U.S. commitment to the NATO alliance and, in particular, the extension of the U.S. "nuclear umbrella" to allies that do not have their own nuclear arsenals. Given that they are based on allied territory and would be delivered by allied aircraft assisted by a range of allied nations, they also represent a way for a number of allies without nuclear weapons to participate in NATO's nuclear mission. Accordingly, in their most recent strategic policy declaration, NATO officials stated that "as long as nuclear weapons exist, NATO will remain a nuclear alliance" and that it would continue to "ensure the broadest possible participation of Allies in collective defense planning on nuclear roles [and] in peacetime basing of nuclear forces."[3] Advocates of basing tactical weapons in Europe also point to recent tensions with Russia as strengthening the argument for keeping U.S. nuclear weapons based there.

Second, such weapons are seen as a potentially important bargaining chip to induce Russia to reduce its own tactical nuclear weapons force, which is reportedly much larger than that of the United States. In the resolution approving the New START treaty, the Senate called on the Administration to pursue an agreement with the Russians that would "address the disparity" in the size of the two countries' tactical nuclear stockpiles. A unilateral reduction in tactical weapons on the part of the United States before entering such negotiations could make reaching an agreement difficult.[4]

Finally, arguably one of the most effective methods that the United States employed to reduce nuclear proliferation over the past 50 years was to extend its nuclear umbrella over allies. The history of the nuclear age contains several examples of such countries seriously considering developing their own nuclear arsenal but abandoning those efforts in part because of U.S. security guarantees (nuclear and conventional). If abandoning tactical nuclear weapons undermined the faith of some of those allies in the effectiveness of those security guarantees, it could prompt them to reconsider their nuclear programs.

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1. Amy F. Woolf, *Nonstrategic Nuclear Weapons*, Report for Congress RL32572 (Congressional Research Service, February 23, 2015), p. 18.
2. Department of Defense, *Nuclear Posture Review Report* (April 2010), p. xii, https://go.usa.gov/xN95h (PDF, 2.8 MB).
3. North Atlantic Treaty Organization, *Active Engagement Modern Defence: Strategic Concept for the Defence and Security of the Members of the North Atlantic Treaty Organisation Adopted by Heads of State and Government in Lisbon* (November 19, 2010).
4. Senate Committee on Foreign Relations, *Treaty With Russia on Measures for Further Reduction and Limitation of Strategic Offensive Arms (The New START Treaty)*, Exec. Rept. 111-6 (October 1, 2010), p. 109, https://go.usa.gov/xNp3C.

ballistic missiles to 300. If Option 4 was implemented for the next generation of systems, DoD would forgo procurement of the last two new SSBNs and decrease the number of ICBMs procured under the GBSD program to 480 (from the currently planned 642).[10] If Option 4 was implemented now, DoD would retire 150 ICBMs at a rate of 50 per year starting in 2018 and 4 Ohio class SSBNs at a rate of 1 per year starting in 2018. (Option 4 is one of many possibilities for restructuring nuclear forces while retaining the strategic triad. For other ways to adjust the size of the triad, see Box 4-3 on page 42.)

Relative to the 2017 plan, Option 4 would substantially reduce the number of aim points presented to an adversary in a large-scale nuclear exchange. The U.S. capability for a limited nuclear strike would be unchanged because this option would retain the triad.

In CBO's estimation, Option 4 would save about $30 billion through 2046 relative to the costs of the 2017 plan if the option was implemented for the next generation of systems. Most of that savings (about $21 billion) would come from procuring 2 fewer SSBNs and about 150 fewer ICBMs. The rest of the savings would come from reducing operation, sustainment, and support costs for SSBNs and ICBMs in the next generation; refurbishing 150 fewer ICBM silos; and procuring 36 fewer new SLBMs. Annual operation and support costs after 2046 would be about $600 million less per year than under the 2017 plan.

If Option 4 was implemented now, it would save about $40 billion over 30 years relative to costs of the 2017 plan. The additional $11 billion in savings would come from reducing operation, sustainment, and support costs for ICBMs and SSBNs, performing fewer life extensions on the current generation of SLBMs, and performing fewer modernizations of the fuzes of ICBM warheads. (The fuze is the portion of the weapon that originates the signal that triggers the firing system.)

Option 5: Field a Dyad Without Nuclear Bombers

Option 5 would eliminate the nuclear mission from strategic bombers and tactical aircraft. It is essentially a combination of Option 2 (which would eliminate nuclear cruise missiles) and Option 3 (which would eliminate nuclear bombs). If implemented in the next generation of systems, Option 5 would cancel the LRSO cruise missile and its warhead as well as the B61-12 warhead LEP, thus ending the nuclear mission for strategic bombers and tactical aircraft. The new bomber, the B-21, would no longer be made nuclear capable under this option; CBO assumed that elimination of the nuclear mission would allow DoD to decrease production of B-21 bombers from the planned 100 to 80. In addition, the F-35 tactical aircraft would not be made nuclear capable. If implemented now, Option 5 would retire the B83 bomb and all versions of the B61 bomb as well as the current-generation nuclear cruise missile (the ALCM) and its warhead.

Although Option 5 is a combination of Options 2 and 3, the impact of Option 5 on the capability of U.S. nuclear forces would be substantially greater than the combined effects of those other options. Under New START counting rules (which CBO used in constructing these options), each deployed bomber counts as a single warhead. The loss of bomber warheads could be easily made up by slightly increasing the number loaded on SSBNs. But bombers carry multiple warheads and can be reloaded, so the total number of weapons available to the United States in a crisis could be substantially smaller under this option.

The numbers of deployed, on-alert, and survivable warheads would be the same, or higher, under Option 5 as under the 2017 plan. However, the ability of nuclear forces to signal intent to adversaries during crises and to execute limited nuclear strikes, to the extent that nuclear-capable bombers are important to those capabilities, would be greatly reduced (see Table 4-3 on page 36). Furthermore, the capability to execute missions using low-yield weapons would be lost because the only low-yield weapons in both the current and planned strategic stockpiles are carried by bombers.

Savings under Option 5 would total about $71 billion through 2046 (relative to costs of the 2017 plan) if it was implemented for the next generation of systems. Savings would be substantially smaller if DoD decided to continue fielding nuclear weapons on tactical aircraft (see Box 4-2 on page 39). The biggest contributor to savings for this option would be the cancellation of the new LRSO cruise missile and its associated warhead and elimination of the expected costs to operate and sustain those systems after fielding them ($28 billion).

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[10] A total of 480 ICBMs would provide 300 deployed missiles and about 50 spares (roughly 10 percent of the total), with enough left over for annual tests throughout the life of the program.

The balance of savings would result from producing and operating 20 fewer B-21 bombers, canceling the B61-12 LEP and tailkit, and forgoing nuclear operations of tactical aircraft. Annual operation and support costs of nuclear forces after 2046 would be about $1.5 billion less than those costs under the 2017 plan.

If implemented now, Option 5 would save about $80 billion over 30 years relative to costs of the 2017 plan, CBO estimates. The additional $9 billion in savings would come from forgoing tactical operations earlier and from retiring the current-generation ALCM, its warhead, and all nuclear bombs sooner.

Option 6: Field a Dyad Without ICBMs

The United States fields ICBMs at three bases with 450 active silos. Under New START, the number of silos housing ICBMs would drop to 400; the remaining 50 silos would be maintained in stand-by status and could house missiles in the future. As part of the GBSD program, which is in its preliminary stages, DoD would design a new ICBM, buy about 640 of those missiles, and refurbish the existing silos, ICBM support equipment, and command-and-control systems. In addition, interoperable warheads would be developed to replace the existing warheads for SLBMs and ICBMs.

If Option 6 was implemented for the next generation of systems, the GBSD program would be canceled and the IW program would be replaced with less complex LEPs for the SLBM warheads (the W76 and W88). If Option 6 was implemented now, all of the current-generation ICBMs would be retired between 2018 and 2021.

Option 6 would affect warhead counts and nuclear forces' capabilities, particularly in a large-scale nuclear exchange. DoD's 2017 plan calls for 400 warheads deployed on ICBMs. It would not be possible to fully make up for the removal of those warheads from the nuclear arsenal—even if all SLBMs were loaded with their theoretical maximum of 8 warheads each, the total number of deployed warheads under New START counting rules would be around 1,520, just short of the limit of 1,550.[11] Carrying more warheads on SLBMs would boost the number of survivable warheads above the currently planned level, but removing ICBMs would substantially reduce the number of warheads on alert (although that number would still remain at nearly 500, even for day-to-day operations; see Appendix C).

In a large-scale nuclear exchange, the number of warheads that could be launched promptly in response to an adversary's strike would be reduced under this option, and the number of aim points presented to an adversary would be substantially smaller than under the 2017 plan (see Table 4-3). In effect, the number of aim points an opponent would have to attack successfully to neutralize the nonsurvivable nuclear delivery systems on U.S. soil would be decreased from 500 to around 20; however, as long as its SSBNs at sea remained undetectable, the United States would still have several hundred warheads on SLBMs available for a retaliatory strike. Because of the reduction in the number of aim points under Option 6, some analysts would argue that this option is destabilizing. The capability of U.S. forces to undertake a limited nuclear strike would be largely unchanged.

Option 6 would save about $120 billion through 2046 relative to the costs of the 2017 plan if it was implemented for the next generation of systems. Most of the savings (about $90 billion) would come from canceling the GBSD program. Additional savings would result from canceling the IW programs, although some of those savings would be offset by the costs of replacing the IWs with LEPs for the current SSBN warheads. Annual operation and support costs of nuclear forces after 2046 would be about $27 billion, a savings of about $2 billion per year relative to the costs of the 2017 plan.

If Option 6 was implemented now, savings would be higher—about $149 billion relative to the costs of the 2017 plan—CBO estimates. The additional $29 billion in savings would come from lower costs to operate, sustain, and support retiring current-generation ICBMs and their associated warheads, as well as from the cancellation of the fuze modernization for those warheads.

Three Options That Would Reduce the Number of Delivery Systems and Warheads Below New START Limits

Other options would involve reducing the number of nuclear warheads maintained by the United States below the New START limits. In 2013, for example, President Obama concluded that it was possible to execute the

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[11] In practice, loading all SLBMs with the maximum number of warheads might not be possible because the correct warhead types might not be available. (The number of warheads of each type in the stockpile is classified.) In addition, fully loading each SLBM might not be desirable because it would reduce flexibility for mission planning.

Box 4-3.

Adjusting the Size of the Nuclear Triad

Although Option 4 shows one example, policymakers could take many approaches to field a smaller nuclear triad. To illustrate the effects of other triad structures, the Congressional Budget Office analyzed the potential savings, relative to the 2017 plan, that would accrue from reducing the numbers of new ballistic missile submarines (SSBNs) and intercontinental ballistic missiles (ICBMs); see the table. Because a triad of any size would require the Department of Defense (DoD) to still develop the new systems for each segment and operate many of the systems after fielding, savings from a cut to either segment would be substantially less than the proportional reduction in the number of fielded systems in that segment.

The Trump Administration's Nuclear Posture Review could lead to an increase in the size of one or more of the segments. Given the long-term trend of reducing the size of nuclear forces, any increase in one segment of the nuclear triad may be used to balance a reduction in one or both of the other segments.

The values shown in the table represent 30-year differences in costs if changes were made in the number of next-generation systems fielded. (CBO has not estimated the savings from the early retirement of current-generation systems.) So, for example, the table shows the costs or savings that would result from purchasing more or fewer Columbia class SSBNs (along with proportionally more or fewer new submarine-launched ballistic missiles) or more or fewer ICBMs under the Ground-Based Strategic Deterrent program. The estimates do not include any changes in costs from producing more or fewer warheads for use on the missiles, or from closing or expanding any bases, although both of those actions could occur, particularly if deep cuts were made to delivery systems. If changes were made to both the SSBN and the ICBM segments, the estimated total change in costs would equal the sum of the changes shown in the table for the individual segments.

Any cuts would reduce the capability of nuclear forces to some degree, which could require the United States to adjust its current strategy, particularly for scenarios that envision a large-scale nuclear exchange. Fielding a large number of ICBMs in widely separated and hardened silos sets a high threshold for any adversary considering a debilitating attack on U.S. nuclear forces. Reducing the number of ICBMs would lower that threshold, and some analysts argue such a change would be destabilizing. However, as long as SSBNs at sea remain undetectable, the ability of the United States to respond to any large-scale attack would remain intact. Some analysts argue that a large-scale nuclear attack is very unlikely in the post–Cold War era and that ICBMs provide little value in the multipolar nuclear environment where regional conflicts that could escalate to war and limited nuclear strikes present the most pressing risks.

Decreasing the number of SSBNs would also have disadvantages. Because of their ability to operate undetected for long periods, SSBNs are the most survivable segment of the triad, ensuring the ability of the United States to respond to an adversary's nuclear attack. Reducing the number of SSBNs might make it difficult for DoD to maintain the number of SSBNs on patrol at the current levels or to meet its goals for the number on patrol in the future. (Because those goals are classified, CBO cannot assess the degree to which smaller

Continued

nuclear mission with one-third fewer warheads than plans at that time had called for and indicated his Administration's intention to pursue negotiations with the Russians to reduce their forces comparably.[12] However, given current geopolitical and diplomatic conditions, such an agreement appears unlikely in the near future. A reduction in U.S. nuclear weapons could be undertaken unilaterally, but some analysts argue that a reduction to 1,000 warheads without a comparable reduction by Russia could be destabilizing.

To illustrate the effects of such an approach, CBO analyzed three options that would decrease nuclear forces to 1,000 deployed warheads, which is about one-third fewer than the New START limit of 1,550 (see Table 4-5). In addition to reducing the total number of warheads, each of these options would combine aspects of one or more of the options discussed in the previous section: Option 7 would field a triad comprising 8 SSBNs, 150 ICBMs, and bombers; Option 8 would field a dyad of 10 SSBNs and 300 ICBMs; and Option 9 would field a dyad of 10 SSBNs and bombers. Like Options 4, 5, and 6, Options 7, 8, and 9 would, on average, increase the number of warheads loaded on individual SLBMs or ICBMs (or both). Potential disadvantages of those

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[12] The White House, Office of the Press Secretary, "Fact Sheet: Nuclear Weapons Employment Strategy of the United States" (press release, June 19, 2013), https://go.usa.gov/xNm6m.

Box 4-3. Continued

Adjusting the Size of the Nuclear Triad

Additional Savings or Costs of Alternative Triad Structures Through 2046

Ballistic Missile Submarines		Intercontinental Ballistic Missiles	
Number in Fleet	Billions of 2017 Dollars[a]	Number Deployed[b]	Billions of 2017 Dollars[a]
16	-30	450	-3
15	-23	400	0
14	-16	350	5
13	-8	300	11
12	0	250	15
11	9	200	19
10	17	150	23
9	26	100	27
8	36	50	32
7	45		
6	55		

Source: Congressional Budget Office.

Shaded areas denote the 2017 plan.

a. Totals reflect changes in procurement, operations, and sustainment and reflect reductions or increases in force size taken at the end of the planned production run. Negative values represent additional costs.

b. Each force would retain 50 more silos than deployed missiles, except for the force with 450 deployed missiles, because the United States currently has only 450 silos. Whether smaller forces would result in base closures is unknown, so those potential savings are not included.

SSBN forces would affect them.) Moreover, a smaller fleet of SSBNs might not be able to support operations in both the Atlantic and Pacific Oceans, as does the current fleet, which might affect the ability of the SSBN force to strike targets in some places.

Modest cuts to the SSBN force might not be detrimental to nuclear forces, however. According to one recent analysis, the number of SSBN patrols has declined over the past decade, which suggests that fewer boats might be sufficient to meet requirements.[1] Current plans lend some support to that idea: The total number of SSBNs in service is slated to drop to 10 between 2032 and 2040 (as Ohio class boats are retired before their replacement SSBNs have finished construction) before rising back to 12. Moreover, after they are fielded, the new SSBNs would be available for deployment over a larger fraction of their lifetime than today's Ohio class boats. The nuclear reactors that power Ohio class SSBNs were designed to be refueled about halfway through the boat's operational life, a process that removed the boat from service for about four years. But the new SSBN is being designed with a nuclear reactor that will not need a midlife refueling, which increases the share of the SSBN fleet that would be available for patrols.

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[1] Hans M. Kristensen, "Declining Deterrent Patrols Indicate Too Many SSBNs," *Strategic Security* (blog entry, April 30, 2013), http://tinyurl.com/hjzbd4p.

increased loadings are a smaller effective range for those missiles and, in the case of multiple warheads on silo-based ICBMs, reduced stability in a crisis.

These options would decrease costs, saving between $66 billion and $175 billion over 30 years relative to the costs of the planned nuclear force. (The savings would depend on when the option was implemented.) Compared with the similar options that would retain New START warhead levels, these options would yield additional savings, most of which would stem from the reduction in the number of delivery systems. (Options that reduced warheads to 1,000 but preserved the same number of delivery systems as specified under the 2017 plan would result in less additional savings.)

Further savings could come from scaling back DOE's nuclear weapons laboratories because of the reduced size of the stockpile, but assessing such savings is beyond the scope of this report.

Even though the options limited to 1,000 warheads would save money, they would provide less capability than planned forces or similar options that maintained New START warhead levels, and they would be able to hold fewer targets at risk. (CBO did not examine the implications of options that would reduce warheads below 1,000; see Box 4-4 for a discussion of that issue.)

Table 4-5.

Details of Options That Would Reduce the Number of Delivery Systems and Warheads Below New START Limits in 2046

	Delivery Systems			Deployed Warheads[a]	
		Launchers[a]			
Options	**Platforms**	**Deployed**	**Total, Deployed and Nondeployed**	**Notional Loading[b]**	**Range of Possible Loadings[c]**
Option 7: Field a 1,000-Warhead Triad					
SSBNs	8 submarines	112	128	672	112 to 896
ICBMs	150 missiles and silos	140	150	219	140 to 420
Bombers	20 B-2, 100 B-21	109	120	109	Up to 1,500
Total		**361**	**398**	**1,000**	**252 to 2,816**
Option 8: Field a 1,000-Warhead Dyad Without Bombers					
SSBNs	10 submarines	144	160	720	144 to 1,152
ICBMs	300 missiles and silos	280	300	280	280 to 840
Bombers	No nuclear bombers[d]	0	0	0	0
Total		**424**	**460**	**1,000**	**432 to 1,992**
Option 9: Field a 1,000-Warhead Dyad Without ICBMs					
SSBNs	10 submarines	144	160	891	144 to 1,152
ICBMs	None	0	0	0	0
Bombers	20 B-2, 100 B-21	109	120	109	Up to 1,500
Total		**253**	**280**	**1,000**	**144 to 2,652**
Memorandum:					
2017 Plan					
SSBNs	12 submarines	176	192	1,041	176 to 1,408
ICBMs	450 missiles and silos	400	450	400	400 to 1,200
Bombers	20 B-2, 100 B-21	109	120	109	Up to 1,500
Total		**685**	**762**	**1,550**	**576 to 4,108**

Source: Congressional Budget Office.

ICBM = intercontinental ballistic missile; SSBN = ballistic missile submarine.

a. The numbers of launchers and warheads were calculated under the assumption that New START counting rules were used for all options.

b. Notional loadings for each option represent an approach to deploy 1,000 warheads that is consistent, to the extent possible, with correct U.S. policies.

c. The range is based on the assumption that warheads of the appropriate types would be available; it does not take into account the actual size of the stockpile. It also reflects the assumption that each B-21 bomber could carry up to 12 nuclear weapons.

d. The size of the bomber force would be reduced under this option, and none of the bombers would carry nuclear weapons. The number of B-21s purchased would decline from 100 to 80 to continue their conventional mission.

Option 7: Field a 1,000-Warhead Triad With Fewer Delivery Systems

Option 7 would field a triad with fewer SSBNs and ICBMs than currently planned. If implemented for the next generation of systems, this option would field 8 SSBNs instead of the planned 12 (by forgoing the purchase of the last 4 of the new boats) and 150 ICBMs instead of the planned 400 (by reducing the purchase of the new GBSD missiles to 320). It would continue the IW program for missile warheads but reduce the number produced by one-third. If Option 7 was implemented now, DoD would retire 4 Ohio class SSBNs at a rate of 1 per year starting in 2018 and would retire 300 of the current-generation ICBMs between 2018 and 2021. The bomber fleet and its weapons would not be affected by this option.

The capability of nuclear forces under Option 7 would be similar to that under Option 4 (which also would retain a triad structure) for crisis management and limited nuclear strikes but would be less than that under Option 4 for large-scale nuclear exchanges. Option 7 would have fewer warheads than the 2017 plan (1,000 rather than 1,550), so the number of warheads in all of the categories that CBO considered would be roughly one-third less than those available under the 2017 plan. Nevertheless, based on an average loading of 6 warheads per SLBM and 1.5 warheads per ICBM, the number of warheads on alert and the number of survivable warheads would each remain above 450 during day-to-day operations and above 700 during a crisis (see Table 4-6 **and** Appendix C). That higher loading of warheads on ICBMs would reverse a U.S. policy of fielding only single-warhead ICBMs, which are considered less tempting to attack and therefore more stabilizing. The capability for a limited nuclear strike would be the same under Option 7 as under the 2017 plan because Option 7 would retain the triad. In a large-scale nuclear exchange, however, Option 7 would present substantially fewer aim points to an adversary because of its reduction in the number of ICBMs.

If it was implemented for the next generation of systems, Option 7 would save about $66 billion through 2046 relative to the costs of the 2017 plan (see Table 4-7 on page 48). About $42 billion of that amount would come from purchasing fewer SSBNs and ICBMs. The remainder of the savings would result from purchasing fewer new SLBMs, producing one-third fewer interoperable warheads, refurbishing fewer ICBM silos, and reducing operation, sustainment, and support costs. After 2046, average annual operation and support costs of nuclear forces would be about $28 billion, which is roughly $1 billion less than under the 2017 plan, CBO estimates.

If implemented now, Option 7 would save about $85 billion relative to the costs of the 2017 plan. The extra $19 billion in savings would result from reducing operation, sustainment, and support costs for current-generation SSBNs, ICBMs, and their associated warheads and from performing life extensions on fewer of the current-generation SLBMs.

Option 8: Field a 1,000-Warhead Dyad Without Bombers

Option 8 would field a dyad of 10 SSBNs (two fewer than planned) and 300 ICBMs (100 fewer than planned) and would remove the nuclear mission from strategic bombers and tactical aircraft. The option is a variant of Option 5, which would field an SSBN–ICBM dyad with 1,550 weapons. Under Option 8, DoD would field fewer nuclear weapons by reducing the average number loaded on each missile.

If this option was implemented for the next generation of systems, DoD would forgo the purchase of the last two new SSBNs, reduce by about 160 missiles the purchase of ICBMs under the GBSD program, and decrease by one-third the number of interoperable warheads produced. To remove the nuclear mission from bombers and tactical aircraft, DoD would cancel the new LRSO cruise missile and the B61-12 LEP and forgo implementing nuclear capability on the new B-21 bomber and the F-35 tactical aircraft. (CBO assumed that DoD could purchase 20 fewer B-21 bombers under Option 8 because they would be performing conventional missions only.)

If implemented now, Option 8 would make the following changes: retire 2 Ohio class SSBNs at a rate of 1 per year starting in 2018, retire 150 ICBMs at a rate of 50 per year starting in 2018, halt ongoing production in 2018 for the W76 LEP for SSBN warheads, reduce the

Box 4-4.

Pros and Cons of Minimum Deterrence

Several recent studies have argued that the United States should pursue a policy of minimum deterrence, which means that the number of deployed warheads would be substantially reduced from today's levels. That goal could be met using different configurations. For example, one recent study suggested a dyad of ballistic missile submarines (SSBNs) and bombers carrying a total of 450 deployed warheads, whereas another argued for a minimum triad of 100 single-warhead intercontinental ballistic missiles, 192 single-warhead submarine-launched ballistic missiles on 12 SSBNS, and 19 B-2A bombers carrying a total of 311 warheads.[1]

Advocates of minimum deterrence make several arguments in support of that position. One set of arguments asserts that the Cold War is over, and the U.S. arsenal is much larger than it needs to be to deter the most relevant current nuclear threats (such as North Korea). Other arguments are that smaller arsenals make it easier to maintain safety and to keep the weapons secure, U.S. reductions would facilitate multilateral negotiations to reduce worldwide stockpiles, and minimum deterrence would be part of a strategy that also reduced the alert status of nuclear weapons, thus decreasing the chance of accidental launches.

Adopting a posture of minimum deterrence would reverse decades of U.S. nuclear policy, however, which has historically emphasized maintaining parity with or superiority over all potential nuclear adversaries. Critics of such a change primarily argue that the planned forces—the strategic triad plus tactical nuclear forces capable of being deployed to areas of crisis or conflict—are needed to maintain the flexibility and resilience needed for deterrence.[2]

Pursuing a strategy of minimum deterrence would mean reducing the number of deployed weapons to about 300 to 400—basically, the levels recommended in the studies mentioned above. Even with a smaller number of deployed weapons, though, 30-year costs would probably remain near $1.0 trillion because of the high fixed costs of the infrastructure for nuclear forces and nuclear weapons laboratories. Even though the Congressional Budget Office has not estimated the costs of those specific proposals, extrapolating from CBO's options with similar force structures suggests that savings could be $20 billion to $60 billion larger over 30 years than the savings under CBO's 1,000-warhead options, which by themselves would save $66 billion to $175 billion relative to the costs of the 2017 plan. Savings could be greater if the Department of Energy's nuclear weapons laboratories were scaled back because of the reduced size of the stockpile, but analysis of those potential savings is beyond the scope of this report.

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1. Global Zero Nuclear Policy Commission, *Modernizing U.S. Nuclear Strategy, Force Structure and Posture* (Global Zero, May 2012), http://tinyurl.com/bj4o3aw (PDF, 431 KB); and James Wood Forsyth Jr., B. Chance Saltzman, and Gary Schaub Jr., "Remembrance of Things Past: The Enduring Value of Nuclear Weapons," *Strategic Studies Quarterly*, vol. 4, no. 1 (Spring 2010), pp. 74–89, https://go.usa.gov/xNpba (PDF, 2.2 MB).

2. See, for example, Keith B. Payne and others, *Minimum Deterrence: Examining the Evidence* (National Institute Press, 2013), http://tinyurl.com/ydchw9nl (PDF, 3.6 MB); and Brad Roberts, *The Case for U.S. Nuclear Weapons in the 21st Century* (Stanford University Press, 2015), http://tinyurl.com/zx4sjrr.

Table 4-6.

Characteristics of CBO's Force Structure Options That Would Reduce the Number of Delivery Systems and Warheads Below New START Limits

				Capability of Option Relative to Planned Forces					
	Number of Warheads[a]			Crisis Mgmt.	Limited Nuclear Strike			Large-Scale Nuclear Exchange	
	Deployed	On Alert	Survivable	Ability to Signal Intent	Low-Yield Capability	Trajectory Flexibility	Capability Against Air Defenses	Prompt Response	Aim Points for Adversary
Option 7: Field a 1,000-Warhead Triad	◑	◑	◑	●	●	●	●	◑	◑
Option 8: Field a 1,000-Warhead Dyad Without Bombers	◑	◑	◑	◔	○	◔	◑	◑	◑
Option 9: Field a 1,000-Warhead Dyad Without ICBMs	◑	◑	◕	●	●	●	●	◑	◔

● Equal to or Greater Than Planned Forces
◕ Greater Than ⅔ of Planned Forces
◑ Between ⅓ and ⅔ of Planned Forces
◔ Less Than ⅓ of Planned Forces
○ No Capability

Source: Congressional Budget Office.

ICBM = intercontinental ballistic missile.

a. For quantitative values of the number of warheads, see Appendix C.

number of current-generation SLBMs undergoing life extensions, retire the current-generation ALCM and its warhead, and retire the B83 bomb and all varieties of the B61 bomb.[13]

Under Option 8, the capabilities of nuclear forces would be largely similar to those under Option 5, except with fewer warheads available. Under CBO's illustrative weapon loading of about five warheads per SLBM and one warhead per ICBM, the number of warheads on alert and the number of survivable warheads would be roughly one-third less under Option 8 than under the 2017 plan—but even so they would remain above 500 in each category for day-to-day operations (see Table 4-6 and Appendix C). Under both options, the forces' capability to signal intent during a crisis and to execute limited nuclear strikes would be greatly reduced relative to currently planned forces because those capabilities rely primarily on strategic bombers. The availability of low-yield weapons would be lost because the only low-yield weapons in both the current and planned strategic stockpiles are carried by bombers. In addition, under Option 8, the number of aim points presented to an adversary in a large-scale nuclear exchange scenario would be reduced relative to the number under the 2017 plan because of the smaller number of ICBMs available.

Option 8 would save about $107 billion through 2046 relative to the costs of the 2017 plan if it was implemented for the next generation of systems. About $32 billion of those savings would come from procuring 2 fewer new SSBNs, 160 fewer new ICBMs, and 20 fewer B-21 bombers. The remainder would come from canceling the new LRSO cruise missile and its warhead, canceling the B61-12, producing fewer interoperable warheads, buying fewer new SLBMs, refurbishing fewer ICBM silos, and reducing operation and support costs. After 2046, annual operation and support costs of nuclear forces would average about $27 billion

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13. Although the option would retire 150 ICBMs, the number deployed would decline only by 100 because the option would discontinue the practice of leaving 50 silos unfilled in a standby mode.

Table 4-7.

Savings Under Options That Would Reduce the Number of Delivery Systems and Warheads Below New START Limits

Billions of 2017 Dollars

	Savings in Acquisition Costs for Modernization Programs, 2017–2046			Savings in Costs of Nuclear Forces[a]				
				Average Annual Savings				
	Research and Development	Production	Total	2017–2026	2027–2036	2037–2046	Total Savings, 2017–2046	Savings in Annual Operating and Sustainment Costs After 2046
Option 7: Field a 1,000-Warhead Triad								
Implement for Next Generation of Systems	0	55	55	0.5	4.4	1.8	66	1.1
Implement for Current Generation of Systems	0	59	59	1.7	5.0	1.8	85	1.1
Option 8: Field a 1,000-Warhead Dyad Without Bombers								
Implement for Next Generation of Systems	17	64	81	2.7	4.1	3.9	107	2.1
Implement for Current Generation of Systems	17	66	83	4.1	4.6	3.9	126	2.1
Option 9: Field a 1,000-Warhead Dyad Without ICBMs								
Implement for Next Generation of Systems	29	77	106	2.7	7.7	3.5	139	2.4
Implement for Current Generation of Systems	30	79	109	4.7	9.3	3.6	175	2.5
Memorandum:								
Costs of 2017 Plan	107	292	399	40	49	35	1,242	29

Source: Congressional Budget Office.

ICBM = intercontinental ballistic missile.

a. Total costs of nuclear forces include costs to operate and sustain current and modernized forces, develop and procure modernized forces, and perform other support activities.

under this option, a savings of about $2 billion per year relative to the costs of the 2017 plan.

If Option 8 was implemented now, it would save an additional $19 billion, for a total savings of $126 billion relative to the costs of the 2017 plan. Those additional savings would come from retiring systems early (thus lowering their operation, sustainment, and support costs), forgoing the nuclear mission for tactical aircraft, and performing fewer life extensions on the current-generation SLBM and its W76 warhead.

Option 9: Field a 1,000-Warhead Dyad Without ICBMs

Option 9 would end the use of ICBMs, changing the triad structure to a dyad comprising 10 SSBNs and the currently planned strategic bomber fleet. It is similar to Option 6, except Option 9 would limit the number of deployed warheads to 1,000 by fielding 2 fewer SSBNs and reducing the average number of warheads per missile on those SSBNs.

If this option was implemented for the next generation of systems, DoD would cancel the GBSD program (including development of the new ICBM and refurbishment of infrastructure), forgo procuring the last 2 new SSBNs, and cancel the IW program in favor of life extensions on the current generation of SSBN warheads. If it was implemented now, DoD would retire all of the current-generation ICBMs and their warheads by 2021 and retire 1 Ohio class SSBN in 2018 and 1 in 2019.

Under Option 9, the capability of nuclear forces would be substantially reduced relative to that under the 2017 plan. The number of warheads deployed would be about one-third lower than planned levels, although the number of survivable warheads would remain above 600 for day-to-day operations (see Appendix C). The number of warheads on alert would be substantially reduced from planned levels but would remain above 300 for day-to-day operations. The capability to manage a crisis situation or to execute limited nuclear strikes would be about the same under this option as under the 2017 plan because those capabilities rely primarily on bombers and probably would require only a small number of weapons. However, with no ICBMs in the force, the capability to engage in a large-scale nuclear exchange would be greatly reduced, as would the number of aim points for an adversary (see Table 4-6 on page 47). Some analysts would argue that such a reduction in the number of aim points would be destabilizing.

Option 9 would save about $139 billion through 2046 relative to the costs of the 2017 plan if it was implemented for the next generation of systems, CBO estimates. Most of those savings (about $90 billion) would come from canceling the GBSD program. The rest would come from procuring and operating two fewer new SSBNs, procuring fewer new SLBMs, and canceling the IW program and replacing it with LEPs for the W76 and W88 warheads. Annual operation and support costs of nuclear forces after 2046 would average about $27 billion per year under this option, about $2 billion per year less than the costs of the 2017 plan, CBO estimates.

If Option 9 was implemented now, savings would total about $175 billion relative to the costs of the 2017 plan. The additional $36 billion in savings would come from avoiding or reducing operation, sustainment, and support costs for ICBMs and SSBNs.

APPENDIX

A

How CBO Estimated Costs

In generating the cost estimates for this report, the Congressional Budget Office performed two primary tasks. The first, and by far most extensive, task was to estimate the 30-year costs of current plans for nuclear forces. Then, using those estimates as a starting point, CBO estimated how costs would change if those plans were adjusted.

CBO's approach to estimating costs in this report is largely the same as it has used in its previously published estimates of the costs of nuclear forces, although there are several important differences in how the estimates were formulated and in how they are presented.[1] The most important difference is how the costs of bombers are treated. In previous estimates of the 10-year costs of nuclear forces, CBO included only 25 percent of the costs of the B-52H and B-21 bombers in its estimate of the total costs of nuclear forces to account for the fact that bombers spend the majority of their time performing conventional (that is, nonnuclear) missions. However, because this analysis considers the effects on costs and capabilities of changes to different segments of nuclear forces, CBO included 100 percent of the costs of the bombers to provide a more complete assessment of trade-offs between options. Estimates in this report differ from those in previous analyses in three other ways: They cover costs over 30 years instead of 10 years; they are presented in constant 2017 dollars instead of nominal dollars; and they incorporate potential cost growth. (In previous reports, estimates of potential cost growth were presented as separate subtotals.)

Costs of Current Plans

To estimate the costs of current plans, CBO first analyzed the fiscal year 2017 budgets from the Department of Defense (DoD) and the Department of Energy (DOE) to identify activities associated with nuclear weapons.[2] Those documents, and their associated detailed budget justifications, provide five years of budgetary plans. As a first step to producing 30-year estimates, CBO projected each of the budget lines identified as relevant to nuclear forces beyond the five years available in the agencies' documents by examining the long-range plans for each program. In some cases, DoD and DOE have produced detailed long-range plans, like the 25-year projections in the Stockpile Stewardship Management Plan from DOE's National Nuclear Security Administration, and the 30-year shipbuilding plan from the Navy. In other cases, CBO based long-range plans on agencies' statements or on historical experience with analogous programs. This report also draws from CBO's analyses of future defense budgets in other published reports.[3]

For each activity, CBO projected costs separately for the relevant appropriation titles. For DoD, those titles are military personnel (MILPERS); operation and maintenance (O&M); research, development, test, and evaluation (RDT&E); and procurement.[4] For DOE, the relevant titles are weapons activities, naval reactors, and federal salaries and expenses.[5]

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[1] See Congressional Budget Office, *Projected Costs of U.S. Nuclear Forces, 2014 to 2023* (December 2013), www.cbo.gov/publication/44968, and subsequent updates: *Projected Costs of U.S. Nuclear Forces, 2015 to 2024* (January 2015), www.cbo.gov/publication/49870, and *Projected Costs of U.S. Nuclear Forces, 2017 to 2026* (February 2017), www.cbo.gov/publication/52401.

[2] The criteria that CBO used to identify budget lines relevant to nuclear forces are described in detail in the first of CBO's reports on the 10-year costs of nuclear forces; see Congressional Budget Office, *Projected Costs of U.S. Nuclear Forces, 2014 to 2023* (December 2013), www.cbo.gov/publication/44968.

[3] In particular, see Congressional Budget Office, *An Analysis of the Obama Administration's Final Future Years Defense Program* (April 2017), www.cbo.gov/publication/52450.

[4] CBO did not project the military construction appropriation title beyond the documented five years because construction needs for individual programs are difficult to predict.

[5] The appropriation title for federal salaries and expenses was formerly referred to as Office of the Administrator.

CBO's approach to completing cost estimates differed somewhat for each of the three categories of costs: costs to develop and produce new systems; costs to operate and sustain fielded forces; and costs of support activities.

Costs to Develop and Produce New Systems

Over the coming decades, DoD plans to develop and produce new or refurbished versions of nuclear delivery systems—that is, ballistic missile submarines (SSBNs) and their submarine-launched ballistic missiles (SLBMs), intercontinental ballistic missiles (ICBMs), strategic bombers, nuclear cruise missiles, and nuclear-capable tactical aircraft—and DOE plans to develop and produce refurbished versions of the nuclear warheads those delivery systems carry. Those modernization efforts are in their early planning stages and would extend for years, so they are generally not yet fully described in budget documentation and their potential costs are highly uncertain.

CBO used several approaches to estimate the costs of those programs. When they were available, CBO used parametric models derived from the actual costs of multiple historical programs.[6] If a parametric model was not available, CBO used historical costs for a single similar program as an analogue. In some cases, appropriate historical analogues were not available, so CBO's estimates are based on agencies' statements about expected costs and CBO's assessment of historical cost growth in similar programs.

The estimate for each modernization program includes the costs to develop the system (which, in DoD, would generally be paid for with RDT&E funding) and the costs to produce the desired quantity (which would be paid for with procurement funding). In general, historical analogues were used to determine the full cost to develop the new system; CBO expressed the actual costs of the analogue systems in 2017 dollars, using the gross domestic product price index to remove the effects of inflation.[7] Historically, new generations of weapon systems usually cost more to develop and produce than earlier generations of the same type, even after adjusting for inflation.[8] To account for that intergenerational increase in cost, CBO added 10 percent to the total cost of the historical analogue for each decade between the year in which the analogue entered development and the year in which the new system would enter development. To forecast future development costs by year, CBO then spread that estimate of the total development cost over a number of years by fitting the current agency budget to a common mathematical distribution used for that purpose.[9] If development costs for the new system were not yet included in the agency's budget, CBO spread the costs in a manner similar to that used in previous programs.

CBO used a similar approach to estimate production costs, relying on parametric models that combine historical costs for multiple systems, when available, or on historical analogues to estimate the costs of the first production unit of the new system. Those models generally rely on physical or performance parameters, like weight or engine thrust, to estimate costs of the first production unit. The costs to produce remaining units were estimated using a year-by-year production schedule (either based on information from DoD or estimated by CBO from public statements by DoD officials) and using a standard approach to account for the gradual decrease in per-unit production costs that generally occurs as more units are produced.[10]

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[6] Parametric models consist of mathematical formulas that relate the actual costs of historical programs to the programs' physical or performance parameters, such as system weight or engine thrust for missiles. Parametric models are used to estimate the costs of new systems using those parameters.

[7] In some cases, a portion of the development costs of the new system were incurred before 2017. CBO included those costs when modeling the total development costs for the system but, for the cost estimates in this report, included only the portion projected to be incurred between 2017 and 2046.

[8] See, for example, Congressional Budget Office, *An Analysis of the Navy's Fiscal Year 2016 Shipbuilding Plan* (October 2015), p. 18, www.cbo.gov/publication/50926.

[9] CBO used a beta distribution to spread development costs. See National Aeronautics and Space Administration, *NASA Cost Estimating Handbook Version 4.0* (February 2015), Appendix F, https://go.usa.gov/xNp7c. Specifically, CBO used a 60:40 beta distribution to spread costs for future programs and as a starting point to fit costs to programs that have started to appear in agencies' budgets. The number of years of development was determined by agencies' planned schedules or by actual schedules for historical programs.

[10] CBO used a 90 percent learning curve (except when noted otherwise) under which the cumulative average unit cost is reduced by 10 percent every time the quantity produced is doubled.

The specific approach and historical data used for each system follow.

New SSBN

CBO used the Navy's estimate of development costs under RDT&E funding ($6.5 billion over the 2017–2028 period) for the new SSBN.[11] That effort to develop a new ballistic missile submarine is well under way and, as of 2018, annual development costs are expected to begin to decline from earlier levels. However, procurement costs are just starting to ramp up for the first production unit, which would be formally authorized in 2021. CBO based its estimate of the cost of the first ship—$13.5 billion in 2017 dollars—on a weight-based model that it developed. (That model and the approach CBO used to estimate the costs of subsequent ships have been described in detail in other CBO publications.)[12] CBO's estimate of annual production costs reflects the assumption that appropriations to pay for each ship would be spread over several years.

New SLBM

CBO based its estimate of development costs for the new submarine-launched ballistic missile ($18 billion in 2017 dollars) on actual costs for the Trident II D-5 missile, with a boost of 50 percent because about five decades will have passed between initial development of the D-5 and the start of development of the new SLBM in the 2020s. To estimate the cost of the first production unit ($170 million), CBO primarily used a parametric model based on engine thrust and other technical specifications (assuming that the new missile would have parameters similar to the current-generation D-5) but also used the actual costs for some components of the D-5 (when they were available).[13] Costs for subsequent units would be lower, resulting in an estimated average cost of $82 million per missile over the course of the program.

New ICBM

The Ground-Based Strategic Deterrent (GBSD) program includes development of a new intercontinental ballistic missile, as well as refurbishment of existing silos and modernization of command-and-control systems. For the ICBM portion of the program, CBO based its estimate of development costs ($16 billion in 2017 dollars) on the actual costs of the Minuteman III missile, with a boost of 50 percent because the Minuteman III began development about five decades ago. CBO estimated the cost of the first production unit of the ICBM ($120 million) by applying the same parametric model used for the new SLBM, but using parameters similar to those of the Minuteman III. That value for the first unit cost resulted in an estimated average cost of $53 million per missile over the course of the program.

GBSD Infrastructure

For the other two portions of the GBSD program (silo refurbishment and modernization of the command-and-control systems), CBO based its estimates of costs for development ($4 billion) and production ($9 billion) on public statements by the Air Force about the costs of the program, combined with historical experience with cost growth in similar programs.

New Bomber

The performance and physical characteristics of the B-21, the new stealthy bomber planned by the Air Force, are classified, which made it difficult for CBO to generate an independent estimate of its costs. Thus, CBO's estimates for the costs of that bomber's development ($28 billion) and production ($69 billion) are based on statements about the costs of the program by the Air Force combined with historical experience for cost growth in similar programs.

New Cruise Missile

CBO's estimate of development costs ($4 billion) for the new nuclear cruise missile, the Long-Range Standoff weapon, is based on the actual development costs of the Advanced Cruise Missile (ACM), the most recent air-launched nuclear cruise missile built by the United States, with a boost of 30 percent because about three decades have passed since the initial development of the ACM. The estimated cost of the first production unit ($12 million) also is based on the actual cost of the ACM, boosted by 30 percent. That value for the first unit cost resulted in an estimated average cost of $9 million per missile over the course of the program.

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[11] Unlike most other major defense programs, the Navy's ship development and production is atypical in that a much larger fraction of development costs is paid for with procurement funds (rather than RDT&E funds) for the first ship of the class. Accordingly, the costs of subsequent ships are much lower relative to the cost of the first unit than in most other defense programs.

[12] See, for example, Congressional Budget Office, *An Analysis of the Navy's Fiscal Year 2017 Shipbuilding Plan* (February 2017), Appendix A, www.cbo.gov/publication/52324.

[13] Technomics, *National Missile Defense Propulsion Cost Estimating Relationships* (August 2000).

Warhead Life Extensions

DOE provides detailed annual cost estimates for the warhead life-extension programs (LEPs). CBO analyzed each of those estimates to generate its own versions of those costs, using a model similar to the one used by DOE to generate the estimates. That model estimates the cost of a LEP by scaling actual costs of the ongoing LEP for the W76 warhead, adjusting for the complexity of the new LEP relative to that of the W76 and for different production quantities. (CBO developed its own version of that model so that it could analyze those effects.) CBO also analyzed the Selected Acquisition Report for the W76 to estimate a rate of potential cost growth for LEPs based on comparisons of DOE's initial and current estimates of the costs for the W76 LEP. In total, CBO estimates that LEP programs will cost $63 billion over the 2017–2046 period.

Costs to Operate and Sustain Fielded Forces

Both DoD and DOE incur costs to operate and sustain fielded nuclear forces. For this analysis, CBO has defined DoD's operations costs as all of its operation and support costs directly related to nuclear delivery systems, including all costs for those fielded systems paid for by the appropriations for military personnel and for operation and maintenance. CBO has defined sustainment costs for DoD as including various modifications and upgrades performed on fielded systems to improve their capability and reliability and to ensure their interoperability with other systems. DOE's sustainment costs include testing and analysis of fielded nuclear warhead systems and their components and addressing any problems identified in testing. CBO estimated sustainment costs for a fielded weapon system by combining all of DoD's acquisition costs—that is, all costs funded by the appropriations for procurement and for RDT&E—for delivery systems (except for major life-extension programs), as well as DOE's costs for sustaining the relevant warhead types and, in the case of fielded SSBNs, the cost of supporting naval reactors on those submarines. CBO's estimates of operation and sustainment costs include the costs for current-generation systems until they are retired and new systems once they have been produced and start to be fielded.

To estimate costs for 2017 through 2021, CBO used the estimates of operation and sustainment costs provided by DoD and DOE in their planning documents. To estimate costs beyond 2021, CBO first generated a projection of what those costs would be over 30 years if there were no changes in the numbers or types of systems fielded. That "full-fleet" step reflects the assumption that operation and maintenance activities and the number of military personnel would continue at the same levels that are planned for 2021. In keeping with DoD's historical experience, CBO projects that, for a constant level of effort or number of personnel, costs for those categories grow somewhat faster than inflation (about 1 percentage point faster than inflation for military personnel costs, and about 1.5 percentage points faster than inflation for O&M). CBO's projection of DoD's sustainment costs after 2021 reflects the assumption that the typical level of effort for each system deployed today would remain the same and that the costs of those activities would grow at the same average rate as similar costs have in the past.[14]

CBO's estimate of the costs for DOE's sustainment of each type of warhead includes an estimate of the growth in those costs using the same growth rate (20 percent total, over five years) that CBO used to estimate DoD's procurement costs for sustainment of fielded systems. CBO expects that the costs to sustain weapon types after they complete their LEPs would be the same as the costs to sustain the weapons they are replacing and that the costs to sustain a given weapon type would not depend on the number of warheads of that type. CBO's projection of DOE's costs for nuclear reactors includes an increase in costs relative to inflation at the same rate as DoD's O&M costs. In its budget documents, DOE does not distinguish between the costs to sustain SSBNs and the costs to sustain other nuclear-powered ships. To estimate DOE's costs to support nuclear reactors for SSBNs, CBO scaled the cost to sustain all nuclear-powered ships by the fraction of those ships that are SSBNs; that same scaling was applied for the full 30 years as new SSBNs enter the fleet and current-generation boats are retired.

Over the next 30 years, as systems are retired and replaced, DoD's costs to operate and sustain them would change. Other costs, however, would remain more fixed. Keeping a fielded system operational requires a substantial infrastructure of facilities, equipment, and trained personnel and, to some degree, that infrastructure

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14. CBO's estimates for O&M and MILPERS used the same methods that were used to analyze the historical-cost scenario described in Congressional Budget Office, *An Analysis of the Obama Administration's Final Future Years Defense Program* (April 2017), Chapter 2, www.cbo.gov/publication/52450. CBO's estimates for growth in RDT&E and procurement used the methodology described in the appendix of that report.

represents a minimum fixed cost that does not depend on the size of the fielded fleet. To account for that mix of fixed and variable costs, CBO divided operation and sustainment costs in its estimates so that half are fixed (to pay for that minimum infrastructure) and half are proportional to the size of the fielded fleet. CBO's estimates of the costs to operate and sustain new systems as they are fielded are built on the assumption that the costs of those new systems would be the same as the costs of the systems they are replacing and that they would have the same ratio of fixed to variable costs.[15]

Because both current-generation and new systems have fixed and variable costs, CBO estimates that total operation and sustainment costs for each segment of nuclear forces would increase during the period when the fleet contains a mixture of both types of systems. For example, under DoD's plan the ICBM force at some point would be composed of half current-generation systems and half new systems. At that point, the operation and sustainment costs for the current-generation systems would be 75 percent of the full-fleet projected costs, comprising all of the fixed costs and half of the variable costs. At the same time, the new systems would also require their own fixed costs for infrastructure of equipment and trained personnel, so operation and sustainment costs for the new systems also would be 75 percent of the full-fleet projected costs. Thus, during the mixed-fleet phase, operation and sustainment costs for the ICBM fleet would total 150 percent of full-fleet projected costs. Once all of the current-generation forces were retired, the infrastructure to keep them operational would no longer be needed, and the ICBM's operation and sustainment costs would drop to the full-fleet projected costs.

Costs of Support Activities

CBO's estimate of the costs of nuclear forces includes various support activities. For DoD, those activities include command, control, communications, and early-warning systems. For DOE, support activities include the complex of nuclear laboratories and production facilities that support the nuclear enterprise. In general, CBO's estimate of costs reflects the assumption that those activities would continue after 2021 at the same level of effort as they had in 2021.

For DoD, CBO projected that support costs would rise somewhat faster than inflation in the years after 2021. Those projections were performed separately for each appropriation title, using the same method described in the section on operation and sustainment costs. One exception to that simple projection involves the satellite systems that CBO included as relevant to nuclear forces—the Space-Based Infrared System early-warning satellites and the Advanced Extremely High Frequency communications satellites. In CBO's projections, which draw on current plans for evolution in the design of those satellite systems, those new designs would be replaced as needed when they reached the end of their service life.

For DOE, CBO's projection of support activities includes all costs for the complex of laboratories and production facilities other than the costs that DOE links to sustainment or modernization of specific types of warheads. Those activities are funded by appropriations for weapons activities and federal salaries and expenses. CBO's projection of those costs includes growth using the same rates that CBO used to estimate DoD's O&M costs—rates that are somewhat higher than inflation. One exception to that projection method is for infrastructure costs. DOE has several major construction projects under way that would last through the mid-2020s. Historically, costs for DOE's construction projects have grown beyond the agency's initial estimates, so CBO's projection includes a cost growth factor for DOE's infrastructure costs. That factor varies by year depending on the level of major construction costs and averages about 30 percent for all infrastructure costs over the 30-year period.

Costs of the Options

To estimate the costs of alternative, smaller force structures, CBO generally removed the relevant budget items from the costs of current plans. A description of the items that were removed is included in the description of each option in the main text. In removing budget items, CBO applied some general rules:

- Reductions in production quantities were taken at the end of the procurement schedule. Because procurement costs tend to decrease as the number of units produced increases, the units at the end of the schedule are the least expensive.

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[15] For the B-21 bomber, which is not a direct replacement for a single current-generation bomber, the operation and sustainment costs would be analogous to those for the B-2 bomber, CBO projects.

- No reduction in development costs was taken unless the system was completely canceled.
- For systems that would be retired early, no additional cost of retirement was added. That is because those systems would have been retired anyway at some point during the 30-year estimation period.
- Options 1, 6, and 9 include the cancellation or postponement of the interoperable warhead programs, which would be replaced with life extensions on existing weapon types. To calculate the resulting costs, CBO used the same model as DOE but lowered the complexity factor and, for Option 9 only, reduced the quantity of refurbished warheads that would be produced.

APPENDIX

B

Combining CBO's Options

For the nine nuclear force structure options presented in this report, the Congressional Budget Office shows costs and savings relative to what they would be under the Administration's 2017 plan. Although some options are closely related to others, each is presented independently. In some cases, however, savings could be increased by combining two or more of the options. But to avoid double counting, care must be taken when combining options because the cuts to programs in some options overlap to varying degrees with program cuts in other options.

CBO estimated the net savings from combining one of the options that would make major changes to the force structure (Options 4 through 9) with one or more of Options 1 through 3 (see Tables B-1 through B-6). In most cases, the net savings are the sum of the savings from the individual options. In a few cases, though, there is some overlap between the program cuts that make up the options; as a result, the net savings would be slightly smaller or larger than a simple sum of savings under the individual options. (Those cases are highlighted in the notes to the tables.)

Some combinations of options are invalid. In general, the force structure options are mutually exclusive or have substantial overlap and should not be combined. Similarly, Options 2 and 3, each of which would cancel one of the nuclear weapons carried by aircraft, should not be combined because doing so would effectively eliminate all weapons carried by bombers. If such a policy is desired, Options 6 and 8 incorporate that change. Finally, some of the approaches under Option 1 are not compatible with some of the force structure options; in particular, delaying the new intercontinental ballistic missile (ICBM) and the interoperable warhead programs is not compatible with the options that would discontinue the use of ICBMs, and delaying the B-21 bomber is not compatible (in the context of nuclear forces) with the force structure options that would remove the nuclear mission from aircraft.

Table B-1.

Savings From Combining Option 4 With Other Options, 2017 to 2046

Option 4: Field a Triad With 10 SSBNs and 300 ICBMs	**Other Options**					**Total 30-Year Savings[a] (Billions of 2017 dollars)**
	Bomber Weapon Options		**Option 1: Delay Modernization**			
	Option 2: Forgo Nuclear Cruise Missiles	**Option 3: Forgo Nuclear Bombs**	**Approach 1: Delay New ICBM**	**Approach 2: Delay B-21 Bomber**	**Approach 3: Delay IW Programs**	
Option 4 Only						
X						30
Option 4 Plus One Other Option or Approach						
X	X					57
X		X				56
X			X			48
X				X		64
X					X	40
Option 4 Plus Two Other Options or Approaches						
X			X	X		82
X			X		X	58
X				X	X	75
X	X		X			76
X	X			X		92
X	X				X	68
X		X	X			75
X		X		X		91
X		X			X	67
Option 4 Plus Three or More Other Options or Approaches						
X	X		X	X		110
X	X		X		X	86
X	X			X	X	102
X	X		X	X	X	120
X		X	X	X		109
X		X	X		X	85
X		X		X	X	101
X		X	X	X	X	119

Source: Congressional Budget Office.

ICBM = intercontinental ballistic missile; IW = interoperable warhead; SSBN = ballistic missile submarine.

a. These savings reflect the assumption that the options would be implemented for the next generation of systems. The savings would be greater if the options were implemented for the current generation of systems.

Table B-2.

Savings From Combining Option 5 With Other Options, 2017 to 2046

	Other Options					
	Bomber Weapon Options		Option 1: Delay Modernization			
Option 5: Field a Dyad Without Bombers	**Option 2: Forgo Nuclear Cruise Missiles**	**Option 3: Forgo Nuclear Bombs**	**Approach 1: Delay New ICBM**	**Approach 2: Delay B-21 Bomber**	**Approach 3: Delay IW Programs**	**Total 30-Year Savings[a] (Billions of 2017 dollars)**
			Option 5 Only			
X						71
			Option 5 Plus One Other Approach			
X			X			89
X					X	82
			Option 5 Plus Two Other Approaches			
X			X		X	99

Source: Congressional Budget Office.

ICBM = intercontinental ballistic missile; IW = interoperable warhead.

a. These savings reflect the assumption that the options would be implemented for the next generation of systems. The savings would be greater if the options were implemented for the current generation of systems.

Table B-3.

Savings From Combining Option 6 With Other Options, 2017 to 2046

	Other Options					
	Bomber Weapon Options		Option 1: Delay Modernization			
Option 6: Field a Dyad Without ICBMs	**Option 2: Forgo Nuclear Cruise Missiles**	**Option 3: Forgo Nuclear Bombs**	**Approach 1: Delay New ICBM**	**Approach 2: Delay B-21 Bomber**	**Approach 3: Delay IW Programs**	**Total 30-Year Savings[a] (Billions of 2017 dollars)**
Option 6 Only						
X						120
Option 6 Plus One Other Option						
X	X					148
X		X				147
X				X		155
Option 6 Plus Two Other Options						
X	X			X		182
X		X		X		181

Source: Congressional Budget Office.

ICBM = intercontinental ballistic missile; IW = interoperable warhead.

a. These savings reflect the assumption that the options would be implemented for the next generation of systems. The savings would be greater if the options were implemented for the current generation of systems.

Table B-4.

Savings From Combining Option 7 With Other Options, 2017 to 2046

	Other Options					
	Bomber Weapon Options		Option 1: Delay Modernization			
Option 7: Field a 1,000-Warhead Triad	Option 2: Forgo Nuclear Cruise Missiles	Option 3: Forgo Nuclear Bombs	Approach 1: Delay New ICBM	Approach 2: Delay B-21 Bomber	Approach 3: Delay IW Programs	Total 30-Year Savings[a] (Billions of 2017 dollars)
Option 7 Only						
X						66
Option 7 Plus One Other Option						
X	X					94
X		X				93
X			X			84
X				X		101
X					X	73
Option 7 Plus Two Other Options or Approaches						
X			X	X		119
X			X		X	91
X				X	X	107
X	X		X			112
X	X			X		128
X	X				X	101
X		X	X			111
X		X		X		127
X		X			X	100
Option 7 Plus Three or More Other Options or Approaches						
X	X		X	X		146
X	X		X		X	118
X	X			X	X	135
X	X		X	X	X	153
X		X	X	X		145
X		X	X		X	117
X		X		X	X	134
X		X	X	X	X	152

Source: Congressional Budget Office.

ICBM = intercontinental ballistic missile; IW = interoperable warhead.

[a] These savings reflect the assumption that the options would be implemented for the next generation of systems. The savings would be greater if the options were implemented for the current generation of systems.

Table B-5.

Savings From Combining Option 8 With Other Options, 2017 to 2046

	Other Options						
	Bomber Weapon Options		Option 1: Delay Modernization			
Option 8: Field a 1,000-Warhead Dyad Without Bombers	Option 2: Forgo Nuclear Cruise Missiles	Option 3: Forgo Nuclear Bombs	Approach 1: Delay New ICBM	Approach 2: Delay B-21 Bomber	Approach 3: Delay IW Programs	Total 30-Year Savings[a] (Billions of 2017 dollars)
			Option 8 Only			
X						107
			Option 8 Plus One Other Option			
X			X			125
X					X	114
			Option 8 Plus Two Other Approaches			
X			X		X	132

Source: Congressional Budget Office.

ICBM = intercontinental ballistic missile; IW = interoperable warhead.

a. These savings reflect the assumption that the options would be implemented for the next generation of systems. The savings would be greater if the options were implemented for the current generation of systems.

Table B-6.

Savings From Combining Option 9 With Other Options, 2017 to 2046

	Other Options					
	Bomber Weapon Options		Option 1: Delay Modernization			
Option 9: Field a 1,000-Warhead Dyad Without ICBMs	Option 2: Forgo Nuclear Cruise Missiles	Option 3: Forgo Nuclear Bombs	Approach 1: Delay New ICBM	Approach 2: Delay B-21 Bomber	Approach 3: Delay IW Programs	Total 30-Year Savings[a] (Billions of 2017 dollars)
Option 9 Only						
X						139
Option 9 Plus One Other Option						
X	X					167
X		X				166
X				X		174
Option 9 Plus Two Other Options						
X	X			X		202
X		X		X		201

Source: Congressional Budget Office.

ICBM = intercontinental ballistic missile; IW = interoperable warhead.

a. These savings reflect the assumption that the options would be implemented for the next generation of systems. The savings would be greater if the options were implemented for the current generation of systems.

APPENDIX

C

Quantitative Values of Numbers of Warheads

This appendix presents quantitative values for the Congressional Budget Office's estimates of the number of warheads under the Obama Administration's 2017 plan for nuclear forces and under CBO's force structure options (see Table C-1). The estimates correspond to values relative to the 2017 plan depicted in Tables 4-3 and 4-6 in the main text.

Table C-1.

Number of Warheads Under Day-to-Day Operations and Crisis Conditions

	Number of Warheads[a]					
	Deployed		On Alert		Survivable	
	Day to Day	Crisis	Day to Day	Crisis	Day to Day	Crisis
2017 Plan and Option 1	1,550	1,600	750	1,250	750	1,100
Option 2: Forgo Nuclear Cruise Missiles	1,550	1,600	750	1,250	750	1,100
Option 3: Forgo Nuclear Bombs	1,550	1,600	750	1,250	750	1,100
Option 4: Field a Triad With 10 SSBNs and 300 ICBMs	1,550	1,600	850	1,300	650	1,000
Option 5: Field a Dyad Without Bombers	1,550	1,600	800	1,300	850	1,200
Option 6: Field a Dyad Without ICBMs	1,500	1,500	500	1,100	1,000	1,450
Option 7: Field a 1,000-Warhead Triad	1,000	1,000	450	750	500	750
Option 8: Field a 1,000-Warhead Dyad Without Bombers	1,000	1,000	550	850	550	750
Option 9: Field a 1,000-Warhead Dyad Without ICBMs	1,000	1,000	300	700	600	950

Source: Congressional Budget Office.

ICBM = intercontinental ballistic missile; SSBN = ballistic missile submarine.

a. All values are rounded to the nearest 50.

List of Tables and Figures

Tables

Figures

About This Document

This Congressional Budget Office report was prepared in response to a request from the former Chairman of the Senate Foreign Relations Committee. In keeping with CBO's mandate to provide objective, impartial analysis, the report makes no recommendations.

Michael Bennett of CBO's National Security Division prepared the report with guidance from David Mosher. Raymond Hall of the Budget Analysis Division contributed to the analysis with guidance from Sarah Jennings. Rachel Austin of CBO provided helpful comments. Jasen Castillo of the George H.W. Bush School of Government at Texas A&M University; Elbridge Colby, formerly of the Center for a New American Security; and Kingston Reif of the Arms Control Association also provided helpful comments. (The assistance of external reviewers implies no responsibility for the final product, which rests solely with CBO.) Edward G. Keating fact-checked the manuscript.

Jeffrey Kling and Robert Sunshine reviewed the report. Christine Bogusz edited it, and Jorge Salazar prepared it for publication. An electronic version is available on CBO's website (www.cbo.gov/publication/53211).

Keith Hall
Director
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