Modernization of US Nuclear Forces: Costs in Perspective

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Introduction

This short research paper addresses two topics that have emerged in the debate about whether, when, and how to modernize U.S. nuclear forces.[1] The first topic relates to the size and scale of the planned nuclear force, with some critics of the modernization plan arguing that the United States is simply replicating the Cold War force for a very different era. The second topic relates to the cost of the modernization effort, with some critics arguing that the cost is unaffordable.[2] This paper begins with a review of the changes in the size and scale of U.S. nuclear forces since the Cold War. It then examines the expected costs of modernization in a comparative perspective.

Some have argued that the United States is simply replacing the cold war force. As U.S. nuclear forces age, two questions come into focus: First, why is modernization needed? Second, what would modernization cost in absolute and relative terms? This paper provides information, based on available unclassified information, relevant to these questions.

Nuclear Forces Past and Future

Assuming U.S. nuclear modernization proceeds as planned in the current Program of Record, how will U.S. nuclear forces of the future compare in size and scale with the Cold War nuclear force? The nuclear force will have changed substantially over this period, becoming significantly smaller and less diverse.

Figure 1 illustrates the reduction in the size of strategic nuclear forces in terms of both warheads and delivery vehicles between years 1990 and 2018.[3] The total number of weapons in the stockpile will have decreased from 21,392 in 1990 to 4,717 by 2018, with deployed warheads

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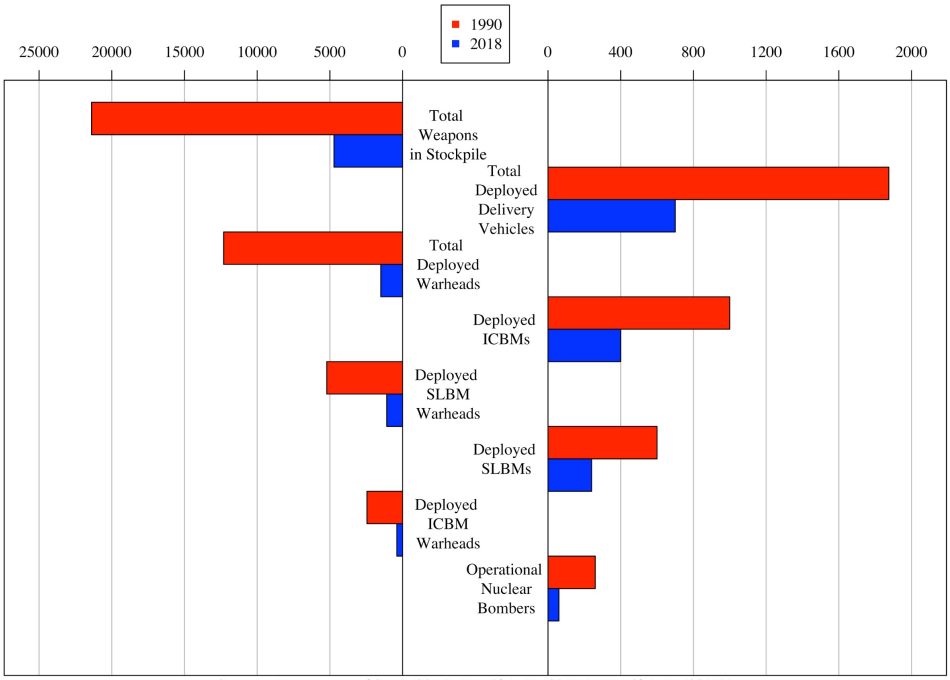
[1] For an overview of the planned modernization, see Woolf, A. F. (2017a). *U.S. Strategic Nuclear Forces: Background, Developments, and Issues*. Congressional Research Service: Washington, D.C.
[2] For examples of such criticisms, see Doyle, J. E. (2016). "Better Ways to Modernise the US Nuclear Arsenal." *Survival*, 58(4), 27–50.; Preble, Christopher A. 17 September 2012. "Challenging the Need to Modernize the U.S. Nuclear Arsenal." *Cato at Liberty*. https://www.cato.org/blog/challenging-need-modernize-us-nuclear-arsenal. Accessed 24 March 2017; Shanker, Thom. 15 May 2012. "Former Commander of U.S. Nuclear Forces calls for Large Cut in Warheads." *New York Times*
[3] Woolf A. F. (2017a)

decreasing from 12,394 to 1,500.[4] Warheads deployed on submarine launched ballistic missiles (SLBMs) will decline from 5,216 to 1,090, and those on ICBMs from 2,450 to 400.[5]

These changes flow in part from the implementation of strategic arms control. As described in Congressional Research Service reports, since the end of Cold War the United States has substantially reduced its nuclear weapons stockpile due in large part to arms control agreements, including the INF Treaty (1987), START I (1991), the SORT Treaty (2002), and New START (2011). Under New START, the United States has committed to meet the central strategic limits of 1,550 nuclear weapons by February 2018. The United States has also committed to reduce the number of nuclear weapon delivery vehicles from the number of total deployed delivery vehicles in 1990 of 1,875 to 700 in 2018. The Department of Defense plans to lower the number of deployed ICBMs from 1,000 to 400 to match the number of deployed ICBM warheads. By 2018 the 12 deployed Ohio-class SSBNs will have 20 SLBM launchers each, bringing the number of deployed SLBMs from 600 to 240. In the air leg of the nuclear triad, the number of nuclear mission bombers will be reduced from 260 to 60 in 2018.[6]

Figure 1: Strategic Nuclear Forces by Nuclear Triad Leg, 1990 and 2018



Sources: Department of State (2015), Woolf A. F. (2017a), Woolf A. F. (2017b)

The nearly complete elimination of nuclear weapons forward deployed in Europe and Asia with non-strategic delivery systems in support of commitments to U.S. allies (called non-strategic nuclear weapons or NSNW) has contributed to the overall reduction of forces. European

[4] Department of State. (2015). *Factsheet: Transparency in the U.S. Nuclear Stockpile*. https://2009-2017.state.gov/documents/organization/241377.pdf. Note that the number of total nuclear weapons listed for 2018 comes from the 2014 number in the fact sheet; Woolf, A. F. (2017b). *The New START Treaty: Central Limits and Key Provisions*. Congressional Research Service: Washington, D.C.
[5] Woolf A. F. (2017a); Woolf, A. F. (2017b).
[6] Ibid.

deployments have been reduced by more than 97 percent since the height of Cold War.[7] In Asia, all NSNWs were withdrawn as a result of the Presidential Nuclear Initiatives undertaken by the George H.W. Bush and Clinton Administrations.

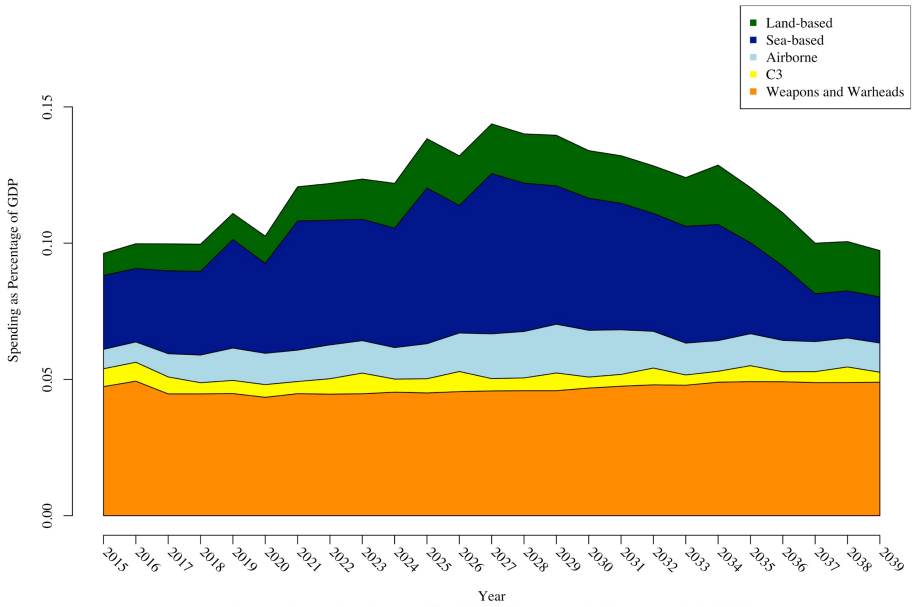
The U.S. nuclear force has also become much less diverse. Due to retirement of warheads, of the 23 different types in the 1990 stockpile, only 11 types remain. Assuming full implementation of the existing stockpile life extension program, further consolidation will further reduce the stockpile from eleven to five weapons types: one will be retired, five will be consolidated into two warheads suitable for use in cruise missiles and gravity bombs, and five ballistic missile warheads will be consolidated into three types of warheads to be interoperable between SLBMs and ICBMs.[8]

The Cost of Modernization in Comparative Perspective

The Center for Strategic and Budgetary Assessments has projected that implementation of the Program of Record for nuclear modernization would cost an average of 0.12% of GDP between 2015 and 2030 before returning to current levels of spending on nuclear forces (for reference, defense spending would average 2.57% over the same period). The projected costs of U.S. nuclear modernization over the next two decades are depicted in Figure 2.[9] This figure breaks down the costs of the nuclear triad by leg and major system and includes costs of developing new systems, operating and phasing out existing systems, research and development, and capital investment.[10]

Figure 2: Costs of Nuclear Maintenance and Modernization of the Triad, 2015-2039

[7] Department of Defense (2008). *Report of the Secretary of Defense Task Force on DoD Nuclear Weapons Management Phase II: Review of the DoD Nuclear Mission*. Washington, D.C. https://www.defense.gov/Portals/1/Documents/pubs/PhaseIIReportFinal.pdf.
[8] Harrison, T., & Montgomery, E. B. (2015). *The Cost of U.S. Nuclear Forces: From BCA to Bow Wave and Beyond*. Washington, D.C.
[9] Congressional Budget Office. (2016a). *Long-Term Implications of the 2016 Future Years Defense Program*. Washington, D.C.; Harrison, T., & Montgomery, E. B. (2015). *The Cost of U.S. Nuclear Forces: From BCA to Bow Wave and Beyond*. Center for Strategic and Budgetary Analysis: Washington, D.C.
[10] Projected GDP is in 2016 dollars (Congressional Budget Office 2016a).



Sources: Congressional Budget Office (2016a), Harrison, T., & Montgomery, E. B. (2015)

The largest amount of spending throughout the modernization process will be in the weapons and warheads category, costing a total $276.9 billion dollars over the duration of the modernization period, averaging yearly expenditures of $9.2 billion between 2015-2025 and $12.5 billion between 2026-2039. This will cover the life extension program for the warheads and bombs associated with the triad of delivery systems and the associated modernization of the infrastructure to do this work.

Delivery system modernization will also be a significant fraction of the total. The dominant cost in this realm is associated with modernization of the ballistic missile fleet with the new Columbia-class nuclear submarine.[11] Currently, the Navy possesses 14 Ohio-class SSBNs, each of which carries 20 missiles. The Navy is planning for 12 Columbia-class SSBNs, each of which will have 16 missile launch tubes and will begin replacing Ohio SSBNs in 2031.[12] These submarines will initially use the current SLBM, the Trident II, but a replacement will be necessary as the missile ages out over the following decade.[13]

The modernization of land-based intercontinental ballistic missiles (ICBMs) will be less expensive but cannot be postponed longer. The existing fleet of 400 Minuteman III ballistic missiles will be replaced beginning in 2030 with the Ground Based Strategic Deterrent (GBSD). Until then, the aging of the existing ICBMs requires significant investments to sustain a serviceable fleet of missiles.[14] Rather than repairing components the current practice is to replace them entirely. By continuing this practice, the Minuteman III is expected to be in service through 2030 with continuous upgrades. Modernization of the air leg of the triad calls is required because

[11] O'Rourke, R. (2016). Navy Columbia Class (Ohio Replacement) Ballistic Missile Submarine (SSBN[X]) Program: Background and Issues for Congress. Congressional Research Service: Washington, D.C.
[12] Congressional Budget Office. (2015).; Congressional Budget Office. (2017). *Projected Costs of U.S. Nuclear Forces, 2017 to 2026*. Washington, D.C.
[13] Woolf, A. F. (2017a).
[14] Woolf, A. F. (2017a). Congressional Budget Office. (2017).

of the aging out of B-52s and B-2s, especially relative to advanced adversary air defenses. The Northrop Grumman B-21 Raider will replace the B-52s and B-2s as it becomes available.[15]

The smallest fraction of the cost of the modernization plan is the command and control system. Despite regular improvements and upgrades, the existing command and control system is reaching the end of its functional life, so plans are in place to field more robust terrestrial, airborne, and satellite capabilities.[16]

The dollar amounts for nuclear modernization are large. But how do they look in comparison to other large projects of the U.S. government? This analysis compares the costs of the Program of Record to three other factors: total GDP, conventional defense costs, and national transportation investments. These comparisons are depicted in Figure 3.[17] Capital investment in transportation is shown to provide a reference to a common spending item.

Figure 3 reflects decisions to invest in procurement, military construction, and family housing in the case of conventional military items, or the construction and rehabilitation of physical assets or other major equipment in the case of nuclear and other defense from 1980 to 2017. These values do not include the costs of operation and management.[18]

Capital investment in nuclear and other defense declined over time from a Cold War-high of 0.076% of GDP in 1985 to a recent low of 0.001% of GDP in 2015. Meanwhile, capital investment in conventional defense has fluctuated through the years. Between 1980 and 1991, policymakers responded to the Cold War requirements by increasing spending significantly, peaking in 1987 with the government investing 1.82% of GDP in conventional defense. After the Cold War ended, investment in conventional defense declined until the early 2000s. Between 2001 and 2015, capital investment in conventional military grew during the War on Terror, Afghanistan and Iraq. At its highest during this period, capital investment in conventional defense was 0.99% of GDP in 2010, just shy of 1% of GDP. Meanwhile, transportation capital spending was constant, averaging 0.34% of GDP between 1980 and 2015.

Figure 3: Capital Investment in select categories, 1980-2017

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[15] United States Air Force. (2016).
[16] Harrison, T., & Montgomery, E. B. (2015).
[17] Office of Management and Budget. (2016). *Historical Tables: Budget of the U.S. Government*. Washington, D.C. In the OMB historical tables, conventional and atomic defense spending compose their own categories with defense-related activities in a separate one. The OMB combines capital investment in defense-related activities (e.g. counterterrorism and privacy adjudication) and nuclear defense in one category, but given the clear dominance of capital-intensive spending in the latter over the former, increases and decreases are most likely dominated by fluctuations in nuclear defense. In the Historical Tables, the category containing nuclear spending is known as "atomic defense." See the Appendix for further details.
[18] Office of Management and Budget. (2016). *Historical Tables: Budget of the U.S. Government*. Washington, D.C. Comparable figures which include both capital investment and spending in operation and maintenance are presented in Appendix figures A1 and A2.

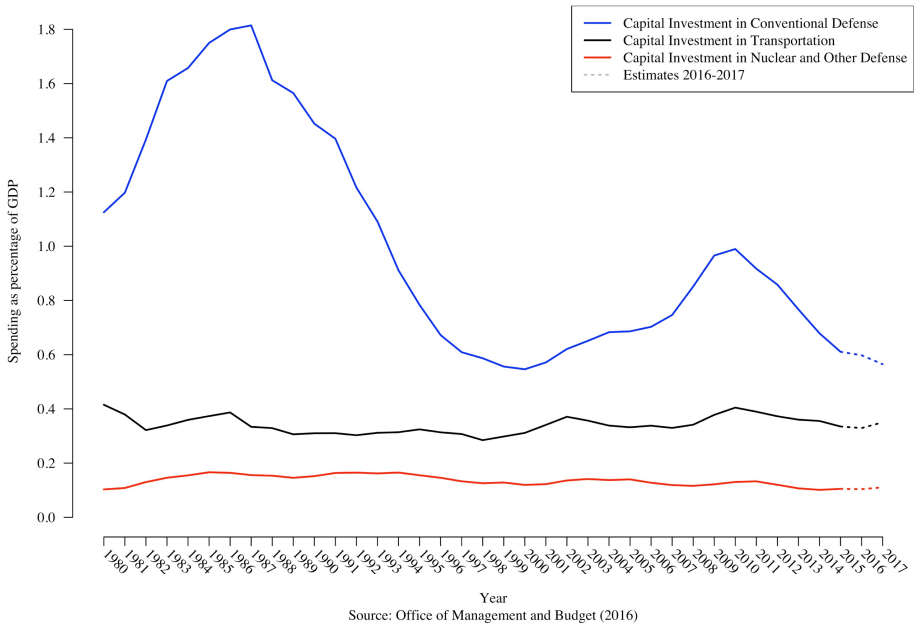
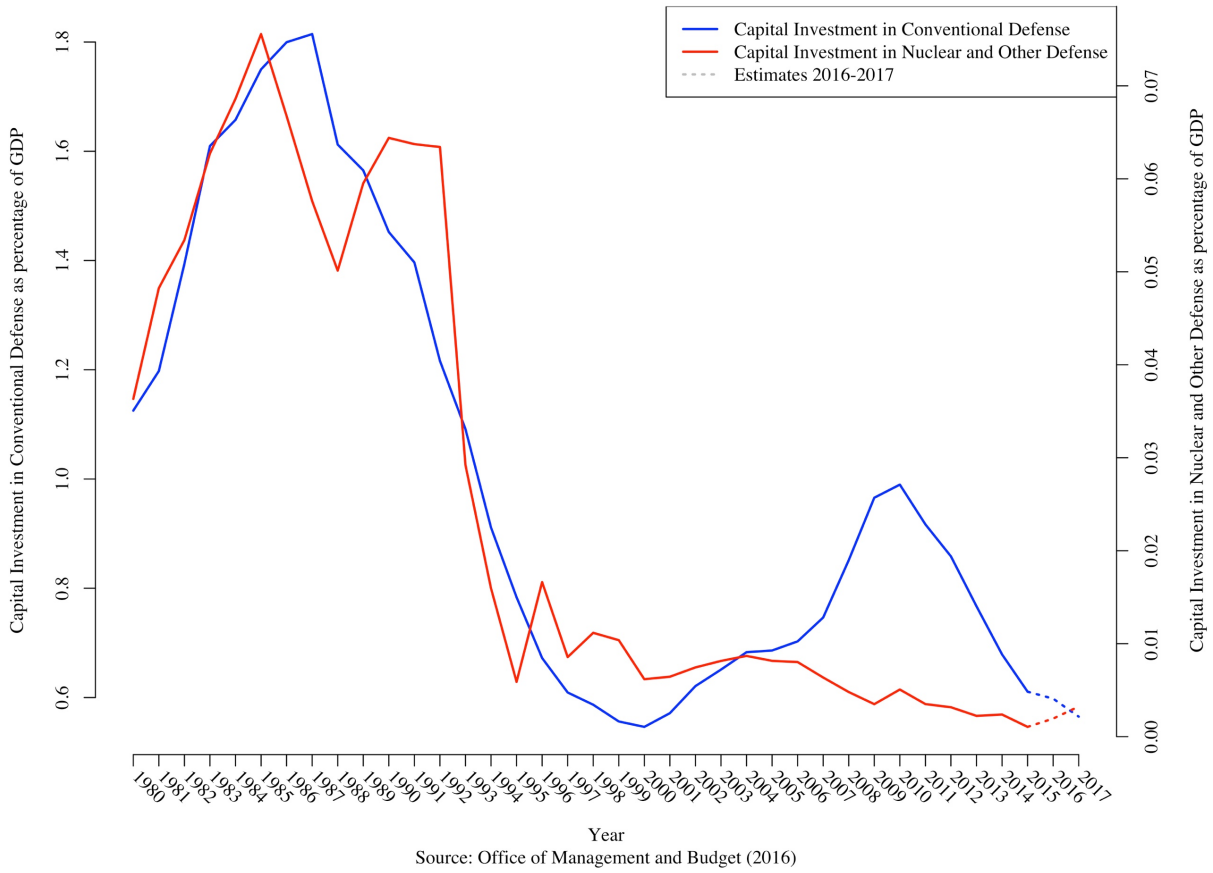


Figure 3 shows that investment in nuclear spending is a small fraction of capital investment in conventional defense, meanwhile Figure 4 compares trends of investment by plotting the data on two scales (the left-hand axis is for conventional defense and the right for nuclear and other defense) between 1980 and 2017.[19] For most of this period, investment in both conventional and nuclear defense increased or decreased simultaneously. Between 1980 and 1992, their relative spending remained constant. However, following U.S. involvement in the War on Terror, Afghanistan, and Iraq after 2001 and until 2011, investment in conventional defense increased while nuclear defense decreased. The latest increase of military spending following 2001 dedicated relatively little investment to nuclear forces. As a consequence, weapons systems have continued to age without substantial development, culminating in a state where current weapons systems are no longer maintainable due to fact that some components are difficult - if not impossible - to acquire.[20]

Figure 4: Capital Investment Trends in Conventional, Nuclear and Other Defense, 1980-2017

[19] Ibid.
[20] Woolf, A. F. (2017a).

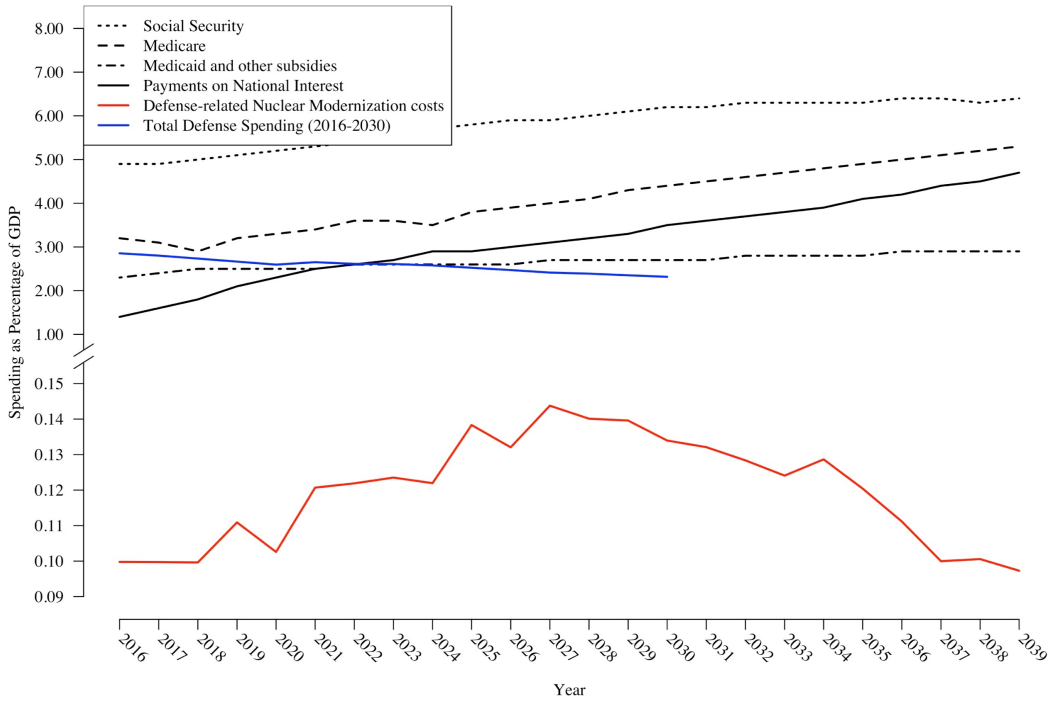


To put the costs of nuclear modernization in perspective, Figure 5 charts modernization costs as a percentage of GDP along with other important spending categories over the next 23 years.[21] While Figures 3 and 4 represented only capital investment, Figure 5 includes the costs of operation and maintenance of the nuclear triad, in addition to capital investment. The cost of modernization over future years is expected to peak in 2025 at 0.116% of GDP, when the other programs, like those related to Medicaid, are expected to be 2.5% of GDP.[22]

Figure 5: Projected Spending on Nuclear Modernization as Percentage of GDP, 2016-2039
(note the break in scale between 0.15 and 1.00 on the y-axis)

[21] Congressional Budget Office. (2016b). *The 2016 Long-Term Budget Outlook*. Washington, D.C. Projections in GDP are taken from the Congressional Budget Office (2016b) report on long-term spending, in constant 2016 dollars.

[22] During the peak cost of modernization in 2025, the United States will spend almost 41 times as much on social security than it will on nuclear defense - inclusive of research, development, engineering and operation costs. At this peak, nuclear modernization will comprise 5.48% of defense spending but only around 0.14% of GDP. When the modernization program finishes and costs return to current levels in 2039, expected spending on Medicare will be 54 times that of nuclear defense spending.



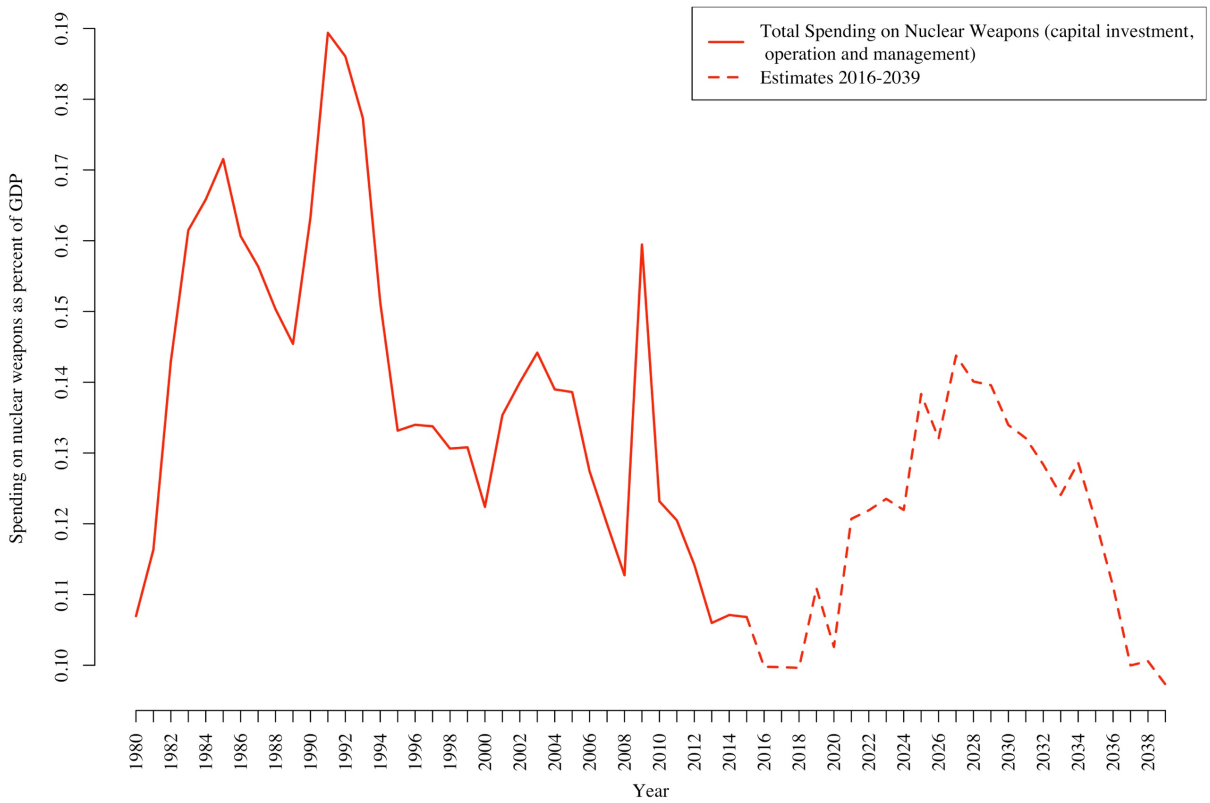
Sources: Congressional Budget Office (2016a,2016b), Harrison, T., & Montgomery, E. B. (2015)

Figure 6 illustrates the history of nuclear modernization's actual and estimated costs between 1980 and 2039.[23] Nuclear modernization will drive the increase in spending, but these costs will remain well below the historical spending levels seen between 1983-1992, even at their projected peak between 2025-2030. The increases in costs is not expected to be a persistent feature of spending, as spending on nuclear forces in total will return to current spending levels (around 0.10% of GDP).[24]

Figure 6: Total Investment and Operational Spending on Nuclear Forces, 1980-2039

[23] Forecasts are from Congressional Budget Office's (2016b) long-term budget outlook and they expect a 2% increase in GDP growth. GDP after 2015 is in constant 2016 dollars.

[24] In 1985, at the height of capital investment in nuclear and other defense, the United States spent 2.25 times more on transportation than on maintaining and improving the nuclear stockpile. By 2015, the United States was investing 11 times more on transportation than in nuclear weapons. During the first peak of military spending since 1980, the United States spent about 23 times as much on conventional military spending than on nuclear and other defense. For recently, during the latest peak in military spending, the United States spent 195 times as much.



Source: Office of Management and Budget (2016), Congressional Budget Office (2016a), Harrison, T., & Montgomery, E. B. (2015)

Conclusions

Two conclusions follow from this short research paper. First, the Program of Record for nuclear modernization will not replicate the Cold War force; instead, it will result in a force that is substantially smaller, with far fewer weapons, delivery systems, and weapon types. Second, the Program of Record will require spending increases over the next two decades. But relative to other major category spending, these increases would represent a small part of total defense spending and are modest relative to some other major spending priorities.

Appendix:

Figures 3 & 4: These data are drawn from tableas in the OMB Historical Tables titled "National Defense Outlays for Major Public Direct Physical Capital Investment: 1940-2017" and "Composition of Outlays for Grants for major Public Physical Capital investment: 1941-2017". While the OMB docment "Introduction to the Historical Tables" does not define what "Other Defense" is, it likely refers to counterterrorism activities that are considered defense funding but that is passed to other agencies, like the FBI, DOJ, or CIA. The OMB considers traditional defense funding as subfunction code (051), which includes budget items for military personnel, operation and maintenance, procurement, research, development, test, and evaluation, military construction and family housing. Meanwhile, atomic defense is its own subfunction code (053), which involves the DOE. "Defense Related Activities" are considered (054) counterterrorism activities, which involves funding for the salaries and expenses for the Federal Bureau of Investigation, Department of Justice, Department of Homeland Security, and the Privacy and Civil Liberties Oversight Board. Table 9.4 of the Historical Tables discusses defense outlays in public capital investment. The table sort defense investments in two categories, "military" and "atomic energy and other defense."

Given that the OMB categorizes defense spending by these three codes, it would make sense to sort atomic defense and defense related activities to the "Atomic Energy and Other Defense" category while the primary subfunction code for personnel, construction, military family housing is associated with the "Military" Category.

Because the codes filed under "Defense Related Activities" are not capital intensive or require substantial amounts of money as opposed to the creation of infrastructure or related weapon systems, it is likely that those defense related activities would comprise a small amount of the total capital investment. As operating nuclear weapons labs and creating the infrastructure for testing is critical, it is very likely that most of those funds are dedicated to Atomic Energy Defense.

The OMB also provides outlays by subfunction, presenting the total amount spent on conventional and atomic defense. These comparisons are presented in Figures A1 and A2 in this section. Note that this includes all spending, including the costs of non-proliferation and environmental clean-up costs as well. While costs increase, bear in mind that the costs of maintaining older equipment increases as the availability of crucial components declines. It does not mean that nuclear weapons were being continually developed or that new versions were created.

Figure A1: Total Spending Select Categories, 1980-2017

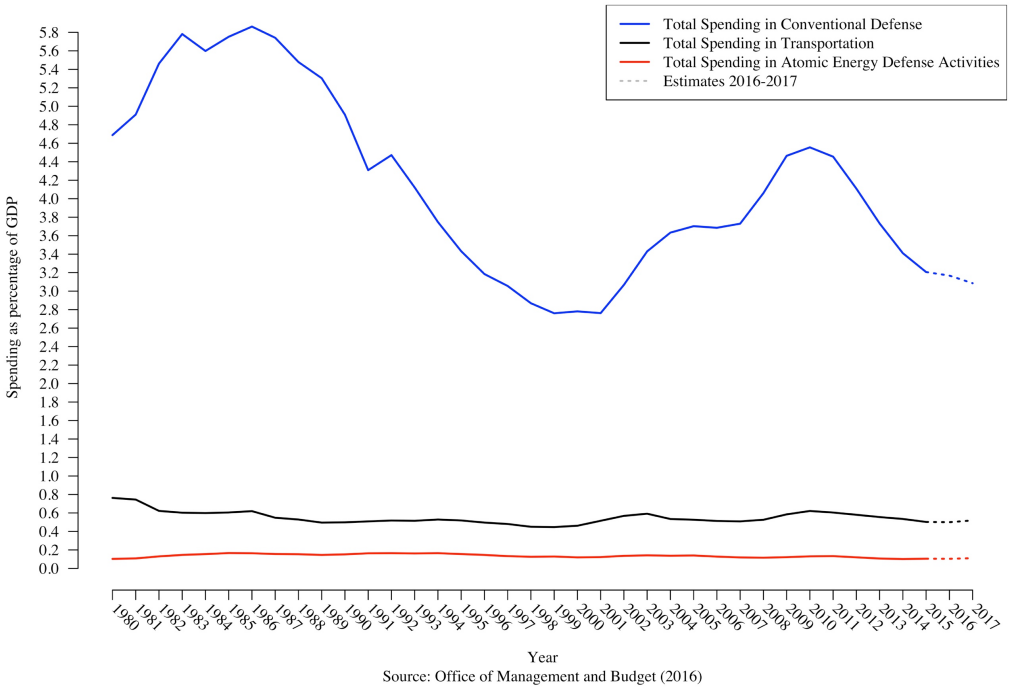


Figure A2: Total Spending in Conventional and Atomic Defense, 1980-2017