ARMS CONTROL ASSOCIATION
The authoritative source on arms control

Published on *Arms Control Association* (http://www.armscontrol.org)

After the Reliable Replacement Warhead: What's Next for the U.S. Nuclear Arsenal?

- Arms Control Today
- Strategic Policy
- U.S. Nuclear Weapons
- Weapons Research & Development
- Features

Jeffrey Lewis

The Reliable Replacement Warhead (RRW) as envisioned by the Bush administration is effectively dead. This past fall, for the second year in a row, the Democratic Congress zeroed out funding for the RRW program despite Bush administration claims that extending the life of the current warhead types in the U.S. nuclear stockpile would, at some distant point in the future, lead to a sharp uptick in aging-related defects.

Lawmakers refused to appropriate $10 million intended "to enable maturation of the design," to resolve questions about certification, and to document past work.[1] As a candidate, President-elect Barack Obama told *Arms Control Today* in answers to written questions that he "will not authorize the development of new nuclear weapons and related capabilities."[2]

This might seem like the end of the story. After all, independent assessments have concluded that the United States today has a stronger basis for confidence in its stockpile of nuclear weapons than at any time in history. Officials at the National Nuclear Security Administration (NNSA) have stated that any aging-related concerns with the country's nuclear stockpile are not expected to emerge for decades, if then. The United States spends billions a year on stockpile stewardship activities, including extensive surveillance and testing of components.

Yet, President Obama will have to articulate a strategy for sustaining the safety, security, and reliability of the stockpile that is capable of commanding bipartisan support. Such a strategy will be essential to supporting other goals articulated in the campaign, including further strategic arms reductions with Russia and working with the Senate to secure the ratification of the Comprehensive Test Ban Treaty (CTBT) "at the earliest practical date."

The Origins and Problems of RRW

Despite the high level of confidence in the stockpile today, a pessimist might be concerned about maintaining that confidence indefinitely without the Cold War practice of designing, yield testing, and manufacturing new nuclear weapons designs on a continuous basis. These concerns prompted Congress in 2004 to create the RRW program to "improve the reliability, longevity and certifiability of existing weapons and their components."

In response to this congressional guidance regarding existing weapons and their components, the NNSA proposed the activities that we now associate with the RRW program: a multiyear effort to introduce a series of new warhead designs into the U.S. stockpile, beginning with the WR1, that would be optimized for high-performance margins, incorporate modern and enhanced security features, and be easier to manufacture, while allowing the NNSA to modernize the nuclear weapons complex.

This conception significantly exceeded the scope and purpose of the original congressional language.[3] In doing so, it introduced unappealing technical and political risks, as well as significant additional costs. Although the stated purpose of the program was to reduce the need for nuclear explosive testing, independent reviews could not assure that the NNSA would be able to certify WR1 without such tests. Furthermore, although administration officials claimed that a more reliable warhead would allow a significant reduction in stockpiled nuclear weapons, the perception that the United States was building a "new" nuclear weapon for the first time since the end of the Cold War overshadowed the administration's announcement that it would reduce the stockpile to levels not seen since the Eisenhower administration. In response, Congress gave the RRW program a cold reception, culminating in the denial of funding for the program in each of the past two years.

Despite Obama's stated views and congressional opposition, RRW advocates are likely to renew their efforts to move forward with WR1 either under the name of the RRW program or some other guise. Indeed, Secretary of Defense Robert Gates recently described the long-term outlook for the stockpile as "bleak," warning that "the information on which we base our annual certification of stockpile grows increasingly dated and incomplete."[4]

Rather than simply renewing efforts to fund the specific WR1 design, the Obama administration should instead implement a comprehensive strategy to address, in an orderly fashion, the broad questions raised in debates about the RRW program. A systematic investigation would have at least three major elements:

- A comprehensive review of U.S. nuclear weapons strategy, culminating in presidential decisions about the purpose and size of the U.S. nuclear weapons stockpile through 2016.

- An independent assessment of the past 15 years of the Stockpile Stewardship Program (SSP), including whether the United States could maintain the stockpile following ratification of the Comprehensive Test Ban Treaty (CTBT).

- An expanded stockpile stewardship program (Stockpile Stewardship Plus) that would investigate, should current Life Extension Programs (LEPs) prove infeasible or undesirable, alternatives to certify the entire arsenal for the foreseeable future. The expanded program would consider the full spectrum of stewardship options from LEPs that are even more conservative than those in the present program to the new designs with new pits envisioned under the RRW program.

These efforts would put future administrations in a sound place to make technically informed judgments about the most cost-effective and appropriate way to maintain the stockpile within a political context that commands broad, bipartisan support.

What Kind of Nuclear Arsenal?

Clearly, the first question that needs to be answered focuses on the role of nuclear weapons today and the numbers and types of arms that are needed for this purpose. Nuclear weapons are increasingly weapons of last resort. In today's world, it is difficult to imagine nuclear weapons serving any role other than to deter attacks using nuclear weapons against the United States and other nations. This may not be U.S. declaratory policy, but deterring nuclear attacks is the only mission for nuclear weapons capable of commanding bipartisan support in Congress.

The administration, however, failed to grasp how the declining role of nuclear weapons would shape the reception to WR1. In fact, administration officials failed to offer a coherent rationale for the U.S. nuclear arsenal and the role of the RRW program within it. Representative Pete Visclosky (D-Ind.), chairman of the House Appropriations energy and water subcommittee, decried what he said was a "vacuum" in administration thinking. "There was no new strategy behind it. There was no plan for what the weapons were to be used for, how many there were to be, or how they were to be made," Visclosky said.[5] The administration also ignored efforts by Congress to communicate that old arguments were now falling on deaf ears.

In the absence of a consensus on the role of nuclear weapons, Congress settled for second best, mandating that any nuclear weapons have the same "military characteristics" as the ones they replace.

In response, the administration chose a design for the RRW with the same yield for the weapon but that subsequently altered other aspects of the warhead. Perversely, in relaxing "Cold War design constraints," the Department of Energy appears to have proposed a warhead that would be significantly more capable against hard targets such as Russian missile silos than the warhead it would replace. (See sidebar) The administration ended up seeming to contradict not only congressional guidance but its own assertions that Russia is no longer an adversary and the United States does not target Russia as though it were a smaller version of the Soviet Union.

Reducing yield requirements might allow designers to improve reliability, surety, and ease of manufacture. Moreover, sacrificing some yield might have allowed the U.S. Navy to reuse existing MK4 aeroshells, saving as much as several hundred million dollars.[6] Yet, there is no evidence that the NNSA seriously considered relaxing the yield requirement beyond a few percentage points or thought more broadly about the purpose of the weapons. Instead, by focusing on replicating the existing yield of the W76, the Bush administration opened the United States to criticism that it is improving the U.S. arsenal. Even if U.S. officials and lawmakers understand that a better hard-target kill capability was not the Bush administration's intention, other countries can easily make calculations similar to those outlined here and reach more cynical conclusions about U.S. motives.

Time for an Independent Assessment of the SSP

The Clinton administration created the SSP in 1993 as a science-based effort to sustain the stockpile without the continuous process of designing, testing, and building new nuclear warheads. The approach was to use computational and diagnostic tools to replace the role of nuclear testing. The scientific understanding of nuclear explosions and tools developed under the SSP underpin both the current LEPs as well as the prospect of certifying a new design, such as the WR1, without nuclear testing. Despite the central importance of the SSP, neither the Bush administration nor Congress has commissioned a comprehensive, independent assessment of the program by a group such as the National Academy of Sciences (NAS) or JASON.[7]

A full and complete understanding of the SSP after its first 15 years is necessary to inform policy judgments about how best to maintain the stockpile in the coming years. It is worth noting how much has changed since the Clinton administration proposed the SSP (then called Science-Based Stockpile Stewardship) in 1993. For example, in 1993 and again in 1999 when the Clinton administration sought ratification of the CTBT, the directors of the national laboratories worried that the administration was counting on unrealistic advances in computing power to model nuclear explosions. Since then, as figure 1 (available in the print edition of *ACT*) illustrates, computing speed has increased by several orders of magnitude, vastly exceeding the 100 teraflop performance goal that the Energy Department established as necessary for stockpile stewardship.[8] Livermore's Bruce Goodwin, whose back-of-the-envelope calculation helped set the 100 teraflop standard in 1995, recently reflected on how ambitious that goal once seemed. "I remember handing my answer in, thinking that they would kick me out of the room because it was insane at the time," Goodwin told Nathan Hodge and Sharon Weinberger.[9] Los Alamos' new computer, RoadRunner, is an order of magnitude faster. The national laboratories are now in a position to answer some of the questions they raised in the 1999 debate over CTBT ratification.

Congress should seek a comprehensive review of "Stockpile Stewardship at 15," perhaps by an independent body such as the NAS or JASON, to inform discussions about the RRW program (and the CTBT). Any review should pay particular attention to two questions: Has overall confidence in the stockpile and the scientific basis for that judgment increased, decreased, or stayed the same after 15 years of the SSP? Can the United States maintain the safety and reliability of its stockpile in the absence of nuclear testing?

The NAS' "Technical Issues Relating to Ratification of the Comprehensive Nuclear Test Ban Treaty" concluded in 2002 that "confidence in the reliability of the stockpile is better justified technically today than it was" when the United States stopped testing in 1992.[10] This is an important fact, that despite aging weapons and a moratorium on testing, the basis for our confidence has improved over time.

Confidence should be distinguished from reliability.[11] The United States has never used yield testing to establish the reliability of nuclear weapons to any level of statistical confidence. Doing so would have required a cost-prohibitive number of nuclear tests. The laboratories have also never assigned a single numerical value to the reliability of weapons. Nuclear explosions remain too complex to model in their entirety. Instead, the United States has always relied on the judgment of experts to establish confidence in the fundamental soundness of the design and manufacturing processes used to make these weapons.

These experts have used the SSP to answer a number of questions, particularly how plutonium in the primary stage behaves during a nuclear explosion—the most worrisome of aging-related defects. Recent peer-reviewed studies have suggested that plutonium pits have lifetimes of at least 85-100 years.[12] As a result, the United States has as good or better confidence in the longevity of its thermonuclear primaries than it did in 1992. Similarly, the national laboratories have used the SSP to demonstrate that cast and wrought pits perform equivalently in current nuclear weapons designs. This finding in 2007 allowed the United States after an 18-year gap to re-establish the ability to make new, or "remanufactured," pits using cast pits.[13]

Although some officials have expressed concern that some of the weapons in the current nuclear stockpile were designed with "thin" margins, the national laboratories have made significant progress in recent years in improving the understanding of performance margins. The NNSA has instituted a program for "quantification of margins and uncertainties" (QMU) associated with key events during a nuclear explosion. During activities for the now-canceled W80 Life Extension Program, Livermore reported greater confidence in the performance of the 20-year-old weapon based on the results of QMU analysis.

When the Senate failed to ratify the CTBT in 1999, many senators explained that the SSP needed to be given more time to demonstrate that the United States could maintain the enduring stockpile warheads without testing. A decade later, it is time to answer that question definitively. The NAS also concluded in 2002 that "[t]he United States has the technical capabilities to maintain confidence in the safety and reliability of its existing nuclear-weapon stockpile under the CTBT, provided that adequate resources are made available to the Department of Energy (DOE) nuclear-weapon complex and are properly focused on this task."

Any comprehensive review of the SSP should consider the question of the reliability of the nuclear arsenal as a whole in the permanent absence of nuclear testing, i.e., under the CTBT, separately from the question of whether the WR1 can be certified without nuclear testing. Some have sought to establish an artificial linkage between the CTBT and the RRW program because both depend on the continuing success of the SSP. Yet, the question of whether the SSP is succeeding overall in its fundamental goals is a different question from whether the knowledge gained should be implemented in the form of life-extending existing warhead designs or fabricating new designs. We have time, perhaps more than a decade, to settle on the best strategy for maintaining the stockpile. On the other hand, the technical community is now in a position to make technical judgments about whether the SSP has made and will continue to make yield testing unnecessary for the maintenance of the stockpile into the foreseeable future.

"Stockpile Stewardship-Plus"

The United States currently has an active stockpile of approximately 5,000 nuclear weapons based on eight designs (the W62 will be retired by the end of 2009). All of these designs entered the stockpile before the end of underground nuclear testing in 1992.

The United States successfully completed an LEP for the W87 in 2004 and is currently conducting LEPs for two more nuclear weapons types. The W76, the warhead that is expected to account for perhaps 40 percent of the deployed force in the future, is undergoing an LEP that will extend its service life by at least 20 years.

Overall, the current LEPs appear to be working quite well. These programs involved changes to the warheads of varying extent. The LEP for the W87 was designated as an ALT, or alteration, because it did not involve significant changes to the operational characteristics of the warhead. The changes to the W76 are expected to be somewhat more extensive and will result in a different Mod, the W76-1.

The potentially negative effect of the accumulation of small changes to warheads during an LEP, however, is a plausible if somewhat esoteric concern. In some cases, materials are no longer manufactured or tacit knowledge has been lost. In other cases, materials are incompatible with worker health and environmental standards.

Under the SSP, the risk of such an accumulation is addressed through "change-control discipline," an effort to minimize to the greatest extent possible, as well as document, any change to the warhead, including the remanufacture of any components. Some efforts at replication may be simply too costly, dirty, or unsafe. In extreme cases, replication of archaic materials may be impractical. The W76 life extension effort illustrates the challenges in remanufacturing exotic, hazardous materials. The LEP was delayed for several months due to problems in reconstituting the ability to manufacture FOGBANK, a classified material used in the interstage of the W76, W78, and W80 warheads.

So far, the U.S. nuclear weapons complex has been able to reconstitute exotic manufacturing capabilities, including those to make plutonium pits and process FOGBANK. The SSP and the LEP process are stronger for having faced and overcome these challenges.

The RRW program is a philosophically distinct approach to stewardship than the LEP because the RRW program would forgo change-control discipline in search of larger design margins. The WR1, for example, was redesigned to do without FOGBANK. Although these approaches are fundamentally different in philosophy, the reality is that policymakers have many choices along a continuum running from efforts to replicate weapons exactly as they entered the stockpile to entirely new designs that have never been tested.

The current LEP and the WR1 fall along this continuum. The national laboratories should maintain the ability to perform work along a significant portion of this continuum, if only to diversify our options in the event that legacy warheads cannot be remanufactured sufficiently close to original specifications to permit certification. There is no need, however, to conduct this research by building a new design such as the WR1 at this time. Most of the challenging and important tasks currently proposed under the RRW program could be conducted as science campaigns in support of the current life extension process. This was the approach recommended by Congress, which directed the NNSA in the fiscal year 2008 energy and water appropriations legislation to establish an Advanced Certification Campaign to address concerns raised by JASON's review of the WR1 design.

This Advanced Certification Campaign is a template for what might be termed "Stockpile Stewardship-Plus." Along with similar campaigns for enhanced surety and ease of manufacture, Stockpile Stewardship-Plus would provide policymakers alternative options within the context of the current LEPs to address unanticipated technical problems, as well as those that might develop over decades. As a last resort, they could support a completely new design, either new pits or canned subassemblies, but this would not be the typical or primary contribution of an expanded SSP. After all, the goal of the RRW program was to increase confidence, surety, and ease of manufacture across the stockpile as a whole. Adding a single new warhead design with those features does not address the legacy systems that will remain in the stockpile for years into the future.

One example of where the SSP might support careful deviations from change-control discipline is the anticipated B61 Mod 3/4/10 LEP planned for 2010-2012. The B61 is the oldest design in the stockpile. It is also extraordinarily complicated. Each B61 has more than 6,000 parts in 1,800 subassemblies that were manufactured by 570 suppliers and nine primary contractors. Remanufacturing the B61 to original specifications is probably infeasible. One option that falls between current LEPs and the RRW program, proposed in a joint study by the American Association for the Advancement of Science, the American Physical Society, and the Center for Strategic and International Studies, is the extensive reuse of components from dismantled warhead types to extend the lifetime of those warheads that remain in the stockpile.[14]

Most of the B61 components lie outside of the nuclear explosive package and are therefore available for extensive testing and modification. The NNSA has also examined the feasibility of reusing pits in an LEP for the B61 3/4/10 LEP. One option might be to make use of the 200 or so W84 pits that remain in the strategic reserve. The W84 and W85 warheads were based on the B61 family, and recycled W85 pits have already been used in the B61-10. The W84 primary is reported to include a modern mechanical safing and arming device.

In this way, much of the excellent and creative technical work done in support of the RRW program can find its way into the important task of sustaining our legacy stockpile. It would also leave open the option, in extraordinary circumstances, of designing and manufacturing a completely new weapon. Such a step should be undertaken as a last resort, only if confidence in a particular type of legacy warhead that is critical to U.S. nuclear requirements were unacceptable and a replacement warhead design could be certified without testing. Other concerns, such as enhanced safety measures and ease of manufacturing, are not sufficient to justify the political and technical risks associated with manufacturing a new warhead.

Conclusion

Over more than 60 years of U.S. nuclear weapons policy, statements about the purpose of our nuclear forces have tended to lag behind the technical, bureaucratic, and political developments. Statements of purpose have provided a post hoc justification for the forces we have, rather than a prescription for the forces we need. Yet, the demise of the RRW program, in the face of technical and political concerns, suggests that the next president will have to embed any decision about sustaining the stockpile in an updated and forward-looking vision of the future role of nuclear weapons in U.S. security policy.

The RRW: Replacing or Improving the U.S. Arsenal?

Jeffrey Lewis

The Reliable Replacement Warhead (RRW) program's WR1 design was intended to replace, not improve, the W76 , one of two warheads that arm the U.S. D-5 submarine-launched ballistic missile and that will make up a significant portion, perhaps 40 percent, of the strategic nuclear weapons deployed by the United States once reductions under the 2002 Strategic Offensive Reductions Treaty are completed in 2012.

The W76 has a yield of approximately 100 kilotons, five times the size of the bomb that destroyed Nagasaki. The W76 entered the stockpile in 1979 at a time when the United States was increasing its military capabilities in response to the perception that the Soviet Union was seeking a capability to fight and win a nuclear war. It was meant to fix a perceived gap in the U.S. arsenal: Through the 1970s, the U.S. submarine force had little or no hard-target capability against Soviet missile silos. The relatively small and inaccurate warhead for the Poseidon was unable to hold Soviet hard targets at risk (see table 1 in the print edition of ACT).

Administration officials sold the WR1 as part of an effort to "relax" Cold War design constraints that placed a premium on keeping warheads light so many of them could be placed on a single missile. Yet by making the warhead heavier—it will have the same aerodynamic characteristics as the W88/MK5—the WR1 will also be more accurate than the W76/MK4. Military officials have testified that the WR1 will be slightly more accurate than the W76/MK4 to compensate for a small loss in yield. This is not surprising. A heavier warhead in the right packaging might have a higher ballistic coefficient, much as a rock drops straight down while a leaf drifts in the wind.

Initial calculations suggest that the heavier, more accurate WR1 may have a significantly greater capability against hard targets. As one can see in figure 1, I calculate that the W76 has a 43 percent chance ("single shot probability of kill") of destroying a target capable of withstanding up to 5,000 pounds per square inch (psi). In contrast, the WR1 would have a 55 percent chance of destroying the same target, roughly equivalent to placing a 160 kiloton warhead in the less accurate MK4 re-entry vehicle. In other words, the effect of replacing the W76 with the WR1 for a 5,000 psi target is the same as increasing the yield of the W76 by 60 percent. By the same calculation, had the National Nuclear Security Administration lowered the yield of WR1 to 60 kilotons, it would still have performed equivalently to the W76 against 5,000 psi targets. These comparisons are illustrated by the "hypothetical warheads" in Table 1 (available in the print edition).

To be clear, increasing military capabilities was not the intent of the RRW program. The ability to destroy a 5,000 psi target is not the only measure of capability, and there are more efficient means to increase the hard-target kill capability, including improved fuses that are being integrated as part of the W76 Life Extension Program. Still, the result is unfortunate.

U.S. Nuclear Weapons Designations

The United States uses the "mark-mod-alt" convention to identify nuclear weapons systems in its stockpile.

Mark (MK). The United States numbers nuclear weapons in a single, sequential series with a designation in the form of MKn (the MK is usually written as Wn or Bn, with W for "warhead" and B for "bomb"). The Nuclear Weapons Council assigns each number, n, sequentially by date of entry into Phase 2A of the nuclear weapons development cycle. Thus the B83 gravity bomb entered Phase 2A before the W88 missile warhead. The Nuclear Weapons Council apparently intended to restart this sequence with the first nuclear-weapon design selected from the RRW program, designating it WR1.

Modifications (Mod). Normally, changes in components that result in changes to operational characteristics, safety or control features, or technical procedures are designated with a Mod number, which the Nuclear Weapons Council also assigns sequentially. For example, Los Alamos repackaged existing B61 Mod 7 gravity bombs into an earth-penetrating steel case designed by Sandia, resulting in the designation B61 Mod 11. The first component set of a new MK is designated Mod 0, although the Mod 0 designation is usually omitted to avoid confusion if no other modifications exist.

Alterations (ALT). If changes in components do not result in changes to operational characteristics and the differences are transparent to military units and other users, the changes are designated as an ALT. For example, the development of new spin rocket motors for the B61 results in ALTs numbered 356, 358, and 359.

Click here to comment on this article.

Jeffrey Lewis is director of the Nuclear Strategy and Nonproliferation Initiative at the New America Foundation and publisher of the blog, ArmsControlWonk.com.

ENDNOTES

1. The Bush administration also requested $23.3 million for supporting work by the U.S. Navy. The House and Senate

defense authorization bills provide no funding for RRW work in this account, and the final bill provided no money for work at the Department of Energy either.
2. "*Arms Control Today* 2008 Presidential Q&A: Democratic Nominee Barack Obama," September 24, 2008, www.armscontrol.org/system/files/20080924_ACT_PresidentialQA_Obama_Sept08.pdf.
3. The House Appropriations energy and water subcommittee explained its decision in 2007 to zero out funding by noting that the "RRW program the [Department of Defense] and NNSA have pursued at the direction of Congress goes far beyond the scope and purpose of the original congressional language and intent."
4. Robert Gates, speech to the Carnegie Endowment for International Peace, October 28, 2008.
5. "Statement of Chairman Peter J. Visclosky, Subcommittee Markup: Fiscal Year 2009 Energy and Water Development Appropriations Act," June 17, 2008, www.house.gov/list/press/in01_visclosky/pr080617.html.
6. Elaine M. Grossman, "New Warhead Might Require New Shells, Navy Says," Global Security Newswire, November 1, 2007.
7. JASON is an independent scientific advisory group that conducts studies on science and technology issues relating to national defense for the U.S. government.
8. For a version of this chart with a logarithmic y axis, see http://www.armscontrolwonk.com/1912/roadrunner.
9. Nathan Hodge and Sharon Weinberger, "A Nuclear Family Rivalry," *Slate*, July 13, 2005, www.slate.com/id/2122382/entry/2122493/.
10. National Academy of Sciences, "Technical Issues Related to the Comprehensive Nuclear Test Ban Treaty," 2002.
11. Robert W. Nelson, "If It Ain't Broke: The Already Reliable U.S. Nuclear Arsenal," *Arms Control Today*, April 2006, pp. 18-24.
12. See Jeffrey Lewis, "3 Studies Show Pu Pits Age Well," ArmsControlWonk, November 29, 2006, www.armscontrolwonk.com/1307/3-studies-show-pu-pits-age-well.
13. Until the closure of Rocky Flats in 1989, U.S. pits were machined.
14. American Physical Society, American Association for the Advancement of Science, and the Center for Strategic and International Studies, *Nuclear Weapons in 21st Century U.S. National Security* (forthcoming).