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If it Ain't Broke: The Already Reliable U.S. Nuclear Arsenal

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The Bush administration through the Department of Energy has proposed developing new family of nuclear warheads to replace the aging weapons in the current U.S. nuclear stockpile. The Reliable Replacement Warhead (RRW) program is intended tc improve the "reliability, security, and longevity" of the U.S. nuclear arsenal without requiring the United States to resume nuclear testing.[1]

The Energy Department's ambitious plans would reorient the primary post-Cold War mission of the U.S. nuclear weapons laboratories from stockpile maintenance to the development of new replacement warhead designs.

At first glance, the RRW program seems a promising solution to the long-term maintenance of the U.S. nuclear stockpile. The stated goal is to develop new replacement warheads that will be easier and less costly to maintain than current weapons, will be more reliable and easier to certify, and will meet modern safety and environmental requirements. Moreover, the Energy Department contends that the program could help support future steep reductions in the total number of U.S. nucle weapons by increasing confidence in the effectiveness of the remaining arsenal.

On closer examination, however, the RRW program seems premature and inherently risky. As administration officials have repeatedly testified, the warheads in the curren well-tested U.S. nuclear stockpile are already highly reliable, more so than the missil that deliver them. Simple changes to existing procedures could increase war head "performance margins" even more . By contrast, even the modest design changes envisioned under the RRW program, ultimately intended to replace large parts of the U.S. nuclear deterrent with untested warheads, will inevitably lead to renewed demands that the United States resume underground nuclear explosive testing. This would encourage other countries, such as China, to resume their own nuclear testing programs and allow them to improve the capabilities of their own nuclear weapons.

Additionally, if the ultimate goal is to reduce the number of nuclear weapons in the U. arsenal, Congress and other policymakers should first re-examine the requirements dictated by the nation's outdated nuclear targeting doctrine. Current U.S. nuclear planning requires the ability to threaten thousands of sites in Russia, China, and elsewhere. It also demands that warheads be far more predictable than other weapo components. Rather than funding a new and costly weapons program, lawmakers would be better served if they confronted the need to end an irrational nuclear targeting doctrine a decade and a half after the end of the Cold War.

The Current U.S. Nuclear Arsenal and Stockpile Stewardship

The United States has not deployed a new nuclear warhead since 1989. The last U.S underground nuclear explosive test occurred in September 1992. Later that year, President George H. W. Bush halted further design work on new nuclear weapons ar signed legislation initiating a moratorium on nuclear testing. As a result, the U.S. nuclear weapons laboratories underwent a fundamental change in mission, from an earlier focus on developing and testing new warhead designs to their current focus o maintaining the U.S. nuclear stockpile without nuclear testing.

As of January, the United States possessed nearly 10,000 nuclear warheads. Approximately 5,700 warheads based on nine design types are currently deployed or missiles, bombs, and other operational weapons or otherwise maintained in ready-to-use status. The United States also maintains a reserve stockpile of approximately 4,200 inactive warheads.[2] Although it greatly reduced the number of its deployed nuclear weapons at the end of the Cold War, the United States chose to keep a stockpile "hedge," arguing that additional weapons might be needed if a serious performance problem were ever discovered in an entire class of deployed warheads or if it faced a renewed strategic threat, such as a nuclear buildup by a resurgent Russia and needed to deploy a larger arsenal rapidly.

Whether the United States could maintain its nuclear deterrent without conducting nuclear explosive tests was hotly debated during the 1990s, but a key endorsement came from the JASON committee, a prestigious group of academic and industrial scientists that has advised the U.S. government for decades. The JASON commit tee determined that, under a ban on nuclear explosive testing, the United States could "have high confidence in the safety, reliability, and performance margins of the nuclear weapons that are designated to remain in the enduring stockpile." In reaching this conclusion, the group explicitly assumed that the United States would not need to develop new nuclear weapon designs. They also warned that the laboratories should not try to make changes to existing weapons: "greatest care in the form of self-discipline will be required to avoid system modifications, even if aimed at 'improvements,' which may compromise reliability."[3]

The Energy Department currently maintains U.S. nuclear warheads through the Stockpile Stewardship Program, a $6.4 billion per year research, engineering, and monitoring program designed during the Clinton administration to maintain the long-term safety, reliability, and security of the U.S. nuclear arsenal without nuclear explosive testing. Each year, 11 sample weapons of each of the nine warhead types are subjected to an extensive series of tests to ensure they will perform as designed and that no age-related problems have developed.

In some cases, nuclear warheads have been rebuilt as part of the stockpile Life Extension Program: engineers refurbish existing nuclear warheads by fixing or replacing the non-nuclear components before aging-related changes jeopardize warhead safety or reliability. Weapons are rebuilt as closely as possible to original specifications, minimizing design changes that could reduce confidence in the reliability of these weapons.

As a result of this approach, since 1997 the secretaries of defense and energy each year have been able to formally certify to the president that the U.S. nuclear stockpile continues to be safe and reliable. As Linton Brooks, administrator of the National Nuclear Security Administration, said recently, "[The] Stockpile Stewardship [Program] is working. We are absolutely convinced today's stockpile is safe and reliable."[4]

Despite the acknowledged success of the Stockpile Stewardship Program, however, some officials at the Energy Department and at the nuclear weapons laboratories have never been happy with restrictions that prevent them from working on new and more exotic warhead designs. Over the last several years, the Energy Department has sought authorization and funding from Congress—sometimes successfully, sometimes not—to begin design work on new low-yield nuclear weapons (mini-nukes),[5] a Robust Nuclear Earth Penetrator for destroying deeply buried and hardened targets,[6] a Modern Pit Facility capable of rapidly producing the plutonium cores of new warheads,[7] and a reduction in the time needed to prepare and conduct an underground nuclear test.

The RRW program seems to be the latest and most ambitious Energy Department proposal yet. If approved, it would certainly keep the nuclear weapons laboratories fu engaged and funds flowing for many years.

RRW Origins

The RRW program emerged in its current form from the Energy Department's fiscal year 2005 budget request. The Energy Department had asked for funds to study new warhead designs through the Advanced Concepts Initiative. Not wanting to fund a program that he believed distracted the laboratories from their primary steward ship mission, Rep. David Hobson (R-Ohio), chairman of the House Appropriations Energy and Water Subcommittee, zeroed out the $9 million Advanced Concepts Initiative request. Instead, he provided equivalent funding, later increased to $25 million, for a

RRW program intended to "improve the reliability, longevity, and certifiability of existir weapons and their components." Hobson believed the program would "challenge the skills of the existing group of weapons designers…without developing a new weapon that would require under ground testing to verify the design."[8]

In fact, the RRW program appears to be a broadly expanded version of an earlier Navy/Energy Department collaboration, which focused on developing replacement warheads for the Trident missiles with designs that would have "decreased sensitivity to aging, increased design margins, [and] increased ability for surveillance" but could be "certified without an underground nuclear test."[9]

Hobson's subcommittee further made clear its intent to avoid a return to nuclear testii by requiring in its report that "any weapon design work…must stay within the military requirements of the existing deployed stockpile…and within the design parameters validated by past nuclear tests."[10]

These provisions were elaborated in the statutory requirements of the fiscal year 200 defense authorization bill that governs current spending.

Almost immediately, the weapons laboratories enthusiastically endorsed the RRW program and greatly expanded its vision. The directors of the national laboratory weapons programs explicitly endorsed an article by four weapons scientists describin the RRW program as a means of "Sustaining the Nuclear Enterprise" while portrayinç the goals of the Stockpile Stewardship Program as "increasingly unsustainable."[11] They argued the laboratories "should shift from a program of warhead refurbishment one of warhead replacement."[12] The Secretary of Energy Advisory Board further described the RRW program as "the first of a family of warheads" for a stockpile that "continuously modernized through a series of design-production cycles that would al low the stockpile to meet an evolving or changing threat environment."[13]

Furthermore, the Energy Department's request for the RRW program is just one part a more ambitious program that will enable the nuclear weapons complex to transforr to a "responsive nuclear weapons infrastructure" capable of quickly producing new warheads "on a timescale in which geopolitical threats could emerge." The most immediate proposal is to re-establish the capability of designing and manufacturing tł plutonium triggers for nuclear weapons on a large scale. Although the Energy Department does not propose funding for a Modern Pit Facility in its current fiscal yeɛ 2007 budget request, the facility remains a long-term goal.[14]

The budget request describes the RRW program as a program aimed at "identifying [nuclear warhead] designs to sustain long- term confidence in a safe, secure, and reliable stockpile." Lawrence Livermore and Los Alamos National laboratories are reported to be in a warhead design competition for replacements for the W76 and Wɛ warheads used in the submarine-launched Trident I and II missiles.[15]

Congress clearly intended the RRW program to be limited to improvements in existin weapons, but some reports describe the RRW program as potentially leading to weapons with new, more exotic capabilities. The Defense Science Board, for exampl recently endorsed the RRW program as part of a larger effort to develop weapons thɛ would produce "special effects," such as enhanced electromagnetic pulse, enhanced neutron flux (a new neutron bomb), and reduced fission-yield (low- radiation) weapon [16] Advanced weapon effects like these would clearly involve designs that would ha to be tested before entering the stockpile.

Faulty Assumptions

The Energy Department claims that the weapons labs could certify any new RRW design as long as it remains well within the parameters of previously tested designs. a March 1 hearing of the House Armed Services Committee, Brooks testified that weapons designers are "confident that their designs will meet our requirements and t certifiable without nuclear testing."

But the Energy Department's plans for the RRW program are based on a set of misleading and faulty assumptions that, if acted on, are likely to worsen rather than improve U.S. national security.

Assumption 1: Stockpile Reliability is Degrading.

First, the very name, "Reliable Replacement Warhead program," wrongly suggests th existing U.S. weapons may be unreliable and need to be replaced. Indeed, the weapons laboratories have reinforced this perception with vague and speculative assertions: "Over the longer term, we may face concerns about whether accumulatec changes in age-affected weapons components, whose replacements might have to b manufactured by changed processes, could lead to inadequate performance margins and reduced confidence in the stockpile."

In fact, there is nothing unreliable with the nuclear weapons the United States alread maintains. As a result of the Stockpile Stewardship Program's basic research efforts, weapons scientists understand the performance and reliability of U.S.nuclear warheads better today than they did when full-scale nuclear weapons tests were allowed. Further, the Energy Department has offered no public evidence to suggest tl Stockpile Stewardship and the Life Extension Programs have been anything but remarkably successful.

To the contrary, Seymour Sack, one of the nation's most prolific weapon scientists wl designed most of the nuclear primaries in the current nuclear arsenal, asserts, "We'v got a reliable stockpile. We have a test base for it. We have now in the last 10 or 15 years far more sophisticated computational abilities than we had doing these designs originally, so things are extremely well understood in terms of the performance.... I don't see any reason you should change those designs."[17]

Indeed, the critical nuclear components appear to be lasting longer than originally expected. Earlier concerns that the plutonium pits would be damaged by self-irradiation as they age have not yet been realized. The Energy Department is scheduled to release the results of these "accelerated aging" experiments later this year, but administration officials have already hinted that minimum pit lifetimes are likely to be much longer, and initial reports have suggested lifetimes in excess of 90 years.[18]

Moreover, the JASON committee suggested as early as 1995 a simple way to improv the warhead "primary performance margins" simply by changing the composition of tl tritium boost gas or by replacing it more frequently.

Assumption 2: Design Changes Can Be Made Safely, Cheaply, and Without Nuclear Tests.

Second, there are few design changes the laboratories could make to existing weapons without compromising safety or other military requirements and without requiring nuclear test explosions.

When the United States still conducted nuclear tests, any new or modified warhead was required to undergo a series of nuclear explosive tests during the development and production phases before it could be certified to enter the stockpile. Indeed, a 1991 report to Congress estimated a minimum of three to four nuclear explosive tests would have to be conducted in order to certify a replacement warhead for the W88.[1

In contrast, the RRW program proposes to make changes to the nuclear explosive package itself, the core of the weapon containing the fissile and thermonuclear materials.

Weapons designers could increase the predictability of the primary by adding additional plutonium and increasing the amount or altering the type of the chemical high explosive that initiates the explosion. Doing so, however, would have a ripple effect on other relevant design dimensions for warheads: their weight, size, shape, ar safety.

The Department of Defense requires that any new warhead not alter the aerodynami characteristics of the re-entry vehicle that would carry it to its target. Current warhead were designed to minimize size and weight so that multiple warheads could fit on lon range ballistic missiles as well as to meet minimum safety requirements. Adding additional plutonium or high explosive to current designs would make warheads heavier or larger than existing weapons or alter their shape. If the warhead has a different shape or has its mass distributed differently than current designs, it might affect how the re-entry vehicle flies. The Defense Department would then be faced wi the major expense of either recertifying that the re-entry vehicle achieves its military goals or designing and flight-testing a new re-entry vehicle to accommodate the new warhead.

In fact, the Navy in 1993 considered and rejected the opportunity to upgrade the safe of the W88 warhead to use insensitive high explosive in large part because of the expected cost required—$3.8 billion in 1993 dollars—to retrofit the Trident third-stage rocket motor. Redesigning a new re-entry vehicle or even a new bus for the Trident missile could be far more expensive than developing a new warhead.

A new design might also create new safety concerns. U.S. nuclear weapons are required to be "one point safe"—having a very small probability of generating a nucle explosion if struck by a bullet or projectile, for example, or if exposed to a high temperature fire or a nearby chemical explosion. Yet, adding plutonium to in crease "reliability" would bring the primary fission device closer to its critical mass, making it easier to detonate at full yield. This would increase the primary performance margins but it would also increase the probability that the warhead could detonate accidentally and hence be less "safe." As a consequence, designers are limited to how much they can increase performance margins without undermining existing safety restrictions.

Assumption 3: The RRW Program Will Mitigate, Not Increase, Political Pressure to Test.

Finally, even if the nuclear weapons laboratories somehow manage to stay within the design parameter "space" of previously tested warheads and produce nuclear primaries with higher performance margins, there would be tremendous political pressure for the United States to conduct nuclear explosive tests before new warhea can enter the stockpile. After all, the Senate failed to ratify the Comprehensive Test Ban Treaty (CTBT) in 1999, in part because of skepticism that the laboratories could guarantee confidence in the existing well-tested stockpile without continued testing. The U.S. nuclear arsenal is based on 50 years of research and more than 1,000 underground nuclear tests. It is implausible that that the Pentagon or a future Congress would accept new war heads, ultimately replacing the entire U.S. nuclear arsenal, based on designs that have never been tested.

As Sidney Drell, a physicist and longtime adviser to the government and the nuclear weapons labs, has said, "I can't believe that an admiral or a general or a future president, who are putting the U.S. survival at stake, would accept an untested weapon if it didn't have a test base."

A worldwide resumption of nuclear testing would decrease U.S. security. Were the United States to resume underground nuclear testing, it is highly likely that Russia, China, and other countries would resume their own test programs as well. Those countries could improve their own nuclear arsenals far more than could the United States if there was a return to testing. Resumed testing by China, for example, would help it to miniaturize its own warhead designs, allowing it to deploy multiple warheads placed on a single missile. Such a breakdown in the moratorium would also profound undermine efforts to limit nuclear proliferation.

A Look at Targeting

Warhead reliability ultimately enters the Pentagon's nuclear war-fighting calculations predicting the mathematical likelihood that a planned nuclear strike will destroy its intended target. Although specific numbers are classified, a U.S. nuclear warhead is thought to be required to detonate with an energy within 10 percent of their design yield, under worst-case battlefield conditions.

Yet, the target "damage expectancy" depends on more than just the precise size of th explosion. It depends far more, in fact, on the performance of the non-nuclear components of the weapon, particularly the accuracy of the final re-entry vehicle in reaching its target. An improvement in accuracy by a factor of two, for example, decreases the required explosive yield al most by a factor of three. It hardly matters, for example, if the W76 warhead detonates with a yield of 100 kilotons or 90 kilotons, when a 35-kiloton explosion will do.

The reliability of these non-nuclear components is high, but their uncertainty still greatly exceeds any uncertainty in the reliability of the core nuclear package. In order to increase the damage expectancy significantly, the Pentagon would have to redesig and improve the reliability of all of these components at very great expense.

Rather than doing that, the Pentagon builds in a great deal of redundancy as it select weapons and modes for any particular targeting scenario. It may increase the yield oı the number of weapons targeting a particular site to hedge against any uncertainty.

So, ultimately the size of the U.S. nuclear arsenal and the need to maintain a large hedge of inactive warheads derives not from small uncertainties in the precise yield o our stockpiled weapons, but in the belief that the United States needs to maintain the ability to put at risk the thousands of sites on its current target list. Before initiating a major rebuild of the U.S. nuclear stockpile, Congress and other policymakers should re-examine the implications and logic of the U.S. nuclear targeting posture.

The Role of U.S. Nuclear Weapons

Almost 15 years ago, President George H. W. Bush determined that the United State had no need to continue to design new nuclear weapons. This policy made it possible for the United States to push for an end to the development and testing of new nucle weapons by all countries and to negotiate the CTBT. Although the Senate has not ratified the CTBT, the global moratorium on nuclear testing still stands and has prevented other countries, such as China, from advancing their own thermonuclear designs.

A great danger, as Congress and other policymakers consider the merits of the RRW program, is that they may accept the false premise that the U.S. nuclear deter rent is already degrading. If this happens, there will be tremendous pressure for the United States to resume underground nuclear testing whether or not a more reliable warhea could technically be developed without testing.

The debate over the RRW program also obscures a more fundamental and practical development: the utility of U.S. nuclear weapons is receding in importance with high-precision conventional weapons increasingly capable of accomplishing many mission that, until recently, would have required nuclear yields. Given that the United States has overwhelming superiority in conventional weaponry, U.S. military strength is undercut, not enhanced, by actions that ascribe greater importance to nuclear weapons. If the world's greatest military power continues to rely on nuclear weapons, then why would countries that the United States considers to be a threat not see ever greater reason to acquire nuclear weapons of their own?

What Does Reliability Mean?

Robert W. Nelson

What does it mean for a nuclear warhead to be "unreliable"? To the Departments of Energy and Defense, a warhead is considered un reliable if it risks detonating with an explosive energy slightly different from its design yield even if it still is guaranteed to destroy its target. But any uncertainty in the target "kill probability" stems primarily on the non-nuclear components of the weapon.

The official Energy Department definition of nuclear weapon reliability is "the probability of achieving the specified yield, at the tar get, across the Stockpile-to-Target Sequence of environments, throughout the weapon's lifetime, assuming proper inputs."[1]

The "specified yield" is a classified number for each warhead, but it has historically been understood to mean the design yield "with an allowable variation of 10 per cent." In other words, if there is more than a minimal probability that a 350-kiloton warhead might detonate with a yield less than 315 kilotons or greater than 385 kilotons, that warhead would be considered unreliable even if it was certain to destroy its intended target.

A reliable warhead must be able to operate in the "hostile environment" of a nuclear battlefield. "Across the Stockpile-to-Target Sequence of environments" means the war head must survive the intense temperature and radiation effects of other nuclear detonations, for example, if an enemy were to develop a nuclear-tipped missile defense. The warhead also must function "throughout the weapon's lifetime," even under the worst-case scenario where its tritium boost gas is at its lowest level.

Yet, these reliability requirements on the nuclear explosive package itself are reportedly more stringent than on the missiles' delivery systems. These requirements are quantified in the damage expectancy, the mathematical likelihood that a planned nuclear strike will destroy its intended target. The damage expectancy depends not only on the warhead's explosive yield but on the overall weapon performance: a successful missile launch, the separation of the first and second missile boost stages, the performance of the missile guidance system, the disengagement of the multiple re-entry vehicle warhead from the missile bus, and the accuracy of the final re-entry vehicle in reaching its target. These damage expectancies, in turn, are embedded in the thousands of lines of computer code used in the Single Integrated Operation Plan (SIOP), the Pentagon's comprehensive plan to conduct thermonuclear war.[2]

Any remaining uncertainty comes far less from the warhead's nuclear components than its non-nuclear-components: the arming and fusing mechanism, the chemical high explosive, and the neutron initiator. These are regularly tested without explosive nuclear tests as part of the stockpile maintenance program. As long as these non-nuclear components perform correctly, current U.S. nuclear weapons are extremely reliable.

According to the National Academy of Sciences, if the firing, neutron-generator, and boost-gas subsystem function within their specified tolerances, the nuclear subsystems in the enduring stockpile historically have been certified to achieve the specified yield range with 100 percent certainty over the entire range of specified stockpile-to-target sequences."[3]

ENDNOTES

1. R. L. Bierbaum et al., "DOE Nuclear Weapon Reliability Definition: History, Description, and Implementation," Sandia National Laboratories, April 1999. See S. I. Schwartz, "Defining Reliable," *Bulletin of the Atomic Scientists* (March/April 2001), pp. 55-56.

2. The United Sates has actually formally changed the name of its strategic nuclear war plan. Known throughout the Cold War as the Single Integrated Operations Plan, it is now known as Operations Plan 8044. See Robert S. Norris and Hans Kristensen, " U.S. Nuclear Forces, 2006," *Bulletin of the Atomic Scientists* (January/February 2006), pp. 68-71.

3. National Academy of Sciences, "Technical Issues Related to the Comprehensive Test Ban Treaty," 2002, p. 25.

Improving Warhead Reliability: Boosting the Boost Gas

Robert W. Nelson

During the Cold War, the U.S. nuclear weapons laboratories developed more than 100 types of nuclear warheads and conducted more than 1,000 nuclear explosive tests.

Their primary goal was to develop ever- smaller and -lighter warheads that could be carried in groups over intercontinental distances by long-range ballistic missiles and bombers.

The first deployed thermonuclear weapon was almost 24 feet long and weighed more than 18,144 kilograms.[1] In contrast, the 1980s-era W87 warhead weighs approximately 227 kilograms and was originally designed to fit with a total of 10 warheads mounted on the MX (Peacekeeper) ICBM.

Most if not all U.S. nuclear warheads are two-stage thermonuclear devices (hydrogen bombs) with plutonium primaries. The "primary" plutonium trigger is really a small atomic bomb, similar in concept to the Nagasaki weapon, used to generate the high temperatures needed to ignite a "secondary" device containing fusion fuel.

A key technology that dramatically in creased the efficiency of the primary and decreased the required size and weight of nuclear warheads is thermonuclear "boosting." The plutonium pit is shaped in a hollow spherical shell and filled just before detonation with a gaseous mixture of hydrogen isotopes: tritium-deuterium "boost" gas. When the weapon is detonated, a chemical explosion first compresses the plutonium shell to supercriticality, initiating a fission chain reaction. The fission energy released compresses and heats the boost gas enough for it to undergo thermonuclear fusion; the boost gas releases a burst of high-energy neutrons into the imploded plutonium shell, which subsequently fission a much larger fraction of the plutonium than would otherwise occur. This process thus dramatically increases, or boosts, the yield of the primary to a level where it can detonate the secondary thermonuclear device. A boosted primary thus uses a minimum amount of plutonium material and chemical high explosive, decreasing the overall size and weight of the warhead.

By contrast, the physics governing the performance of the secondary is relatively simple: as long as the primary explosion releases a certain minimum energy, the secondary is guaranteed to burn all of its fusion fuel and the weapon will detonate with its designed explosive yield.[2]

Consequently, the yield of the boosted fission primary is designed to always exceed, by the "primary margin," the minimum energy required to ignite the secondary, even under worst-case conditions . The major uncertainty in the performance of the warhead physics package is thus determined by any uncertainty in the primary margin.

Because tritium in the boost gas decays over time, with a radioactive half-life of 12 years, at some point there will not be enough to guarantee that the primary has the yield needed for the secondary to burn all its fusion fuel. To guard against this, the tritium gas must be replenished at regular intervals. Primaries are said to be in their worst-case condition right before these replenishments take place. The Department of Energy already guards against any diminution in reliability by requiring that primaries be capable of triggering a boosted explosion even if the tritium gas is at the end of a transfer interval.

Because of these design parameters, there are simple ways to ensure warhead reliability without resorting to a Reliable Replacement Warhead (RRW)-type program. The easiest way is to add additional boost gas to the primary or decrease the time interval when the gas is replaced. As early as 1995, the JASON defense advisory committee recommended such an approach to the Energy Department. "The primary yield margins can be increased by simple changes in initial boost-gas composition, shorter boost-gas exchange intervals, or improved boost-gas storage and delivery systems. These modifications have been validated by previous nuclear test data and would not require additional testing."

Thus, the Energy Department could improve the reliability of the weapons in the existing nuclear stockpile without making any changes to warhead design simply by adding additional boost gas or decreasing the time interval between gas transfers. These simple steps had not been taken as of 1999, however, when the JASON committee expressed "disappointment at the slow pace, low priority and limited scope of the lab/Energy Department efforts to provide enhanced primary performance margins."[3]

ENDNOTES

1. Mk-17 weighed 19 metric tons and had a yield of 15-20 megatons.

2. R. L. Garwin and V. Simonenko, "Nuclear Weapons Development Without Nuclear Testing," Pugwash Workshop on Problems in Achieving a Nuclear-Weapon-Free World, October 1996.

3. "Primary Performance Margins," JASON Report JSR-99–305, December 1999, found at www.fas.org.

Legal Authority for the Reliable Replacement Warhead Program

The following language in the fiscal year 2006 Defense Authorization Bill provides the current legal authority for the Reliable Replacement Warhead program. The key legislative language is excerpted below:

(a) Program Required—The Secretary of Energy shall carry out a program, to be known as the Reliable Replacement Warhead program, which will have the following objectives:

1. To increase the reliability, safety, and security of the United States nuclear weapons stockpile.

2. To further reduce the likelihood of the resumption of underground nuclear weapons testing.

3. To remain consistent with basic design parameters by including, to the maximum extent feasible and consistent with the objective specified in paragraph (2), components that are well understood or are certifiable without the need to resume underground nuclear weapons testing.

4. To ensure that the nuclear weapons infrastructure can respond to unforeseen problems, to include the ability to produce replacement warheads that are safer to manufacture, more cost-effective to produce, and less costly to maintain than existing warheads.

5. To achieve reductions in the future size of the nuclear weapons stockpile based on increased reliability of the reliable replacement warheads.

6. To use the design, certification, and production expertise resident in the nuclear complex to develop reliable replacement components to fulfill current mission requirements of the existing stockpile.

7. To serve as a complement to, and potentially a more cost-effective and reliable long-term replacement for, the current Stockpile Life Extension Programs.

(b) Report—Not later than March 1, 2007, the Secretary of Energy and the Secretary of Defense shall submit to the congressional defense committees a report on the feasibility and implementation of the Reliable Replacement Warhead program required by section 4204a of the Atomic Energy Defense Act, as added by subsection(a).

The report shall—

1. identify existing warheads recommended for replacement by 2035 with an assessment of the weapon performance and safety characteristics of the replacement warheads;

2. discuss the relationship of the Reliable Replacement Warhead program within the Stockpile Stewardship Program and its impact on the current Stockpile Life Extension Programs;

3. provide an assessment of the extent to which a successful Reliable Replacement Warhead program could lead to reductions in the nuclear weapons stockpile;

4. discuss the criteria by which replacement warheads under the Reliable Replacement Warhead program will be designed to maximize the likelihood of not requiring nuclear testing, as well as the circumstances that could lead to a resumption of testing;

5. provide a description of the infrastructure, including pit production capabilities, required to support the Reliable Replacement Warhead program;

6. provide a detailed summary of how the funds made available pursuant to the authorizations of appropriations in this Act, and any funds made available in prior years, will be used; and

7. provide an estimate of the comparative costs of a reliable replacement warhead and the stockpile life extension for the warheads identified in paragraph (1).

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ENDNOTES

1. For a recent discussion of the RRW program goals, see Linton Brooks, Presentatic on "The Future of the U.S. Nuclear Weapons Stockpile," Washington, DC, January 2! 2006, found at www.armscontrol.org (hereinafter Brooks presentation); Raymond Jeanloz and David Mosher, Remarks on "The Future of the U.S. Nuclear Weapons Stockpile," Washington, DC, January 25, 2006, found at www.armscontrol.org.

2. Robert S. Norris and Hans M. Kristensen, " U.S. Nuclear Forces, 2006," *Bulletin of the Atomic Scientists*, (January/February 2006).

3. "JASON Nuclear Testing Study: Summary and Conclusions," JASON Report JSR-95-320, 1995.

4. Brooks presentation.

5. Robert S. Norris and Hans M. Kristensen, "What's Behind Bush's Nuclear Cuts?" *Arms Control Today* , October 2004, p. 6.

6. Wade Boese, "Congress Cuts Nuclear Bunker Buster Again," *Arms Control Today*, December 2005, p. 23.

7. Steve Fetter and Frank von Hippel, "Does the United States Need a New Plutoniur Pit Facility?" *Arms Control Today*, May 2004, p. 10.

8. David Hobson, Address to the Arms Control Association, " U.S. Nuclear Security ir the 21st Century," February 3, 2005.

9. Office of the Secretary of Defense, "Nuclear Weapon System Sustainment Programs," May 1997, p. 18. For a more in-depth discussion, see Natural Resources Defense Council, "End Run: Simulating Nuclear Explosions Under the Comprehensiv Test Ban Treaty," 1997.

10. Conference report of the House Appropriations Energy and Water Subcommittee accompanying the fiscal year 2005 energy and water development appropriations bill H.R. 2419.

11. K. Henry O'Brien et al., "Sustaining the Nuclear Enterprise—A New Approach," Lawrence Livermore National Laboratory, Los Alamos National Laboratory, and Sanc National Laboratory, May 2005.

12. *Ibid.*

13. The Department of Energy, "Recommendations for the Nuclear Weapons Comple of the Future: Report of the Secretary of Energy Advisory Board Nuclear Weapons Complex Infrastructure Task Force," July 13, 2005.

14. See Fetter and von Hippel, "Does the United States Need a New Plutonium-Pit Facility?"

15. See Ian Hoffman, "Times Good for Bomb Designers: Scientists Drawing Up Plans for New Nuclear Weapons With Aim of Replacing U.S.Arsenal," *Tri-Valley Herald*, February 5, 2006.

16. Department of Defense, "Report of the Defense Science Board Task Force on Future Strategic Strike Forces," February 2004.

17. See Ian Hoffman, "Lab Officials Excited by New H-bomb Project," *The Oakland Tribune*, February 7, 2006.

18. The *San Francisco Chronicle* reported that "a study due later this year will project an extended life span for plutonium bomb components, of perhaps 100 years," J. Sterngold, "Upgrades Planned for U.S. Nuclear Stockpile; Agency Leader Expects Significant Warhead Redesigns," *San Franciso Chronicle*, January 15, 2006. For a discussion of the technical issues related to warhead aging, see Raymond Jeanloz, "Science-Based Stockpile Stewardship," *Physics Today*, December 2000, pp. 44-50.

19. R. Kidder, "Assessment of the Safety of U.S. Nuclear Weapons and Related Nuclear Test Requirements: A Post-Bush Initiative Update," UCRL-LR-109503, December 10, 1991.