

**Summary Report**  
**March 23, 2006 Workshop on the Reliable Replacement Warhead**  
**Sponsored by the Union of Concerned Scientists and the**  
**American Association for the Advancement of Science**

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On March 23, 2006 the Union of Concerned Scientists and the Center for Science, Technology and Security Policy at the American Association for the Advancement of Science hosted a workshop of technical experts to discuss the Department of Energy's plans to replace existing warheads in the U.S. nuclear stockpile with new warheads developed under the Reliable Replacement Warhead (RRW) program. The purpose of the workshop was to review the reliability of the current US nuclear arsenal and to clarify the possible benefits and limitations of the RRW program as currently envisioned by the Department of Energy.<sup>2</sup>

The workshop participants included active and retired scientists and engineers from the three national nuclear weapons laboratories; representatives from the National Nuclear Security Administration and the U.S. Strategic Command; and leading academic and non-governmental technical experts with years of experience advising the U.S. government in nuclear weapons design, nuclear weapons stockpile maintenance and U.S. nuclear weapons policy.

The meeting was unclassified. Nevertheless, a great deal of technical information is unclassified and could be discussed freely at the meeting. In order to encourage frank discussion, the meeting was held under Chatham House Rule: participants are free to use any information discussed, but neither the identity nor the affiliation of any participant may be revealed. This summary adheres to these rules, and information in it may be used and cited.

For simplicity, this report sometimes divides participants into two broad categories, describing them as either supporters or skeptics of the proposed RRW program. However, the participants held a broader spectrum of opinion than this simple division suggests.

**Background:**

*This information in this section was not explicitly discussed at the workshop, but provides basic background information for the reader.*

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<sup>2</sup> An excellent review of the current congressional debate over RRW is given in "Nuclear Weapons: The Reliable Replacement Warhead Program," by Jonathan Medalia (CRS Report for Congress RL32929 updated March 9, 2006), available at <http://www.fas.org/sgp/crs/nuke/RL32929.pdf>. See also "Sustaining the Nuclear Enterprise—A New Approach," by K. Henry O'Bryan, Bryan L. Fearey, Michael R. Sjulín, and Greg A. Thomas, 2005, available at <http://www.nuclearfiles.org/menu/key-issues/nuclear-weapons/issues/facilities/TriLab-SSP-2005.pdf>. The directors of the nuclear weapons programs at the three nuclear weapons laboratories formally endorsed this paper; it is sometimes referred to as the "Tri-Lab Report."

As of January 2006, unclassified estimates indicate the United States possesses nearly 10,000 nuclear warheads.<sup>3</sup> Approximately 5,700 warheads based on nine design types are currently deployed on land and sea-based missiles, bombs and cruise missiles. Under the Strategic Offensive Reductions Treaty (SORT) the number of strategic warheads will be reduced to 1700-2200 by December 31, 2012.

In addition, the United States maintains approximately 4,200 warheads in a reserve stockpile; these inactive warheads do not have components with limited lifetimes (e.g., tritium boost gas) installed or maintained. This number may increase as active warheads are reduced under the SORT Treaty. According to the Departments of Energy and Defense this stockpile “hedge” needs to be maintained in the event a serious performance problem were ever discovered with an entire class of deployed warheads, or if the United States faced a renewed strategic threat and needed to deploy a larger arsenal rapidly.

The United States has not deployed a new nuclear warhead design since 1989 and conducted its last underground nuclear test explosion in September 1992. Although the U.S. Senate did not give its advice and consent to ratify the Comprehensive Test Ban Treaty in 1999, as a signatory to the Treaty the United States continues to maintain a moratorium on nuclear explosive testing.

The Department of Energy currently maintains the U.S. nuclear stockpile under the science-based Stockpile Stewardship Program (SSP)—a basic research, engineering and warhead surveillance program designed to maintain the long-term safety, reliability, and security of the U.S. nuclear arsenal without nuclear explosive testing.<sup>4</sup>

Stockpile surveillance is formalized under the Stockpile Evaluation Program (SEP): Sample warheads from each warhead type are randomly selected and subjected to an extensive series of tests to ensure they continue to perform as designed and that no age-related problems have developed.<sup>5</sup> There are several thousand non-nuclear components to a warhead, including the conventional (chemical) high explosive used to initiate the nuclear explosion. Except for the Nuclear Explosive Package (the core nuclear components of the warhead, which are the primary fission trigger, the secondary thermonuclear device and the radiation case), all parts of the warhead can be fully tested in a nuclear test ban environment just as well as they could have been previously.

Weapons are disassembled and the parts inspected, including the nuclear components (one per weapon type is destructively disassembled each year). The non-nuclear parts are subjected to extensive functional tests. In addition, approximately 30 percent of the sample weapons are

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<sup>3</sup> Robert S. Norris and Hans M. Kristensen, “U.S. Nuclear Forces, 2006,” *Bulletin of the Atomic Scientists*, (January/February 2006), available at [http://www.thebulletin.org/article\\_nn.php?art\\_ofn=jf06norris](http://www.thebulletin.org/article_nn.php?art_ofn=jf06norris).

<sup>4</sup> The reliability of a weapon refers to the probability that it will be delivered to its target and explode at or near its design yield (it is generally assumed that the requirement is that the yield be within 10% of the design yield). Safety refers to the ability of the weapon to prevent accidental detonation, and security refers to the ability of the weapon to prevent unauthorized use. In general, a nuclear weapon refers to the entire weapon system, including the nuclear warhead and its delivery system.

<sup>5</sup> See Kent Johnson et al., “Stockpile Surveillance: Past and Future,” Sandia Report SAND95-2791, September 1995, available at <http://www.fas.org/sgp/othergov/doe/lanl/osti/197796.pdf>.

flight-tested—with their nuclear payloads removed or replaced with surrogate non-fissile material—on bombs, cruise missiles or ballistic missiles.<sup>6</sup>

As a result of this approach, each year since 1997 the directors of the nuclear weapons laboratories have certified each of the weapon types to be safe and reliable. In turn, the secretaries of defense and energy have issued formal memoranda to the president that the U.S. nuclear stockpile continues to be safe and reliable, and that nuclear explosive testing is not needed at this time.

If warhead surveillance does detect a problem with a particular warhead type, the nuclear weapons program applies knowledge gained through the stockpile stewardship science programs to repair or replace warhead components. These Life Extension Programs (LEPs) correct design-related flaws and prevent aging-related changes from diminishing warhead safety or reliability.

The philosophy of the Life Extension Programs has been to rebuild warheads as closely as possible to their original design specifications, minimizing any changes that might reduce confidence in the reliability of these weapons.<sup>7</sup> Engineers have been particularly careful to minimize changes to the Nuclear Explosive Package (NEP), because it is the only component that cannot be fully tested without producing a nuclear explosion.<sup>8</sup>

In contrast, the Reliable Replacement Warhead Program proposes to redesign the nuclear explosive package of U.S. nuclear warheads, with the constraint that the basic design parameters not deviate from well-understood regions of previously tested warheads. The stated goal of the RRW program is to enhance intrinsic warhead safety and security while reducing costs and improving confidence in the long-term reliability of the stockpile, and to do so without nuclear testing.

The current legal authority for the Reliable Replacement Warhead program was stipulated in the fiscal year 2006 Defense Authorization Bill.<sup>9</sup> 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:

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<sup>6</sup> C. Boroughs, “Nuclear Weapons Surveillance Program is vital foundation for managing the aging stockpile,” *Sandia Lab News*, Vol 55, No. 2, January 2003, available at <http://www.sandia.gov/LabNews/LN01-24-03/labnews01-24-03.pdf>.

<sup>7</sup> Note there is always a tradeoff between the required reliability of a weapon (or of any product) and one’s confidence in that reliability. Reliability and confidence levels are expressed as probabilities, and are generally determined statistically through testing. The reliability is the probability that a weapon would function as designed if used in the intended environment, and confidence is the probability that a weapon has a reliability equal to or greater than a specified reliability. For example, one will have higher confidence that the reliability is 90%, than it is 99%.

<sup>8</sup> The United States has observed a moratorium on nuclear testing since 1992. Since then it has conducted non-nuclear hydrodynamic tests on substitute nuclear primaries made from non-fissile nuclear isotopes of plutonium (or uranium) in an identically configured pit.

<sup>9</sup> Public Law 109-163, the FY2006 National Defense Authorization Act, Section 3111.

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.

Whether the RRW program will be able to achieve these seven objectives is the subject of this workshop.

### **Introduction:**

The moderator of the first session opened the meeting with the following statement, which highlights many of the key issues discussed at the workshop:

“The Reliable Replacement Warhead program is a consequential program. If it proceeds, it would lead to a complete redesign and replacement of the entire stockpile and would hold major implications for deterrence, nonproliferation, the Comprehensive Test Ban Treaty, the nuclear weapons enterprise, and the ability of that enterprise to respond to the needs of the Department of Defense. It could lead to an overarching new mission for the labs, a renaissance for the production plants, design of several new warhead types, and production of perhaps a few thousand new warheads. It has the potential to cost, and to save, billions of dollars over a period of decades.”

“Yet there are many unknowns for both RRW and the Life Extension Programs

(LEPs) it would replace. Will LEP fail? Can we be confident that RRWs will work without nuclear testing? What is the useful life of plutonium in pits, can we have confidence in the answer without testing, and what is the relationship between plutonium life and pit life? Must we act before we know the answers to these questions? Can we afford to wait until we know the answers?”

These and other issues were debated at the workshop. The key topics are summarized below, although not necessarily in the order they were discussed.

### **The proposed RRW program**

The Department of Energy proposes that the nuclear weapons laboratories develop new warheads specifically designed for increased longevity and enhanced safety and security.

In particular, design teams from Los Alamos, Sandia and Livermore National Laboratories submitted proposals for the first RRW design competition in March 2006. A winning design will be chosen in late 2006 and is intended to replace the W76 warhead for the Trident II Submarine Launched Ballistic Missile (SLBM). The design may relax previous military characteristics, allowing the warhead to be larger and heavier for a given yield. However, it was stated that the new warhead is required to fit within the Mark-5 reentry body, which is currently used for the W88 warhead. Some participants pointed out that the Mark-5 would probably have to be flight tested and recertified for the new RRW warhead.

In the near term, the weapons labs will continue to focus on replacement of existing (or “legacy”) warheads through the Life Extension Programs. Between 2012 and 2015, DOE hopes to demonstrate the ability to design, develop, produce and certify new replacement warheads. DOE plans for RRWs to slowly replace legacy warheads, and, if successful, envisions transformation to an all-RRW stockpile in the coming decades (figure 1).

According to its supporters, the RRWs will:

- have increased reliability due to increased performance margins and lifetimes for assured long-term stockpile reliability;
- have enhanced safety, security and use control;
- be easier to manufacture than it is to remanufacture existing warheads; and
- be certifiable in the long term without nuclear testing.

In addition, the RRW program will:

- allow for reduced stockpile size;
- make the U.S. nuclear stockpile less expensive to maintain;
- reduce the likelihood that a nuclear test will be required for technical reasons;
- provide essential training to new generations of weapon designers; and
- free up resources for stockpile and infrastructure transformation, while adjusting the refurbishment workload.

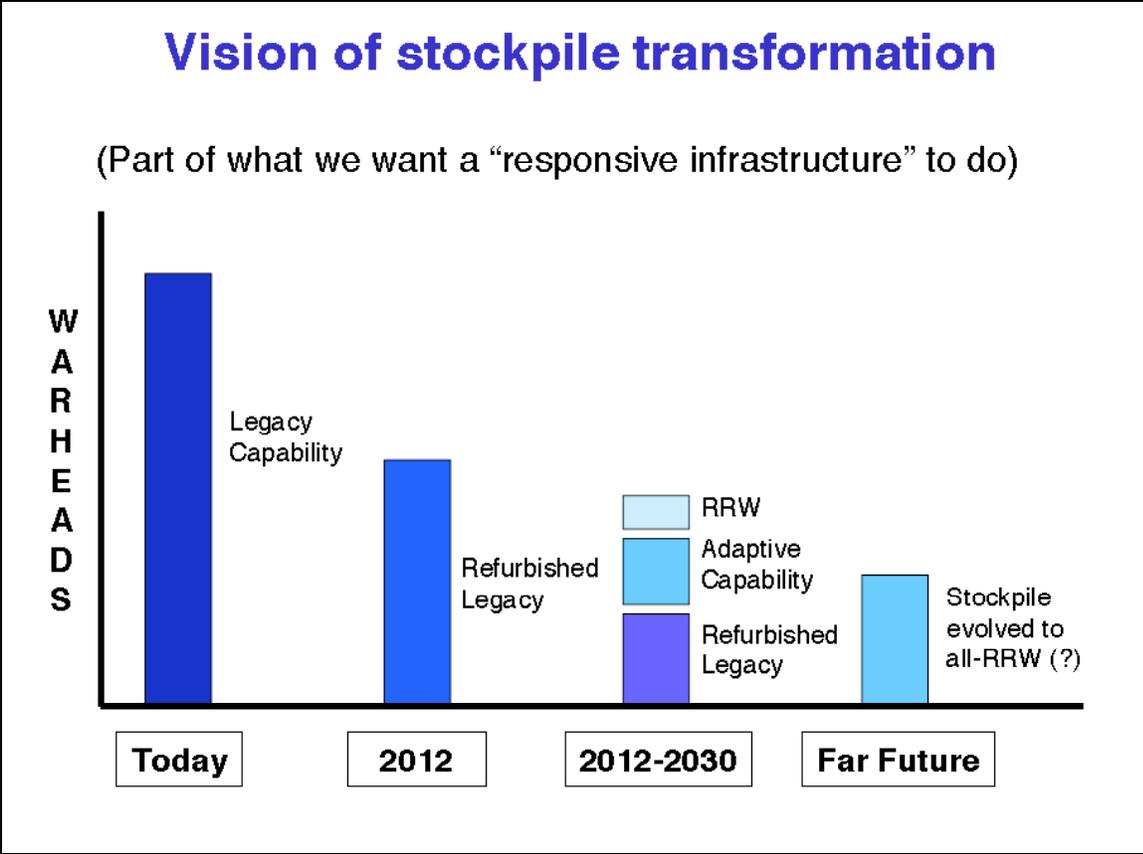


Figure 1: DOE's vision of stockpile transformation. Legacy (existing) U.S. nuclear weapons will continue to be refurbished under the Stockpile Life Extension Programs (LEPs), while the total number of warheads will be reduced. Starting in 2012, the arsenal will be a mix of refurbished legacy weapons, and replacement warheads developed under the RRW program. If authorized and funded by Congress, the future stockpile could also include warheads with new “adaptive” capabilities, such as a new earth penetrating weapon. In the far future after 2030, DOE envisions the entire U.S. nuclear stockpile could be replaced under the RRW program.

### Sustainability of Legacy Weapons Types and Infrastructure

All participants agreed that the U.S. nuclear stockpile is currently highly reliable, and that the Stockpile Stewardship Program (SSP) is working—today.<sup>10</sup>

RRW supporters voiced concern, however, that SSP may not be able to sustain confidence in

<sup>10</sup> Some participants expressed concern that the National Nuclear Security Administration (NNSA)—which oversees the DOE nuclear weapons programs—has described the current health of Stockpile Stewardship Program differently in its testimony to Congress. In particular, they pointed to the report of the House Appropriations Committee (H. Rept. 109-86) accompanying the FY2006 Energy and Water Development Appropriations Bill (H.R. 2419), which states, “congressional testimony by NNSA officials is beginning to erode the confidence of the Committee that the Science-based Stockpile Stewardship is performing as advertised.” (See also Medalia, 2006 CRS Report for Congress RL32929, CRS-43-45.) The report further states that the committee “used the potential of RRW as the rationale to reduce or delay several requested programs.” In particular, “the committee recommended reducing the budget request for Directed Stockpile Work, a major category of Weapons Activities that directly supports weapons in the stockpile.”

the reliability of the US nuclear stockpile in the long term. Because current warhead designs and manufacture involves a large number of complex and costly processes, supporters argued that the infrastructure needed to maintain and remanufacture legacy weapons is proving difficult to sustain and is not “responsive”—the current weapons infrastructure could not easily adapt if a significant problem were discovered in an entire class of warheads, or an unexpected geopolitical threat required a surge warhead production capacity.

RRW supporters further argued that current warheads have narrow design tolerances. Over time, modifications introduced in the Life Extension Programs (LEPs) could result in an accumulation of small changes—changes in the manufacturing process, the substitution of materials, and small modifications to incorporate modern safety and surety methods—that will ultimately reduce confidence in warhead reliability and could cause them to fail.

Supporters also pointed to severe aging problems that have previously occurred in some weapons—in both nuclear and non-nuclear materials. They argued that, over time, confidence in warhead reliability might decrease as weapons age.

RRW supporters argued that a new warhead—specifically designed for improved performance margins, increased modularity for ease of assembly and disassembly, and using safer materials—could resolve many of these difficulties, while revitalizing the nuclear weapons complex and enabling a more responsive infrastructure.

#### *RRW skeptics respond*

RRW skeptics responded that the Stockpile Stewardship and Life Extension Programs have been a tremendous success. There is little—if any—evidence to suggest that current warheads cannot be maintained indefinitely with the same high level of confidence and reliability as when they first entered the stockpile.

They stated that confidence in warhead reliability may actually increase with time—as information gained from the science programs leads to increased understanding of the behavior of warhead components and materials as they age—while the cost to maintain them diminishes.

#### **Stockpile Aging:**

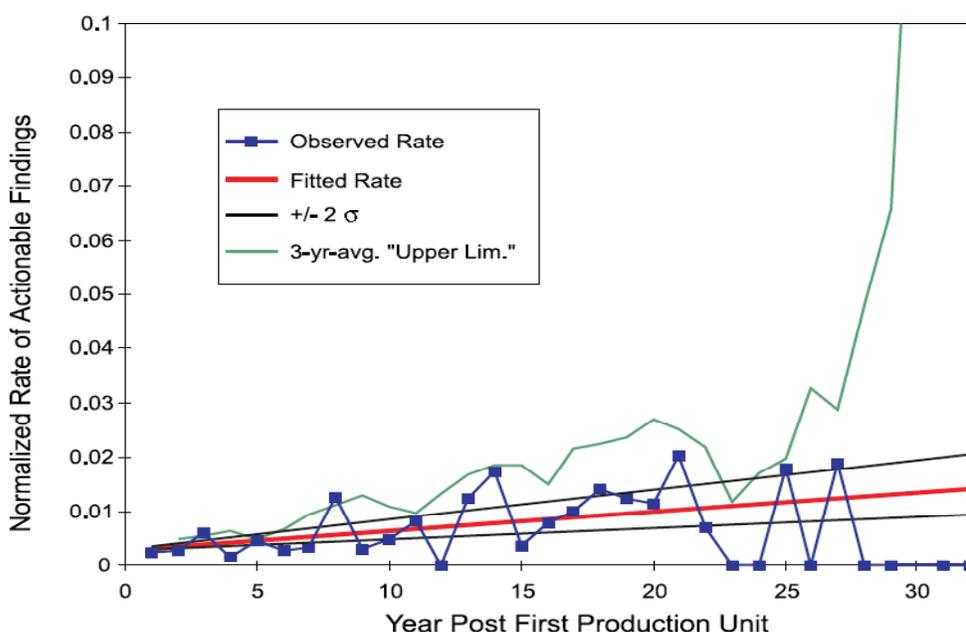
RRW supporters stated that warheads typically had design lives of 20-25 years, before being replaced by more sophisticated weaponry. Skeptics responded that these were minimum required lifetimes, and that weapons do not “turn into dust” when their lifetime is reached: “if weapons had a finite lifetime, they would be dead by now.”

A key issue, then, is whether the defects discovered over time show any *systematic* signature of warhead aging, or whether these were built-in “birth defects” due to flaws in the initial design and production. Birth defects can be detected and corrected. In principle, problems that develop due to aging could occur unexpectedly and might indicate a finite lifetime for a given warhead type if components are not remanufactured or replaced. A prime objective of

the Stockpile Stewardship Program is to make certain aging changes are not unexpected and that aging problems are fixed through Life Extension Programs or interim repairs.

From 1958-1996 the Stockpile Evaluation Program sampled nearly 14,000 weapons. Of these, approximately 2.8 percent revealed “actionable findings,” which required some corrective action (e.g., changes to the warhead itself or to a procedure) to maintain the stated reliability—or, in some cases, the weapon’s stated reliability was reduced. About 1.3 percent of the 14,000 weapons were found to have failures that, if not corrected, would prevent the warhead from operating as intended, within a small fraction of the design yield.<sup>11</sup>

Figure 2 shows the normalized rate of actionable findings as a function of years since the warhead type entered production.<sup>12</sup>



**Figure 2:** The blue curve is the fraction of warhead inspections that resulted in “actionable findings,” as a function of years since the warhead type entered production. The upper (green) curve shows the 90% confidence bound—“the range of potential finding rates which would be expected to include the true rate 90% of the time”—as calculated in the 1995 Sandia Stockpile Surveillance Report.<sup>13</sup> The three straight curves are derived from a maximum likelihood analysis, show the best-fit and +/- 2-sigma confidence limits.<sup>14</sup>

<sup>11</sup> General Accounting Office Report to the Committee on Armed Services, U.S. Senate, “Nuclear Weapons: Improvements needed to the DOE’s Stockpile Surveillance Program,” GAO/RCED-96-216, 1996, available at <http://www.gao.gov/archive/1996/rc96216.pdf>. Specific yield requirements for each weapon type are classified, but generally thought to require detonation under Stockpile to Target Sequence (STS) conditions within 10% of their design yield.

<sup>12</sup> S. Drell, et al., “Remanufacture,” JASON report JSR-99-300, Mitre Corporation, 1999, available at <http://www.fas.org/RLG/JSR-99-300.pdf>.

<sup>13</sup> K Johnson, et al., 1995.

<sup>14</sup> Sigma is the standard deviation; for a normal distribution, 68% of the values will lie between  $\pm$ sigma, and 95% will lie between  $\pm$ 2 sigma.

The rapid increase in the 90% confidence bound at 25 years after production simply reflects the small number of weapon units tested with those ages—demonstrating the tradeoff between actual reliability and the statistical confidence in that reliability.

The best-fit curve has a slope of approximately  $1/(2800 \text{ yrs})$ . Thus, as of 1996, these data do not indicate any systematic aging trends over periods of 30 years. Any aging signature in the rate of actionable findings is quite weak and at most indicates aging time-scales of thousands of years.

Many participants urged that the 1995 Stockpile Surveillance Report be updated.

RRW supporters argued that “birth defects” would be easier to detect in weapons that would be easier to disassemble, and that materials less susceptible to aging could be used, as is planned for the RRWs. One skeptic responded that an RRW could introduce new birth defects.

### **Nuclear Weapon Reliability**

During the discussion, participants distinguished between total weapon reliability (including the delivery vehicle), the reliability of the warhead, and the reliability of the Nuclear Explosive Package.

[*Rapporteur’s note:* the Department of Energy definition of nuclear weapon reliability is: “the probability of achieving the specified yield, at the target, across the Stockpile-to-Target Sequence of environments, throughout the weapon’s lifetime, assuming proper inputs.”<sup>15</sup> In general, a nuclear weapon refers to the entire weapon system, including the nuclear warhead and its delivery system.]

It was noted that a warhead is deemed reliable if its yield does not vary from its design yield by more than a specified amount, and that this amount is set not by a military requirement but by the measurement accuracy of the yield of a nuclear explosive test, which is roughly 10%.

RRW skeptics argued that redesigning the Nuclear Explosive Package for increased performance margins and ease of manufacture and maintenance would have little effect on overall reliability, since the total weapon reliability is dominated by the delivery system.

It was noted that approximately 15% of test launches result in some type of delivery system failure that would prevent the warhead from reaching its target. The reliability of the warhead, which is dominated by its non-nuclear components, was stated to be greater than 98% with high confidence. It was agreed that the reliability of existing nuclear weapons is generally dominated by the reliability of the delivery system. DOD will require higher

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<sup>15</sup> R. L. Bierbaum et al., “DOE Nuclear Weapon Reliability Definition: History, Description, and Implementation,” Sandia National Laboratories, April 1999 available at <http://www.wslfweb.org/docs/usg/reli99.pdf>. See also S. I. Schwartz, “Defining Reliable,” *Bulletin of the Atomic Scientists* (March/April 2001), pp. 55-56.

missile reliability in successors to the Minuteman III ICBM and Trident II SLBM, but it is not feasible to require that missiles have reliability comparable to that of the warhead.

Finally, it was stated that the reliability of the Nuclear Explosive Package has traditionally been assigned a value of 1.0—or “O-N-E”—in formal reporting, with the intent to convey very high confidence that a device that was properly constructed and that had been properly handled would perform as expected on receipt of the appropriate arming, fusing, and firing signals.

There are few moving parts in the NEP itself; it is “inherently robust.”

It was noted that neither past nuclear explosive testing nor the Stockpile Evaluation Program has ever provided a statistical basis for the reliability of the nuclear explosive package. Rather, confidence in the performance of the Nuclear Explosive Package is based on past nuclear test data, above ground experiments, computer simulations, surveillance data, and technical judgments. Nuclear explosive tests were proof tests that verified that the design worked.

Finally, confidence, reliability and military requirements are interrelated and can be traded off against one another. It was noted that by relaxing the required reliability of the Nuclear Explosive Package, the confidence level could be increased.

It was stated that the Program Officers Groups (POGs) might be willing to accept some reduction in overall system reliability in exchange for increased confidence, safety and surety. The primary concern of the Department of Defense is maintaining confidence in the overall enterprise.

### ***“Performance Cliffs”***

RRW supporters argued that current U.S. warheads NEPs were designed too close to “performance cliffs” in order to optimize their yield-to-weight ratios when they were designed.<sup>16</sup> Their concern is that the tight design constraints leave little margin for degradation that could result from remanufacturing or aging.

One of these performance cliffs concerns the yield of the primary, as illustrated in figure 3. If the primary yield drops below a minimum required yield, the thermonuclear secondary could fail to detonate. Of course, U.S. nuclear warheads were designed so that the primary yield would exceed this minimum requirement but there are uncertainties in both the position of these “performance cliffs” and in the actual yield of the primary under realistic conditions. Therefore, possible changes due to remanufacturing or aging could move the primary yield closer to the edge of the performance cliff, and by an unknown amount.

It was agreed that this primary performance margin could be increased in current weapons by changing the composition and/or reducing the exchange interval of the deuterium-tritium

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<sup>16</sup> In order to get as many warheads into one delivery vehicle as possible, warheads were made as small and light as possible while still maximizing the explosive yield.

boost gas, without modifying the Nuclear Explosive Package. Doing so would increase the yield of the primary, all other things being equal. The JASONS publically suggested this approach as early as 1995. It was stated that this has been implemented for most systems in the stockpile.

However, it was stated that existing nuclear warheads have other performance cliffs that cannot be addressed in this way. The situation was described as a multi-dimensional “performance mesa” rather than a single performance cliff. RRW supporters argued the solution would be to design replacement warheads with increased primary performance margins, further from the edge of the performance mesa.

RRW skeptics asserted that current performance margins are adequately large.

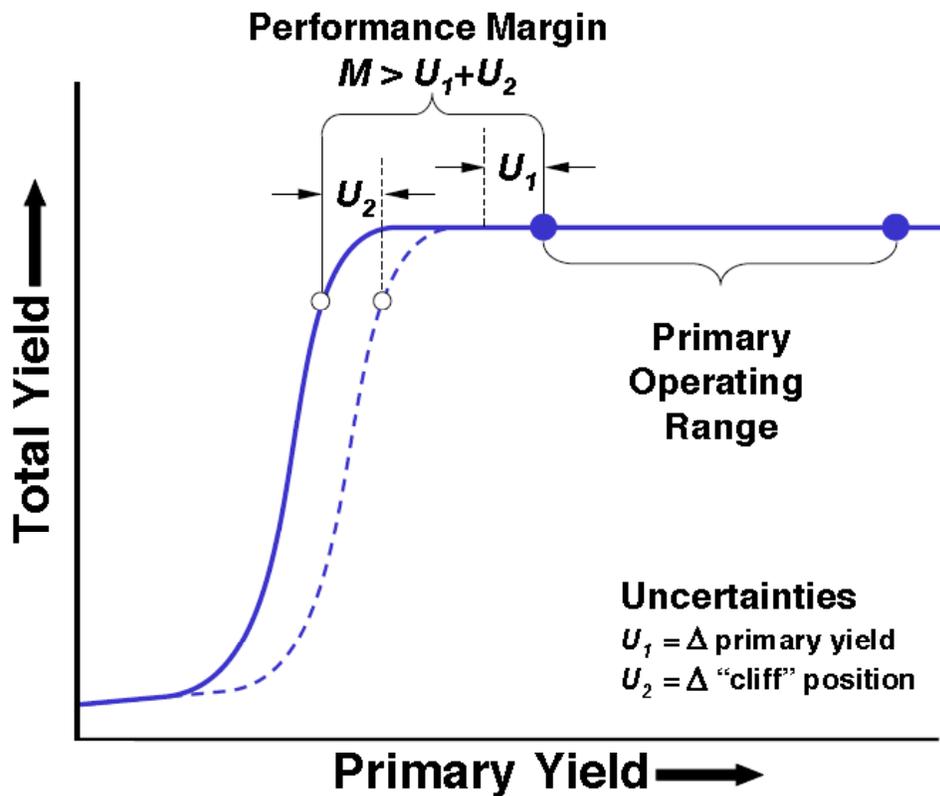


Figure 3: A thermonuclear weapon will detonate at its full design yield as long as the yield of the primary fission device exceeds a critical minimum value; at lower primary yields the secondary will fail to detonate and the total yield drops dramatically. There is some uncertainty in both the position of this “performance cliff” and the minimum yield of the primary. As a consequence, the minimum design yield of the primary must exceed both of these uncertainties by a significant “performance margin,”  $M > U_1 + U_2$ . In some cases, changing the composition of the deuterium-tritium boost gas, or reducing the gas exchange interval, can improve primary performance margins without modifying the Nuclear Explosive Package. However, it was stated that not all performance cliffs could be improved in this way.

## **Would RRW warheads need to be tested?**

RRW supporters said that the RRW design will stay within the well-understood parameters of previously tested designs. As a consequence, they believe the United States can design and certify new warheads without conducting additional nuclear explosive tests. However, because a specific warhead design has not yet been formally evaluated and approved, they were not certain that this will be the case.

It was stated that RRW designs would probably replace conventional high explosives (CHE) with safer insensitive high explosives (IHE). It was also stated that substitute materials, such as stainless steel, would likely replace beryllium and other materials that are environmentally hazardous or difficult to handle. At least one participant questioned whether a warhead with these changes could be certified without conducting a nuclear explosive test. RRW supporters countered that these changes have, in fact, been tested as part of the design families that will be the progenitors of RRW primaries and secondaries.

## **The Nuclear Weapons Infrastructure and Costs**

RRW supporters argued the infrastructure needed to build and maintain the current stockpile under SSP is overly complex and costly. They said that maintaining legacy warheads requires too many processes, and involves hard-to-manufacture components and environmentally toxic materials that can be difficult to handle. Warheads are not modular enough and are hard to assemble and disassemble. Moreover, the use of conventional high-explosive makes warheads less safe in accident scenarios, and makes weapon surveillance more difficult and time consuming.

RRW supporters maintained that new warhead designs could simplify the manufacturing and maintenance processes, leading to warheads that are cheaper and easier to build and maintain.

RRW supporters also stated that the current manufacturing infrastructure is not responsive: the weapons complex could not react rapidly and flexibly to unexpected technical problems or to geopolitical change. As a consequence, they argued, the DOE must maintain a large and expensive stockpile of inactive warheads as a hedge.

Because replacing current warheads with several RRWs would require a robust and efficient manufacturing infrastructure, supporters argued the RRW program would naturally lead to a responsive infrastructure.

More specifically, the nuclear weapons complex would have the capability to design and deploy a new warhead—potentially, with new military characteristics—in a period as short as 3-5 years.

RRW skeptics challenged what they described as an unsubstantiated assumption by RRW supporters: that the cost of maintaining warheads of existing types will increase indefinitely.

They argued that the costs of maintaining existing warheads under the SSP could decrease over time as information gained from the LEP programs leads to increased understanding of the weapons.

They further questioned the long-term cost savings associated with building and maintaining a large responsive infrastructure.

Skeptics critiqued the lack of any formal economic analysis demonstrating cost savings from the planned RRW program. The cost savings discussed did not include an estimate of the payback time to recover initial spending outlays for RRW. Supporters said that such estimates would be inappropriate at this time since no RRW design has yet been approved, and plans for overhauling the weapons infrastructure are at an early stage.

### **Stockpile Reductions**

As noted above, RRW supporters stated that the stockpile hedge could be reduced or eliminated only after a responsive infrastructure is demonstrated. Even then, they added, the stockpile must still have a range of weapon capabilities in order to fully counter unforeseen future threats, and multiple warhead types to guard against the discovery of a “common mode” warhead failure.

RRW skeptics stated there is no technical requirement for the current size of the hedge; it was a political decision. RRW and a more responsive infrastructure may make reducing the hedge more politically viable.

It was stated that DOD will also require a variety of warheads designs in the stockpile of the future, and would not support a single type of RRW warhead. DOD wants future warheads to have improved modularity and “a balance across delivery platforms.” In this case, the stockpile could possibly be reduced to four types of warheads: two warhead types for ICBMs and submarine launched ballistic missiles (SLBMs,) and two warhead types for bombs and cruise missiles.

It was stated that DOD will want to maintain legacy weapons, and will continue to support the Life Extension Programs, until they are confident in any new RRW warheads. Assessing whether such confidence can be achieved for a new design without nuclear explosive testing is one of the principal objectives of the RRW feasibility study now under way.