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Sustaining The Nuclear Enterprise – A New Approach

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"I am committed to achieving a credible deterrent with the lowest-possible number of nuclear weapons consistent with our national security needs, including our obligations to our allies." – President George W. Bush, May 2001.

We concur with the assessment and strategy expressed in this paper.

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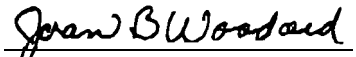

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Sustaining The Nuclear Enterprise -- A New Approach

EXECUTIVE SUMMARY

Nuclear weapons continue to play an essential role in United States (U.S.) National Security Policy. A succession of official reviews has concluded that nuclear weapons will continue to have a role for the foreseeable future. However, under evolving U.S. government policy, that role will be quite different from what it was during the Cold War–the nuclear weapons stockpile and the nuclear weapons enterprise will need to continue to change to reflect this evolving role. Stockpile reductions of the early 1990s and the Stockpile Stewardship Program, established after the cessation of nuclear testing in 1992, began the process of change. Further evolution is needed to address changing security environments, to enable any further reductions in the number of stockpiled weapons, and to create a nuclear enterprise that is cost effective and sustainable for the long term.

The Stockpile Stewardship Program (SSP) has successfully maintained the nuclear weapons stockpile for more than a decade, since the end of nuclear testing. However, as we project forward, the current application of SSP looks increasingly unsustainable. Current plans foresee maintaining nuclear warheads produced in the 1980s until about 2040. As these warheads continue to age and are refurbished, an accumulation of small changes could lead to increased risk or increased uncertainty in warhead certification. These current plans are also straining both the nuclear weapons production and the certification infrastructure making it ill-prepared to respond rapidly to problems or changes in requirements. Furthermore, these plans merely preserve nuclear weapons with a ponderous and expensive enterprise required to support old technology. SSP can address this increasing challenge, but only at significantly increasing cost.

A new approach should be considered. This approach should build on the strengths of the existing Stockpile Stewardship Program, but must start with an improved vision of the future stockpile and enterprise, and find a path that moves us toward that future. The goal of this approach is to achieve a more affordable, sustainable, and responsive enterprise. In order to transform the enterprise in this way, the warhead designs that drive the enterprise must change. Warhead designs that emphasize manufacturability, certifiability, and increased safety and security can enable enterprise transformation. It is anticipated that such warheads can be certified and sustained with high confidence without nuclear testing. The Stockpile Stewardship Program provides many of the tools to provide such designs, and could be redirected to develop replacement designs and produce them for stockpile.

The immediate challenge facing the nuclear weapons enterprise is to find a credible path that leads to the vision of the future stockpile and enterprise. This vision of sustainable warheads with a sustainable enterprise can best be achieved by shifting from a program of warhead refurbishment to one of warhead replacement. The nuclear weapons stockpile and the nuclear weapons enterprise should transform together to achieve this vision. This paper suggests a potential path and approach that can begin this process of transformation. If it succeeds, the United States, the NNSA and the DoD should have a sound basis for meeting today's and tomorrow's nuclear weapons requirements.

THE NEED FOR A NEW APPROACH

The National Defense Authorization Act for 1998 states, " It is the policy of the United States-- (A) to maintain a safe, secure, effective, and reliable nuclear weapons stockpile; and (B) as long as other nations control or actively seek to acquire nuclear weapons, to retain a credible nuclear deterrent." In 1993, the National Defense Authorization Act required establishment of a "stewardship program to ensure the preservation of the core intellectual and technical competencies of the United States in nuclear weapons, including weapons design, system integration, manufacturing, security, use control, reliability assessment, and certification". In May of 2001, the President stated, "I am committed to achieving a credible deterrent with the lowest possible number of nuclear weapons consistent with our national security needs, including our obligations to our allies." The National Nuclear Security Administration (NNSA), in coordination with other elements of the U.S. Government, is supporting these fundamental requirements through the Stockpile Stewardship Program.

Nuclear weapons continue to play an essential role in United States (U.S.) National Security Policy. A succession of official reviews has concluded that nuclear weapons will continue to have a role for the foreseeable future. However, under evolving U.S. government policy, that role will be quite different from what it was during the Cold War–the nuclear weapons stockpile and the nuclear weapons enterprise must continue to change to reflect this evolving role. Stockpile reductions of the early 1990s and the Stockpile Stewardship Program, established after the cessation of nuclear testing in 1992, began the process of change. Further evolution is needed to address changing security environments, to enable any further reductions in the number of stockpiled weapons, and to create a nuclear enterprise that is cost effective and sustainable for the long term.

The Stockpile Stewardship Program (SSP) has successfully maintained the nuclear weapons stockpile for more than a decade, since the end of nuclear testing. However, as we project forward, the current application of SSP looks increasingly unsustainable. Current plans foresee the challenging tasks of maintaining and refurbishing nuclear warheads produced in the 1980s until about 2040. As these warheads continue to age and are refurbished, an accumulation of small changes could lead to increased risk or increased uncertainty in warhead certification. This approach could limit options for responding to unforeseen technical problems. It is also straining both the nuclear weapons production and the certification infrastructure making it ill-prepared to respond rapidly to problems or changes in requirements. Furthermore, these plans merely preserve nuclear weapons with out-dated technology and a ponderous and expensive enterprise required to support old technology. SSP can address this increasing challenge, but only at significantly increasing cost. The projected costs to execute the Stockpile Stewardship Program as planned exceed the Future Years National Security Plan (FYNSP) budget projection. Further cost increases could arise for potential new security upgrades and modernization of the infrastructure. This is a risky path.

With the limitations of the current application of SSP, the United States must retain a relatively large number of reserve weapons to ensure against contingencies. Reserves must be retained to assure capability to respond rapidly to technical problems in the deployed stockpile, or to changes in the international security environment. The required response might include a rapid upload or a change in the characteristics for some fraction of the deployed stockpile. If a technical problem were to arise that involves a system that makes up a large fraction of the deployed force, the needed reserve or responsive capacity would need to be accordingly large. Because today's nuclear weapons design and manufacturing infrastructure does not have the ability to respond rapidly to changes, stockpile reserves are relied on to provide risk mitigation.

The Life Extension Program (LEP) approach has performed service life extension of some of the weapons in the current stockpile via refurbishment. The first completed life extension program extended the service life of the W87 ICBM warhead until 2030. Other LEPs are underway to extend the service life of the B61-7, -11 bomb warheads, W76 SLBM warhead, and the W80 cruise missile warhead. These programs are largely geared to replicating original warhead design to meet the existing requirements. Considerable resources are being expended to assure that the refurbished warheads meet military mission needs with high reliability and confidence. To assure this confidence, the LEPs minimize change, so that refurbished designs are close to the nuclear-tested designs. This effort exercises many of the "core intellectual and technical competencies" mandated for the Stockpile Stewardship Program, but not all. Should a future technical issue emerge that can only be resolved by a fundamental design change, the current application of SSP neither preserves the competencies nor transfers the knowledge needed to design, develop, and manufacture replacement warheads of significantly different design.

To be clear, the Stockpile Stewardship Program is working, and can continue to work. The issue is finding the most cost-effective and sustainable application of SSP. The approach we will discuss later calls for NNSA to use the tools of SSP to move towards a stronger and sustainable approach that uses design options that are both easier to manufacture and easier to certify without nuclear testing, and create an infrastructure that is able to respond to an uncertain future, even as total capacity is reduced.

Historical Design Impacts

The weapons within the enduring stockpile, designed in the 1970s and 1980s, were designed to meet Cold War requirements with the technologies available then. That combination led to design choices and manufacturing techniques that are certainly not the best choices today, and are unlikely to be appropriate 20 years from now. Indeed, some processes and materials cannot be reproduced today.

One of the strongest drivers in the design and fabrication of Cold War strategic nuclear weapons was to achieve a high yield-to-weight ratio. To optimize yield-to-weight, design and manufacturing trade-offs did not consider cost as a major driver. To achieve high yield-to-weight, and because nuclear testing was used to confirm performance, performance margins could be relatively small. Also, because planned service lifetimes were relatively short, longevity beyond a decade or two was not a factor in material or

design choices. Finally, because a large manufacturing complex was available, exotic materials and highly exacting manufacturing tolerances could be used.

Many of these past choices are driving large costs today. Some hazardous materials were used as part of the design optimization; however, today's more stringent health and safety standards make handling some of those materials cost-prohibitive. In addition, certification of replacement components for these past highly-optimized designs also can be quite costly and require lengthy certification programs.

The existing LEP replication approach also limits our ability to modernize the safety and security of US nuclear weapons. In the past, new safety and security technologies were introduced into the stockpile (and tested) as weapon systems were replaced on a regular basis, and in accord with the security threats of those days. When new weapon development ceased, safety and security upgrades became much more problematic.

While U.S. weapons continue to meet safety and security requirements, as threats to U.S. security evolve, particularly post-September 11, 2001, the security requirements for nuclear weapons will likely increase, both in terms of site security and security features designed into the warheads themselves.

In summary, through stockpile stewardship and through the life extension program, NNSA successfully continues to maintain confidence in the safety, security, and reliability of existing weapons without requiring a resumption of testing. However, the current replication approach to LEPs has serious limitations. Today's path limits the enterprise's ability to respond to unexpected stockpile problems or to changing requirements, limits safety and security improvements, limits our ability to reduce the number of weapons within the stockpile, and results in a cost inefficient complex. Further, this path neither preserves nor fully exercises the design expertise and manufacturing capabilities necessary to be able to respond to evolving or emerging threats.

A NEW APPROACH

A new approach should be considered. This approach should build on the strengths of the existing Stockpile Stewardship Program, but must start with a new vision of the future stockpile and enterprise, and find a path that moves us toward that future. Rather than bringing the past to the future (the current path), this new approach must bring the future to the present.

The goal of this approach is to achieve a more affordable, sustainable, and responsive enterprise. In order to transform the enterprise in this way, the warhead designs that drive the enterprise must change. Warhead designs can be developed that emphasize manufacturability, certifiability, and increased safety and security, and enable enterprise transformation. The Stockpile Stewardship Program provides many of the tools to provide such designs, and could be redirected to develop replacement designs and produce them for stockpile.

Vision of the Stockpile

The stockpile should be able to meet U.S. defense strategy goals and be able to address an uncertain future with uncertain adversaries. The U.S. nuclear stockpile of the future likely will have fewer weapons, both in the deployed and non-deployed forces. These weapons should be different in regard to safety, security, reliability, sustainability and, if necessary, in capability. An important consideration for planning the future stockpile must be affordability over the lifetime of the warheads. The warheads in the future stockpile should incorporate designs that minimize life-cycle costs and use cost as a key factor in determining the appropriate mix of warheads needed to maintain our deterrent and assure that the future stockpile can meet DoD needs.

The safety and security features of future U.S. nuclear weapons will need to improve in response to changing security threats in concert with enhancements at nuclear weapon installations. Warhead reliability should be strengthened to assure that, even with reduced stockpile numbers and with a receding test history, confidence in the U.S. nuclear deterrent remains high. Given the existing no-testing environment, high reliability and confidence can best be achieved by designing and fielding warheads that have larger performance margins. These margins must be sufficient to accommodate known and quantified uncertainties. In addition, to hedge against unknown failure modes, the stockpile should retain sufficient diversity to assure that no single problem dramatically weakens the entire stockpile.

Sustainability is achieved, in part, by enhancing safety and security, by increasing margins, and by including sufficient diversity. But it also requires a "design for manufacture" and "design for certification" philosophy. In general, a sustainable warhead design is one that has sustainable high reliability, is more easily manufactured and certified, has strengthened safety and security, can be maintained in service, and ultimately dismantled at a manageable cost. "Design for certification" is a broad concept encompassing a range of physics and engineering approaches leading to a high confidence produce. Potential attributes of a certifiable design include increased margins, functional simplicity, the use of well characterized technology, and features which facilitate non-nuclear testing and qualification. Future stockpile weapon designs should avoid the need for new nuclear testing, avoid difficult-to-manufacture and hazardous special materials, and should enable cheaper more efficient fabrication and assembly. Designs that incorporate larger margins will likely be more tolerant to manufacturing variability, aging, and to uncertainties in scientific modeling. With an adequate ratio of margins-to-uncertainties, it is anticipated that future warheads can be certified and sustained with high confidence without nuclear testing. This increased "manufacturability and certifiability" should help to reduce the strain on NNSA to support the stockpile in the long term.

Future designs must also address more than just design margins and manufacturability. In the post-911 security environment, the nuclear weapon security posture requires improvement. Early integration of use control and security systems within the weapon design could reduce operational security risks and associated costs. Incorporating weapon design architectures with upgradeable components that could adapt to evolving trends in technology could offer more flexible sustainment. Built-in field and flight test

capabilities could also lower stockpile surveillance costs as well as reducing security risks. Finally, a strategy that reduces risks and balances costs and responsibilities between DoD and NNSA is needed to achieve a sustainable and affordable deterrent. A careful re-examination of required capabilities, the prudent use of design commonality, and the cost-effective leveraging of commercial and military technology could lead to additional reductions in costs and to a more sustainable nuclear enterprise.

Vision of the Enterprise

To meet requirements, the nuclear weapons enterprise of the future should be smaller, responsive to change, safe and secure, and able to design, produce, certify, and maintain the nuclear weapons needed for deterrence. It must be affordable. Changes in the design of stockpile weapons will enable changes in the enterprise that develops, produces, and certifies them. This means changes in both the production complex and the national laboratories.

To the extent that the United States pursues reliable replacement warheads that are more manufacturable, it can look forward to a smaller, more secure and cost-effective production complex. Warheads designed for both manufacturability and certifiability should allow the laboratories and plants to be more efficient and responsive.

Responsiveness is one of the key attributes of the future enterprise. The 2001 Nuclear Posture Review (NPR) identified a responsive infrastructure as one of the three principal elements of the "New Triad." In principle, the responsive infrastructure can allow for a reduction in stockpile nuclear weapons. As the enterprise demonstrates that it can rapidly address critical technical issues and can augment the nuclear weapons stockpile if needed, a greater portion the reserves of contingency warheads may be able to be retired and dismantled.

Stockpile Stewardship Tools

The Stockpile Stewardship Program (SSP) provides many of the tools necessary to create a credible path to this vision for the future enterprise and will be essential to developing and sustaining the future stockpile without nuclear testing. In the past, stockpile safety, security and performance were confirmed through nuclear testing. With SSP tools, researchers are now better able to evaluate the stockpile by analyzing individual materials and components, integrating this information into computer simulations, while also using earlier nuclear test data for validation. These "tools" consist of a broad range of activities and facilities designed to deepen our understanding of nuclear weapons physics and engineering, while addressing issues that could affect weapons safety, security, reliability, and effectiveness.

These tools include an expanded program of small-scale and integrated experimentation in materials and complex processes involved in the operation of nuclear explosives. The SSP has constructed and developed several facilities to conduct sophisticated high-explosive hydrodynamics experiments, sub-critical plutonium experiments, high-energy-density physics experiments, and other materials science studies. The SSP has also invested in microsystems technology, which will help enable designs strategies needed to

provide affordable stockpile surety solutions. Continued support and development of these efforts, along with massively parallel computing facilities using test-validated predictive codes, will enable high-fidelity two- and three-dimensional simulation of the operation of the nuclear explosive package, the command and control systems integral to the warhead, and the overall warhead system for the stockpile of the future.

This tool set helps to enable warhead design and development, and provides some of the basis for enterprise transformation. Reliable replacement warhead designs will likely require modified internal components in stockpile warheads. Without a return to nuclear testing, confidence and certification will depend on fundamental and demonstrable understanding of the nuclear operation of these replacement warheads. Without the tools developed by SSP (and their continued support and advancement), the stockpile can neither be sustained nor transformed through refurbishment or replacement.

A CREDIBLE PATH TO THE FUTURE

The immediate challenge facing the nuclear weapons enterprise is to find a credible path that leads to the vision of the future stockpile and enterprise. The enterprise currently faces a conundrum. If the NNSA focuses entirely on the path of refurbishing Cold-War-era warheads, it may not be able sustain or develop the infrastructure needed to meet future requirements. On the other hand, if NNSA reprograms resources to develop future capabilities, it could fail to meet some of its current requirements. Also, the tools of Stockpile Stewardship still under development will be needed for either the refurbishment or replacement approach. A path that allows the nuclear weapons enterprise to shift from refurbishment to replacement must be found.

To evolve from the current Cold-War-based stockpile to a sustainable deterrent stockpile, a plan to transform the future stockpile must be developed. The goal of this plan should be to evolve the stockpile and the supporting nuclear weapons enterprise together to achieve more manufacturable, more certifiable, safe, secure, and reliable warheads supported by a smaller, responsive, and cost-effective infrastructure. However, during this transformation, confidence must be maintained in the existing warheads and infrastructure. This will require careful reprioritization of existing resources or additional near-term resources, in order to begin the process of transformation, which will allow for a more efficient and more affordable enterprise.

At this time, the most viable path to the future begins with credible reliable replacement warheads whose design and manufacturing philosophy should be incorporated into the currently planned warhead life extensions. This should be combined with refurbishment of a significant number of warheads under the currently planned LEP to help to rebuild and demonstrate capability, while supplying refurbished warheads for the future stockpile. However, the current plan to refurbish all warheads for the long-term strains the enterprise, commits to a future stockpile dominated by Cold War design, and precludes sufficient resources being made available for transformation. The enterprise must soon begin the shift to the production of reliable replacement warheads for existing (or subsequent) DoD delivery systems.

The shift to replacement rather than refurbishment will not be easy. Replacement warhead design concepts and approaches should begin with feasibility and cost studies conducted jointly with NNSA and DoD. These studies should maximize participation by the design and manufacturing entities within the NNSA, as well as with appropriate elements in DoD. The feasibility studies should produce plans to develop and produce reliable replacement warheads and warhead components, and a credible path to transform the enterprise and stockpile. The feasibility assessment and plan would provide necessary information for a subsequent decision to embark on the path of transformation.

CONCLUSION

The Stockpile Stewardship Program, while successful thus far, must move to a new approach. Continuing to maintain and refurbish Cold-War-era warhead designs is straining the nuclear weapons enterprise and its resources. This paper makes the case that the new vision of sustainable warheads with a sustainable enterprise can best be achieved by prudently shifting from a program of warhead refurbishment to one of warhead replacement. The nuclear weapons stockpile and the nuclear weapons enterprise should transform together to achieve this vision. A potential path and approach has been suggested that can begin this process. If it succeeds, the United States, the NNSA and the DoD should have a sound basis for meeting today's and tomorrow's nuclear weapons requirements.