REPORT ON THE FEASIBILITY OF USING EXISTING PITS FOR THE RELIABLE REPLACEMENT WARHEAD PROGRAM

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I. INTRODUCTION

A. Section 3121 of Public Law 110-181 requires that the Administrator for the National Nuclear Security Administration (NNSA), in consultation with the Nuclear Weapons Council (NWC), carry out a study analyzing the feasibility of using existing pits in the Reliable Replacement Warhead (RRW) Program. The report shall include an assessment of:

1. Whether using existing pits in the program is technically feasible;

2. Whether using existing pits in the program is more advantageous than using newly manufactured pits in the program;

3. The number of existing pits suitable for such use;

4. Whether proceeding to use existing pits in the program before using newly manufactured pits in the program is desirable; and

5. The extent to which using existing pits, as compared to using newly manufactured pits, in the program would reduce future requirements for new pit production, and how such use of existing pits would affect the schedule and scope for new pit production.

B. The report shall also include a comparison of the requirements for certifying:

1. Reliable replacement warheads using existing pits;

2. Reliable replacement warheads using newly manufactured pits; and

3. Warheads maintained by the Stockpile Life Extension Program.

C. This report has been prepared in consultation with the Nuclear Weapons Council.

II. EXECUTIVE SUMMARY

Direct pit reuse, the use of existing pits with no modifications, does not meet all the objectives of the RRW program, but can offer limited improvements in performance margin and surety for some systems. Modifications of existing pits would allow for more margin and surety improvements than direct reuse; this would require some of the same investments in our R&D and manufacturing infrastructure as is required to establish a production capacity for new pits. Using newly manufactured pits offers the most flexibility for improving performance margin, surety, and for meeting all of the goals of the RRW program. The Nuclear Weapons Council believes that a pit production capacity of 50-80 new pits per year is the capacity that should be implemented, consistent with the March, 2008 DoD/DOE white paper . All options for the future stockpile will require investments in the science tools that allow us to assess and certify the stockpile in the absence of nuclear testing.

III. BACKGROUND

A. RRW Program

1. Today, our nuclear deterrent stockpile is safe, secure and reliable. There are, however, serious technical concerns regarding maintaining the aging Cold War stockpile over the long term without nuclear testing. The NNSA Administrator's December 4, 2007 classified letter to congressional authorization and appropriations committees highlighted those concerns. His letter identified technical problems in the stockpile that could become more challenging with time. He cited the Laboratory director's concerns about long-term confidence in the stockpile, and the ability to certify it into the future without nuclear testing.

2. Certification of our aging warheads will continue to be a technical challenge for our best scientists. The possibility of de-certification or unscheduled LEPs cannot be ruled out. We expect that warhead certification will become more difficult, especially as life extensions and component aging move warheads further away from tested designs. This puts increasing demands on reducing the uncertainties in our predictive capabilities for nuclear weapons.

3. This is the impetus for the RRW program. Congress identified the following seven RRW objectives in Section 3111 of the National Defense Authorization Act for Fiscal Year 2006:

    a. increase the reliability, safety, and security of the U.S. nuclear weapons stockpile;

    b. further reduce the likelihood of the resumption of underground nuclear weapons testing;

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

    d. 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;

e. achieve reductions in the future size of the nuclear weapons stockpile based on increased reliability of the replacement warheads;

f. 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; and

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

4. Two different studies have examined RRW concepts for the replacement of existing weapons: (1) RRW-1 was a concept and feasibility study on a replacement weapon for a reentry system and focused on the technical feasibility of certifying a weapon with a new pit design and manufacturing process. Work on the feasibility study was suspended in January 2008 pursuant to the Consolidated Appropriations Act, 2008; (2) RRW-2 was a concept study on a replacement weapon for air-carried systems (gravity bombs and cruise missiles) and required the use of existing pits in the design. That study has also been suspended.

B. Warhead Certification

1. The quantification of margins and uncertainties (QMU) is the developing methodology used to describe the certification of nuclear weapons. A figure-of-merit, (e.g., confidence factor), is the ratio of the margin to failure (M) to the associated quantified system uncertainties (U), generally stated as M/U. The uncertainties are not directly known from statistical analysis, and therefore the numerical value of M/U is combined with expert judgment and nuclear test constraints to assess certification. The process of quantifying margins and uncertainties relies on:

   a. The existing nuclear test data base. The data from tests of original weapons designs relevant to today's updated systems are used as an integral validation of our understanding of nuclear weapons. Improved methods of analyzing historical data are an important part of improving QMU. As weapons age and or undergo modification this data becomes less directly applicable to the certification of a system.

b. Experimental facilities and experiments allowed under the test ban, such as focused science experiments, integrated hydro tests, and sub-critical experiments. The data from these experiments continues to improve our understanding and helps validate our models of the detailed underlying physics of nuclear weapons.

c. Simulation codes and modeling. The ongoing development of weapons simulation codes, including improvements in the validated theory and models that feed into them, provides the surrogate for nuclear testing and underpins modern certification.

d. Supercomputing facilities. Nuclear weapons certification continues to drive the need for world-leading supercomputing facilities. These computers enable the addition of high-fidelity improvements to simulation codes that provide insight into weapon physics.

e. The continued development of the QMU methodology. Improved understanding of nuclear weapons physics/engineering and the application of new methods for uncertainty quantification improves fidelity of confidence assessments.

f. The people who work for the nuclear enterprise. This is the most important element of our nuclear deterrent. Continuous exercise of their intellectual and technical competencies is imperative for our nuclear future.

C. Plutonium Pit R&D and Manufacturing

1. Of critical importance to our nation's nuclear deterrent are the plutonium capabilities needed for a responsive nuclear weapons infrastructure. Whether we ever produce another new nuclear warhead, the United States must ensure the safety and reliability of our aging warheads first introduced into the stockpile decades ago. Continuing excellence in plutonium research to include actinide chemistry, materials characteristics, and better understanding of plutonium metallurgy involving the complex alloys of plutonium that are employed in today's stockpile is required. We must also maintain the ability to conduct surveillance of plutonium components in warheads so that we are never surprised by the onset of age-related degradation.

2. Another key factor in a responsive infrastructure is warhead production capacity; that is, the rate at which it can refurbish existing warheads or produce replacement warheads. Currently, the production of plutonium pits is the most constraining limitation on capacity. A right-sized production capacity will depend on the size and composition of the overall stockpile, performance margins of warhead types comprising that stockpile, and the viability of pit reuse options. Uncertainties in each of these factors make it difficult to assess definitively future required production capacity.

3. Currently, we have a very small production capacity (about 10 pits per year) at the existing Los Alamos Technical Area 55 (TA-55) facilities. This, we believe, is insufficient to support the stockpile for the long term for several reasons:

    a. Depending on warhead type, our best estimate of minimum pit lifetime is 85-100 years. While this exceeds previous estimates, degradation from plutonium aging still introduces uncertainty in overall system performance, particularly for lower margin systems. As the stockpile continues to age, we must plan to replace considerable numbers of pits in currently stockpiled weapons.

    b. If a future decision is made to field replacement warheads, we will require expanded pit production capacity to introduce sufficient numbers of warheads into the stockpile.

    c. Finally, at significantly smaller stockpile levels than today, we must anticipate that an adverse change in the geopolitical threat environment, or a technical problem in the stockpile, could require manufacture of additional warheads on a relatively rapid timescale.

4. A variety of future pit production alternatives have been evaluated as part of the planning for transforming the nuclear weapons complex infrastructure. The best economic and technical alternative, for all potential pit production capacities, is to retain and build on the existing R&D and production facilities at Los Alamos. In light of the uncertainties addressed above, we believe we should plan to introduce a production capacity of 50-80 pits per year by 2017. Such a capacity has the potential to support smaller stockpile sizes, particularly if coupled with potential reuse of pits.

IV. REPORTING REQUIREMENTS

A. Section 3121 requires this report to cover the following:

1. "An assessment of whether using existing pits in the RRW program is technically feasible;"

    a. The RRW studies that were underway to confirm feasibility were suspended in January 2008 pursuant to the Consolidated Appropriations Act, 2008. The following assessments, therefore, are based on the judgment of design experts at NNSA national laboratories.

    b. The use of newly designed pits provides the most opportunities to improve margin and surety and is the most technically feasible. The use of existing pits with no modifications in a replacement weapon design limits performance margin and surety improvements. Reuse of existing pits with modifications could provide more margin and surety enhancements in some systems, but it would require new investment in manufacturing capabilities. This is the sub-optimum solution for cost, design, and sustainment.

    c. Gravity bomb designs, due to the large available weight and volume, allow the most opportunities for desired improvements and are therefore the most technically feasible candidates for pit reuse. Reentry system and cruise missile designs with existing pits may also be feasible, but would be much more challenging; employing pit reuse may involve tradeoffs such as lower performance margin and some of the most capable surety enhancements.

2. "An assessment of whether using existing pits in the program is more advantageous than using newly manufactured pits in the program;"

    a. A new pit designed specifically for a replacement weapon system would be more advantageous because it would allow the most flexibility to increase performance margin and surety while exercising a responsive infrastructure that produces a sufficient number of pits to sustain the stockpile.

b. Until we are able to reestablish sufficient capacity to produce new pits, we must plan to employ existing pits in warhead replacement or life extension programs. Depending on the level of surety improvements required, modifications to the pit will still be necessary. These modifications will require some of the same capabilities as needed for new pit manufacturing, qualification, and subsequent weapon certification and may introduce additional uncertainties in such certification.

3. "An assessment of the number of existing pits suitable for such use;"

   NNSA maintains material, including pits, identified for a strategic reserve in order to provide replacements to the stockpile if needed. Some systems have most of their pits committed in the stockpile, and would not be available for reuse, unless they were reused for self-replacement. Other systems have a large number of pits available in retired systems or in storage that may be candidates for reuse. Most would require some level of pit manufacturing infrastructure to perform modifications to improve performance margin and surety. Generally older pits are less desirable and most lack lifetime assessment evaluations while newer pits are limited in numbers or are committed to the current stockpile.

4. "An assessment of whether proceeding to use existing pits in the program before using newly manufactured pits in the program is desirable;"

   New pit designs and new pit manufacture are required to achieve the full benefits of the RRW program. Until sufficient production capacity is restored, reuse of existing pits would be considered for near-term warhead replacement options. To achieve margin and surety gains however, modifications to the existing pits might be necessary, which, in turn, would require some of the same investments as are necessary for new pit manufacture.

5. "An assessment of the extent to which using existing pits, as compared to using newly manufactured pits, in the RRW program would reduce future requirements for new pit production, and how such use of existing pits would affect the schedule and scope for new pit production;"

a. Future requirements for new pit production depend on a number of factors in addition to reuse, including overall stockpile size, numbers and types of warheads, ages/lifetimes of pits in the current stockpile, and when achievement of full operational capability of modern pit manufacturing and responsiveness of the nuclear enterprise begins to allow replacement of pits in the stockpile.

b. The Nuclear Weapons Council believes that a pit production capacity of 50-80 new pits per year is the capacity that should be implemented, consistent with the March, 2008 DoD/DOE white paper. Based on the stockpile size and finite life of every pit, this production rate would support both minimum turn over of the stockpile and a responsive infrastructure to offset augmentation requirements. Delays in achieving this capacity would increase future capacity requirements for a given stockpile size.

c. NNSA's current planning scenarios may include reuse of existing pits in gravity bombs, where it is the most technically and logistically feasible, consistent with surety, safety, and reliability. To that extent, reuse is included as an option for the requirements, scope and schedule of new pit production. Pit reuse in reentry and cruise missile systems, due to its increased technical risk and potentially undesirable tradeoff between performance and surety, was not factored into plans for new pit production.

d. To maximize the ability of a reuse pit to meet RRW objectives, modifications to the pit would be required. With the exception of metal preparation and foundry operations, these modifications would require some phases of pit manufacturing and other technologies. A study to evaluate the costs of this subset of manufacturing capabilities has not been done.

e. Pit production is a necessary element of a responsive infrastructure. A responsive infrastructure is a key part of the nation's nuclear security in providing a hedge against unforeseen technical challenges in the nuclear stockpile or from geopolitical events. An exercised, responsive infrastructure and trained workforce, facilitated by RRW, would reduce our reliance on non-deployed warheads, and allow for the possibility of reductions in the size of the non-deployed stockpile.

f. Absent a pit manufacturing requirement, critical skills will erode, increasing the cost and risk of re-establishing design and manufacturing capabilities in the long-term.

B. Certification Comparison

1. Background

The process of certifying a weapon cannot be predicted in advance of understanding the specific components of the weapon. The certification effort would follow a program designed by one of the NNSA laboratories and would vary in depth and complexity depending on the departure of the modified design from known system baselines and the understanding of the uncertainties thereof. The following is a qualitative discussion of the relative difficulty of the certification of a weapon system employing a spectrum of pit options.

2. "Compare the requirements of certifying reliable replacement warheads using existing pits;"

a. Reuse of an existing pit not in its original primary has indirect ties to only a few nuclear tests. In order to certify a weapon, one must have sufficient margin in the system to overcome the associated uncertainties. Due to the challenges of using existing pits in systems for which they were not designed, there are limitations to how much margin can be added, and therefore limitations in the certification confidence for these systems.

b. Adding surety features to an existing pit introduces uncertainties and limits the amount of margin that can be added to the system. Because of the already limited margin that can be added to a design for some existing pits, it is challenging to incorporate modern surety features in these systems. Additional time and integrated experiments would be required to meet these certification challenges.

c. In the specific case of reusing not just the pit, but the entire primary, a much stronger tie to nuclear testing can be established. If the reused primary has high margin, this can provide more confidence in certification. However, the number of primaries that are adaptable to modern surety requirements is limited.

d. Certification of newly manufactured pits of existing designs is not trivial. We were recently able to reestablish production of small numbers of pits at the TA-55 facility at Los Alamos. That effort, the first manufacture of a war reserve pit since the shut down of the Rocky Flats facility two decades ago, involved a decade long effort costing over a billion dollars. It provided an important lesson about the costs associated with letting capabilities erode or disappear.

3. "to the requirements for certifying reliable replacement warheads using newly manufactured pits;"

    a. Replacement warheads involving new pit designs can achieve higher performance margins than existing warheads in the stockpile, or replacement warheads incorporating existing pits. The NNSA laboratory directors state that their best technical judgment *today* is that it will be less likely that we will need nuclear testing to maintain the safety, security, and reliability into the future of the nuclear stockpile if we pursue an RRW path employing all the tools of the Stockpile Stewardship Program than if we continue to rely on today's legacy warheads.

    b. The recent success of the TA55 pit production capability demonstrated that the process of qualifying the manufacture of a known pit design is possible. Qualifying a newly designed pit is also possible. Using a newly manufactured pit designed for the new system would allow the greatest performance margin, resulting in higher confidence relative to weapon certification using existing pits.

    c. Using a newly designed pit would allow for replacement weapons that are optimized for surety capabilities and still have improved margin to maintain the ability to certify.

4. "to the requirements for certifying warheads maintained by the Stockpile Life Extension Program."

    a. Life extension programs (LEPs) to date have involved incremental changes to existing systems where there was a significant relevant nuclear test base with which to compare the changes. For each LEP, significant effort has been required for recertification. To date, these efforts, which relied on the tools developed by the ongoing Stockpile

Stewardship Program, have supported certification with confidence for these programs.

b. The existing stockpile was designed with the intent of optimizing the yield to the weight of the system. This process did not maximize the performance margin, and LEP-like modifications to low margin systems present certification challenges, even with relevant nuclear tests.

V. CONCLUSIONS

A. The multiple objectives of the RRW program would be best met by newly manufactured pits. Until we can achieve adequate pit production capacity, we must plan on using existing pits for any warhead replacement or life extension programs. Pit reuse without modification would allow limited margin and surety improvements; reuse of modified pits would allow additional margin and surety improvements; new pits would allow the most flexibility for increasing performance margin and surety.

B. Gravity bomb designs, due to the large available weight and volume, allow the most opportunities for desired improvements and are therefore the most technically feasible candidates for pit reuse. Reentry system and cruise missile designs with existing pits may also be feasible, but are much more challenging and may involve tradeoffs in performance or surety that are undesirable.

C. Surety improvement and certification of replacement weapons with existing pits is possible, although higher certification confidence can be achieved with newly manufactured pits.

D. Pit manufacturing and production capabilities are necessary elements of a responsive infrastructure. New pits offer design flexibility for performance and surety advantages, and will ultimately be necessary due to the limited lifetime of pits. The Nuclear Weapons Council believes that a pit production capacity of 50-80 new pits per year is the capacity that should be developed, consistent with the March, 2008 DoD/DOE white paper. Based on the stockpile size and finite life of every pit, this production rate would support both minimum turn over of the stockpile and a responsive infrastructure to offset augmentation requirements. Delays in achieving this capacity would increase future capacity requirements for a given stockpile size.

E. The people who work for the nuclear enterprise are the most important element of our nuclear deterrent. Continuous exercise of their intellectual and technical competencies is imperative for our nuclear future. This future also requires investment in the underlying science behind nuclear weapon operation, as these investments would yield the essential tools that would allow NNSA to assess and certify replacement warheads, or warheads modified by more aggressive life extension programs.

F. All nuclear stockpile sustainment alternatives require investment in NNSA's aging production facilities and capabilities to enable a more flexible and agile manufacturing infrastructure. An exercised, responsive infrastructure and trained workforce would reduce NNSA's reliance on the "hedge" of non-deployed warheads and allow for reductions in the size of the non-deployed stockpile.

G. Due to the current uncertainty about our future stockpile, it is important that we review all of our technical options, including RRW. This information is necessary to assess the risk, benefit, and cost tradeoffs between a future stockpile of LEP-like weapons, or beginning a transition to a stockpile with an increasing component of RRWs. This data will be very important for the next Administration to make an informed decision about our future stockpile.