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Stewarding a Stockpile of Varying Size

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The nation depends on the Nuclear Weapons Complex to maintain a safe and reliable nuclear stockpile. Ideally, the size of the stockpile would be optimized to reflect stewardship abilities, reliability, safety, cost, etc. A perfectly optimized stockpile size is not realistic. Furthermore, the optimized value would likely change even before it could be realized. This necessitates the ability to steward different sized stockpiles. Every time the stockpile size changes there are certain elements and factors that need to be analyzed in order to ensure its vitality and future. Some of these elements will change significantly as numbers decline others will remain more constant and are even needed if numbers go to zero. It is vital that these necessary elements aren't permitted to atrophy as numbers decline. At any stockpile size the most important of these elements is the ability to maintain expert personnel. A second element that should always remain is the ability to conduct surveillance and maintain the health of the stockpile. Another necessary factor is to maintain a production capability in order to react and respond to unpredictable events.

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Introduction

Since its inception in 1942, the nation has turned to the Nuclear Weapons Complex (NWC) for nuclear weapon design, development, production, maintenance, surveillance, refurbishment and dismantlement. Several events since then have altered the focus of the NWC. The most notable of these was the end of the Cold War and the events that followed. More recent events also point toward future changes in the scope of the NWC.

When the majority of the nuclear weapons were being designed and built (1942-1992), the flexibility and reliability of U.S. nuclear deterrent force was ensured by having a large quantity and variety of weapons with frequent (10-15 year) replacement of aging designs.[1] During this time the U.S. government opened 27 design/production sites as a part of the NWC. Also, an additional 21 test sites and 5 prototype research reactors were opened.[2] Then, the Cold War ended and focus shifted. By the end of 1994, 20 of the 27 NWC design/production sites, 19 of the 21 test sites and all research reactors were closed.[3]

Global strategic environments and policies also changed. In the early 1990s all new nuclear weapons production was more or less halted.[4] This meant that all development engineering for current nuclear weapons systems were canceled. This marked the first time that there were no active nuclear weapon development programs at the NWC. During this same year the United States entered into a moratorium on yield producing nuclear weapon tests.[5] These changes presented new challenges to maintaining a safe, secure and reliable nuclear weapons stockpile. There was a fundamental shift in the emphasis of the NWC with respect to the stockpile: instead of quantity and frequent replacement the focus moved to enhancing reliability and longevity of the current stockpile.

President Barack Obama's 2009 speech in Prague outlined his vision of a world without nuclear weapons.[6] If this vision ever becomes reality some would say that the NWC could effectively be eliminated and resources reallocated to other areas. Others argue that it must be maintained on some level should there ever arise a need for rapid rebuild. Either way there has been a continued trend toward stockpile reduction (even if zero is never reached).[7] The latest step in these shrinking numbers took place with the ratification of the New START treaty in February, 2011. President Obama's vision, and recent policies enacting deep stockpile reductions, places the NWC on the cusp of potentially another shift in the future. It also presents policy makers with the increasingly complicated question of what is the optimal number of

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[1] National Nuclear Security Administration. *Managing the Stockpile.* June 2012. http://nnsa.energy.gov/ourmission/managingthestockpile.

[2] Loeber, Charles R. *Building the Bombs: A History of the Nuclear Weapons Complex.* Sandia National Laboratories, 2002, 169-172.

[3] Ibid.

[4] Ibid.

[5] Ibid.

[6] Kelleher, Catherine M., and Scott L. Warren. "Arms control Association." *Getting to Zero Starts Here: Tactical Nuclear Weapons.* October 2009. http://www.armscontrol.org/act/2009_10/Kelleher.

[7] *Treaty Between The United States Of America and the Russian Federation on Measures for the Further Reduction and Limitation of Strategic Offensive Arms (New START).* April 8, 2010. http://www.state.gov/documents/organization/140035.pdf.

weapons in order to ensure the stockpile to meet the nation's objectives. Decision made today will determine if the nature of the NWC acts on or reacts to the dynamic future of the global nuclear weapons policy.

Optimization of a Dynamic Stockpile

What is the *optimal* number of nuclear weapons in the stockpile? It is human nature to optimize. This is especially true of scientists and engineers. In mathematics, optimization of a function nearly always occurs in a particular domain. When considering very elaborate (often non-linear) multivariable functions, optimization can be a futile task until the domain is changed to a subset of the whole, greatly simplifying the problem.[8] The catch is that the optimization of a function can change dramatically across different domains. Further exacerbating the difficulty of optimization is that choosing the focal subset can quickly become subjective in nature. The optimizer often cares more about the functional response due to certain variables and inherently placesmore weight on these arguments than others. What is more important in the eyes of one is often less significant for another. This can quickly transform stockpile optimization into more of a debate than a science.

Optimization of the size of the stockpile is an impossibly difficult, non-linear, multivariable problem in constant flux. Trends and fluctuation in stockpile size shape the structure of the NWC and nuclear weapon policy. The debates are very politically charged and under significant scrutiny due to a perceived small margin of error and potentially unforgiving ramifications. There are literally thousands of variables influencing the problem. Tradeoffs between reliability, safety, maintenance, deterrence, surveillance, cost as well as the perception of society, potential political gain, international relations etc. are all taken into consideration. The importance and weight of each varies for different countries, governments, organizations and individuals. Treaties and numbers are negotiated to establish *better* not *best* cases.

Due to the nature of the task, reduction often focuses symbolically on reaching seemingly arbitrary round numbers such as 1000, 500, or even zero weapons. These round numbers seem to please the masses causing policy makers to strive to achieve them. This leads to a quasi-backward approach of deciding on a final value then figuring out how to make it happen as opposed to using needs, analysis and capability to determine a more optimal stockpile size. Although this approach isn't wholly ideal the complexity of the problem necessitates it on some level.

A perfectly optimized stockpile size is not realistic. Furthermore, the *optimized* value would likely change even before it could be realized. This necessitates the ability to steward different sized stockpiles. Every time the stockpile size changes there are certain elements and factors that need to be analyzed in order to ensure its vitality and future. Some of these elements will change significantly as numbers decline others will remain more constant and are even needed if numbers go to zero. It is vital that these necessary elements aren't permitted to atrophy as numbers decline. First and foremost, at any stockpile size the most important of these elements is the ability to maintain expert personnel. A second element that remains for a stockpile of varying size is the ability to conduct surveillance and maintain the health of the stockpile. Lastly, is the ability to react and respond to serious events that may require a return to previous number levels.

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[8] Fourer, Robert. *Optimization Methods.* Northwestern University, 2004. B-143.

The remainder of this paper will attempt to outline the necessary elements of stockpile stewardship and what it means for the Nuclear Weapons Complex. It will also venture into addressing future actions for further deep reductions to take place and suggest future analysis that may become necessary.

Expertise

Experts have always been the most valuable asset to the stockpile and the nuclear weapons complex. From the beginning, the best and brightest minds in the nation were necessary to develop the first nuclear weapons.[9] Experts in science, engineering, systems management and manufacturing were needed to accomplish the goal. It would not have been possible otherwise. The need for able personnel continued through the Cold War to hold onto the technological edge. Even though no new weapon designs have been introduced in decades experts are still relied upon for stockpile surveillance and maintenance as unforeseen problems arise.[10]

The current stockpile is maintained through Life Extensions Programs (LEPs) targeting Cold War era designs.[11] With each passing year the NWC says goodbye to more and more of the experts that designed these weapons. These experts are being replaced by a new generation with significantly less experience in nuclear weapons. One prominent example is those who participated in underground testing are becoming rare. This dwindling experience is expected due to the lack of design and the classified nature of nuclear weapons. One cannot get an education or degree in nuclear weapon design or study the nuances of weapon testing and development in school. This problem is compounded by the difficulties in transferring this valuable knowledge from one generation to the next (even within the classified world of the Nuclear Weapons Complex). The ability and ease of transferring this knowledge and understanding is greatly overestimated.

Also, with the current approach of maintenance through LEPs there is the risk that cascading small changes to Cold War era designs could produce unpredictable and unforeseen changes in weapon reliability. Those most capable of predicting these changes are the ones who made the original design, but they are on their way out the door. Without the proper expertise no amount of resources would be sufficient to produce a confident solution to these unforeseen problems.[12] Some argue that this could be mitigated with advancements in simulation codes and models. Sufficiently sophisticated and accurate models could allow less knowledgeable people to evaluate problems and produce solutions. Relying on models becomes a very scary proposition. Simulations and models are shaped around assumptions, our existing knowledge, and known test data. This limits them due to our biases, known failure scenarios, and doesn't allow them to accurately predict cases outside of our current knowledge base.

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[9] Loeber, Charles R. *Building the Bombs: A History of the Nuclear Weapons Complex.* Sandia National Laboratories, 2002, 7.

[10] Ibid. 175-176.

[11] Ibid. 179.

[12] Adams, Marvin L., and Sidney D. Drell. *Technical Issues in Keeping the Nuclear Stockpile Safe, Secure, and Reliable.* December 2008. http://cstsp.aaas.org/files/DrellAdamsBrief.pdf.

As will be discussed in more detail later, a corresponding drop in hedge numbers will most likely change the way surveillance and maintenance are conducted.[13] Current surveillance relies heavily on destructive (non-nuclear) testing of hedge weapons. Identifying problems in nuclear weapons is not trivial (especially considering they cannot be fully tested at this time) nor are the problems and their associated solutions. New non-destructive surveillance methods would likely be incorporated into stockpile stewardship. Development of these methods would require an uptick in necessary personnel and weapon experts.

Taking it one step further, deep reduction in stockpile numbers (hundreds to zero) may require a fully new designed weapon(s) that will need Subject Matter Experts (SMEs) on electrical, mechanical, chemical and nuclear levels as well as system level management and manufacturing. In 2008, the Secretary of Defense Robert Gates warned that "To be blunt, there is absolutely no way we can maintain a credible deterrent and reduce the number of weapons in our stockpile without either resorting to testing our stockpile or pursuing a modernization program."[14] Deep reductions will almost certainly need modernization or Underground Tests (UGTs) (or both). Either way, there will be a pressing need for nuclear weapon experts. Some see the move toward zero weapons in the future as inevitable. If that is truly the case it would be very beneficial to consider a fully modernized design sooner rather than later when generations of expertise have left the NWC.

Another difficulty is attracting the experts of tomorrow. From personal experience, the current trend of no new designs yields an associated perception among many recent graduates that careers in nuclear weapons aren't sustainable. Even experienced scientists and engineers may perceive jobs in the NWC as poor long-term career choices that aren't challenging or interesting given the lack of development and design. It also appears that those who do end up working for the NWC tend to not stay as long as they used to.[15]

There is a fallacy among many weapon critics and analysts that as numbers go down the necessary quantity of capable personnel goes down with it. It is necessary that the nation realize there is no longer a proportional relationship between the size of the stockpile and the number of experts needed for proper stewardship. In fact, it is likely inversely proportional as stockpile levels decline.[16] A 50 percent reduction in stockpile numbers cannot be maintained by a 50 percent reduction in personnel. The relationship may have been linear in the early days of nuclear weapons but given the political stance on weapon design and testing this is no longer the case. As numbers continue to decline it will soon arrive at a point (if it hasn't already) where

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[13] Johnson, Kent, and Carl Ekdahl, Richard Krajcik, Lui Salazar, Earl Kelly, Robert Paulsen Josheph Keller. *Stockpile Surveillance: Past and Future.* January 1996. http://www.fas.org/sgp/othergov/doe/lanl/osti/197796.pdf, 13-16.

[14] The New Deterrent Working Goup. "U.S. Nuclear Deterrence in the 21st Century, Getting it Right." July 2009. http://www.centerforsecuritypolicy.org/upload/wysiwyg/center%20publication%20pdfs/NDWG-%20Getting%20It%20Right.pdf.

[15] U.S. Government Accountability Office. *Strategies and Challenges in Sustaining Critical Skills in Federal and Contractor Workforces.* April 2012. http://www.gao.gov/assets/600/590508.txt.

[16] Adams, Marvin L., and Sidney D. Drell. *Technical Issues in Keeping the Nuclear Stockpile Safe, Secure, and Reliable.* December 2008. http://cstsp.aaas.org/files/DrellAdamsBrief.pdf.

any reduction in stockpile size will have little if any effect on the necessary manpower to maintain the stockpile.[17]

Of the most important methods of ensuring experts connected to the NWC is continued Research and Development (R&D). R&D efforts will need to be increase and take place alongside nuclear weapon stewardship in order to maintain experts and entice new employees to join the fold.[18] As research efforts continue to bridge the gap between cutting edge technologies and their potential application to the weapons world the nuclear weapon complex will be able to maintain the necessary expertise and attract capable personnel from across the nation. A breakup in the relationship between cutting edge technologies and nuclear weapons could potentially result in a hemorrhage of top minds from the complex. Given the current economic scene, public and political pressures to persuade the nation to slow funding to these research efforts are becoming more common.

All future decisions regarding the NWC should keep in mind that a stockpile of any size needs people that can identify, evaluate, diagnose, and fix problems that may arise and, if necessary, design, produce and modernize the stockpile of tomorrow. Capable personnel are by far the most valuable asset to the stockpile, more valuable even than the stockpile itself. Given time, resources, and the right people the stockpile could be reproduced. But no amount of time and resources would be sufficient without the expertise. When expertise is lost efforts to bring it back to its previous state are difficult and costly. It may not even be impossible to obtain an equivalent level of the previous understanding. A lapse in knowledge of nuclear weapon design, even for seemingly trivial components, could have lasting effects. The Nuclear Weapons Complex must always have access to the outstanding minds of the nation.

Surveillance

Complex systems never stay in the same state. They require constant attention to maintain. A nuclear weapon combines electrical, mechanical, nuclear and chemical aspects making them one of the most complex systems ever developed. Radiation, aging effects, degradation and obsolete/limited-life components make it necessary to constantly monitor the stockpile.[19] No matter the future stockpile size, aside from zero, there must be a way to evaluate the state of health of the weapon(s). In the beginning this was done in Trinity fashion. A weapon in question was taken out and tested in full capacity. This continued through the cold war with atmospheric, underwater, and underground testing. The dangers of atmospheric testing were soon realized and all testing was relegated to underground. Soon after the Cold War ended underground testing ceased as well in the United States. Since then, the stockpile stewardship

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[17] U.S. Government Accountability Office. *Strategies and Challenges in Sustaining Critical Skills in Federal and Contractor Workforces.* April 2012. http://www.gao.gov/assets/600/590508.txt.

[18] Ibid.

[19] U.S. Department of Energy . *The Stockpile Stewardship and Management Program, Maintaining Confidence in the Safety and Reliability of the Enduring U.S. Nuclear Weapon Stockpile.* May 1995. http://www.fas.org/nuke/guide/usa/doctrine/doe/st01.htm.

program has evaluated the state of weapons through 'no-yield' component and system testing as well as materials experimentation with a newfound focus on simulation and modeling.[20]

Much of the current evaluation and surveillance relies heavily on non-nuclear full weapon destructive Joint Test Assemblies (JTAs).[21] During these tests the nuclear explosives package is removed and the weapon is fitted with diagnostics to monitor the mechanical and electrical systems.[22] The weapon is then deployed in *live* fashion and scrupulously analyzed and scored. These evaluations are paramount to understanding the state of an aging stockpile. They also depend heavily on the size of the inactive stockpile. The destructive nature of the testing necessitates this hedge be established such that weapons in a state, more or less, identical to those in the active stockpile can accurately represent aging and other trends of the active stockpile.

The major risk with future stockpile surveillance is being able to maintain these methods as numbers decline.[23] Particular interest is given to hedge numbers. As long as there are sufficient hedge numbers this type of testing is ideal in the absence UGTs. It allows experts to analyze the state of the stockpile and directly diagnose any non-nuclear issues that arise. This type of testing establishes the safety and surety of the stockpile to assure the nation that the stockpile can be properly handled and deployed. It also establishes the effectiveness of the stockpile's deterrent effect by proving the reliability of weapons for our nation and demonstrating to the opposition that our weapons remain capable.

Even if active stockpile numbers approach zero the size of the inactive stockpile could facilitate continued testing of this nature. If hedge numbers decline in parallel with the active stockpile there will come a point when a transition to a different type of surveillance would need to take place. If not, the nation would destructively test itself out of a stockpile all together.

Developing the surveillance methods of tomorrow is a very difficult endeavor both technically and logistically. It would almost certainly make the expertise previously mentioned all the more important. There are some who disagree and it has been suggested that at low weapon numbers there would be a seamless and even practical change in surveillance techniques. They are of the opinion that stockpile evaluation would no longer need to be test-based and destructive but would evolve to be a thorough investigation of the weapon systems, subsystems and components in more of a bench-top environment. In this process every device, electronic board, and mechanical part would be evaluated individually. In short, open up every weapon in the stockpile and test every component in a rotational manner then replace parts that need replacing. Those in favor of these methods have indicated that surveillance of this nature could go on indefinitely without ever having a need to produce new weapons or designs. Hedge

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[20] Johnson, Kent, and Carl Ekdahl, Richard Krajcik, Lui Salazar, Earl Kelly, Robert Paulsen Josheph Keller. *Stockpile Surveillance: Past and Future.* January 1996. http://www.fas.org/sgp/othergov/doe/lanl/osti/197796.pdf, 13-16.

[21] National Nuclear Security Administration. *Managing the Stockpile.* June 2012. http://nnsa.energy.gov/ourmission/managingthestockpile.

[22] Johnson, Kent, and Carl Ekdahl, Richard Krajcik, Lui Salazar, Earl Kelly, Robert Paulsen Josheph Keller. *Stockpile Surveillance: Past and Future.* January 1996. http://www.fas.org/sgp/othergov/doe/lanl/osti/197796.pdf, 7.

[23] Ibid.

numbers could be eliminated.[24] But, there are huge risks with this type of surveillance. Before something like this could be considered there are many huge hurdles that would need to be overcome. Cost, complexity, proving system reliability, and part obsolescence are just a few of the major obstacles.

With regards to cost and complexity, it is naïve to assume that surveillance of this nature would be simple and cost efficient. *Cracking* open a nuclear weapon and checking all of its components to see which have degraded then replacing those that are near failure is a daunting task. Even at small stockpile numbers this would be an astronomically huge effort with huge upstart costs of establishing a test cycle rotation, training personnel, developing test equipment/techniques, establishing acceptance/rejection requirements, etc.

Then, there is the task of proving system reliability numbers to ensure military requirements are met. System level analysis is difficult via subsystem/component testing. Parts of a whole may function correctly by themselves but fail when combined. Proving that the weapon, as a whole, is *healthy* would become a statistical nightmare without high level tests. Reliability requirements would likely need relaxing. Furthermore, there exists a misguided assumption that you don't damage the weapon during the surveillance process. It is very difficult to examine components and subsystems for functionality without destroying them (or at the very least reducing their lifetime) due to human factors and the nature of each individual part. All of these things would need great consideration in order to implement a program such as this.

Obsolescence of components and parts is another continuous problem even with today's modernization efforts.[25] An excellent example of the impact of part obsolescence is that of vacuum tubes. As technologies advanced the vacuum tube has been all but replaced by the semiconductor based transistors in electrical systems. They perform very similar functions but a transistor cannot directly replace a vacuum tube without significant changes being made to the system. Vacuum tubes will not last forever and they are no longer being produced, so a system using vacuum tubes cannot be maintained. All *modern* parts become extinct eventually. The idea of indefinite stockpile maintenance without continually modernizing weapon components/systems through LEPs is not realistic unless NWC production facilities are capable of designing and producing all components necessary for nuclear weapons.

Some may suggest surveillance and testing of weapons gravitate toward simulations and models. Simulation and modeling are valuable tools that should continuously be advanced but will never be enough, by themselves, to evaluate the complete state of nuclear weapons.[26] As stated earlier, relying completely on models is impossible because they are based on our incomplete perception of reality and lean upon assumptions drawn from that perception. This

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[24] Nuclear Weapons Complex Consolidation Policy Network. *Transforming the U.S. Strategic Posture and Weapons Complex.* April 2009. http://www.nukewatch.org/policynetwork/StrategicPosture_Summary.pdf., 15-17.

[25] Center for Counterproliferation Research. *U.S. Nuclear policy in the 21st Century: A Fresh Look at National Strategy and Requirements, Executive Report.* July 1998. http://www.ndu.edu/centercounter/nucpolicy.html.

[26] Nuclear Weapons Complex Consolidation Policy Network. *Transforming the U.S. Strategic Posture and Weapons Complex.* April 2009. http://www.nukewatch.org/policynetwork/StrategicPosture_Summary.pdf., 15.

makes them excellent at predicting known trends but limits their ability to anticipate the unpredictable issues.

Ideal surveillance, from a reliability standpoint, would be based on full scale underground nuclear testing. This is not likely to happen so it is becoming more apparent that surveillance techniques will need to change if deep reductions in stockpile numbers continue to occur. Considerations must be taken to ensure that numbers are not reduced beyond the capability to evaluate the health and reliability of the stockpile. Future reductions in hedge numbers will quickly bring us to a decision making point regarding surveillance.

Production Capability

The main risk with regards to production of nuclear weapons is the loss of capability. It is easy to fall into the mindset of 'if we did it once we can do it again'. Building thermal nuclear weapons is not like riding a bike. Reestablishing production facilities and capabilities would be an astronomical effort both financially and logistically. Often times highly specialized abilities can never be fully brought back to their previous state once they've lapsed. Regardless of future stockpile size great care should be taken to ensure that these abilities are maintained on some level.

The stockpile will not last forever and simple maintenance requires the ability to manufacture weapon related product. This is evident by the dynamic nature of the stockpile. As long as zero weapons is not achieved components will need to be reproduced, replaced or repaired at some point. A peer review study performed by the JASON group done at Los Alamos National Laboratory and Lawrence Livermore National Laboratory on the aging of Plutonium, released in unclassified form in November 2006, concluded that the minimum expected lifetime of plutonium pits in U.S. nuclear weapons is 85 years.[27] That is a long time but the day will come when primaries and secondaries need replacing. The same goes for every component in a nuclear weapon. None of them last forever due to degradation and aging effects. Many components in nuclear weapons are produced externally and, as mentioned earlier, they may become unobtainable or obsolete in the future. All of these concerns point to the necessity of maintaining production capabilities.

There is always the concern of unexpected reliability or safety issues discovered in routine surveillance. All weapons have related materials and components. A significant common-mode failure could cripple the stockpile.[28] Having the expertise and surveillance techniques to identify these problems is not enough. There must be an accompanied ability to manufacture solutions to the problems and restore the stockpile to a satisfactory state.

In the future there may be a need to bolster weapon numbers due to unforeseen technological or political events. Technological breakout should always be a concern. Over the centuries there have been notable war-related technological leaps ranging all the way from gun powder to thermal nuclear weapons. These breakouts have all drastically altered the way we approach war and international relations. After the atomic weapon was developed there have

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[27] JASON Program Office. *Pit Lifetime.* November 2006. http://www.fas.org/irp/agency/dod/jason/pit.pdf.

[28] U.S. Department of Energy . *The Stockpile Stewardship and Management Program, Maintaining Confidence in the Safety and Reliability of the Enduring U.S. Nuclear Weapon Stockpile.* May 1995. http://www.fas.org/nuke/guide/usa/doctrine/doe/st01.htm.

been large advancements in technologies with fighter jets, unmanned air vehicles, satellites, etc. but none of these has had the same impact as the development of nuclear weapons. It would be careless to assume that an enemy could never produce a *next generation weapon*. If that were ever to occur it would be vital that we maintain the ability to react.

Stating that capabilities need to be maintained is the easy part. How can this be done when so few weapons are being produced and a shrinking stockpile? Low-rate constant production is difficult but many believe it to be the best solution.[29] The ability to produce weapons would be maintained by constant production at an equal rate to that of the *natural* weapon attrition caused by surveillance, dismantlement, replacement, etc. Measures would be necessary to evaluate how production capacities of specific components and materials must be sized to maintain the stockpile through this type of steady-state, continuous production. Achieving any sort of steady-state, low-rate production would be difficult in the near-term as a result of the extended period of very limited production that has occurred since the Cold War.[30] For this to be fully established it may become necessary for a revitalization of the weapon designs and NWC facilities. Sustainment of a smaller more advanced stockpiles would likely be more cost-effective in the long term. The transition towards established production of a modern, high-margin, high-reliability warheads would surely increase cost during a *transition period* but would almost certainly translate into long-term budgetary savings. But spending now to save in the long run is often seen as political suicide. Nevertheless, from the standpoint of expertise, surveillance, and production this would be an ideal solution. If continuous low-rate production were fully implemented, stockpile stewardship resources would likely shift to a design, research, and surveillance emphasis with and established production capability.

It is important to remember that if significant and deep stockpile number reductions occur the demonstrated ability to *ramp-up* production may be the most powerful deterrent.

Future Considerations

Many questions were briefly touched on or eluded to in the previous sections. As stockpile numbers continue to decline policy makers will need to find real answers to these and many other questions.

- *Should a high-margin/high-reliable weapon design be readdressed?*[31]

To ensure that those who know more about weapon development are still around to participate in the design of a new warhead sooner would be better. This is especially important considering the design will most likely never be fully tested. An effort such as this would be a huge undertaking with long lead-times. The length of time for full implementation of a new warhead could make the development outlast its critical need date. Producing a high-margin warhead design based on previously tested principles would likely help assure reliability, ease of surveillance, and production. It would also likely lower long-term budgetary commitment.

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[29] Ibid.

[30] U.S.Department of Defense. "Increasing Transparency in the U.S. Nuclear Weapons Stockpile." May 2010. http://www.defense.gov/news/d20100503stockpile.pdf.

[31] Medalia, Jonathan. *The Reliable Replacement Warhead Program: Background and Current Developments.* July 2009. http://www.fas.org/sgp/crs/nuke/RL32929.pdf., 1-3.

Keeping in mind that the undertaking of a new weapon design in the midst of diminishing arsenal trends would raise domestic and international political concerns.

- *Should NWC facilities be consolidated and/or upgraded?*

Decisions on the desired future capabilities of the stockpile must be made in the near-term to appropriately size and equip the NWC. For instance, new production infrastructure such as the Chemistry and Metallurgy Research Replacement (CMRR) facility and the Uranium Processing Facility (UPF) were originally sized for a specific annual production capacity.[32] These production capacities will likely decrease during the lifetime of the facilities production but could also increase given unforeseen political events. Similar to a weapon redesign, very large scale facility upgrades would also raise questions among international nuclear powers.

- *At what point will the nature of surveillance and stewardship need to change?*

Maintaining status quo, stockpile numbers can only go so low given current stewardship techniques. The nation must ensure that a decision on stockpile/hedge size doesn't overstep the capability to produce safe and reliable weapons and conduct extensive evaluation of the stockpile. If weapon requirements on reliability and confidence were relaxed other options may become available but safety can never be compromised. Ensuring that hedge numbers remain high through low-rate continuous production would ensure the viability of current surveillance techniques even with deep active stockpile reductions but this would likely cause significant political angst.

- *Should the number of types of weapons be reduced? Should the triad be reduced?*

The threat of common-mode failures requires multiple tail number overlap in capability. If an unexpected failure eliminated a particular weapon the integrity of the triad would likely remain given this overlap. But, as numbers decline, at some point it becomes impractical to maintain this level of overlap. Furthermore, the necessity of a full triad is always in debate. That debate will become more heated as stockpile numbers are reduced.

Summary

The nation depends on the Nuclear Weapons Complex to maintain a safe and reliable stockpile. It has been over 20 years since a new design has entered the stockpile. Over this timeframe the number of weapons in the stockpile has decreased dramatically. With the ratification of New-START the active stockpile will reach numbers below two-thousand for the first time since the 1950s.[33] Even though President Barack Obama outlined a goal of zero many knowledgeable about nuclear weapon policy would say that it is more of a dream than a goal. Future deep reductions would require a shift in the approach of the NWC with regards to stockpile management. The problem is complicated when technical and political hedging strategies are

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[32] U.S. Department of Energy. *Supplemental Environmental Impact Statement for the Nuclear Facility Portion of the Chemistry and Metallurgy Research Building Replacement Project.* August 2011. http://nnsa.energy.gov/sites/default/files/nnsa/inlinefiles/Chapter%2001.pdf., 61.

[33] U.S.Department of Defense. "Increasing Transparency in the U.S. Nuclear Weapons Stockpile." May 2010. http://www.defense.gov/news/d20100503stockpile.pdf.

considered. At low numbers, hedging could be provided by a responsive infrastructure that is continually in low-rate production and constantly exercising design capabilities. Other concerns could be mitigated via deployment of a modern, high-margin warhead design and a production facilities capable of designing and producing all nuclear weapon components. Regardless of the future of the NWC and the stockpile there are certain factors that should remain constant when it comes to proper stewardship. The most important of these factors are expertise, the ability to conduct surveillance, and the ability to maintain production capabilities.