Summary of the Science & Technology Workshop
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The overarching theme of this workshop can be summarized in the following question: *Is there a technical challenge facing the stockpile that must be addressed urgently?* The broad consensus was that there **is** a challenge facing the stockpile: sustaining sufficient expertise to maintain the nation's nuclear deterrent. Indeed, many felt that the foundation of enduring, responsive deterrence is not hardware or facilities, but rather the expert personnel in the complex. Further, there was consensus that there is little, if any, relationship between the size of the stockpile and the need for and size of a well-trained laboratory staff: regardless of how large or small the arsenal is—including zero weapons— there is a need for an expert workforce. There is a relationship between the size of the stockpile and the size of the workforce, but the asymptotic size is not zero.

In addition, while the thrust of this workshop was the scientific and technical issues underlying the future of U.S. nuclear weapons policy, there was clear recognition that there must be both a clear policy and presidential leadership before any substantive changes can be made to the weapons labs and production complex.

The workshop focused on three sets of questions, indicated in italics below. However, these questions are strongly coupled and it proved difficult to confine answers to a specific question. In addition, while some decisions can be made independent of stockpile size, many hinge on the size and composition of the arsenal and thus require specific policy guidance. Because of this murkiness, this paper deals with themes that emerged from the meeting, rather focusing only on these questions.

> *How can the nuclear stockpile be kept safe, secure, and reliable in the face of aging, the end of nuclear testing, and calls in some quarters for drastic downsizing of the nuclear enterprise? What are the critical elements of the program that must be supported, regardless of the size of a reduced stockpile?*
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> *Will the legacy science-based stockpile stewardship program, life extension programs, and enhanced surveillance of the existing stockpile be able to do the job, or will substantial modernization be necessary?*
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> *If required, is modernization best done through concepts such as Reliable Replacement Warhead (RRW), through a new but undefined concept that Congress has called Advanced Certification, or through an evolving combination of RRW and legacy stewardship? Would a modernized stockpile allow increased confidence in our stockpile, thereby achieving faster reductions in its numbers?*

The discussion can be coalesced into four main themes: urgency, the number of labs needed, costs, and the size and composition of the "hedge".

Areas requiring urgent action

Areas of consensus

There was broad consensus that any urgency facing the nuclear weapons enterprise is not in the aging of the hardware (*i.e.*, imminent weapon failure) but rather in the aging of the personnel. The science-based Stockpile Stewardship Program (SSP) has worked well to certify, without nuclear testing, the on-going capabilities of the weapons. Stockpile stewardship has been successful by at least two fundamental measures, namely, that it has discovered causes for serious concerns in the stockpile and has successfully addressed these concerns. In addition, SSP has helped transfer the skills of those weapons scientists with testing experience to new scientists without it. SSP has matured, with robust internal and external reviews, to a point where it can be used in a robust fashion for certification and to identify potential future needs. The Life Extension Programs (LEPs) have worked well but are expensive and will eventually require refurbishment of the cold war complex. The current approach of the LEPs, which has replaced individual weapon components to extend the life of weapons in the legacy stockpile, may not be the best (most cost effective), or even an adequate, procedure for resolving all future concerns.

However, there are personnel problems facing the weapons labs. The labs' expert staffs are not inexpensive but are indispensable for the lab missions. Further, the lab personnel are aging; those few left with testing experience will soon be mostly retired and the ability to attract and retain the best and brightest of the current and next generations will continue to diminish, particularly if the mission is not clear and well supported by the U.S. government. It is important to note that a smaller stockpile does not imply simpler or fewer problems that must be solved by expert personnel and that there is an increasingly broad spectrum of national security problems that require nuclear expertise, including nuclear proliferation, counter-terrorism, nuclear forensics, technical support to the Department of Defense, the Federal Bureau of Investigation, the intelligence community, and treaty verification for the Department of State.

There is no great urgency to rebuild the weapons production complex in its Cold War configuration; to do so would be very expensive. A spectrum of options exists for less expensive methods to address life extensions of the existing weapons (see below), especially given that the Life Extension Program has worked successfully to date.

Areas of disagreement

There was no consensus in the notion that the current Life Extension program will involve increasing risk as we move in to the future, meaning new techniques must be developed to mitigate that risk.

Number of labs needed

Areas of consensus

There was consensus that peer review of one lab's work by the other lab is very useful and has identified problems in both labs' work. Indeed, peer review has saved, by some estimates, $10B in cost avoidance over the past 10 years. The ongoing confidence in and certification of weapons systems requires and will continue to require peer review. See, for example, the JASON report JSR-07-336E "Reliable Replacement Warhead Executive Summary" for a broader discussion of this topic.

In addition, even if the U.S. has a zero-weapon deployed arsenal, we must have sufficient experts to understand the actions of other nations on broad spectrum of activities; these, too, require peer review. Further, there will likely be an ongoing need for capacity (equipment required to build) and capability (expert manpower required to build), regardless of the stockpile size. It was also agreed that the labs cannot be replaced by industry, as there is the need for ongoing research at facilities that industry does not have, and the labs cannot be replaced by academia, as academia requires complete openness while the labs can and do work on very classified projects.

The lab missions have already been broadened and now include work for others. This does not dilute capabilities, as the “others” are 80% Department of Defense and most of the remaining “others” are law enforcement and the intelligence community.

Areas of disagreement
There were several items in this theme that generated a great deal of discussion.

- Does a lab-within-a-lab (ala the French system) work for peer review? What about moving one set of design teams to the local Sandia?
- Can external peer review (by, *e.g.,* JASON or the Strategic Advisory Group/Stockpile Assessment Team [SAG/SAT]) suffice? Who adjudicates disagreement (*e.g.*, lab directors or JASON)?
- What is the required rate of production (trickle production versus 50 pits per shift per year)?
- If the U.S. no longer make changes to weapons (perhaps after a successful RRW?), does the lab system still require peer review?
- Does an “independent” or a truly external assessment approach work?
- Must the labs be focused on a “product” or is basic or related research sufficient as a way to maintain expertise?
- Who certifies the certification process? JASON, SAG/SAT, or a separate independent permanent group of experts?

Costs
Areas of consensus
The participants in this meeting agreed that the costs associated with the weapons complex are not well understood. While the National Nuclear Security Administrations (NNSA) has a model that some believe is accurate, it is not widely used or shared. However, the participants agreed that the fixed costs are very large (on the order of $5 billion per year), even if no weapons are produced. The only real way to save money is to close one or more facilities. Therefore, more attention needs to be paid to performing costing studies. And as noted above, the status quo will result in unsustainable costs

Areas of disagreement
The participants could not agree whether RRW or LEP is cheaper; this disagreement is mostly due to poor and incomplete cost studies.

Size & composition of the hedge

Areas of consensus

There was broad agreement that as size of deployed stockpile decreases, it becomes more challenging to perform surveillance activities: fewer weapons imply that smaller numbers (or a larger fraction) of the stockpile is available for surveillance activities. The reserve stockpile could be valuable for cherry-picking parts for repairing weapons.

Areas of disagreement

Is the hedge the expert workforce, the size of the stockpile, or production capacity?

In addition to the above four major themes, the following themes were also discussed.

Status of lab/production complex

Areas of consensus

Other than the personnel issue, the new facilities at the labs are in decent health: good science continues to be done excellent and new scientific capabilities continually coming on line (such as the National Ignition Facility [NIF] and the Dual-Axis Radiographic Hydrodynamic Test Facility [DARHT]. However, the old facilities (both lab and production) are showing signs of neglect. In particular, the production complex is badly neglected. Many participants wondered if a BRAC[1]-like process to work on complex consolidation. There was broad agreement that while delaying decisions increases costs, it is more important to get decisions right and that it is important to distinguish actions and changes that are *required* for the U.S. to maintain a safe and reliable nuclear deterrent from those that are *desirable*. Finally, computing needs will continue to grow and the labs must stay at leading edge of capabilities in this area.

Areas of disagreement

- Will LEPs function indefinitely, or will an RRW-like process become inevitable?
- What types of personnel are needed? Will they be solving science problems or engineering problems?
- What will the lab personnel do? Will they work on ongoing or new designs, on stewardship activities, or on "work for others"? Further, research is critical, but is it sufficient to keep the required levels of expertise?
- Should the labs remain part of the Department of Energy, should they move to the Department of Defense, or should a new entity be created to manage them?
- Does the complex need to produce one weapon a month or one a week to stay sufficiently expert?

Underground Testing

Areas of consensus

Since the end of underground nuclear testing in 1992, the stockpile stewardship program has been successful in maintaining the safety, security, and reliability of the US nuclear stockpile

[1] Base Re-alignment and Closure. The military has used several BRAC commissions to close and consolidate facilities post-Cold War.

without nuclear testing. For example, given current simulations, have been able to compute implications of corrosion defects that would otherwise have been resolved by testing. There do not appear to be any technical reasons for a return to underground testing for the foreseeable future.

RRW versus LEPs

Areas of consensus

There is a spectrum of activity between the endpoints of complete system replacement (RRW) and replication of legacy weapons (LEP). One point along this spectrum is the notion of "enhanced replacement LEPs", wherein some components are reused from existing warheads, some are remanufactured from existing designs, and some are manufactured from new designs. The best point on spectrum depends on what is learned as stockpile stewardship continues, how the stockpile requirements evolve, and what advanced features are required.

As noted above, the ability to remove a constant number from (and hence ever growing fraction of) the stockpile for disassembly and diagnostics degrades as stockpile shrinks. Inserting (wireless) microsensors into/onto components thus becomes more critical as the size of stockpile decreases. The ability to do *in situ* monitoring and diagnostics would be greatly enhanced by the addition of such technology. In particular, this would create a statistically larger sample which would improve diagnostic capability.

A not-inconsiderable amount of time will be required to get new production of *anything* online, and the first batches will likely be made with the old/existing complex. The exploration of multiple options along the RRW/LEP spectrum would create greater flexibility to respond appropriately to changing requirements and to potential surprises.

It was noted that both the current (General Kevin Chilton) and the preceding (General James Cartwright) Commanders of STRATCOM have testified that their main concerns for nuclear weapons were reliability, safety, and security. Neither had yield as a top concern.

Areas of disagreement

Participants could not agree on the need for insensitive versus conventional high explosive, the impact of RRW & "enhanced replacement LEPs" on military capability, the potentials for pit and/or secondary reuse or the relationship between reliability and surety.

Aging

Areas of consensus

The plutonium studies completed in 2006, followed by a JASON report[2], indicate that plutonium aging is not a near term problem and will not impact weapons performance. In addition, there is a need for more scientific studies both on plutonium aging and on other weapon components.

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[2] R.J. Hemley, et al. "Pit Lifetime." JSR-06-335, January 11, 2007.

Final Thoughts

The overarching theme of this workshop was the need for policy to direct the work of the nuclear weapons complex. The development of a new U.S. nuclear weapons policy could allow a major reduction in the overall costs of maintaining the stockpile. This would manifest itself in several ways. First, an improved margin of safety, security and reliability could lead to increased confidence by the Department of Defense and thus a smaller stockpile that enhances nonproliferation and arms control negotiation options. Second, changes in the approach to nuclear weapons production could save significant money in how the weapons are maintained, as the present Cold War-production approach involves many steps that are difficult to reproduce today without significant cost investment and the nuclear weapons production complex cannot produce all the components of a stockpiled weapon today. Third, reductions in the stockpile open a "spectrum of approaches" that could be tailored to address any problems found in existing weapons without underground testing. As part of this, advanced surveillance techniques can be developed to find problems quicker and with more confidence. Reductions in the stockpile would also reduce the costs of transportation, disassembly and destruction of weapons and could allow "cherry-picking" of weapons parts to sustain the stockpile. Finally, fixing problems in the stockpile could employ a variety of methods based on economic analyses. These could vary from "traditional" or "incremental" life extension programs utilizing remanufactured parts, to "enhanced reuse" life extensions with parts from other certified reserve or retired weapon systems, to remanufactured weapons (trickle manufacturing) based on previously tested components.