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# **The US nuclear weapon infrastructure and a stable global nuclear weapons regime**

John D. Immele and Richard L. Wagner<sup>1</sup>

19 January 2009

## **Abstract**

*The objective of this paper is to reconcile two ways of thinking about the US nuclear weapons (NW) infrastructure: 1) the infrastructure planning perspective, typified by NNSA's Complex Transformation and oriented toward deterrence and dissuasion, and 2) the "vision" perspective, for which the objective is to create a global NW regime in which the nuclear weapon danger is minimized. Disconnects between these points of view are at the root of the US impasse on NW. We integrate these two perspectives in a type of vision that we believe encompasses and overarches others: a global nuclear weapon regime that is stable in the sense that geopolitical shifts, political crises, or technical developments do not lead, quickly or over an extended period, to conditions in which there are incentives for weapon use. Crisis stability is a well developed concept that applies to forces-in-being. Infrastructure stability, as we develop it in this paper, assures that changes in forces over months or years do not result in crisis instability.*

*We focus mainly on nations' infrastructures and the stability of relationships among them, rather than on stockpiles and forces-stability, for two reasons: Even at the next plateau of stockpile reductions, infrastructures will have a greater role in dissuading future threats and shaping the NW postures of others states; secondly, neither the major powers nor current and potential/latent proliferants can be secure at very low numbers (perhaps even at "zero") without understanding and managing the role of latency and infrastructure.*

*We first define and discuss the overarching concept of a stable regime and then within that the role of infrastructure capabilities. We develop a warning-and-response framework for characterizing infrastructure capabilities from two perspectives – infrastructure-based dissuasion and the stability of infrastructure relationships in a broader regime.*

*We then develop criteria for infrastructure stability: balancing responsiveness with restraint and transparency / confidence-building. We briefly consider the structure of possible cause-and-effect relationships between how one nation strikes its balance between (infrastructure) responsiveness and restraint and how other nations strike that balance.*

*We then present a specific and somewhat detailed application of these general ideas: designing the US infrastructure to further a global regime characterized by fewer weapons and stable relationships among infrastructures. Considerations include both US infrastructure-requirements for dissuasion and the two criteria for stability.*

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<sup>1</sup> The information contained in this report reflects the views of the authors who are solely responsible for its validity, accuracy and completeness. Neither Los Alamos National Laboratory nor the US Government endorses the accuracy of information herein.

*We find that current planning for both pit and CSA production is generally consistent with criteria for both effective dissuasion and for the degree of restraint and transparency needed to move toward a stable infrastructure regime. We urge, however, that more explicit attention be given to designing production capabilities for transparency/verification. We also find that large inventories of weapon components and the capacities of facilities for weapon reconstitution pose a potential instability problem inconsistent with such a regime.*

*We also consider the responsiveness, restraint, and transparency issues associated with the Labs' science and technology bases, and with exploration of RRW and "non-standard" designs. Both to sustain the labs' responsiveness over the long term and to move toward a stable regime, we urge enlarging the labs' mission-space to encompass much more comprehensively national nuclear security writ large, including the science and technologies for threat-reduction, non- and counter-proliferation, verification and confidence-building, countering nuclear terrorism, and nuclear material controls. Extensive international collaboration, where possible, would increase transparency and build confidence for a stable regime.*

*The paper concludes with considerations for managing capability and infrastructure at very low levels of weapons inventories in ways consistent with infrastructure stability, with application both to the major nuclear states in the long term and other states more immediately. This paper is a work in progress, and all of these topics need further study.*

## **I. Introduction**

Our objective in this paper is to integrate, or at least inter-relate, two important bodies of thinking:

- US planning for the future US nuclear weapons infrastructure and its capabilities -- e.g. current planning for "Complex Transformation" , and
- desires and plans – "visions" – for a future global nuclear weapons regime in which the danger of their use is much reduced or eliminated.

We believe that disconnects between these points of view or ways of thinking are at the root of the impasse in dealing with the future of US nuclear weapons that has existed since the end of the Cold War.

To the extent that planning for the US nuclear weapon infrastructure is or has been based explicitly on national security strategy, its objectives are deterrence and dissuasion of potential adversaries, assurance of allies, etc. (This is consistent with the treatment of nuclear weapon infrastructures as the third leg of a new strategic triad in the 2001 Nuclear Posture Review.<sup>2</sup>) Such planning has been virtually silent on how the US infrastructure relates to a future regime in which the dangers from nuclear weapons are substantially reduced – i.e., a vision for the future.

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<sup>2</sup> "Nuclear Posture Review Excerpts," January 8, 2002, available at [www.globalsecurity.org/wmd/library/policy/dod/npr.htm](http://www.globalsecurity.org/wmd/library/policy/dod/npr.htm); J.D. Crouch, "Special Briefing on the Nuclear Posture Review," January 9, 2002, available at [www.defenselink.mil/news/Jan2002/g020109-D-6570C.html](http://www.defenselink.mil/news/Jan2002/g020109-D-6570C.html).

There have been a number of types of visions for the future of nuclear weapons since 1945 – international control, abolition (notably, in recent years, in the 2007 Wall Street Journal article by Schultz et al<sup>3</sup>), dominance of defenses over offenses, or some combination of these. Sometimes fairly concrete plans have been proposed to achieve such visions – for example, the 1946 Baruch Plan and the 1996 report of the Canberra Commission.<sup>4</sup> Some studies are currently underway,<sup>5</sup> stimulated in part by the article by Schultz et al, to lay out fairly detailed pathways to abolition.<sup>5</sup>

We frame our work in this paper in terms of a different kind of vision: a global NW regime<sup>6</sup> that is stable against upsets – that is, against political crises, accidents, inadvertence or misunderstanding, or longer term geopolitical or technical developments -- that could lead, quickly or after an extended period, to the use of nuclear weapons, including possibly large-scale use. The central theme of the paper is to outline how the US nuclear weapon development and production infrastructure can be configured -- by balancing responsiveness against restraint and by enhancing transparency -- to enhance stability in the near- to mid-term, as weapon inventories are reduced to some “next plateau” and thus to advance, in part by example, development of a comprehensive, stable, global regime in the long term,<sup>7</sup> In the terms used in the 1993 Nuclear Posture Review, configuring the US infrastructure in this way could be part of a “lead but hedge” strategy – leading, by exercising some degree of restraint and enhancing transparency; hedging, by retaining some balanced degree of responsiveness.<sup>8</sup>

This work is a first step toward something rather ambitious. Applying the general idea of stability to nuclear weapons is not new, but extending it to a broad regime, as we attempt to do here, and developing a detailed instantiation of one part of such a regime, is new.

The general concept of a stable global regime for nuclear weapons is complex, with many parts. More particularly, a full treatment of nuclear weapon stability would recognize that it is influenced by other military/strategic capabilities (missile defense, non-nuclear strike, etc.), but we have chosen to address here only nuclear weapon postures. We then for the most part deal with nuclear weapon infrastructures, rather than weapons/inventories-in-being (although we do explore the relationship between infrastructures and weapons-in-being to some extent). Within the US nuclear weapon infrastructure, we chose to address the NNSA infrastructure rather than

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<sup>3</sup> Schultz, George, William Perry, Henry Kissinger and Sam Nunn, “A World Free of Nuclear Weapons,” Wall Street Journal, January 4, 2007: A15.

<sup>4</sup> The *Canberra Commission on the Elimination of Nuclear Weapons* was initiated by the Prime Minister of Australia in November 1995 to deliberate on issues of nuclear proliferation and how to eliminate the world of nuclear weapons. The result of the Commission was published by the Australian Government Department of Foreign Affairs and Trade as the *Canberra Report* in August 1996.

<sup>5</sup> Perkovich, George and James Acton, *Abolishing Nuclear Weapons*, Adelphi Paper 396, International Institute for Strategic Studies, Routledge, NY, 2008; Perkovich, George, Jessica Mathews, Joseph Cirincione, Rose Gottemoeller, and Jon Wolfsthal, *Universal Compliance: A Strategy for National Security*, Carnegie Endowment for International Peace, Washington DC, March 2005; Daalder, Ivo and Jan Lodol, “The Logic of Zero: Toward a World Without Nuclear Weapons,” *Foreign Affairs*, vol. 87, no. 6, 2008, pp. 80-95; Garry J. George, *Integrated Nuclear Security in the 21<sup>st</sup> Century*, to be published 2009.

<sup>6</sup> “Regime” is a defined term in international relations studies, of which regime theory is a sub-discipline. We mean it here as broadly as it is meant in that discipline, although we only develop part of the broader concept.

<sup>7</sup> Ambassador Ron Lehman was using the phrase “balancing readiness and restraint” some years ago, and we credit him for it, although we may not be using it here in exactly the ways he intended.

<sup>8</sup> The 1993 Nuclear Posture Review was issued in 1994 and approved by the President on 18 September 1994. Conclusions of this NPR are summarized in the *Annual Report to the President and the Congress*, William J. Perry, February, 1995.

the DoD NW infrastructure for the sake of a paper of manageable size that lays out the principles. Perhaps the most important way in which we have limited the scope of our discussion is in how we address the large and difficult question of how the configuration of the US infrastructure might influence other nations' configuration of their infrastructures. Rather than speculating on the particulars of how other nations and combinations might react, we present a general framework for shaping, and we develop three principles for configuring infrastructures that also represent three principles for US leadership.

Others might think that exploration of a stable regime should emphasize other aspects; we encourage such thinking. To adequately develop the concept of a stable regime will require a much fuller examination than can be detailed in a single paper.

### **A. Why do we focus on infrastructure(s)?**

There are three general reasons. First, when the Cold War ended, highest-stakes world situations in which weapons-in-being are *immediately* relevant "receded into the future". The Cold War is over, but geopolitical situations could arise again in which the stakes, though perhaps different in nature from those of the Cold War, are as high, or nearly as high. There is a wide range of possible geopolitical futures and world (dis)orders, of course, but whatever the geopolitical future might be, the nuclear weapons of those futures are "latent in" the infrastructures that can develop and produce them. From a deterrence perspective, that is what is meant by "*capability/infrastructure-based deterrence / dissuasion*".<sup>9</sup>

Second, nations could not reduce inventories of weapons-in-being to very low numbers (or "zero") without understanding and structuring the role of latency and infrastructure-capabilities.

And third, proliferation issues will increasingly be about "latent NW capability" – nations developing or sustaining nuclear weapon or nuclear fuel cycle infrastructures that could allow them to respond to security concerns that they judge might arise in the future. Some proliferators may have actual weapons-in-being (there are some of these today). As technology continues to grow and spread, more nations will have latent capability to proliferate, with only latent weapons, and with infrastructures in a wide range of readiness to develop and produce actual weapons. Most, perhaps, may rely on the increasing capabilities of their general science, technology, and industrial bases, rather than having dedicated nuclear weapon or material infrastructures. Critical, of course, is the nuclear energy / nuclear material infrastructure which, combined with laboratory studies and awareness of weapons design, will strongly determine readiness. Although differing in degree there are several tens of nations with latent NW capabilities.

Increasingly, then, it is NW *infrastructures* that "cast a long shadow" into the future.

## **II. What do we mean by "a stable regime"? How do infrastructures relate?**

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<sup>9</sup> The ideas here build on "capability-based deterrence" discussions circa 1993 that were part of the thinking behind Science-Based Stockpile Stewardship (SBSS). See J. D. Immele, P. D. Goldstone and T.K. Scheber in the article "Redefining the U.S. Nuclear Weapons Program and the DOE Nuclear Weapons Complex" in *Los Alamos Science*, July, 1993. Earlier work by R. L. Wagner and T. Gold, *Long Shadows & Virtual Swords: Managing Defense Resources in the Changing Security Environment*, 1990, was influential in the shaping of such thinking.

In common and scientific parlance, “stable” means that small changes or perturbations do not lead to bigger and still bigger ones. In this paper, we specialize the idea, while still retaining the general sense, to mean structuring nuclear postures so that political or technical changes do not escalate or “run away”, leading to NW use – either 1) immediately, if nations’ inventories of weapons-in-being are in crisis-unstable relationships, or 2) over a longer term, if weapon redeployment and/or production races result.

This concept of stability encompasses events and developments that could take place over the full range of scenario-times, from very short (minutes to hours) to very long (many years). It is a continuum that includes:

- First-strike/crisis stability of forces-in-being, to avert use over minutes to days
- Stability over weeks to months to avert force-generation races, mobilization races.<sup>10</sup> (This could include, for example, re-MiRVing )
- Infrastructure stability, which deals with weapon development and production extending over many months to many years, (and which is the main subject of this paper)

By “infrastructure stability” we mean configuring nations’ infrastructures, and bilateral or multilateral relationships among them, so that political tensions or instabilities do not lead to weapon development and production competitions that -- because of various imbalances in infrastructures and their responsiveness, or perceptions of such imbalances – could lead, downstream, to larger or different inventories of weapons-in-being that are in crisis-unstable relationships. The latter might, in turn, lead to deliberate or inadvertent use, possibly even unprecedentedly catastrophic large-scale use. The ensemble of these types of stability can in principle apply to any nuclear weapon posture – large to “zero”, current or future, first-time or reconstituted, in-being or latent.

The concept of stability as applied to nuclear weapons is not new. The earliest work that we know of was the seminal work of Lt. Gen. Glenn Kent in the 1970s. Kent and his co-workers developed the concept of bilateral first-strike stability, and applied it to the key issues of those times -- achievement by the Soviet Union of nuclear weapon “parity” with the West and issues that accompanied it, including improved accuracy resulting in counterforce capabilities and concomitant issues about survivability; and strategic missile defense and counters to it such as multiple warheads. Kent’s work was central to configuring Cold War strategic postures and to arms control – in particular the ABM treaty of 1972 and the limitations on MiRVs of SALT and START.<sup>11</sup>

Our concept of a stable regime extends this work in two ways: to longer times – weeks, months, years – and to multilateral cases. Bilateral first-strike/crisis stability is (or once was) a fully developed and instantiated set of concepts, built up from Kent’s original thinking by a community of analysts whose work matured over many years. In contrast, extensions of that work to include the *dynamics* of *multilateral* stability over weeks, months, and years are not nearly as well developed. Some work on such extensions was done by the TRAC Nuclear Panel,

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<sup>10</sup> The concept of mobilization instability over days and weeks is the central theme of *The Guns of August* by Barbara Tuchman, which is about the days and weeks that led up to the beginning of World War One.

<sup>11</sup> An excellent review may be found in Glenn A. Kent and David E. Thaler, *First-Strike Stability – A Methodology for Evaluating Strategic Forces*, RAND Report R-3765-AF, August 1989.

DTRA's ASCO, and Los Alamos between 1998 and 2001, but much more needs to be done to bring them to the same level of maturity. The complete ensemble of these concepts of stability – some well-developed, some so far fairly rudimentary -- is what would comprise a stable regime as we think of it in this paper. Much more needs to be done.

A full treatment of nuclear weapon stability would include:

- Nuclear weapons and their infrastructures
- (Missile) defenses and their infrastructures
- Non-nuclear strategic kinetic strike weapons (and their infrastructures?) that can influence nuclear postures
- Conventional forces
- Possibly other “strategic” capabilities.

It would also include other aspects of the regime<sup>12</sup> constructed to assure stability, including (for example): transparency, verification, and confidence-building measures; sanctions against non-conformance; and the treaties, institutions, and other arrangements that might bring about and embody all of this. In our work here, however, we address only nuclear weapons -- and, in particular, their infrastructures and verification and transparency related to infrastructures.

This general concept of stability and a regime that embodies it can be thought of as a meta-vision – a concept or ensemble of concepts that overarches, and is a metric/criterion for, other visions, including abolition, and defense-dominance. Thus the desirability of abolition, for example, and paths to it, would be assessed by examining its stability, as we have defined and described it above.

We are not speaking here about a *political* regime that is stable. Indeed, our thinking is oriented toward dealing with the possibility of political instabilities, which we suspect will be endemic over many decades to come. Rather, we are talking about stability of relationships among weapon postures. But there is an important relationship between weapon-posture stability and political instability. A stable weapon posture-regime is more likely to be able to ride out political instabilities without weapons being used, and – in part because of that -- it may help to ameliorate or limit the severity of political instabilities<sup>13</sup>.

Figure 2.1 summarizes much of what we have said above. This graphic shows that the general idea of stability encompasses the entire scenario-time range from minutes to many years, and mentions some of the terms that have been applied to stability-issues along that time line. Below that, it shows the assets that would be configured to achieve stability in each time-frame. The lower portion depicts some of the multilateral actions needed to build and sustain the regime: configuring assets for stability, assuring verification and transparency of the stability features of the assets, and the associated instruments and institutions– treaties, etc. The box is where we focus our analysis – mainly on scenario-times of months to years, on the infrastructures, and on verification/transparency related to them. We consider only briefly weapons-in-being. We limit discussion of nuclear material production to the last section on very low numbers of weapons. We also do not address how treaties might be constructed.

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<sup>12</sup> “Regime” is a defined term in international relations studies, of which regime theory is a sub-discipline. We mean it here as broadly as it is meant in that discipline, although we only develop part of the broader concept.

<sup>13</sup> We do not, however, subscribe to the suggestion once advanced by Ken Waltz, that nuclear proliferation would have a beneficial effect in stabilizing international relations.

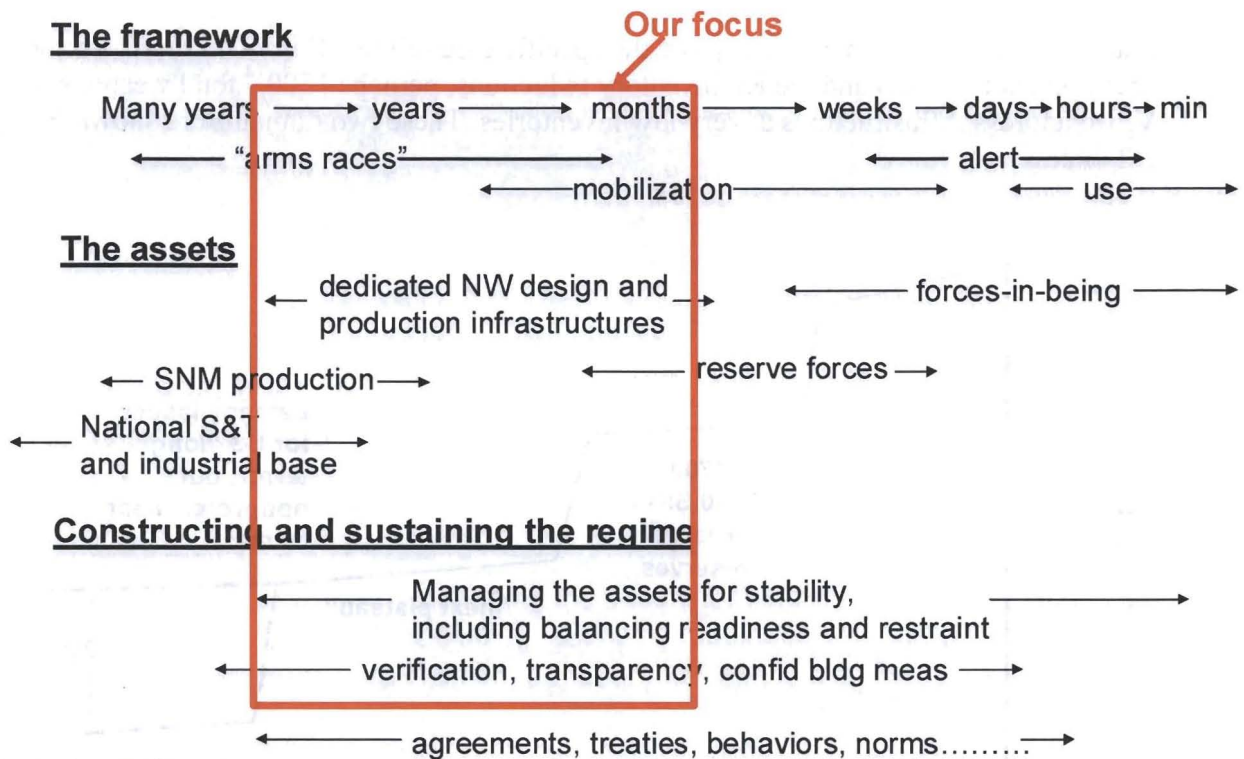


Figure 2.1. A framework for stability over the entire scenario-time range from minutes to many years and its relationship to nations’ assets that might be configured to achieve stability in each time-frame. The lower portion depicts some of the multilateral actions needed to build and sustain the regime. The box is where we focus our analysis – mainly on scenario-times of months to years, on the infrastructures, and on verification/transparency related to them.

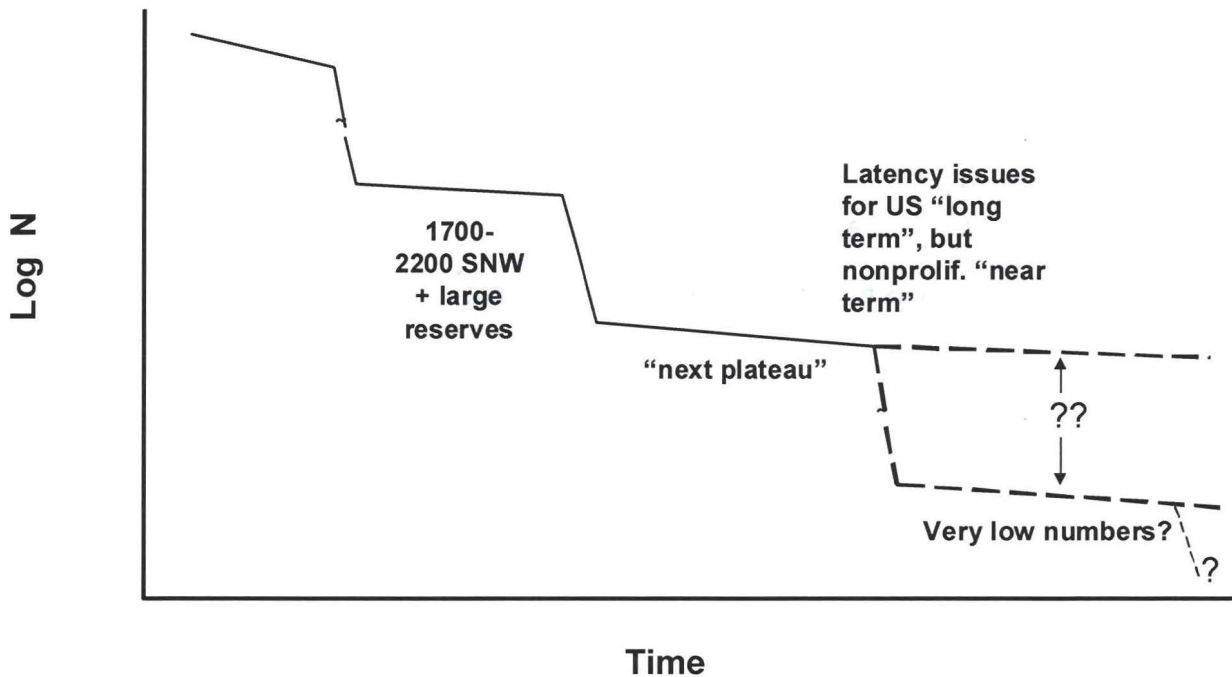
Figure 2.1 also indicates an idea that is central to our discussion later: developing infrastructure stability by balancing readiness and restraint in infrastructure capabilities. And it shows that we do address the infrastructure-related aspects of verification and transparency.

In the next few pages, we will discuss weapons/forces-in-being very briefly; we will develop the idea of balancing readiness and restraint; and we will develop a framework for addressing verification/transparency.



### A. The relation of infrastructures and forces/weapons-in-being

Later, in Section IV, where we explore the specific case of the US infrastructure, we focus on the “next plateau” for US and the RF inventory reductions: perhaps 1500<sup>14</sup> total weapons. In Section V, we address infrastructures at very low inventories. These two domains are shown in Figure 2.2, below.



*Figure 2.2. Weapon inventories for which we address infrastructure: (1) the next plateau for the US and the Russian Federation and (2) very low inventories. The latter is relevant to proliferation and regional nuclear competition in the near term and to the major nuclear states in the longer term.*

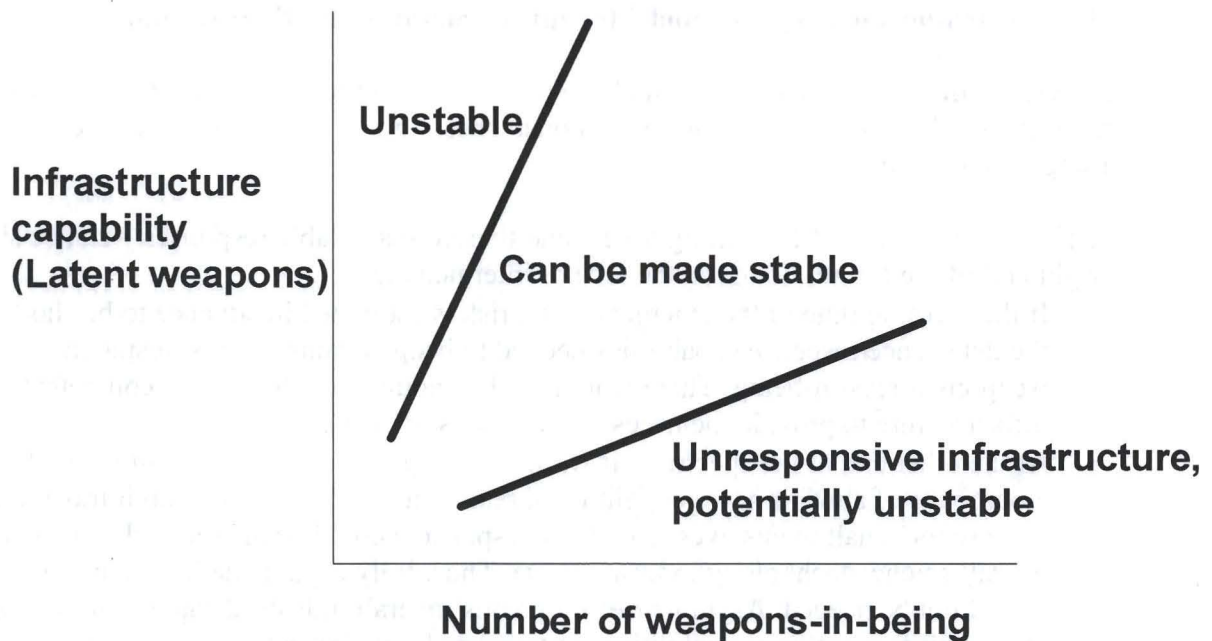
In a fuller treatment, much more could be said about weapons-in-being and crisis stability, including, for example, multilateral crisis stability (much more complicated than the bilateral case of the Cold War), sensitivity to the nature of deterrence – for example “existential” deterrence – and the role of limited missile defense.

Of course, there is a strong relationship between weapons-in-being and infrastructures. For example,

<sup>14</sup> While we cannot prejudge the outcome of the next Nuclear Posture Review or the Congressional Commission on the Strategic Posture of the US, a stockpile of 1500 weapons (including nonstrategic weapons and reserves) represents a “next plateau” considerably reduced from the current inventory but substantially more than, for example, China, France or the UK. The number of total weapons could be more, say 2500, or less, perhaps 1000; our conclusions would be the same.

- Inventories of weapons/forces-in-being can stabilize against infrastructure instabilities that might be produced by differences in infrastructures or uncertainties about their capabilities
- Infrastructure capabilities can stabilize against uncertainties/differences in forces/weapons-in-being, perhaps especially at low numbers

A more general description of the relationship between (numbers of) weapons in being and (capabilities of) infrastructures is shown in the following graphic:



*Figure 2.3. General stability of relationships between infrastructure capabilities and sizes of inventories of weapons-in-being.*

There are three major sectors in this space plus the region near the origin – or “zero.” (We later treat the case of low numbers but acknowledge that true “zero” is unique and will require further analysis.) In the upper left sector, with large infrastructures and small inventories, there is likely a region of instability. Weapon inventories that are large compared to original inventories, or perhaps different in ways that lead to force-instability, could be built rapidly in the relatively large infrastructures. Disparities in infrastructure capabilities or in production start-times could result in large inventory disparities and qualitative or quantitative crisis/first-strike instabilities.

In the lower right sector, if something goes wrong in the inventory of weapons-in-being, the infrastructures are incapable of dealing with it, and a possible instability in relationships among nations’ weapons-in-being could also result (although for a different reason than in the upper left).

In the middle, where inventories and infrastructure-capabilities are more nearly matched, the relationships are more likely to be stable. The original inventories of weapons-in-being could stabilize against disparities in rate of inventory increases, at least for a time. Conversely, infrastructures can respond to disparities that might develop in inventories-in-being. The current US posture, which we discuss in detail in Section III, may be near or below the lower boundary of the stable zone, because US production capabilities are so limited and because the US inventory consists of weapons whose performance-margins are generally rather small. We develop this point further in Section III.

### **B. A warning and response model for infrastructures and their stability.**

It is useful to think of infrastructure capabilities in terms of their responsiveness to new needs or to risks that could emerge.<sup>15</sup> The idea of responsiveness carries with it the idea of response to warning of some kind.

Referring back to figure 2.1, warning time – and therefore available responses – can be short (on the right end of the figure), long (on the left) or intermediate:

- If the warning time of the emergence of a risk is estimated in advance to be short, then the deterrence/response capabilities needed to hedge against it must reside in weapons/forces-in-being. There would not be enough time for even a competent infrastructure to provide the necessary weapons or changes.
- At the other end of the spectrum, if warning is expected to be long – for example, the emergence of a major new geopolitical threat – then dedicated weapon infrastructures that are too small themselves to be fully responsive could be augmented from a nation's overall science/technology/industrial base. Thus, fully capable dedicated infrastructures would not be needed. Asymmetries in nations' overall industrial capabilities could result in instabilities as those capabilities are translated into dedicated infrastructures and weapons, but there is little that could be done about that.
- It is in the case of intermediate warning – several months to a several years – that dedicated infrastructures are relevant, and configuring them for stability will be important. It is this region that we mainly address in this paper. The relations among nations' postures for mid- to long-term warning and response, as reflected in their dedicated nuclear weapon infrastructures, are what mainly shape the (infrastructure) stability of a future NW regime for averting future rapid, competitive, possibly autocatalytic, (re)armament/breakout among/between both major powers and smaller states, including both actual and latent proliferators.<sup>16</sup>

### **III. Three criteria for evaluating infrastructures and how they relate to a stable regime: responsiveness, restraint on responsiveness, and verification and transparency.**

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<sup>15</sup> An alternative and fruitful way to frame much of what we say in this paper might be in terms of risk-management. In 2008, the TRAC distributed a paper within OSD and elsewhere that laid out how to address a wide range of nuclear weapon issues in risk-management terms.

<sup>16</sup> Of course, SNM production could be the pacing item in breakout in some scenarios, rather than weapon-production capabilities per se. We address SNM production to some extent in Section III.

This section presents, in general and conceptual terms, three characteristics of infrastructures – any nation’s infrastructure – that are central to assessing and configuring them for stability. In Section IV, we then use these criteria or principles to assess current and planned *US* infrastructure in concrete, specific terms.

#### **A. Infrastructure requirements for deterrence and dissuasion**

The first criterion is simply the responsiveness of the infrastructure to a nation’s needs for its own national security deterrence, dissuasion, assurance, etc. We elaborate on this criterion further in section IV with particular application to the US.

This would be the only criterion (along with cost) if the objective of achieving a stable regime were absent or ignored. But the point of this paper is to blend the deterrence objective with the achievement of a stable regime. To do this, other criteria or approaches are needed, which we outline in the following two or three pages.

#### **B. Achieving a stable regime by nations’ balancing responsiveness and restraint-in-responsiveness of infrastructures.**

The second criterion we propose for stable infrastructures is restraint vis-à-vis the responsiveness in the first criterion. In a stable regime, the responsiveness of nations’ infrastructures would be mutually/multilaterally equilibrated by each nation balancing two aspects of its own interests:

- Its interests in the responsiveness of its own infrastructure, as it would view those interests in the absence of an international regime of stable infrastructures balanced against
- Its interests in achieving or sustaining such a regime.

This balance would be achieved by each nation exercising some restraint in the responsiveness of its own infrastructure, in order to induce restraint on the part of others – in other words, by striking a second, related, kind of balance, between responsiveness and restraint.

In fact, each nation has a *self*-interest in achieving such a regime. Restraint on the part of others would represent a form of threat reduction, and in a sense, this is the interest a nation has in achieving or sustaining a stable regime.

Addressing the question of exercising restraint in infrastructure-capability in order to induce such restraint by others is one instantiation of a much larger question: how one nation’s nuclear weapon posture (or one nation’s behavior in general) shapes others’ postures and behaviors. This is an important and difficult subject that we do not address in this paper, other than to sketch, toward the end of this Section a very general conceptual framework for thinking about it. As a first step we proposed the three principles or criteria and will show how they apply for the US.

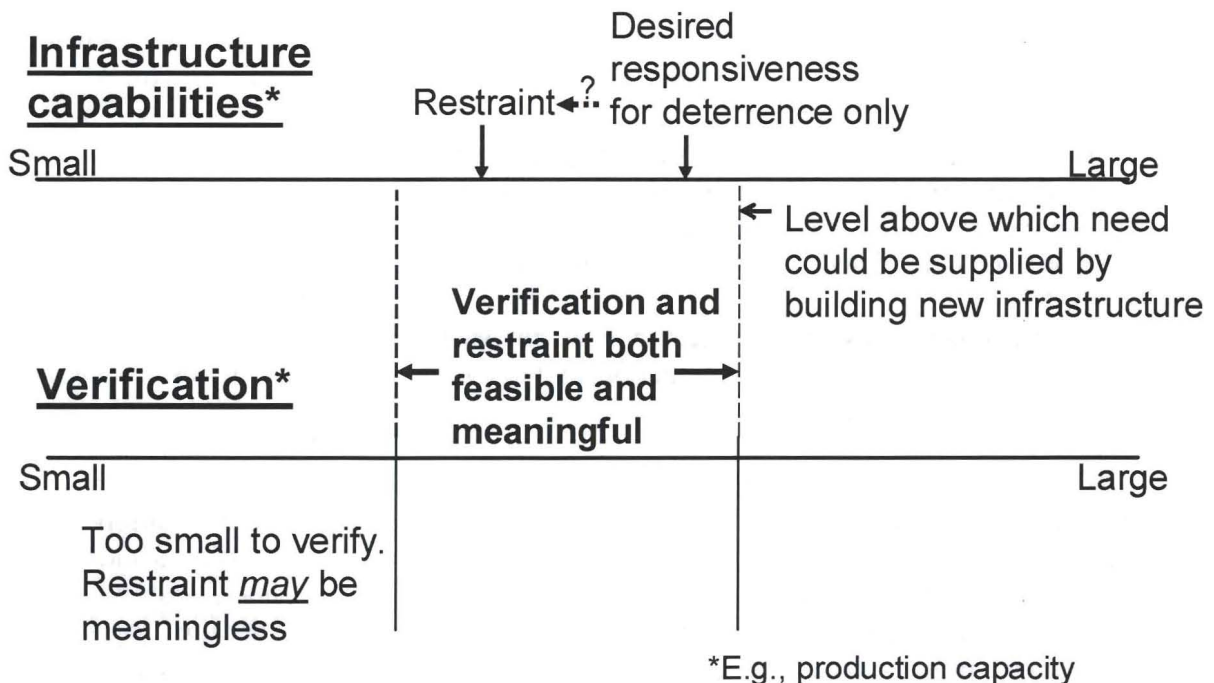
**C. A framework for relating responsiveness and restraint to what can be verified.**

Our third criterion for stable infrastructures is verification and transparency. Striking the right balance between responsiveness and restraint must be evident to potential adversaries and allies alike. Here, we suggest a general framework for relating it to the balancing of responsiveness and restraint that we discussed above.

For any level of transparency or intrusive verification, there are limits to what can be confidently confirmed by other nations. A corollary is that deliberately restraining infrastructure capabilities below the limit of verification has little value in inducing restraint in others. Potential adversaries and many others in the international community will conservatively assume that a particular nation could do, or is doing, whatever can be done up to the limit of verification.

At the higher end of the infrastructure-capability spectrum, it does not make sense for a nation to build a dedicated nuclear weapon infrastructure large enough to deal with risks that have a long warning time. New or augmented, dedicated infrastructure could be built from a nation's overall science, technology and industrial base as needed. Verification (even if quite practical) is essentially meaningless in this case.

Thus there is a range of infrastructure-capability in which restraint and verification are meaningful, as shown in the following graphic.



*Figure 3.1. A framework for responsiveness/restraint and verification. Below some level of capability, verification will be difficult, and potential competitors might assume that capability will exist up to that level. High levels of capability are often hedges, and above some level of need, nations might assume that warning times for the hedged scenarios would be long enough*

*to build more infrastructure. The range between these bounds is the useful range for considering balancing responsiveness with restraint.*

We will use this general framework, and simpler graphics based on it, in much of Section IV.

**D. How does the US or any nation's NW posture – in particular, how it balances responsiveness and restraint – shape other nations' postures?**

In the real world, nuclear weapon postures are in some sense all inter-related (as, reflected, for example, in the NPT regime). But this inter-relatedness has structure. Part of the structure today consists of a set of bi-lateral or tri-lateral relationships among nations which are disparate in the "size" and nature of their nuclear weapon dimension. They are sufficiently disparate that thinking through, and actually building, a stable regime must, in part, be tailored to each of them. Downstream, there can be an aggregation of the different cases into a comprehensive regime. We list some representative cases here, both to illustrate the different cases and because we will pick one – the US case – to apply the three criteria. Cases include:

- US and Russia (and each of these vis-à-vis China) – large postures
- India and Pakistan (and China) – smaller postures
- DPRK (weapons-in-being, and more latent) vis-à-vis Japan, ROK (under the US umbrella)
- Israel (a smaller posture) and Iran (latent, as of today), and possibly other middle-east nations (even "more latent").

An analysis of these relationships and how each is influenced by the others' postures is an immense, difficult, and pivotal question. We cannot do it justice here, for two reasons: it is very complex, and much of what is needed to address it relates to international relations, which is not our area of competence. But our sense is that it is polarized, with ardent believers and ardent skeptics. To illustrate what we believe is the true nature of it – a middle ground – we simply sketch what seems to us to be the logical structure of the matter. (This structure applies to any pair or ensemble of nations, and to any influence topic, but we will speak in terms of the particular case of the US and of nuclear weapons.)

In principle, the US nuclear weapon posture can shape another nation's posture both/either:

- Desirably – e.g., to deter or dissuade potential adversaries (including capability/infrastructure-based dissuasion), to assure allies and others, etc.
- Undesirably – e.g., it could provoke potential adversaries into actions we do not wish; or it could frighten rather than re-assure allies and others

We want to emphasize that the positive, desirable aspects of shaping (e.g. dissuasion) cannot be invoked without also considering the negative aspects.

And shaping can be some combination of:

- Direct shaping/influence -- the nation whose posture it is the US intent to shape responds directly to the US posture.
- Indirect shaping – the US posture influences other nations and the international community, which in turn act (directly or more diffusely) to shape the posture of the nation we desire to shape.

In each of these four cases – desirable or undesirable, direct or indirect – the “strength” of the shaping can range from negligible to large. A full analysis of shaping/influencing – and thus of regime-building – would require addressing all of these possibilities. For now, the US goal should be to lay the technical and political framework – by taking the right first steps. We suggest that the transformation of the US infrastructure should be in accord with the three principles presented above:

1. Responsiveness / meeting US national security requirements
2. Balancing responsiveness with restraint for the sake of infrastructure stability
3. Transparency and confidence-building with a view toward a verification regime in the longer term.

#### **IV. Application of these principles to the US NW infrastructure**

At the start of this paper, we said that our objective is to reconcile, or at least inter-relate, two important bodies of thinking:

- US planning for the future US nuclear weapons infrastructure and its capabilities -- e.g. current planning for “Complex Transformation” , and
- desires and plans – “visions” – for a future global nuclear weapons regime in which the danger of their use is much reduced or eliminated.

We do this, in the following section, by considering the design characteristics of the US NW infrastructure and suggesting how they can be managed according to the three principles above to contribute to a stable global NW regime – which is *our* vision.

Abolition is not practical in the near term – it is at least a generation away – so the US infrastructure must be designed to sustain the nuclear deterrent at the “next plateau” while at the same time allowing for future shrinkage. In some ways, the US nuclear weapons policy and programs are already conformed to make this paradigm shift; science-based stockpile stewardship was designed on the principle of maintaining capability. Planning of both the manufacturing and Lab capabilities has been open and transparent through the Environmental Impact Statement processes detailed below for the overall program and individual sites. In other ways, the US (and Russian) approaches have run counter to the paradigm change: the US has kept large stockpiles of reserve weapons and components, and has left in place an oversized and very inefficient manufacturing infrastructure.

That said, there are important demands on the US NW infrastructure. We outline them here, in effect an elaboration of the first criterion briefly introduced in section III. They effectively define the infrastructure requirements of a capability-based nuclear posture:

- Assessment & certification without nuclear testing
- Sustainment of weapons-in-being (at the next plateau / near-term)
- Responsiveness / adaptation to new requirements – could be weapons security, more margin or a military effect not already stockpiled. (Both the 1993 and 2001 NPRs required that the Complex be capable of new design “if required.”)
- Understanding nuclear intelligence / threat of proliferation
- Deterrence of / preparedness for nuclear terrorism

- S & T for new opportunities in areas such as verification, nonproliferation, nuclear weapons security for other nuclear weapons states.

The first three are usually associated with responsive infrastructure and maintaining nuclear deterrence through Stockpile Stewardship. With the exception of “new requirements / new design” these expectations have been generally accepted and performed well in the “Science Based Stockpile Stewardship” (SBSS) program. The latter three requirements are more often associated with Threat Reduction; however, they combine with the first three as a more complete set of requirements for capability-based deterrence and for “national nuclear security.” The capability rests partly in the footprint and facilities of the infrastructure, but more importantly it resides in the expertise of the stockpile stewards themselves. All six requirements have been part of the national security directives for Stockpile Stewardship. An important aspect of their complementarity is that with lower emphasis on weapons-in-being and nuclear threats, the emphasis of Stockpile Stewardship ( writ large) will shift from the first three requirements toward the latter three. Together they balance capability-based deterrence and dissuasion with a commitment to reduce the nuclear danger.

Because we believe that abolition is not practical in the near term – it is at least a generation away (if it is achievable at all) – the US infrastructure must be designed to sustain the nuclear deterrent at the “next plateau”, and at the same time it should point the way toward future postures for the US and others that are further reduced. This section examines what practical steps the US can take in order to have a nuclear weapons policy and capability based on some weapons-in-being but with an emphasis shifting toward latency and responsive capability.

In some ways, the US nuclear weapons policy and programs are already conformed to make this paradigm shift; science-based stockpile stewardship was designed on the principle of maintaining capability. Planning of both the manufacturing and Lab capabilities has been open and transparent through the Environmental Impact Statement processes detailed below for the overall program and individual sites. In other ways, the US (and Russian) approaches have run counter to the paradigm change: large stockpiles of reserve weapons and components have been retained and an oversized and very inefficient manufacturing infrastructure left in place.

In this section of the paper we focus exclusively on the NNSA infrastructure for warheads, rather than the DoD infrastructures for delivery systems and operations. In a full treatment of nuclear weapon infrastructures in a stable regime, both warhead and delivery system infrastructures should be addressed, and both can be addressed using the same principles we developed earlier and apply, in this section, to the US warhead infrastructure. In this section, we focus on the warhead infrastructure primarily because it is at the leading edge of the current debate on nuclear weapons futures, and the overall DoD technology and industrial base is immense and healthy, though it has certain nuclear-specific deficiencies that should be rectified.

We first address the NNSA manufacturing infrastructure, and then the labs.

#### **A. US NW manufacturing infrastructure vis-à-vis the three criteria for national security and infrastructure stability**



The capabilities of the US NW manufacturing infrastructure have declined since the end of the Cold War. It is our belief that several measures need to be taken to assure their long-term viability. We assess the current capabilities, and discuss how the US might “build down” to an infrastructure that is less expensive to maintain and more in line with reduced stockpiles and the criteria for stability that we developed earlier: balancing responsiveness with restraint and transparency of infrastructure.

The nuclear weapons manufacturing complex today is at a crossroads and faces a difficult set of choices. With the end of underground nuclear testing (UGT) in 1992, the nation had no new production scheduled for nuclear weapons. The initial emphasis of the Stockpile Stewardship program was on the scientific tools to certify weapons without nuclear testing. Without much to do and with resources directed elsewhere, weapons production capability essentially atrophied. In many cases, the nation lost the ability to restart manufacturing streams and processes for legacy weapons materials. This is evidenced by the continually escalating costs and schedule delays for remanufacturing old material and components in the Life Extension Programs (LEPs).

The National Nuclear Security Administration (NNSA) has initiated a program, called Complex Transformation, to provide a manufacturing capability appropriately downsized for the future.<sup>17</sup> NNSA has just recently issued its Record of Decision (ROD) for the Supplemental Programmatic Environmental Impact Statement (SPEIS) for Complex Transformation. The ROD specifies the locations and upper limits for the capacities of the most expensive facilities required – those for manufacturing plutonium (Pu) and highly enriched uranium (HEU) components. Funding and, in effect, authorization to proceed have been deferred to the next Administration and Congress and the hoped-for consensus that might emerge after the deliberations of the *Congressional Commission on the Strategic Posture of the United States*<sup>18</sup> and the next Nuclear Posture Review.

In terms of the graphic introduced earlier for stable infrastructures, we suggest in figure 4.1 that the present manufacturing infrastructure is on the border of stability for the long term because it is neither responsive nor sustainable. Among the difficulties, Los Alamos cannot make more than a dozen pits per year (ppy), and the footprint at Y12 is too expensive to maintain indefinitely. Transformation of the manufacturing capability at the next plateau should be to a smaller but more capable footprint.

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<sup>17</sup> *Complex Transformation Supplemental Programmatic Environmental Impact Statement*, DOE/EIS-0236-S4, Oct. 24, 2008 ([http://www.complexttransformationspeis.com/project.html](http://www.complextransformationspeis.com/project.html)) and *Record of Decision for the Complex Transformation Supplemental Programmatic Environmental Impact Statement*, Federal Register, vol. 73, no. 245, Dec 19, 2008, pp. 77644-63.

<sup>18</sup> *Interim Report – The Congressional Commission on the Strategic Posture of the US*, Dec. 15, 2008 ([http://www.usip.org/strategic\\_posture/interim.html](http://www.usip.org/strategic_posture/interim.html)).

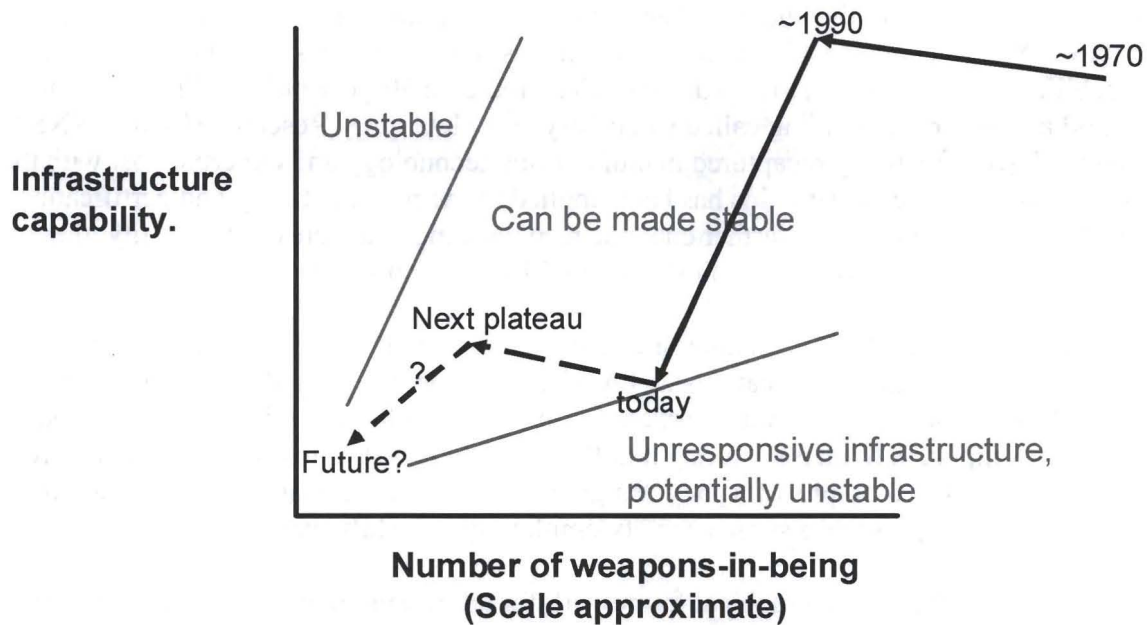


Figure 4.1. In terms of the graphic introduced earlier for stable infrastructures, the present manufacturing infrastructure is on the border of stability for the long term because it is neither responsive nor sustainable, e.g., cannot make more than a dozen pits and the footprint at Y12 is too costly to maintain indefinitely. Transformation of the manufacturing capability at the next plateau should be to a smaller but more capable footprint.

The manufacturing complex contains many elements. Our analysis does not address every element, but instead focuses on three facilities that are the most visible and expensive, and which we judge to be crucial to stability:

1. Pu – sizing the capability and capacity at Los Alamos (How many ppy? What if no new pits? No RRW?)
2. HEU – vastly too big (and expensive). Downsize to what footprint and how many HEU components per year?
3. Storage and disposition – and potential redeployment – of large numbers of pits and HEU components.

We will address these questions in the context of our three design criteria for an infrastructure that both serves US national security requirements for deterrence and is visibly consistent with the long-term goal of infrastructure stability in a future regime with even fewer weapons-in-being.

## *Pu pits*

During the Cold War five major sites, now closed and dismantled, conducted plutonium research and fabrication. With the unplanned and unexpected shutdown of pit production at Rocky Flats, CO in 1989, a sustained national commitment was required to reestablish the very limited capability that now exists at Los Alamos. Centered on a 30-year old building at Technical Area-55 and a 55-year old building called Chemistry and Metallurgy Research (CMR), NNSA and Los Alamos have effectively recaptured manufacturing technology and expertise lost with the Rocky Flats closure. In the interim, this has been applied to the manufacturing and certification of about ten W88 (Trident) ppy. To further enhance responsiveness and ensure flexibility, these activities are now evolving to demonstrate fabrication of different pit types.

NNSA has declared the Los Alamos site as its “preferred alternative” for pit manufacturing in the future. With some modifications to TA-55’s manufacturing building and the replacement of the CMR nuclear facility now authorized (but not funded) for analytical chemistry and materials testing to support both manufacturing and Pu research, Los Alamos’ capacity will increase from around 10 ppy to 20-50 pits of legacy design or 50-80 easier-to-manufacture RRW pits. (The higher number represents a surge capacity employing two shifts per day.)

The following Figure is a graphical framework for addressing how pit-production capacity comports with our criteria of responsiveness, restraint, and transparency. (It applies also to the HEU capacity, which we address below.)

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A few                      ~50                      >125-250 per year

*Figure 4.2. Balancing responsiveness, restraint, and transparency for Pu and HEU component production. Around 50 ppy (and probably a similar number for enriched uranium parts) is a natural level at which manufacturing capability is matched with minimum capacity. Limiting capacity to significantly lower rates would be hard to verify without monitoring the outgoing shipments. Walkthroughs by international observers could verify that the footprint and glove boxes are not sufficient for significantly higher rates of production.*

We believe that a capacity to manufacture about 50 ppy is a proper balance between responsiveness and restraint, and is adequately verifiable, thus meeting the requirements for both US security and for a stable infrastructure regime. For a total stockpile inventory of 1500 weapons,<sup>19</sup> consisting of perhaps four to seven weapon types (giving perhaps 200-400 weapons per type), a production capacity of 50 ppy is:

- Adequately responsive. Within 4 to 8 years, the US could replace one weapon type that might have developed problems, or produce one new additional type of weapon, if needed.

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<sup>19</sup> As noted in an earlier footnote, the number of total weapons could be more, say 2500, or less, perhaps 1000; the nature of our conclusions would be the same.

- Adequately restrained. At 50 ppy, it would take 20 to 30 years to double the size of the US stockpile – a length of time for which there should be no stability concerns. If the US undertook to double the stockpile in a shorter time, it would need to build new capacity at Los Alamos or elsewhere, which would be very visible. If both the original 50 ppy and a new facility with a capacity of 200 ppy were employed, it would take about 10 years to double the size of a 1500 weapon stockpile – still not particularly destabilizing. (An important exception to this point is pit reuse as discussed in the third question.)
- Adequately verifiable. It is possible to inspect a 50 ppy facility and be assured that it is not capable of producing more than, say, 100 ppy – a capacity at which it would take 15 years to double the size of a US stockpile of 1500 weapons. (We discuss transparency/verification in somewhat more detail two pages farther on. Suffice it to say, here, that a program to expand capacity beyond that upper limit would be observable under the transparency regime discussed below, and would take time.)

It is also interesting that the US will have arrived at a minimum capacity matched to pit assembly line capability by “going through zero.” That is to say, the US has planned a minimal pit capacity almost from the ground up after the closure of Rocky Flats. The footprint is small and not so expensive to operate that reducing its throughput to well below 50 ppy for periods of time would appear wasteful.

Why not a lower number, especially for pits? It is true that the longevity of plutonium pits from the 1980s is turning out to be favorable. As a result, pit reuse and SLEPS reduce the need for plutonium manufacturing in the near-term. However, there are life-limiting processes at work and the widely-trumpeted JASONS’ estimate<sup>20</sup> of 100 years is not true for some key weapons systems. Further, we would suggest that the nation not bet the deterrent on never being surprised by the discovery of an aging problem. It takes too many years at 12 ppy to replace a weapons type that might have 250 or more units deployed. Such a limited capacity, and aging scientific and manufacturing facilities, will not support anticipated future needs and, if not redressed, would require maintaining a larger stockpile of weapons or components than otherwise would be desired as a hedge against technical problems in the stockpile.

Furthermore, there would be little to gain in the interest of restraint by limiting capacity to well below 50 ppy – say, to 10 ppy – in part because verification would be problematic at that level. The US will always have a plutonium research capability which could probably, if needed, fabricate 10 ppy, and whether it were doing that or not would require more intrusive – near full-time – monitoring of operations in the facility or of nuclear material shipments into and out of Los Alamos.

On the other hand, if the US succeeds for a few more decades with pit reuse, how would the pit manufacturing capability at Los Alamos be sustained? What would the people and facility work on? A key point here is not to lose the manufacturing expertise and capability which was so costly to recover; it is certainly in the spirit of capability-based dissuasion and deterrence to have a modest, self-sustaining operation which is capable of making the longest-lead item in the

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<sup>20</sup> R.J. Hemley et al., *Pit Lifetime*, JSR-06-335, MITRE Corp., January 11, 2007, available at <http://www.fas.org/irp/agency/dod/jason/pit.pdf>.

inventory. A pit fabrication line need not make 50 pits each year; its vitality can be upheld by a combination of

- Manufacturing a few pits of various, existing weapons types. (Each one has some unique features.)
- Surveillance and testing of pits from the aging stockpile
- Design and certification of advanced pit types with enhanced safety and security features.

### ***HEU components***

The *status quo* for uranium component production facilities is quite different than for plutonium. US uranium facilities at Y-12 near Oak Ridge TN date to the Manhattan Project. Y-12 sustains an overly large and inefficient capacity associated with production of HEU components and secondaries, including HEU forming and machining, assembly, disassembly, dismantlement, surveillance, and storage. In addition, Y-12 has analytical chemistry and material characterization capabilities to support production and qualification, and maintains extensive chemical processing and HEU recovery facilities. They also maintain capabilities and facilities for the production of non-SNM components, including depleted uranium. The footprint and maintenance costs for the above are extremely expensive. Securing these facilities to the terrorism threats we face post-9-11 is increasingly difficult and costly, as is the cost of implementing the formal safety processes that are now demanded of an antiquated set of facilities.

Because of uranium corrosion problems, a number of Life Extension Programs (or RRW) will require replacement of the uranium components. So the 50-80 capability / minimum capacity discussed above would seem to be needed now. Y-12 can get by with the existing plant; however, it has now been shown by an independent Business Case Analysis that a smaller, replacement facility called Uranium Production Facility (UPF) will be many billions of dollars cheaper over the long-term.<sup>21</sup> NNSA has declared the Y-12 site to be their “preferred alternative” for UPF based on independent analysis of several competing sites.

In contrast to the minimum capacity matched to capability for pits, the Uranium Production Facility considered for Y-12 is baselined for 125 HEU components per year, and the overall capability and footprint at Y-12 is not “going through zero.” Are 125 HEU components per year the right level for a stockpile at the next plateau? Other questions should be addressed: How does the planned footprint vary with notions of component reuse being proposed by the Laboratories? Does the HEU capability in the UK provide any lessons for capability matched with minimum capacity? Finally, some thought should go into a UPF design that could transition to only a few units per year – with sufficient transparency and verification to assure the confidence of other nations if/as the weapons states approach low numbers of weapons-in-being.

### ***Transparency of pit and HEU manufacturing***

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<sup>21</sup> TechSource, Inc., *HEU Operations Independent Business Case Analysis*, Santa Fe, New Mexico, September 2008. Savings of \$6.5B net present value to 2060 are estimated for a new UPF with a capacity of 125 components per year vice costs of \$37B for the no action alternative.

Plans for US facilities – both present and future – are open for all to see. Within the Executive branch of government, the original Program Environmental Impact Statement for Stockpile Stewardship<sup>22</sup> and the recently issued Supplement to the PEIS for Complex Transformation (referenced earlier) have been subject to a wide set of public hearings and supporting documentation. In addition, a Site-wide EIS has been published for each Lab or Plant. The EIS process for NNSA has essentially been a public form of strategic planning. Similarly, Congressional debate – whether approving or disapproving – is open. Whatever decisions are made with regard to manufacture of Pu or HEU components, the US will have set a good example for transparency of its intentions.

It is also quite practical for the facilities that result from the above planning to be made available for verification by international partners. In 1999, the Director of Russia's Tomsk-7 facility visited PF-4 at Los Alamos.<sup>23</sup> Of course, some operations and parts were cloaked to protect sensitive steps in the manufacturing sequence, but the overall footprint and glove box utilization was then and could again be opened periodically for verification. We believe that this sort of walk-through combined with an adversary's own intelligence (e.g., satellite photography) and publicly available information would provide a reasonable estimate of the lower and upper bounds of capability and capacity at Los Alamos for pits and at the UPF for HEU components. It is important, however, that the design and construction of these facilities be planned with transparency and verification in mind.

The UK and French programs are also well understood, although the production capacities have not been as openly discussed and easily accessed as in the US. The Russian program is also understood in general terms, although considerable transparency issues remain in detail for their current nuclear weapon program, and future transparency is a substantial concern for Russia in general. The lack of transparency of weapons production in China, Israel and the Indian subcontinent – and for latent capabilities elsewhere -- is a concern that must eventually be addressed.

### ***Storage, disposition and potential redeployment of pits and HEU components***

NNSA and DoD have retained a fairly sizeable (the exact numbers are classified) reserve of weapons in case one or two weapons systems fail or political and military circumstances, however unlikely, require that the US redeploy additional weapons that have been taken out of the active inventory. There is also a considerable reserve of components from disassembled weapons that could be used if necessary. The 2001 Nuclear Posture Review (footnoted earlier) required a substantial hedge because of concerns about the capabilities of the NNSA infrastructure, which has not made more than a few dozen pits in nearly 20 years and which is expensive and unwieldy -- e.g., HEU components.

With a smaller, more responsive manufacturing infrastructure, this dependence on a large reserve should diminish without compromising assurance to allies nor dissuasion of potential adversaries that the US can resupply additional warheads if necessitated by new circumstances.

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<sup>22</sup> *Final Programmatic Environmental Impact Statement for Stockpile Stewardship and Management*, DOE/EIS-0236, Nov. 1996 (<http://www.complexttransformationspeis.com/project.html>).

<sup>23</sup> Sig Hecker, private communication, Dec. 16, 2008.

But for now, storage magazines are packed with reserve components and the Pantex assembly / disassembly plant near Amarillo, Texas, has 65 nuclear bays<sup>24</sup> in Area 12 that might be employed for inspection and assembly / reassembly of stored components into warheads. Our view is that this very large capacity for component reuse must be seen by other nations as by far the greater concern for reconstitution – including reMIRVing – of the US nuclear force structure, than either new facility for Pu or HEU fabrication. The situation is similar in Russia, but at present component reuse is of much less concern for other countries.



*Figure 4.3. Restraint and transparency for storage and potential redeployment of pits and HEU components. The large number of stored components and large footprint available at Pantex for assembly / reassembly places the US at the right end of the scale. This capacity must be considerably reduced for stability to be more in line with a stockpile of approximately 1500 weapons. Capacity for reassembly of 100 weapons per year and commensurate storage would probably be adequate to hedge against deterrence and dissuasion needs. (Requirements for surveillance, remanufacture/ replacement of weapons at the new plateau and permanent dismantlements add considerably to the total weapons operations at Pantex, especially in the near term.)*

Transparency issues for component reuse are also more difficult than for new pit and HEU manufacturing. The good news is that once those components are stored well away from assembly / disassembly capacity and slated for disposition, there are verifiable arms control regimes for converting Pu and HEU to peaceful uses. For Pu, the approach agreed by the US and RF for pit conversion and burning as mixed oxide reactor fuel can be supplemented with safeguards and verification of material quantities and character such as those in the TriLateral (US / RF / IAEA) demonstration earlier this decade.<sup>25</sup> It remains an open question how many of the remaining pits and HEU components can be declared excess and entered into such a regime.

A verifiable regime for SNM components or reserve warheads that are not declared excess needs work. The challenge is to assure international partners of the accounting of warhead components and materials while at the same time assuring SNM security from terrorist attack and minimizing inefficiency and intrusiveness within classified operations. In the late 1990s, the subject was engaged in support of warhead accounting proposed for START 3. Methods are reviewed in an NAS study published several years ago<sup>26</sup>, and a fairly complete regime is defined by Rinne<sup>27</sup> in

<sup>24</sup> TechSource, Inc., *Independent Business Case Analysis of Pantex Surveillance and Evaluation Facility Alternatives* (Santa Fe, NM: TechSource, Inc., September 2008).

<sup>25</sup> L. Avens, J.E. Doyle, and M.F. Mullen, "The Fissile Material Transparency Technology Demonstration (FMTTD)," presented at the 42nd Annual Meeting of the Institute of Materials Management, July 15-19, 2001, Indian Wells, CA, LA-UR-01-3570. See also D.G. Langner, R.P. Landry, S. -T. Hsue, D.W. Macarthur, D.R. Mayo, M.K. Smith, N.J. Nicholas, R. Whiteson, T.B. Gosnell, Z. Koenig, S.J. Luke and J. Wolford, "Attribute Measurement Systems Prototypes and Equipment in the US," presented at the 42nd Annual Meeting of the Institute of Materials Management, July 15-19, 2001, Indian Wells, CA, LA-UR-01-765.

<sup>26</sup> *Monitoring Nuclear Weapons and Nuclear-Explosive Materials*, Committee on International Security and Arms Control, National Academy of Sciences, ISBN 0-309-09597-2, Washington, DC (2005).

the New Court Treaty. The latter combines initial declarations with subsequent monitoring (tags / seals / nuclear material counting at the portals of nuclear facilities) of the transfer of material or components between sites. Its application to the current NNSA complex (or its Russian counterpart) would be very cumbersome; however, prototyping of the process and methods might be undertaken in the US, or in the UK where the infrastructure is considerably less complex.

A companion question is whether the extensive assembly/disassembly (A/D) capacity and footprint at Pantex can be made smaller and transparent? If not, then the Device Assembly Facility at NTS offers an alternative venue for A/D.

Until there is some confidence in limits on reconstitution through reassembly of reserve warheads and components, arms reduction treaties must trust instead the verification of limits on the number of deployed SNDVs (strategic nuclear delivery vehicles). The US and Russia have reduced Cold War strategic weapon deployments by a factor of 5. Both formal and informal means of "proof" have been offered and generally accepted. However, without verification of warhead numbers or warhead assembly activities, the warning and response times are shorter for SNDV counting.

In summary for the NNSA manufacturing infrastructure, decisions need to be made now that will maintain support for the deterrent and reduce the cost of operating old facilities, because of the long lead times to build new facilities to remanufacture or replace aging components. These investments can be planned in a way that provides a responsive infrastructure, but also demonstrates restraint and a vision toward a lower number of weapons-in-being. Designing and building facilities and operations in such a way as to provide for verification will be important.

## **B. US NW laboratory infrastructure and programs**

It is not only the weapons themselves and the factories that make them that assure allies and deter potential adversaries; it is also the capability to certify the performance and safety of the weapons and to adapt weapons and strategy to new or emerging threats or opportunities. Writ large, the excellence of US scientific and engineering personnel engaged in defense R&D and the ability of the US modern defense industrial base to bring advanced defense technology rapidly to the field are highly respected internationally among friend and foe alike. There is a strong case that the breadth and scope of the U.S. strategic modernization program of the late 70's and early 80's, including the perceived potential of an SDI program then in the early stages of R&D, was a key element in President Gorbachev's decision to seek an end in the late 1980's to strategic competition with the West and an end to the Cold War.

The role of the Laboratories in capability-based deterrence is not a new idea. While it appears in the context of the "new triad" and was emphasized in 2001 Nuclear Posture Review by the Bush Administration, it was similarly a part of the Clinton Administration's NPR in 1994 (referenced earlier) and was a principle in the founding of the stockpile stewardship program. An adept, well-informed and imaginative science and technology infrastructure was seen as critical not

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<sup>27</sup> Robert L. Rinne, *An Alternative Framework for the Control of Nuclear Materials*, Center for International Security and Cooperation, Stanford University, May 1999.



only to certify the stockpile without nuclear testing and to respond to possible new requirements, but also to early detection and validation of foreign intelligence gathered to anticipate developments around the world. A future competitor seeking to gain some nuclear advantage would be forced to conclude that its buildup cannot occur quicker than the US could act to detect, innovate and reconstitute appropriately.

The above is not to say that the Labs' size and programs are invariant to nuclear policy and force structure. As we did, above, for the nuclear manufacturing infrastructure, we pose three questions affecting Lab infrastructure and programs and test these questions against the three criteria of responsiveness, restraint and transparency:

1. How to best sustain the science and technology base required for a capability- based nuclear posture? (Near term will be different than long term for US, but the vector is important.)
2. What efforts should there be to understand what is possible for non-standard design? (Types of nuclear explosives different from those now in the inventory.)
3. Whether and how RRW should be pursued.

We take the questions in this order because the S&T required to fulfill the six national security expectations defined earlier is the *sine qua non* of stockpile stewardship, as the stockpile evolves (in whatever way) over the long term. Designing a Lab infrastructure for the future must begin here.

### ***How to best sustain the science and technology base required for a capability- based nuclear posture?***

The fundamental measure of the labs' capabilities is *understanding*. That understanding resides in competent people. Sustaining and extending that understanding requires computational, experimental, engineering and other facilities, as well as competent people to operate them. But the national leadership must think of the labs' capabilities in terms of what they understand.

The understanding is of two kinds – 1) understanding of the *science* (including engineering and material properties) involved in nuclear explosions and their effects and 2) understanding of actual nuclear weapon *designs* and of the full design space that encompasses them. By “design space” we mean all the ways in which it might be possible to produce explosive output from fission and fusion. These two kinds of understanding, although closely related and interdependent, are different from each other in important ways. Design understanding depends on understanding the science, but it is not the same thing as that, and the extension of one to the other is not trivial.

Since the cessation of US nuclear testing and of the vigorous Cold War program of development and production of new designs for the US stockpile, understanding of the *science* involved in nuclear explosions has improved dramatically due to the SBSS program, which was put in place deliberately to compensate, to the extent possible, for the cessation of nuclear testing.<sup>28</sup>

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<sup>28</sup> We make no judgment, in this paper, about whether this improved understanding, and continuation of improvement, will be sufficient to sustain the stockpile over the long term without nuclear testing. But there is no doubt that it has improved greatly.

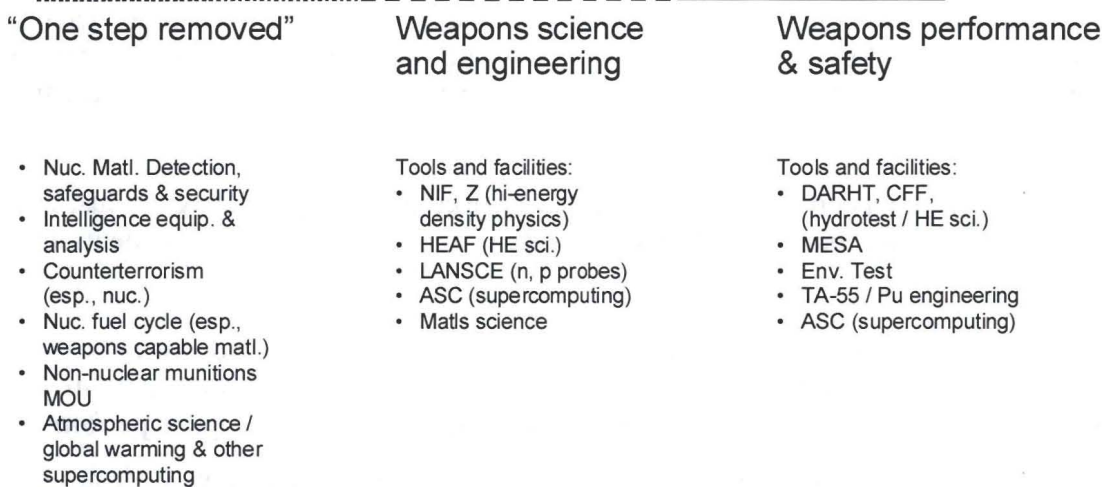
However, since the cessation of testing and new weapon development in the early 1990s, understanding of weapon *design* has changed in mixed ways. It has improved for the design class that constitutes the stockpile. On the other hand, the Labs are losing understanding of classes of designs that were once relatively well understood, and the envelope of design understanding has not been expanded. We will describe these changes further in the section on non-standard designs. In what follows immediately, we discuss the science and the S&T infrastructure in more detail.

The capabilities of an agile science infrastructure are essential to predicting not just weapons yield and performance but also weapons response to abnormal safety environments and terrorist attack scenarios.

To facilitate our later discussion of the evolution, over time, of the responsiveness and stability-related features of S&T infrastructure capabilities, we have grouped those capabilities, including personnel and facilities, in three categories of “immediacy” to final weapons performance:

- Immediately and directly relevant to weapons performance and safety: hydrotesting (e.g., DARHT, CFF) -- the only integrated, full-scale tests of nuclear weapons function available absent nuclear testing (albeit with some surrogate materials) - and environmental testing of engineered configurations to vibrational and thermal conditions that a weapon must experience. Supercomputing to model the complex physics of nuclear weapons.
- Weapons science and engineering: Underpinning foundations for high-energy density physics (National Ignition Facility (NIF), SNL’s Z-Machine) and high explosives physics (HEAF) as well as the calculational and experimental tools to understand engineering and materials properties.
- “One step removed”: These are areas which help underwrite the Labs’ overall science base. Some are part of a broader “national nuclear security mission” and can even enable arms reductions, e.g., nuclear detection methods for safeguarding and securing nuclear material, intelligence equipment and analysis, preparedness and prevention of nuclear terrorism, understanding the weapons potential for various nuclear reactor fuel cycles. Some are synergistic S&T that benefit from and often improve nuclear weapons science, e.g., non-nuclear munitions (precision applications of high explosives and materials dynamics at high strain rate) and a host of supercomputing challenges such as global warming.

These categories are shown in the figure below:



*Figure 4.4. Essential capabilities for Science-Based Stockpile Stewardship include facilities and personnel with a range of “immediacy” to ultimate weapons performance. At the “next plateau” of arms reductions, all of these capabilities must be exercised with no loss of emphasis on weapons performance and safety (hence the solid line), although to sustain the right side in an era of shrinking budgets, and because they are important in their own right, the left side must be made into a more comprehensive program. In a later section, we discuss a shift in profile to the left that would accompany and support responsiveness and stability in a future regime with greatly reduced weapon inventories.*

In the next few decades (the “next plateau”) all of these capabilities must be exercised with no loss of emphasis on weapons performance and safety. Continued assessment of legacy systems, which generally have had small performance margins, depends crucially on these modern tools of SSP and are bolstered by thorough peer review. As issues identified through surveillance are resolved – through LEPs and other measures – performance uncertainties are not allowed to grow so much that they require nuclear testing to resolve. A strong science base is especially important in light of the moratorium on nuclear testing.

These nuclear S&T capabilities are a hedge against the uncertainties of a possibly chaotic future. To dissuade, they must be of the highest quality and adapt well to changes. However, to facilitate movement toward a more restrained position for the US in the future – and as a template for others -- NNSA must invoke an “architecture” for the Labs that can gracefully scale back work on the right end of the scale - weapons performance - and increase emphasis on the left end of the scale – science that is not just “one step removed” but actually enables more confident arms reductions and nonproliferation environments. Such an architecture for Lab missions is depicted in the figure below:

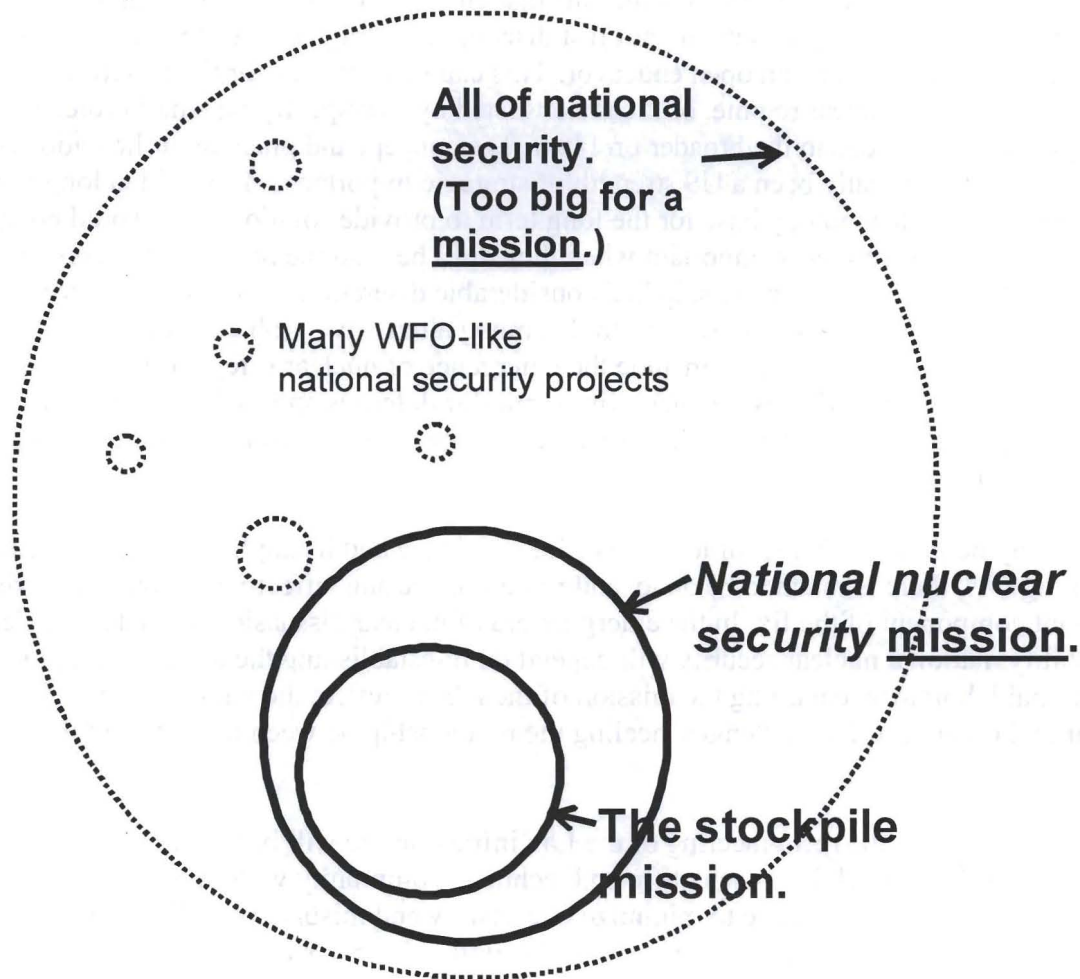


Figure 4.5. An expanded nuclear mission (outer solid circle) for the nuclear weapons Labs would be more conducive to reducing the weapons stockpile mission over time and increasing emphasis on science and technology – see the left-hand column of figure 4.3 – that enables more confident arms reductions and nonproliferation, is more restrained in stockpile work, but allows future responsiveness to be reconstituted if needed. This is not how the Nation manages the Labs today.

An expanded nuclear mission (outer solid circle) for the nuclear weapons Labs would be one more conducive to reducing the weapons stockpile mission over time and increasing emphasis on science and technology that enables more confident arms reductions and nonproliferation, and is a basis for reconstituting responsiveness if needed. This is not how the Nation manages the Labs today: while the Labs and NNSA consider technology for intelligence, nonproliferation, verification and counterterrorism to be part of their mission, projects outside the stockpile weapons circle are fragmented rather than integrated, and they do not explicitly underwrite the Labs' infrastructure (the RTBF account). We believe that a mission must be more integrated and sustained than now.

An important aspect of the broader national nuclear security mission – indeed, a definition of *mission*, in a sense -- is the integrated solutions that emerge from Laboratories that are responsible for the whole problem and not just disconnected fragments of the problem. Science, by its nature, is and must be an open endeavor. This can be exploited for the benefit and stability of the future global nuclear regime, or it can be wasted by overspecifying small projects and stifling creative solutions to the broader problem. The concept and practice of the national laboratory has historically been a US strength of strategic importance. It provided long-term focus, building the technology base for the long term to provide solutions that would not appear for a long time, but were very important when they did - beyond the horizon for industry, too big for universities. Laboratory leadership had considerable discretion to define Laboratory tasks within broad, long-term mission-areas, to trade among alternative problems and to match problems and solutions. Examples include the emergence of nuclear safeguards, nuclear intelligence, compact warheads for submarines, nuclear defenses and tools for the human genome such as laser cell sorting – all from a weapons program much less bureaucratized and parsed than today.

The US may be in some danger of losing its lead in science and its applications. In remedying or preventing this, there is much to be done, and rebuilding strong, effective national labs will be an important component of the fix. In the emerging era of nuclear dissuasion and latent nuclear (in)stability, national nuclear security will depend on re-establishing the concept and practice of the national laboratory, enlarging the mission of the labs to reflect the larger scope of this era's nuclear and other security challenges, healing the relationship between the labs and the government.

A final ingredient in the reengineering of the Lab infrastructure will be to more closely couple the larger – indeed the global -- scientific and technical community with the Labs, and build on the inherent openness of science to minimize uncertainty and misunderstanding that could imperil the stability of a future nuclear regime. Work that is “one step removed” is especially amenable to collaboration with former adversaries. This openness and transparency will help with both US security goals of assure and dissuade as well as the international objective to demonstrate restraint and to lower the nuclear profile.

### ***What efforts to understand what is possible for non-standard design?***

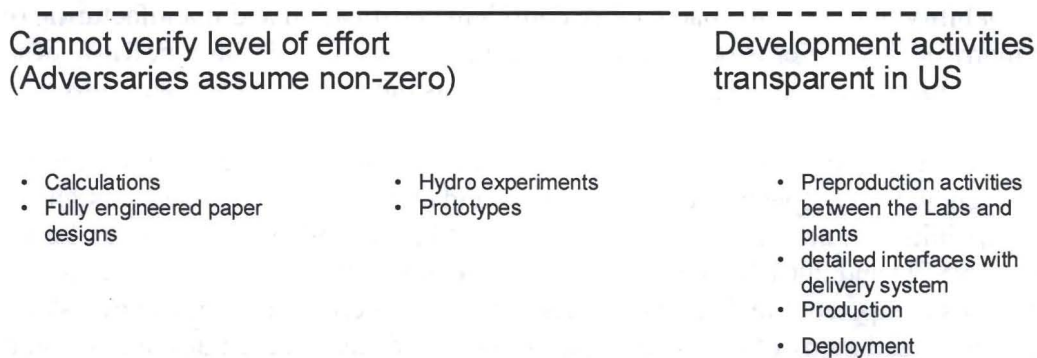
While the SSP has resulted in substantial improvements to weapons *science* since the mid-1990s, the labs' understanding of nuclear weapon *design* across the design space has had a mixed record. Understanding of the class of designs that are currently in the US stockpile – all of which are within the class of “standard” designs -- has improved greatly. After all, that was the main intent of the SBSS (and of the broader Stockpile Stewardship Program (SSP) of which SBSS was a part). But design-understanding (and even awareness within the new generation of Lab personnel) has generally diminished across the wide range of other classes of designs that were explored during the Cold War -- some of which were once in the US stockpile but are no longer there, and the many others that were explored to some degree, and often tested at NTS and sometimes prototyped. Furthermore, expanding the boundaries of understood design-space, which had been an objective of the program during the entire Cold War, essentially stopped in the early/mid-1990s (with the exception of high-margin designs such as RRW -- which are, in

fact, “standard” designs -- and improvised nuclear devices that might be used by nuclear terrorists).

It was once thought important to understand as much of the design-space of nuclear explosives as possible for two reasons: to understand the range of options for future US weapon designs, and to anticipate and understand foreign developments as well as potential nuclear devices improvised by terrorists. The exploration of non-standard design space has been stopped partly because of priorities for resources, but more importantly, there have been express prohibitions by the Congress with regard to low-yield weapons (concerns about “nuclear warfighting”) and more generally the belief that “new nuclear weapons” would be inconsistent with long-term policy objectives for the global nuclear weapons regime.

A decision not to know what is possible, and not to have a range of options in varying states of readiness, should be made at high levels of government, based on a thorough assessment, which has not been done. This limitation on full exploration of nuclear weapons design space may be reasonable if viewed as part of a *balance between readiness and restraint*. On the one hand, there are the risks of technology surprise and losing the ability to design something new. On the other, a strong scientific program provides some basis for quick recovery, and there are many who believe that too much hedging against surprise encourages other nations to look for similar technology advantage or surprise.

Options for exploring a wider range of design space could be chosen from among a range of kinds of work: calculational investigations only, engineered paper designs, occasional experiments and prototypes, preproduction activities and detailed interfaces with specific means of delivery. These are graphed below:



*Figure 4.6. Readiness vs. restraint and transparency for non-standard designs and RRW. A range of efforts is possible: calculational investigations, fully engineered paper designs, occasional experiments and prototypes, preproduction activities and detailed interfaces with specific means of delivery.*

In a balanced approach, computational and engineering studies of designs explored earlier by the US, and some computational work to enlarge the envelope of understanding of what is possible, would be re-established, both as part of training new personnel and as needed in the analysis of

foreign programs. Work of this type has a low profile and will be assumed by adversaries to be ongoing anyway. Hydro experiments and prototyping should be continued for the understanding and disablement of potential terrorist devices. Preproduction activities with the Plants and Navy or Air Force delivery systems on non-standard designs with special effects (e.g., EMP, earth penetrator) are quite visible in the US. Foregoing them could be an aspect of restraint.

### ***Whether and how to pursue RRW?***

It is within this same framework of Figure 4.6 that a program such as RRW should be considered. The relaxation of yield-to-weight requirements and reduced MIRVing since the end of the cold war have permitted additional weight and volume so that those warheads that remain in the US inventory could have

- greater margin against reliability-performance issues – seen by the Labs as especially important for maintaining stockpile confidence without nuclear testing
- more easily manufactured materials
- safety and security features that reduce the cost of guarding both the weapons and the manufacturing infrastructure.

The reliable, replacement warhead (RRW) concept has been proposed by NNSA and the Labs to incorporate these capabilities.

Rather than take sides on RRW we would point out that it is just one element of the “higher road” job of modernizing the manufacturing capability and sustaining the deterrent without nuclear testing. There are many on both sides of the nuclear debate who say they are willing to take a fresh look at RRW in the next Administration.

RRW is not a “new design” because the design is pedigreed in nuclear tests before 1992; it is of the same type as the other weapons already in the stockpile; and its purpose is not a different military capability but rather to enable more confident certification and manufacturing of nuclear weapons many decades after the end of nuclear testing. Almost by definition, RRW designs are all in same the narrow region of design physics space as the current legacy weapons.

However, RRW engineering is different enough from currently deployed designs that it will sustain and renew the competence of the scientists and engineers to do a “new design” if they have to. (Capability for new design was a requirement in the 1993 NPR, 1995 Stockpile Stewardship NSPD and 2001 NPR.) An infrastructure that only makes parts to decades-old blueprints loses competence and responsiveness; it cannot recruit and engage new talent. RRW has already exercised many of the skills required for new design in the Labs and to some extents at the Plants: The cycle of computational design and exploration is exercised followed by experiments that require new blueprints. Engineering (sometimes called weaponization) issues are explored that must be coordinated with the military delivery system and with the production plants. For designs that pass these tests, prototypes can be manufactured that utilize new tooling and manufacturing processes. Exercising these capabilities – even if the weapon is not deployed – is central to the idea of capability-based deterrence.

The recent AAAS-APS-CSIS study<sup>29</sup> notes that there is a “spectrum of options” ranging between two extremes. At one extreme is the replication of weapons as they were originally introduced into the stockpile, using outdated materials and manufacturing processes, regardless of costs or modern assessments of the designs. At the other extreme is the development of replacement warheads such as RRW with more robust margins but not new capabilities. The best option along the spectrum should be decided after thorough study of the options and will depend on the issue being addressed and the requirements that are imposed. We agree with this idea. RRWs should be deployed only if the gains in margin, security or manufacturability warrant replacement of legacy systems. Whatever the outcome of the trade-off studies, the exploration of RRW designs is consistent with a stable, capability-based regime because they are replacements rather than new capability.

### *Transparency of weapons R&D*

The budgets and programs of the US Labs are well known and widely debated. Facilities as well as new developments such as RRW are openly funded and debated. Major facilities for weapons performance and science, such as DARHT and NIF, are visible to the national technical means of other states, and they can be made more transparent via walkthroughs and unclassified publications and collaboration. The participation of weapons Labs in other national security activities, e.g., nonproliferation technology and nuclear material safeguards, detecting terrorist materials, as well as unclassified basic research, e.g., materials, global climate, computational methods, provides the rest of the world insight into the scale and quality of those Laboratories.

At the other end of the spectrum, unpublished (or classified) computational and engineering studies have a low profile and will generally be assumed by adversaries to be ongoing anyway.

To assure that the hedge dissuades, and that it does not provoke, conveying accurate perceptions of the capabilities and activities to everyone – friends, potential adversaries, and others -- will be important. Indeed, to move toward a future in which, globally, nuclear benefits are realized and nuclear risks are contained, increasing openness and transparency, writ large, will be key, especially to approach very low levels of weapons-in-being.

Abstinence from nuclear tests or test preparations has an important place in the transparency and verification of weapons R&D. While it may be true that some designs can be fielded without nuclear testing, the confidence of international partners in restraint of new weapons development will not be sustainable in the face of nuclear tests or preparations for same. The Science Based Stockpile Stewardship program is widely acknowledged for its success in avoiding circumstances that might lead the US to return to testing. However, many believe Nuclear Test Readiness undermines US credibility on article VI of the Non-Proliferation Treaty and the test moratorium. A maturing suite of small- and full-scale experimental capabilities, including those at Nevada Test Site (NTS), are transforming the character of US “readiness” to perform a nuclear test, if needed. Experimental physics and the measurements the Labs would make today are not those of the 1980s. Instead they are based on 21<sup>st</sup> century diagnostics developed for hydrodynamic testing and high-energy density physics (NIF, Z). Operations at NTS have been

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<sup>29</sup> *Nuclear Weapons in 21st Century U.S. National Security*, Report by a Joint Working Group of AAAS, the American Physical Society, and the Center for Strategic and International Studies, December 2008.



similarly transformed away from old-fashioned “nuclear test readiness.” So, capability-based deterrence should allow the US to emphasize restraint over readiness at the Nevada Test Site but at the same time have sufficient base to reconstitute fully diagnosed nuclear testing within 2-3 years.

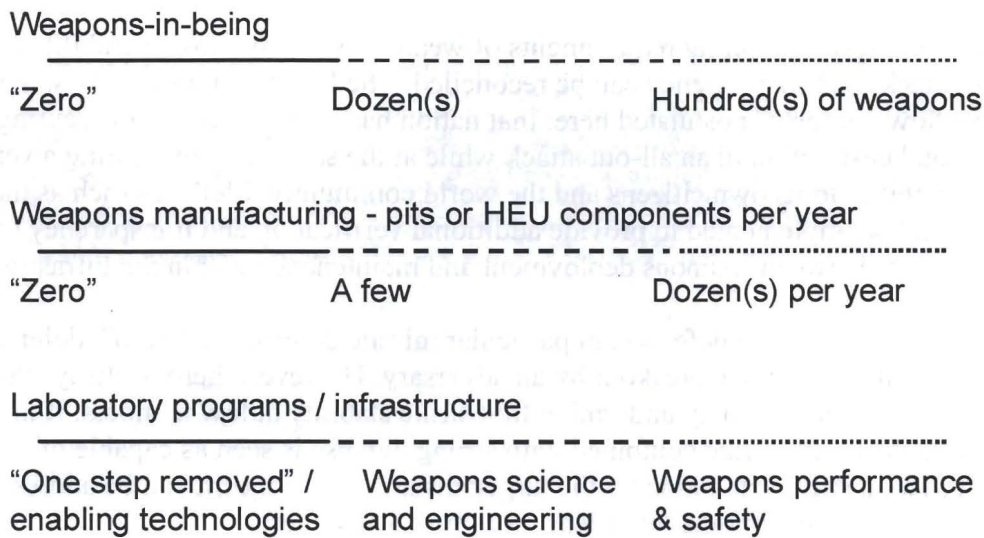
In summary, the Labs and their programs can and should be structured to sustain capability in the near term and to facilitate deemphasis of nuclear weapons in the long term.

## V. Managing capability at low numbers

In this section we examine the implications of very low stockpile numbers and associated infrastructure by testing potential manufacturing and Lab infrastructures against our three criteria: the national security of individual states, restraint vs. responsiveness, and transparency. The analysis presented here is but a first step toward understanding what infrastructures should look like for “zero” to a very small number of weapons-in-being. Also we do not address the changes in the global political and military environment needed to enable weapons stockpiles at such low levels.

This paradigm shift is relevant not only for major powers’ nuclear posture that has been our focus so far, but also for managing proliferation and the weapons capabilities of smaller states. It has always been true, but is increasingly evident (e.g., Iran, N. Korea) that preventing and managing proliferation revolves around infrastructures and latent capabilities more than around weapons-in-being. When the focus shifts to deterrence-of-attack and proliferation actualized, it is because political circumstances in the region of interest have motivated a state to convert latent capability into weapons-in-being.

For the US and RF, we define “low” overall stockpile numbers as roughly 50-100 weapons-in-being or less; this is at least a factor 10 less than most people are talking about at the “next plateau.” The capacity of the associated manufacturing infrastructure might range from a few to a few dozen weapons or components per year. The laboratory infrastructure would include all elements from “one step removed” to weapons performance and safety but with emphasis shifting away from the latter. The elements of a “zero to low numbers” regime should ideally reinforce one another as shown in the following graph. A few weapons-in-being would help stabilize against asymmetries in infrastructures with limited manufacturing capability and deemphasis of direct weapons work at the labs. Conversely, an infrastructure with small but finite ability to respond would stabilize low numbers of weapons-in-being.



*Figure 5.1. "Low numbers" for the US and RF might correspond to an overall stockpile of roughly 50-100 weapons-in-being or less. The capacities of associated manufacturing infrastructure might range from a few to a few dozen weapons or components per year. The Laboratory infrastructure might include all elements from "one step removed" to weapons performance and safety but with emphasis shifting away from the latter. However, remaining infrastructure would provide the capability to reconstitute over time if necessary. (The relative phasing in time among these three assets needs further study.)*

This chart addresses labs and production facilities dedicated to nuclear weapons, or at least facilities acknowledged to be dual use and subjected to verification. But latent capabilities reside also in nations' overall science, technology and industrial bases. Weapons can be designed, including some degree of weapon engineering, in research facilities of many kinds, and in university physics departments. Most weapon components could be fabricated in manufacturing facilities developed for a wide range of other purposes. Even Pu or HEU parts could, perhaps with some risk, be fabricated in a wide variety of facilities that are used for other hazardous materials. At very low numbers, such non-weapons-dedicated capabilities become a serious – perhaps dominant consideration. Much of what we discuss in the following pages is addressed to dedicated facilities, though from time to time we refer to non-dedicated capabilities too.

***Weapons-in-being***

The major nuclear powers (e.g., the P5) could not get to "zero" without going through this phase. The smaller nuclear states (India, Pakistan and Israel) are more or less at this stage at present. By definition, states with no weapons-in-being (whatever their latent capabilities) are at "zero."

While our intent is to concentrate on infrastructure, there are several "technical" issues that should be mentioned for weapons-in-being. One is that at low numbers and as insurance against

reconstitution by others, nations would have more confidence in higher margin designs and they would be easier to manufacture.

Secondly, the seemingly conflicting requirements of weapons security / invulnerability (against all avenues of attack) and transparency can be reconciled. The UK deterrent is only somewhat larger than the “low numbers” postulated here; that nation has well succeeded in securing its forces against total destruction in an all-out attack while at the same time presenting a very clear picture of its capability to its own citizens and the world community. Methods such as the New Court Treaty could be implemented to provide additional verification and transparency of weapons movements between weapons deployment and maintenance within the infrastructure.

A third point regards the role of defenses, in particular missile defense. At “zero”, defenses could provide a hedge against offensive breakout by an adversary. However, there is always the concern that the same defenses may undermine first strike stability at low numbers, if the combination of an offensive strike combined with strong defense is seen as capable of eliminating all second strike retaliation by the targeted state. This concern can be addressed with penetration aids and unconventional (or at least non-missile) delivery.<sup>30</sup>

### ***Weapons material and manufacturing***

The most difficult part of becoming a nuclear weapons state is the acquisition of weapons capable material. While the major powers already have enough plutonium and enriched uranium to supply a remanufacture of their weapons, a *verifiable ban on the production of weapons-capable material* is essential for limiting the latent capability of nations that do not have nuclear weapons. And as progress in disposition of SNM not in weapons proceeds for the major powers, such a ban will be important as it applies to them too. Most of the nuclear states have already ceased the production of weapons plutonium and HEU, and opening their facilities to verification, e.g., the Additional Protocol, is quite practical. It is states other than the P5 who must be persuaded to join a fissile material control regime, formalized in a treaty (FMCT) regime – nations with no or only a little fissile material who want the option for more.

A companion regime is the placement of the *nuclear fuel cycle under trusted auspices*. Whether uranium enrichment or plutonium reprocessing, nuclear fuel cycle technology is a two-edged sword – “atoms for peace” or “atoms for weapons.” At lower levels of extant weapons, stores of and the infrastructure to handle even reactor-grade Pu or partially enriched uranium provide a basis for reconstitution on a time scale of a few months to a few years. Credible proposals have been offered internationally to place the nuclear fuel cycle into trusted hands. In one proposal<sup>31</sup>, uranium enrichment and Pu reprocessing would be under international auspices. In another<sup>32</sup>, there would be a few “fuel cycle states” that would sustain these capabilities in combination with a regime of international verification and materials accounting. Other nations would forswear these capabilities in return for guaranteed reactor services.

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<sup>30</sup> Garry J. George, *Integrated Nuclear Security in the 21<sup>st</sup> Century*, to be published 2009.

<sup>31</sup> Mohamed ElBaradei, “Towards a safer world,” *The Economist*, 16 October (2003). See also *Multilateral Approaches to the Nuclear Fuel Cycle: Expert Group Report submitted to the Director General of the IAEA*, INFCIRC/640 - 22 February 2005.

<sup>32</sup> 11 February 2004 speech at the National Defense University by US President George W. Bush.

Whatever the ultimate implementation, “zero” is a very insecure place for a nation whose neighbor or competitor has a nuclear fuel cycle not subject to international verification. And even verification does not prevent breakout. Verification is, in essence, a mechanism for warning, and it must be accompanied by international sanctions that could be rapidly and confidently executed in order to provide the level of assurance needed at very low numbers.

*Security of weapons and material.* Clearly of great concern to all nations is the loss of weapons or weapons-capable material by any one nation to a transnational or terrorist entity. Programs to enhance the security of nuclear stores and transportation will, of necessity, not be fully transparent. On the other hand, each nation holding those materials can do a lot to reassure its own citizens as well as the rest of the world. The US has a leadership role here and has exercised it by assisting other nations through sharing its process and overall approach (materials protection, control and accounting) as well as specific technologies.

The emphasis so far in this section has been on weapons material. For the nuclear states, we must also ask the appropriate *character and size for the infrastructure that manufactures pits and HEU components and then assembles them into full weapons.* As indicated in the bar graph above, these facilities or capabilities would evolve to very small in size (a few to a dozen components per year) as the number of weapons declined. They would remain non-zero until the US and other nuclear states had very high confidence in “zero” nuclear weapons and “zero” likelihood of political relapse.

At very low numbers of weapons-in-being, there are at least three possibilities for a minimum / “near zero” manufacturing infrastructure:

1. Depending on the broader industrial base to fabricate weapons components. This is the most affordable route for non-SNM components such as fire sets and piece parts made from standard metals or plastics. As noted above in reference to figure 5.1, an evasive nation might (albeit with safety risks) also fabricate Pu or HEU parts in facilities suitable for other hazardous materials.
2. Fabrication at nuclear Laboratories. For Pu and HEU components, we note the examples of the UK Aldermaston and early US where a few units were built at the Labs.
3. Transition or conversion of most of a nuclear manufacturing site to non-weapons activities while retaining some minimum dedicated weapons capability, or at least the ability to reconstitute it.

Latent capability in states that have never manufactured weapons will, of course, be centered on the first and second options. The third option can be a consideration for nuclear states only if it is verifiably restrained and cost-effective. Verification capabilities vary among these options, and among possible political/military scenarios for sustainment and/or reconstitution.

Examples in the US have their counterparts in the other nuclear states: Weapons manufacturing capabilities at Los Alamos (Pu components), Oak Ridge Y-12 (HEU components) and Pantex (final assembly). US pit manufacturing at Los Alamos has “gone through zero” and is being built back up to a relatively small number of ppy. The footprint is small and will be amenable to sliding back down to low numbers albeit with some verification of output and / or conversion to other activity. The Uranium Production Facility planned for Y-12 is now being baselined for 125

HEU components per year, and the overall capability and footprint at Y-12 is not “going through zero.” So considerable thought should go into how Y-12 could transition to only a few units per year – with sufficient transparency and verification to assure the confidence of others as all Nations approach zero. Similarly, the capability for weapon assembly / reassembly at Pantex where, as previously noted, there are a large number of nuclear-capable bays, should be re-assessed. At low numbers, should the relatively limited A/D capability at Nevada DAF (Device Assembly Facility) be substituted for Pantex?

In scaling down weapons material production and the manufacturing of engineered parts, it is not difficult to envision the high degree of transparency required as nuclear forces approach “zero”: What levels of restraint and openness do the US and the global community want to see for weapons manufacturing plants or nuclear fuel cycles in Russia, China, India and Pakistan, Israel, N. Korea, Iran? How might we improve on the standard now being set in nations like Japan, Sweden, Australia, New Zealand and S. Korea – nations that may have considered nuclear weapons but have (to a large extent) convinced the world community that they are not doing so now? Of course, the devil is in the details and much work remains to be done.

### *Weapons Laboratories*

As indicated in figure 5.1, we would expect, at very low levels, that weapons expertise and a strong science base at the Laboratories would remain an important reconstitution capability that would assure allies and dissuade adversaries against breakout. Conversely, the makeup of Laboratory footprint and programs would have to be restrained in order not to provoke suspicions and thus stimulate the very behavior on the part of other nations that we seek to avoid while making progress toward a world without the threat of nuclear usage. In the spectrum of weapons and nuclear science technologies shown, we would expect direct work on weapons performance (e.g., hydrotesting) to be non-zero at least until very high confidence in “zero” NW and “zero” likelihood of political relapse. Of course, the library of nuclear weapons knowledge and the computer codes could not be easily or reliably forgotten – and we believe it would be unwise to try.

As direct weapons performance work approaches “zero”, the tools and facilities for weapons science (e.g., NIF, Z, LANSCE, ASC, materials) would remain but would be transparently and increasingly engaged in unclassified work. Similarly, science and technology “one more step removed” and enabling confidence in reduced weapons and proliferation threats would continue. These include

- Weapon elimination and verification technologies
- Global MPC&A / safeguards / security
- Nuclear smuggling detection and counterterrorism programs
- Technical support for the Intelligence Community, including both hardware and analytical
- Nuclear fuel cycle programs, esp., those related to weapons capable material such as reactor grade Pu
- Non-nuclear munitions work
- Computational modeling of many kinds of complex phenomena, such as atmospheric science / global warming.

It is especially in this world “near zero” that NNSA Laboratories, their infrastructure and the programs bulleted above must be managed as an integral whole rather than buying small projects “by the slice” in the areas of intelligence, nonproliferation and nuclear counterterrorism.

In executing the above Laboratory programs, it is again not difficult to envision the high degree of transparency required as nuclear forces approach “zero”: What levels of restraint and openness do the US and the global community want to see for Laboratories in Russia, China, India and Pakistan, Israel, N. Korea, Iran? How might we learn from nations with strong programs in nuclear energy and materials management, but little or none in weapons – Japan, Sweden, Australia, New Zealand and S. Korea? The discussions above have been notional in this regard and much detailed work needs to be done.

## **VI. Summary**

US nuclear weapons capabilities – extant force structure and nuclear weapons infrastructure as well as declared policy – influence other nations’ nuclear weapons postures, at least to some extent. This influence can be desirable or undesirable, and is, of course, a mixture of both. How strong the influence is, and its nature, are complicated, controversial, and – in our view – not well understood but often overstated. Divergent views about this influence and how it might shape the future global nuclear weapons regime seem to us to be the most serious impediment to reaching a national consensus on US weapons policy, force structure and supporting infrastructure.

We believe that a paradigm shift to capability-based deterrence and dissuasion is not only consistent with the realities of the world and how it has changed, but also a desirable way for nuclear weapon postures and infrastructures to evolve. The US and other nuclear states could not get to zero nor even reduce nuclear arms and the nuclear profile much further without learning to manage latent capability.

This paper has defined three principles for designing NW infrastructure both at the “next plateau” and “near zero.” The US can be a leader in reducing weapons and infrastructure and in creating an international regime in which capability gradually substitutes for weapons in being and is transparent. The current “strategy” of not having policy or a Congressionally-approved plan for transforming the weapons complex is not leadership.

If we can conform the US infrastructure to the next plateau and architect it in such a way that it is aligned with further arms reductions, it will have these benefits: The extant stockpile can be reduced in size, while the smaller stockpile still deters attack on the US and Allies. The capabilities of the infrastructure will dissuade emergence of new challenges/threats; if they emerge, nevertheless, the US will be able to deal with them in time. We will begin to transform the way other major powers view their nuclear capability. Finally, and though of less cosmic importance, it will save money in the long run.

Posted on the Strategic Weapons in the 21<sup>st</sup> Century Conference web site:  
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