Strategic Weapons in the 21st Century:
Hedging Against Uncertainty

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"Forces, Infrastructure, Science and Technology:
The Future of Stockpile Stewardship"

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The Challenge

My premise in writing this paper is this: the United States has maintained a safe secure and reliable nuclear stockpile[2] for the past 16 years without relying on explosive underground tests (UGTs). The Stockpile Stewardship Program (SSP) has been successful, more so than many anticipated. But we must recognize that ***continued success is not assured*** and, furthermore, global changes—both in political/strategic circumstances and in technology—present uncertain, new challenges.

Two figures illustrate important aspects of today's nuclear challenges. Figure 1 shows that the total number of nuclear weapons in the arsenals of the United States and Russia, who collectively possess more than 90% of the world total, has decreased by approximately 75% since 1986. However, as illustrated in Figure 2, the international consensus that once favored fewer nuclear weapons states has recently begun to erode. Some two dozen states that heretofore decided to forgo nuclear weapons, thinking that their national security could be protected without them, reportedly are reconsidering their positions, and more will do so, inevitably, if present trends persist. Moreover, with the global spread of technology, the threat that the world's most terrible weapons might fall into the hands of terrorists has escalated.

The trend, as I see it, is not favorable for our non-proliferation efforts. This poses a serious challenge for our nuclear posture, as well as for diplomatic efforts to forge effective political cooperation on a global scale. Maintaining and strengthening a nonproliferation regime will require cooperation, not only with the nuclear states, but also with the more than 180 nations who so far have voluntarily agreed to forego nuclear weapons. Increasingly they have the technical capability, certainly for making single stage uranium fueled gun type weapons, such as the United States detonated over Hiroshima in 1945.

The "800 lb gorilla in the room" in formulating nuclear policy to meet U.S. security needs remains Russia. There are the 2001-2002 Moscow declarations announcing that the United States and Russia have overcome the Cold War legacy, calling for "the creation of a new strategic framework," and announcing that "Neither country regards the other as an

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[2] The discussion in this paper focuses exclusively on the program and infrastructure of the National Security Administration (NNSA) in the Department of Energy. The Department of Defense, of course, is responsible for major parts of the U.S. nuclear deterrent.

enemy or threat." I doubt any one is ready to put that in the bank today, and as long as that is so, nuclear deterrence is not about to go away.

The U.S. and the former Soviet Union relied on nuclear deterrence to navigate successfully through the perilous years of the Cold War. But it would be dangerously wrong to draw comfort from that achievement. The clarity of the bipolar U.S.-Soviet world has given way to the ambiguities and uncertainties of today's world in which international security is threatened by transnational terrorists, unstable and failed states, and regimes that scorn a world order based on broadly accepted principles. The dangers inherent in such a stew are magnified by easier access to nuclear technology, inadequately protected stockpiles of plutonium and highly enriched uranium, the growing availability of missiles worldwide, and black-market nuclear supply networks. They are further exacerbated by a growing interest, spurred by economic and environmental concerns, in developing nuclear power to meet increasing civilian energy demand around the world. With today's technology, a nation that develops the infrastructure to master the fuel cycle for nuclear power has a "latent" nuclear weapons capability.

These developments have led to increasing concerns that nuclear deterrence as implemented during the Cold War is becoming decreasingly effective and increasingly hazardous in today's world in which nuclear know-how, material and weapons are spreading ever further and faster. We are teetering on the edge of a new and more perilous nuclear era, facing a growing danger that nuclear weapons will proliferate into worrisome and unpredictable hands. This calls for a U.S. nuclear policy and program that balance the pull of nuclear deterrence with a need to rebuild through aggressive diplomacy a global commitment against proliferation.

The Stockpile Stewardship Program

Since the end of the Cold War and up to the present, the United States has succeeded in maintaining a strong nuclear deterrent by developing an effective Stockpile Stewardship Program (SSP). When I say successful, I am referring to two fundamental measures. First, it has discovered causes for serious concerns in the stockpile, which is what it should do if such causes exist. Second, it has successfully addressed these concerns with well executed Life Extension Programs (LEPs) and conscientious follow-up to Significant Finding Investigations (SFIs).

I believe that the most important component of a responsive infrastructure that can maintain a safe, secure and reliable nuclear weapons enterprise is personnel with the requisite expertise. This includes experts in surveillance, dismantlement, manufacturing, design, assessment, system integration, including replacement parts for limited life components into an operating system, and basic science.

Expert personnel constitute more of a deterrent to evolving threats than do facilities or even existing weapons. Given sufficient resources, people with the appropriate expertise can respond quickly to unanticipated problems or changes in requirements and can provide confidence in the solutions they produce. Without such people, no amount of resources will yield timely solutions in which confidence is justified.

Expert personnel have always been important to the complex. Although we no longer call for new designs for new military missions, we still rely on the expertise of designers to assess and solve potential problems as they are identified over time. They must devise and assess possible solutions that can be developed and employed with confidence without relying on nuclear explosive testing. This is a challenge that demands both innovation and adherence to change discipline so as not to introduce more unknowns that could result in lower confidence in the redesigned weapon.

Moreover, there is an increasingly broad spectrum of national-security problems that also require nuclear-weapons expertise. I have in mind the increasing need to assess proliferation risks under a variety of scenarios; the need for "nuclear forensics" to help identify the origins of nuclear material, radiological dispersion devices, and nuclear explosive devices, whether obtained before or sampled after explosions; the need for a capability to disarm and disable interdicted devices; and a growing need to verify treaties and monitor nuclear weapons-related technologies. Expertise will also be needed to train the relevant inspectors.

These additional requirements further underscore the need for expert personnel as the foundation of a nuclear-weapons complex that can respond to a changing world. They must have resources and support enabling them to retain and hone their expertise while providing the tools necessary for appropriate responses to surprises and policy changes. Experimental science and data are critically important; so is a strong program of Research, Discovery, and Development. This need has been recognized, by and large, as a substitute for UGTs since President George H.W. Bush initiated a moratorium on such tests in 1992. It has been supported by the development of super-computers to perform high fidelity simulations and model building and advanced scientific instruments of great power; i.e., DARHT at Los Alamos, NIF at Livermore. However, significant budget cuts in the weapons program at the labs over the past two years have raised serious concerns for the continuing health of this program that must be addressed as we look forward.

The Future of SSP

A major question as we look to the future is:

Will the U.S. be able to maintain a safe, secure, and reliable stockpile by adhering closely to original designs of today's stockpile weapons; will we need to introduce new designs; or will we need an evolving combination of both?

There is a broad spectrum of options ranging between two extremes. At one extreme, we can focus on efforts to replicate weapons as they were introduced into the stockpile, perhaps still using hazardous materials and outdated manufacturing processes. At the other extreme, we can replace weapons using new designs, close to, but not identical with, designs that have been subjected to nuclear tests, trusting our ability to predict their performance.

To date the LEPs have operated toward the replication end of the spectrum, while the RRW program was intended to be a venture toward the other end. A "hybrid" strategy in between could involve repackaging "old" components, tested as part of old designs, into new designs. In fact, LEPs have not stayed completely at the replication end of the spectrum. Outside the Nuclear Explosive Package (NEP) of a weapon there are components that can be tested to a significant extent under operational conditions. Some of these have been replaced by newly designed components, for advanced fuzing and firing systems (AFFs), permissive action links (PALs), and more robust boost gas transfer systems. These are examples of the new-design end of the spectrum. Some components inside the NEPs have been replaced by components that differed from the originals to some extent in design and/or processing. For example, the replacement W88 pit for the Trident force employed new personnel using new manufacturing processes and different facilities.

Future LEPs will continue to involve replacement components that are not simply replicates of the originals. The choice for a best option in the spectrum of possible changes will depend on the issue being addressed and the requirements that are imposed. The best option depends on the problem.

Looking forward, a key question is: How does one measure the evolution of risks due to multiple changes over time during the life of a warhead? One frequently hears the following statement: "Over time, accumulating changes lower confidence and difficulties increase." Standing alone this can be misleading, even very wrong.

In evaluating risks it is also necessary to include the impact of the important gains in our understanding of nuclear processes under explosion conditions that we have gained over the past fifteen years from our multifaceted SSP program. The quantity of importance in measuring risk or confidence is the ratio, M/U, of margins M to uncertainties U. M is a measure of the amount by which the output of any given stage of a system exceeds the minimum, or threshold, that may exist for the system to achieve its design goal. U is our uncertainty in determining M as a result of limitations in actual data or of lack of understanding of the basic process itself. This ratio, M/U, should be significantly larger than unity. Predictive science of material processes in conditions of nuclear explosions is making progress. It is a young and important scientific challenge and has a long way to go. The experiments and analyses that exploit the latest advances in supercomputers are opening important new avenues of progress. Some recent successes in reducing U have enabled us to more than double the lifetime for retaining the plutonium in the primary of a warhead. Also important will be our growing ability to actually understand the basic physics processes during the boost phase that is being gained from the National Boost Initiative. In addition, significant increases in margins (M) have been achieved as a result of designing and installing more robust boost gas transfer systems.

Significant increases in M, and hence in M/U, can be also achieved by relaxing Cold War requirements for operations in hazardous environments. The concerns then were driven by the possibility of fratricide or neutron pre-initiation due to nuclear tipped ABM systems. (If changes in the world's strategic conditions were so grim as to create an incentive for a return to deploying such systems, we would not be considering SSPs and testing restraints!)

Soon the National Ignition Facility will make it possible for us to produce data in the lab on the behavior of matter at extreme pressures and temperatures as occur in nuclear explosions, as well in stars. We are making important progress in determining M/U and understanding possible changes in its value over time.

Data and a deeper understanding of the science of nuclear explosions gained over the past decade have increased my personal confidence in our deployed nuclear forces.

<u>Whither the Reliable Replacement Warhead (RRW) and Stockpile Modernization</u>

The RRW Program asked important and difficult questions that should be answered. The three weapons laboratories did excellent technical work in attempting to answer whether the WR-1 design proposed by LLNL/SNL could successfully achieve its goals of higher confidence in safety, security, and reliability within the restraints highlighted by Congress: no new designs for new military missions and no underground explosive tests. These two restraints were imposed on the basis of a judgment by the government that they are important in order not to harm prospects for achieving U.S. strategic/political goals of reducing the nuclear danger and simultaneously strengthening the nonproliferation regime, which rely on broad international cooperation. JASON completed a Congressionally mandated, detailed technical review of the RRW program, focusing on the WR-1 effort. At the time, WR-1 was still work in progress, but funding has subsequently been terminated.

After recognizing excellent work by the labs, JASON summarized its findings as follows:

> *"…certification is not yet assured. The certification plan presented needs further development. For example, additional experiments and analyses are needed that explore failure modes, and assess the impact on performance of new manufacturing processes. Substantial work remains on the physical understanding of the surety mechanisms that are of high priority to the RRW program. Establishing that the case for confidence in any RRW has been satisfactorily made will require a new peer review process."*

Based on what we have learned so far from the LEP and RRW experiences, I recommend that we should proceed as follows: Given the challenge of certifying even tested variants of current designs, a program for maintaining a safe, secure, and reliable stockpile should explore a wider segment of the spectrum of options. We still have far to go before answering whether new designs that incorporate all the desired attributes can be created, can be fielded without UGTs, and can provide confidence as high as we have currently in the legacy weapons.

Exploration of multiple options along the spectrum would help maintain the capability to respond appropriately to changing requirements and to potential surprises. Each point in the spectrum represents an approach that has strengths and weaknesses. Until an approach is explored in some detail we will not know these strengths or weaknesses in sufficient detail—or the overall costs—to support informed decisions about how best to address a given stockpile issue. Investigation of multiple options thus supports the flexibility and responsiveness that is desired in the complex. It provides a means by which personnel (including designers) can hone their expertise, and could help attract outstanding minds into the weapons program.

Maintaining flexibility in the programs has a direct impact on the infrastructure that NNSA should maintain, including support for elements of the legacy stockpile. How large a uranium production capability will we need at Y12? Is there any need for new secondaries? Decisions on targeting requirements, force size and component reuse will be critical to any decision sizing and staging a decision.

This is also true for plutonium pit production at LANL and surge capacities for the Chemistry and Materials Research Replacement (CMRR) building. The need for flexibility will also impact how NNSA organizes its R&D and certification programs. Rather than measuring the success of R&D primarily in terms of its leading to new deployments through a direct acquisition process, we should view its success in terms of preparing potential capabilities that will be available if and when needed at a later date. This point was addressed in a broader context for the U.S. defense establishment by Richard Wagner and Ted Gold in 1990 in their prescient paper[3] "Long Shadows and Virtual Swords". With the success thus far of LEPs and SFIs, I am aware of no urgency to go into a deployment or acquisition mode.

While our discussion has focused on the technical issues, it will also be essential to keep in mind the strategic/political implications of actions initiated in maintaining and modernizing U.S. nuclear forces. Not only what we do, but how we do it, will be important. U.S. decisions and actions about nuclear weapons can be expected to affect the nuclear policy choices of other nations—non-nuclear, as well as nuclear—on whose cooperation we must rely in efforts to reduce the global nuclear danger. Relevant factors include structuring new programs with the maximum transparency, and making clear their limited purpose and our intention to reduce reliance on nuclear weapons.

Conclusions

In concluding, I repeat, continued success of stockpile stewardship is not a foregone conclusion. A responsive infrastructure that can continue to maintain a safe, secure and reliable nuclear weapons enterprise must include several key components. The most important component is top-notch expert personnel, without whom confidence in the U.S. nuclear deterrent will erode along with U.S. ability to respond to changing threats and other national-security requirements. These experts must be engaged in a flexible program with stable support that includes several cornerstone elements: 1) Vigilance in the search for and discovery of problems in the stockpile; 2) High-fidelity computational simulations; 3) A robust experimental program; 4) The ability to integrate an operating system including a mix of new and legacy parts; 5) Strong peer review; 6) An active research and development program exploring a range of stockpile options.

And from Washington, steady program support.

[3] Published by the American Association for the Advancement of Science in a volume entitled "Science and International Security" edited by Eric Arnett.

Figure 1

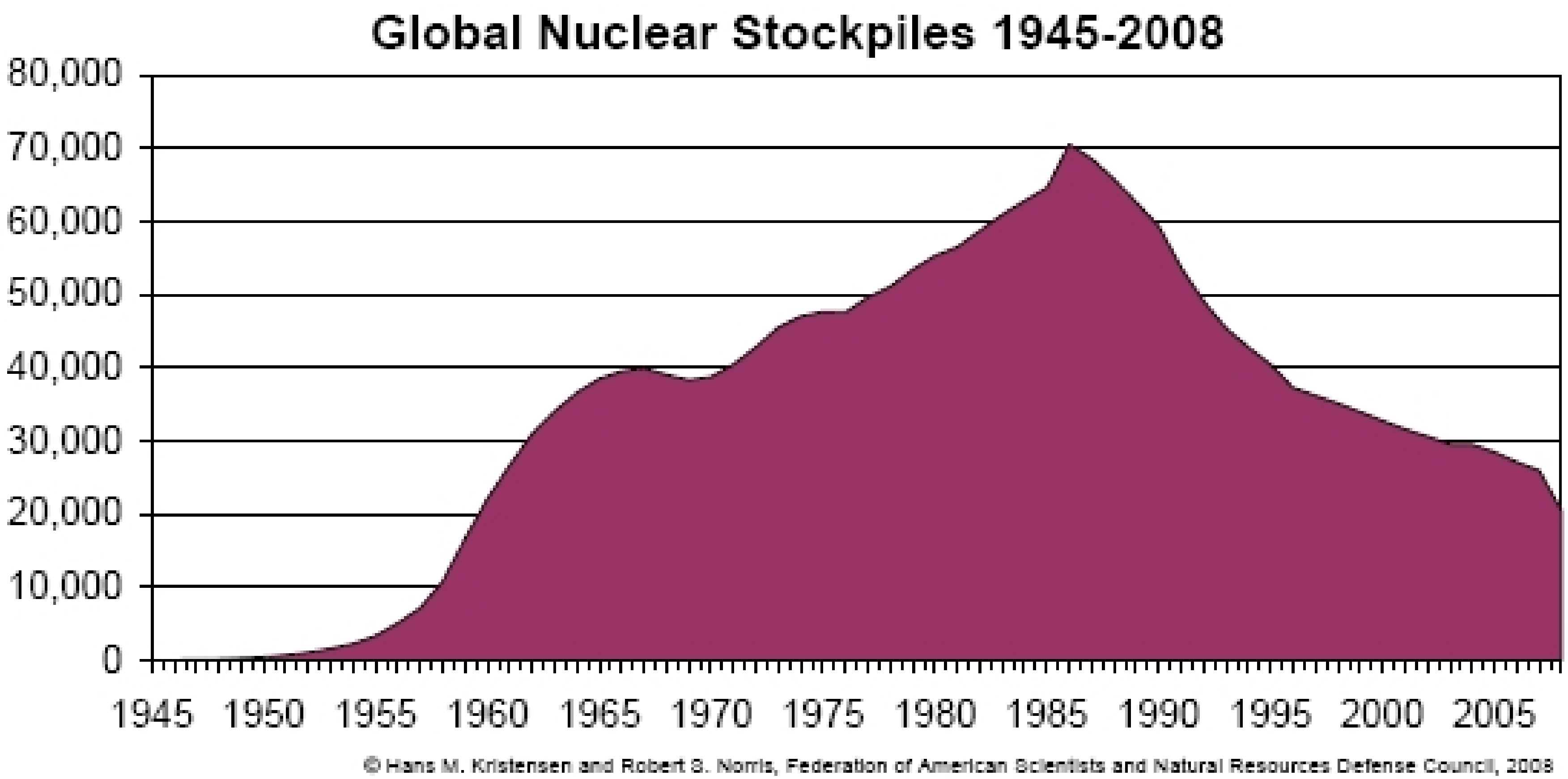
Global Nuclear Stockpiles 1945-2008
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
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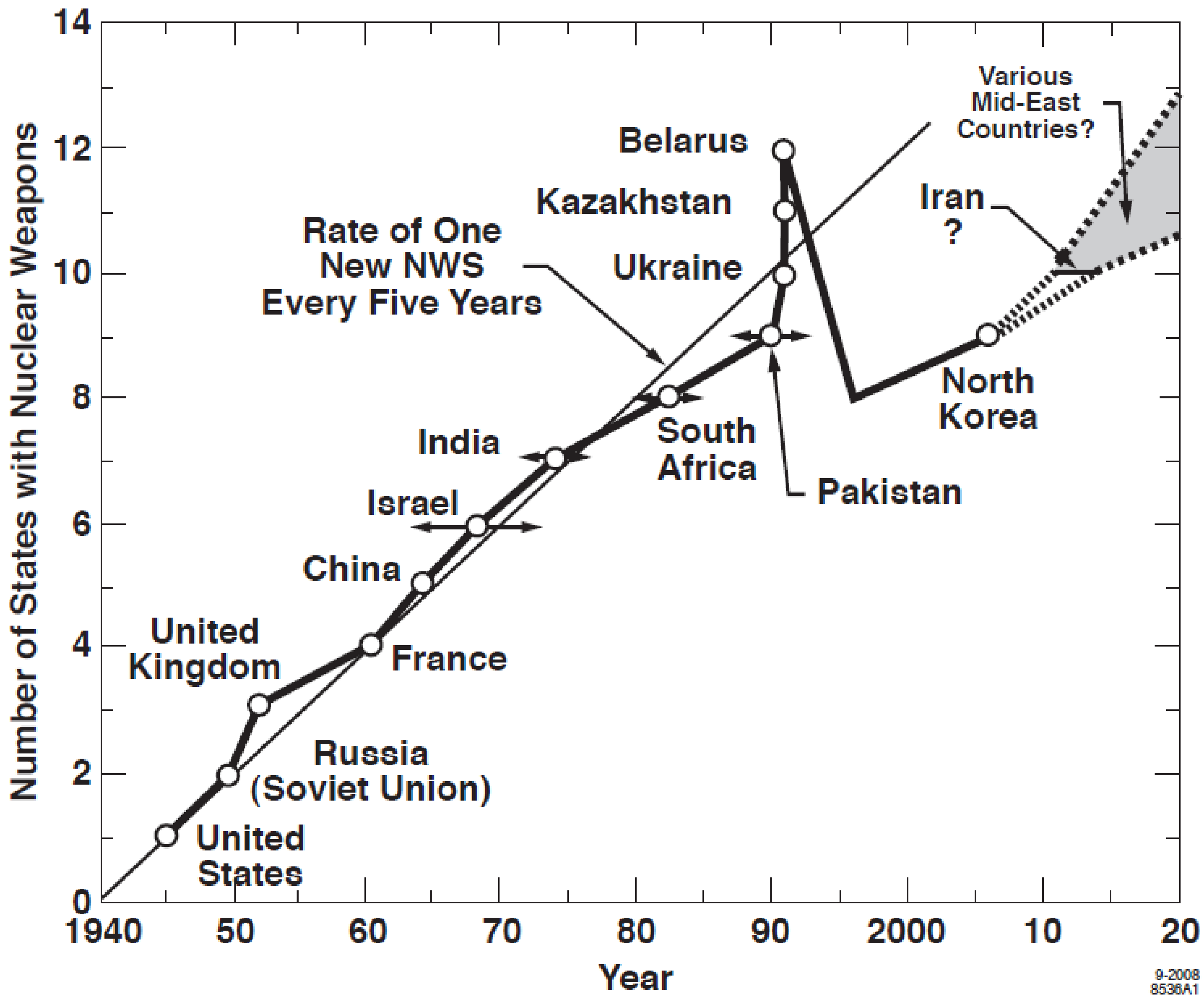
Figure 2



Number of States with Nuclear Weapons
Year
0
2
4
6
8
10
12
14
1940
50
60
70
80
90
2000
10
20
United States
Russia (Soviet Union)
United Kingdom
France
China
Israel
India
South Africa
Pakistan
Ukraine
Kazakhstan
Belarus
North Korea
Iran ?
Various Mid-East Countries?
Rate of One New NWS Every Five Years
9-2008
8536A1