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Nuclear Deterrence in the 21st Century: The Role of Science and Engineering

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The Changing Role of Deterrence

For five decades after the Second World War, the role of nuclear weapons in the U.S. defense posture was largely to deter the Soviet Union (as well as other potential smaller adversaries, e.g., China) from attacking the United States, its allies, and friends. Of near equal importance is the nuclear umbrella role (security assurances) to discourage (dissuade) other nations from pursuing nuclear weapons within their security environment. These roles were critical to the formulation and development of the Nonproliferation Treaty.

However, when the sudden collapse of the Soviet Union ended the Cold War, the larger role of nuclear deterrence fundamentally changed. While we will continue to retain nuclear weapons to serves as instruments of retaliation, the dynamics of deterrence are evolving where substantially fewer deployed weapons will likely be able to address a more diverse set of potential adversaries.

Twenty-first century security challenges are today much more multi-polar and, ofttimes, asymmetric. A few key counties still have substantial nuclear arsenals, and have active and growing nuclear weapons programs that threaten vital US national interests. Maintaining a credible US nuclear deterrent in the eyes of both our allies and adversaries, as well as supporting nonproliferation goals, will continue to be critical to US national security.

Overlaid against this national security backdrop are concerns arising from a growing world population including its effects on climate, food, and energy—greatly complicating security challenges before policy makers today.

This changing paradigm requires additional means to assure allies that the United States remains a trusted security partner and to deter potential adversaries from aggressive actions that threaten global stability. Every U.S. President since Truman has affirmed the role of nuclear weapons as a supreme deterrent and protector of last resort of U.S. national security interests.

Recently, President Bush called for a "… credible deterrent with the lowest-possible number of nuclear weapons consistent with our national security needs, including our obligations to our allies."[1] How can this be achieved? Can we continue on a path of further nuclear reductions while sustaining the national security benefits of nuclear deterrence? Science and engineering have a key role to play in a possible new paradigm for nuclear deterrence, a concept described as as "capability-based deterrence."

Capability-Based Deterrence

[1] *Remarks by the President to Students and Faculty at National Defense University*, Fort Lesley J. Mcair, Washington, D.C., May 1, 2001.

Capability-based deterrence asserts that an agile, repeatedly demonstrated capability to develop and produce deployable nuclear weapons can greatly strengthen the deterrent , and enable meaningful reductions in total stockpile size. In this view, the country can rely, in part, on a working weapons complex that delivers limited numbers of physical products rather than large numbers of reserve or deployed warheads. Such a strategy could be viewed as attractive in that it maintains the benefits of deterrence while enabling the achievement of key goals, such as stockpile reductions. Indeed, the head of the National Nuclear Security Administration (NNSA) stated in December 2007—while introducing the proposed transformation of the nuclear weapons complex—that “the United States' future deterrent cannot be based on the old Cold War model of the number of weapons. Rather, it must be based on the capability to respond to any national security situation, and make weapons only if necessary.”[2] A shift to a capability-based deterrence would represent a shift in nuclear policy emphasis, where the role of science and engineering would become a critical element to establishing the agility and confidence required for such a strategy.

The principal elements of capability-based deterrence are the weapons themselves (albeit fewer and potentially designed to the specific requirements of this strategy) along with the design, development, and manufacturing elements of the weapons complex itself. It is not only the capabilities of the forces themselves that assure allies and deter potential adversaries, it is also the capability to sustain and modernize these forces, while also demonstrating that ability to rapidly respond to new or emerging threats.

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[2] *Remarks by Thomas D’Agastino on the Introduction of the Complex Transformation PEIS*, US Department of Energy Headquarters, Washington, D.C., Dec. 17, 2007.

The notion of capability-based deterrence is not completely new. It appears in the Bush Administration's "new strategic triad" concept and was emphasized in the administration's 2001 Nuclear Posture Review. It was similarly a part of the Clinton Administration's NPR in 1994 and was a principle in the founding of the Stockpile Stewardship Program. This science-based program of experimentation, improved diagnostics, and greatly increased computational capabilities gave us the tools to assess and redress the needs of the stockpile. New experimental facilities for scientific discovery research that strengthens understanding of the physics of weapons performance contributed to the program's remarkable technical success and provides us confidence in the ability to transition to the capability based deterrence.

Enabling a Capability-Based Deterrent

One of the most critical elements of this strategy is the timeliness and agility of this capability, because we must detect and respond to a potential adversary quickly enough to counter any provocative act.

An examination of the timing question provides an interesting contrast to the Cold War posture. In decades past, we had to maintain a moments-notice ready response to a provocative act. This led to bombers on constant standby, intercontinental missiles on hair-trigger alert, and submarines on continuous patrol in the world's great oceans. The answer to the timing question was minutes. Today, the type of threat that might require the large arsenal from the past to counter such a threat may not become manifest for several years. Indeed, in an environment of stockpile reductions – both the United States and Russia have reduced their arsenals by more than 90 percent from their Cold War peaks – we no longer require the large nuclear forces that characterized the Cold War.

Should an adversary decide to restart an arms race, the investment would be large and, in principle, the time required sufficient for the United States and its allies to respond. This element is key. Although it would seem that several years might be sufficient warning, given that today any nuclear weapon life-extension effort takes in excess of a decade (for a just few hundred warheads, if the U.S. had a demonstrated and agile capability that could be mounted, in years (vice decades), adversaries could potentially be deterred from even pursuing provocative acts .

In essence, we move from deterrence through large numbers of deployed and reserve weapons to deterrence through smaller number of deployed weapons and a robust and agile infrastructure and capability. This strategy could potentially preserve many of the benefits of nuclear deterrence while also enabling additional stockpile reductions.

The promise of this strategy–the ability to provide an agile and diverse response to many threats–is also an advantage not realized when we relied solely on a stockpile of Cold War-optimized, high yield-to-weight weapons. Further, the talents of modern science and engineering become prominent, where the U.S. agility arises from a capability-based deterrent grounded in science. The challenge is to support and demonstrate a steady-state capability to execute a complete cycle of warhead design, certification, development, and production over a three-to-seven-year timeframe. Today's very outdated and archaic production complex, and '70s-era design practices within our current deterrent, can not achieve this goal.

The NNSA has proposed a transformation of the nuclear weapons complex aimed precisely at enhancing agility and confidence. This is not entirely theoretical. Recent developments within the NNSA complex have demonstrated a few key elements of this potential agility, most notably a few recent stockpile life-extension program activities, as well as the Reliable Replacement Warhead (RRW) feasibility study.

The Reliable Replacement Warhead

In the RRW study, Laboratory design teams were able to provide highly mature designs in less than 12 months–largely thanks to modern engineering and design tools created under the stockpile stewardship program. Further, the Laboratories built prototype demonstration hardware, and conducted limited non-nuclear proof tests of their designs within 18 months. Note that in the '80s, this level of design maturity required several years. These proof tests exercised a portion of the production complex and provided a concrete example of agility and timeliness possible in a fully functional capability-based deterrent.

Also important to RRW designs was the relaxation of a past Cold War key objective, i.e., maximizing yield-to-weight ratios. The RRW designs instead increased performance margins, backing away from known failure modes characteristic of the legacy stockpile. Increased performance margins coupled with advances in weapons science provided high-confidence in certification without the need for nuclear testing. Further, advanced safety and security features could be included into designs allowing much higher safety, security and surety in the warhead, while also improving efficiency in manufacturing operations.

Summary

In sum, a movement toward active, fully-functional and demonstrated capability-based deterrence could help the nation meet possible future policy objectives, including: further reductions in stockpile size, continuing to certify the nuclear deterrent without nuclear testing, and moving towards our Article 6 commitments under the Nuclear Nonproliferation Treaty.

Two key enablers of such an articulated capability-based deterrent are the transformation of the weapons complex (as proposed by NNSA) and the adoption of many of the concepts and approached undertaken under the RRW effort—all of which were made possible through the science and engineering methods and tools developed under the Stockpile Stewardship Program.

While that U.S. government has proposed that we move towards a "… credible deterrent with the lowest-possible number of nuclear weapons consistent with our national security needs …, we can only move in this direction in an environment in which our security is maintained, allies remain assured of our commitments, and adversaries are dissuaded and deterred.

However near or remote a world free of nuclear weapons may be, a capability-based deterrence working in concert with requirements based on today's threats can facilitate stockpile reductions while maintaining our security and limiting technical risks.

Recommended Reading:

"Toward a Nuclear Free World", George P. Shultz, William J. Perry, Henry A. Kissinger, and Sam Nunn, , Wall Street Journal Editorial, Jan. 15, 2008.

"Minimum Deterrence", Jeffrey Lewis, Bulletin of the Atomic Scientists, Vol. 64 (3) pp.38-41, 2008.

"Can Deterrence be Tailored?" M. Elaine Bunn, Strategic Forum, No. 225, pp. 1-8, 2007.