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**Monitoring and Verification R&D**

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**Abstract**

The 2010 Nuclear Posture Review (NPR) report outlined the Administration's approach to promoting the agenda put forward by President Obama in Prague on April 5, 2009. The NPR calls for a national monitoring and verification R&D program to meet future challenges arising from the Administration's nonproliferation, arms control and disarmament agenda. Verification of a follow-on to New START could have to address warheads and possibly components along with delivery capabilities. Deeper cuts and disarmament would need to address all of these elements along with nuclear weapon testing, nuclear material and weapon production facilities, virtual capabilities from old weapon and existing energy programs and undeclared capabilities. We only know how to address some elements of these challenges today, and the requirements may be more rigorous in the context of deeper cuts as well as disarmament. Moreover, there is a critical need for multiple options to sensitive problems and to address other challenges. There will be other verification challenges in a world of deeper cuts and disarmament, some of which we are already facing. At some point, if the reductions process is progressing, uncertainties about past nuclear materials and weapons production will have to be addressed. IAEA safeguards will need to continue to evolve to meet current and future challenges, and to take advantage of new technologies and approaches. Transparency/verification of nuclear and dual-use exports will also have to be addressed, and there will be a need to make nonproliferation measures more watertight and transparent. In this context, and recognizing we will face all of these challenges even if disarmament is not achieved, this paper will explore possible agreements and arrangements; verification challenges; gaps in monitoring and verification technologies and approaches; and the R&D required to address these gaps and other monitoring and verification challenges.

**Introduction**

There is growing interest in, and hopes for, nuclear disarmament in governments and nongovernmental organizations (NGOs) around the world. With the calls from luminaries like George Schultz, Henry Kissinger, William Perry and Sam Nunn for a world without nuclear weapons, disarmament has for the time being at least, moved from the political fringe to the mainstream. President Obama furthered the goal when in Prague on April 5, 2009, he spoke of "America's commitment to seek the peace and security of a world without nuclear weapons."[2] He recognized that this objective "will not be reached quickly -- perhaps not in my lifetime. It will take patience and persistence. But now we,

[1] The views expressed are the authors' own and not those of the Los Alamos National Laboratory, the National Nuclear Security Administration, the Department of Energy or any other agency.

[2] Remarks by President Barack Obama, Hradcany Square, Prague, Czech Republic, April 5, 2009.

too, must ignore the voices who tell us that the world cannot change."[3] The 2010 Nuclear Posture Review (NPR) report outlined the Administration's approach to promoting the agenda put forward by President Obama in Prague for reducing nuclear dangers and pursuing the goal of a world without nuclear weapons while maintaining, as long as nuclear weapons remain, a safe, secure and effective arsenal, both to deter potential adversaries and to assure U.S. allies and other security partners that they can count on America's security commitments.

Reflecting the belief that the prospects for a world without nuclear weapons would depend on political, military and technical conditions, the NPR calls for a national program to address these conditions, including a monitoring and verification R&D program to meet future challenges arising from the Administration's nonproliferation, arms control and disarmament agenda. The Administration is committed to:

- Implementing New START
- Negotiating a follow-on to New START
- FMCT negotiations
- CTBT ratification and entry into force
- Enhanced safeguards and
- Russian and Chinese stability and transparency.

These are seen by the administration as concrete steps leading toward the vision of a world without nuclear weapons.

Realizing this agenda will require the development of technologies, procedures and systems for monitoring and verification that take into account uncertainty about the next agreement or other steps, about possible verification requirements and about the path to, and prospects for, the ultimate objective of a nuclear-weapon-free world. In this context, and recognizing we will face all of these challenges even if disarmament is not achieved, this paper will explore possible agreements and arrangements; verification challenges; gaps in monitoring and verification technologies and approaches; and the R&D required to address these gaps and other monitoring and verification challenges.

**Future monitoring and verification requirements will be unprecedented**

New START verification draws largely from the provisions of old START, and focuses on delivery systems with some attention to accounting for deployed warheads.
It is often assumed that the difficult and complex task of verifying warheads and their dismantlement would occur later rather than sooner on the path to zero; however this view may be incorrect. The US position raises the issues of warhead position in the context of the follow on to New START. Verification of a follow-on to New START could have to address deployed and non-deployed, strategic and nonstrategic, warheads,

[3] Ibid.

along with continuing attention to delivery systems. This could involve intrusive warhead verification, which raises the question of whether this will be acceptable to the Russians; and whether we will be the able to pursue effective warhead verification and transparency. Because of these uncertainties, there have been proposals to avoid the daunting challenges of warhead verification at this stage of the process.

On the basis of the US position, there have been proposals for a total ceiling of warheads, perhaps 3000-3500, including deployed strategic warheads, non-deployed strategic warheads. For at least the strategic deployed warheads, there would be a sub-ceiling of perhaps 1000 warheads. Verification would be based on the warheads, but would not involve elaborate schemes to identify and track warheads, and it may be argued that such monitoring is probably not necessary at the proposed levels. As noted, it would be a complex and difficult task. We do not yet have a workable system; and if it is probably unacceptable to Russia. There are procedures in New START for verifying deployed warheads that are limited but should be adequate at the levels proposed. But it is recognized that there will be even more limited capability for addressing non-deployed and nonstrategic warheads, involving perhaps declarations, centralized storage and perhaps some transparency measures. This would result in a two tiered system that, as suggested, may be acceptable at the proposed levels of arms.
While such limited verification may be deemed acceptable at the next phase of reductions, deeper reductions and the goal of "zero" will require different, more far reaching measures.

Deeper cuts and disarmament would need to fully address warheads as well as delivery systems, testing, facilities, virtual capabilities from existing or shut-down nuclear weapon and existing nuclear energy programs and material and weapon production and related capabilities. Verification would also be faced with unprecedented new requirements. Key challenges include:

- Warhead transparency/verification
- Dismantlement transparency/verification
- Material, warhead and delivery vehicle production baselines/verification
- Material disposition transparency/verification
- Clandestine facilities/materials/weaponization detection / verification

We believe we know how to address only some elements of these challenges today, and some of those only marginally; the requirements may be more rigorous in the context of deeper cuts as well as disarmament, although the political-military conditions that could make this level of progress possible would presumably affect verification requirements at some time and to some degree.

The verification of dismantlement or elimination of nuclear warheads and components is widely recognized as the most pressing problem we can identify today. The considerable research and development done in the United States and elsewhere on warhead and dismantlement transparency/verification since the early 1990s reveals the enormity of the

problems and the challenges of developing effective capabilities to verify very small arsenals, let alone "zero," however defined.

The United States has focused on developing attribution measurement systems to determine whether an item is like, or consistent with, a nuclear weapon (e.g., mass, isotopic ratios, etc.) and information barrier systems to prevent direct inspector or third party access to these measurements. However, they have serious technical challenges, including the need to address authentication, transparency and other issues.

There has also been considerable work on verification schemes that follow an item through the dismantlement process. They are limited, especially by the uncertainties concerning the item at the point of entry, wherever that may be, by the possibility of illicit activities that may occur during the process and by potentially overwhelming costs.

All of these problems derive from tensions between the secrecy of nuclear-weapon information and the transparency needed for verification. Some problems are increasing as weapons are moving from deployed status to increasingly consolidated storage (which can affect the value of chain of custody procedures for verification). They are also affected by limits on access, by different classification systems among states and by other issues.

These difficulties may prevent the ability to ensure that the item brought into the verification system is a weapon, is fully consistent with being a weapon or has a "weapon origin." If so, this could raise questions about whether one is genuinely addressing warheads and their dismantlement directly, and may put a premium on focusing on weapon-usable material that may or may not have been removed from a weapon. Such an approach has its own issues, and does not address the problems of past production uncertainties and of detecting clandestine activities.

There will be other verification challenges in a world of deeper cuts and disarmament, some of which we are already facing.

There will need to be a fully operational verification regime for a CTBT, where OSI implementation remains an issue. As numbers are reduced, improved monitoring for low yield tests and supercritical experiments will be critical for effective verification, as will transparency at declared or shutdown test sites where some activities are likely to continue.

There is new attention to the challenges of monitoring an FMCT due to the sensitivities of some of the materials and facilities that would presumably be under its scope. There are issues with the use of IAEA safeguards to verify a CTBT, including the challenges of managed access, whether and under what conditions the use of environmental sampling will be permitted and the difficulty and costs of retrofitting old facilities for safeguards implementation.

At some point, if the reductions process is progressing, uncertainties about past nuclear materials production will have to be addressed. They will not be fully reconciled, or even reconcilable. However, these uncertainties will have to be significantly reduced, using declarations, transparency, new techniques in nuclear archeology and other means.

Past weapon production uncertainties, along with existing or mothballed production capacity, will have to be addressed. To the extent production capabilities will be important in dismantling weapons, there will be some interest in ensuring redirection to production or other illicit activities are not occurring, and the existing asymmetries in capacity between the US and Russia (and other nuclear-weapon states) are likely to present negotiating difficulties. Production capacity that derives from civil nuclear activities will also need to be addressed.

IAEA safeguards will need to continue to evolve to meet current and future challenges, and to take advantage of new technologies and approaches. Cheap and effective wide-area environmental monitoring and novel detection technologies and techniques will be among the new tools required to meet these anticipated challenges, especially for material accountancy in bulk handling facilities and for the detection of undeclared facilities and activities. Proliferation resistance measures that enhance the effectiveness and efficiency of safeguards ("safeguardability" or safeguards by design) will increase in importance as nuclear energy expands. Along with better use of existing authorities, particularly special inspections, new authorities and capabilities may be required.

Transparency/verification of nuclear and dual-use exports will also have to be addressed, and there will be a need to make nonproliferation measures more watertight and transparent.

Other verification challenges will also be encountered, including those for other WMD and delivery systems. Delivery vehicles and testing may no longer be the focus of strategic reductions as one goes lower, but they will have to be even more carefully addressed, including clandestine production and storage, dual-use systems, unconventional delivery and other issues.

**Some old arms control issues will have new importance as arms reductions proceed.** Deeper cuts and disarmament highlight the issue of irreversibility, which complicates verification and presents a serious technical challenge. In the past, it has largely been seen as increasing the time and cost involved in the reconstitution of weapons, ideally so that it is no less than what would be required to produce a new weapon. While this may have been acceptable at the high levels of weapons in the past, and may be acceptable at current force levels. It becomes far more questionable as numbers decline further. There are few clear alternatives. Yet nuclear weapons cannot be disinvented, and virtual capabilities will to some degree continue to exist in a nuclear–free world and they will allow disarmament, in principle, to be reversed.

The implicit assumption one often hears is that virtual capabilities enable disarmament and nuclear-weapon states can choose whether or not to rely on these capabilities as a

hedge against disarmament. In practice, these capabilities could in an agreement be merely recognized; sanctioned and preserved; or proscribed and dismantled to the extent possible.

If virtual capabilities (without forces in being) are to serve as a hedge--albeit one of uncertain value--this would require, among other things, human capital and facilities that cannot just be mothballed and will need to be exercised. This may appear threatening, and raises questions about crisis stability at the least. The acceptance of such a strategy by nonnuclear-weapon states and NGOs is by no means certain. It has been criticized by some abolitionists.

**Being at the cutting edge of ST&E will best enable us to meet future challenges**
Although many pieces of the puzzle are in place or are understood, we do not today know how to verify very low numbers or zero. Nor do we fully know what the completed puzzle would look like, i.e., what the path to the goal of disarmament involves in terms of specific provisions for specific treaties, agreements and other steps over time. We need to develop the verification tools and systems approaches that could allow us to meet this complex set of challenges and the uncertainties of negotiations (bilateral, multilateral and international). There is a critical need for multiple options to address sensitive areas where classified or proliferation-sensitive information may come into play along with other challenges.

At a time when despite some rhetoric the trend line has been toward lesser attention to verification—due to current force levels and the changing post-Cold War US-Russian relationship, especially after the "reset"—there is a real opportunity to explore verification options. Any realistic time frame for disarmament should allow considerable scope to invest resources at the national and international levels to undertake research, development and demonstrations in an effort to address the anticipated (and perhaps unanticipated) verification challenges of disarmament now and for the next decade at least.

This is a strategic planning and program development exercise. Strategic planning requires:

- Prioritization of possible negotiations. verification challenges and gaps in technologies and approaches;
- Developing a plan for an enduring program for R&D in an effort to address the anticipated and perhaps unanticipated verification challenges over the next decades that includes
    - US R&D and
    - International R&D; and
- Ensuring ST&E human and material resources

Program development involves:

- Research, development and demonstrations of multiple options to requirements based upon
    - Cooperative, treaty-based approaches and
    - US approaches (including national technical measures).