LAWRENCE
LIVERMORE
NATIONAL
LABORATORY

LLNL-CONF-636653

Applicability of Nonproliferation Tools and Concepts to Future Arms Control

M. Dreicer, G. Stein

May 15, 2013

ESARDA Annual Meeting
Bruges, Belgium
May 28, 2012 through May 30, 2013

Disclaimer

Applicability of Nonproliferation Tools and Concepts to Future Arms Control

Mona Dreicer[1], Gotthard Stein[2]

[1] Lawrence Livermore National Laboratory
Livermore, California, United States
[2] Consultant, Forschungszentrum Jülich GmbH
in der Helmholtz-Gemeinschaft 52425 Jülich, Germany
E-mail: dreicer1@llnl.gov, g.stein@fz-juelich.de

Abstract:

A Working Group on Broader Perspectives on Nonproliferation and Nuclear Verification (WG3) was organized by the ESARDA/INMM International Safeguards and Nonproliferation and Arms Control Technical Divisions, in October 2011. The group considered how nonproliferation tools and culture could facilitate verification of future nuclear treaties. Two of the key challenges identified were providing confidence by monitoring and verification of the warhead lifecycle and fissile materials in States with nuclear weapons. These issues are complicated by a lack of consensus on disarmament goals, complexity of the weapons complex in some P-5 States, the technical capacity in countries without nuclear weapons, restrictions on the sharing of sensitive information to prevent proliferation, and the level of confidence in verifying compliance that can be achieved. Following-on from this discussion, a state-level approach could offer approaches to overcoming the obstacles that exist for verifying possible future arms control agreements. Next steps and potential R&D for technical verification and analysis are outlined.

Key Words: nonproliferation; arms control; verification

1. Introduction

A Working Group on *Broader Perspectives on Nonproliferation and Nuclear Verification* was organized by the *INMM International Safeguards and Nonproliferation and Arms Control Technical Divisions* in the frame of the ESARDA/INMM conference Aix en Provence October 2011. The presentations focused on the technical topics related to international security and stability in global nonproliferation and arms control regimes, specifically asking how nonproliferation tools and culture might facilitate in the verification of future nuclear treaties with a focus on:

- Identifying existing tools and considering their applicability to the new challenges of verifying nuclear arms reductions?
- Modifications needed for this new context?
- Opportunities for use
- Existing gaps; and
- Needed R&D

The Working Group concluded[1] that a more systematic analysis of applying existing nonproliferation mechanisms might be useful, particularly for implementing international safeguards in weapons states, furthering the concept of remote monitoring, better understanding the implications of uncertainty in verification regimes, and the utility of applying a state-level approach, as currently being explored by the IAEA, to arms control. The group asked the following questions:

- "What is zero?" What will be accepted as "complete disarmament"?
- What would be an overarching framework for a network of verification regimes?
- Would verification standards change as reductions are implemented?
- Who are the Stakeholders: multilateral vs. bilateral parties, NWS vs. NNWS, or open society stakeholders such as NGOs, Industry, and the general public
- How can weapons-sensitive, proprietary, and classified information be protected?

Some of the challenges in verifying future arms control agreements might be addressed by various models for governance taking into account the questions highlighted above. Rather than aiming for a universal agreement, a step-by-step approach working to implement a web of complementary verification regimes is the most likely. This paper will not address the political aspects of this issue but focus on establishing technical mechanisms to increase transparency and verification. To build confidence in the ability to monitor and verify compliance, further development of the following concepts are needed: R&D for advancing technical capabilities, greater engagement with a wide variety of potential stakeholders (e.g P-5, IAEA, NNWS, United Nations, etc), and demonstration projects are needed. The ideas in this paper will be presented to the INMM Nonproliferation and Arms Control Division and the ESARDA Subgroup on Disarmament of the Novel Technology Subgroup and the VTM Group.

2. The Complexity

A weapons program is an interlinked complex of facilities and processes where materials (i.e. plutonium and/or uranium), components and weapons are produced, transported and stored (Figure 1). In some States, there are stages of the weapons lifecycle where civilian and military weapons activities are not clearly separated. There are various bilateral and multilateral programs that have worked to establish materials control, accounting and safeguards systems in nuclear weapons and non-nuclear weapons states. Although not simple to achieve, comprehensive safeguards systems could be put into place in State with nuclear weapons taking into account the protection of national security and proliferation-sensitive information[2].

The difficulty of designing a comprehensive warhead verification regime that could be verified with high-level of confidence has been debated since the 1960's (in the U.S. at least). If we assume that reductions of nuclear stockpiles will be accomplished by a network of different initiatives, a compatible set of continuity of knowledge regimes must begin by verifying baseline declarations and continue by monitoring movements of accountable items, any new production or dismantlement, transportation and storage for strategic nonstrategic, deployed and stored warheads. It will also be necessary to monitor irreversible dismantlement of warheads and safeguarding of resulting material, as well as new civilian nuclear material production not currently safeguarded under IAEA safeguards in nuclear weapons states of those not party to the NPT.

A framework will be needed to make progress in such a complex political, security and technical situation. Given a common approach, it might be possible to take information and inspections from the network of different agreements and initiatives and draw conclusions regarding a State's compliance with arms control commitments. Taking stock and learning from existing initiatives is the first step.

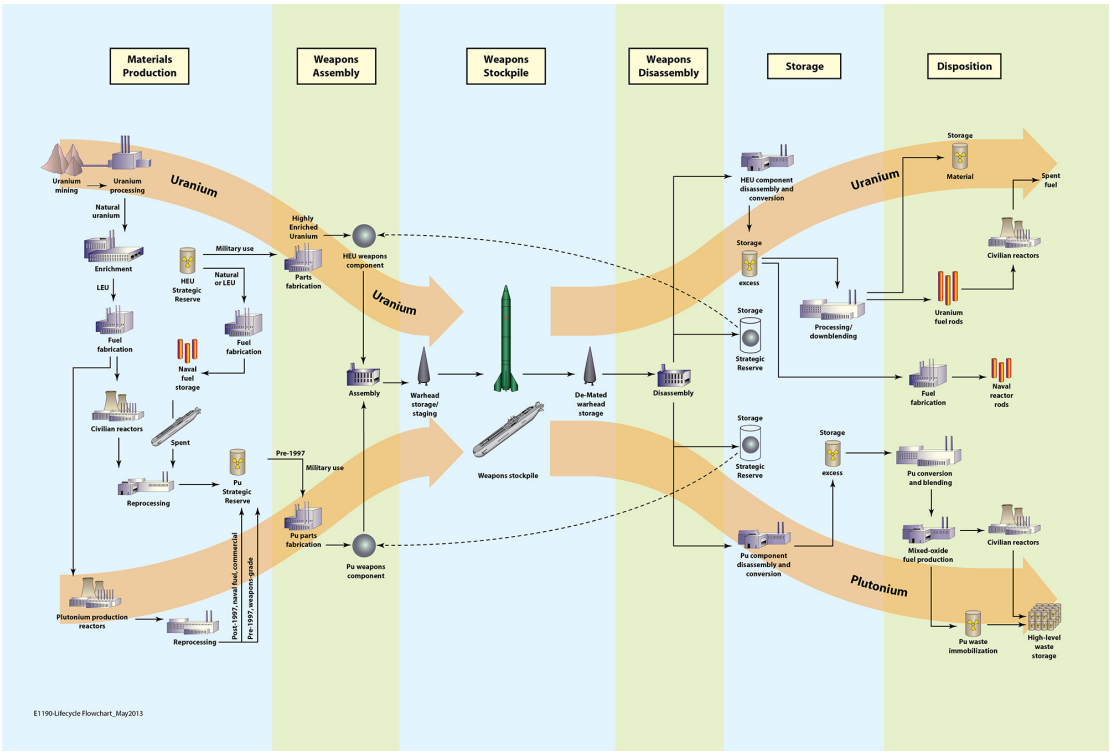

Figure 1. Nuclear materials and weapons lifecycle

3. Existing Mechanisms

There are many international nonproliferation programs that focus on nuclear security and/or material accountancy. IAEA Safeguards agreements and the Additional Protocol are the most prominent mechanism for verifying the peaceful uses of nuclear material in Non-Nuclear Weapons States. Negotiations to create some sort of fissile material control regime that would limit production of nuclear material for weapons in Nuclear Weapons States and States outside the Nuclear Nonproliferation Treaty has not yet been achieved but continues to be on the international security agenda. Initiatives undertaken bilaterally (U.S-Russia) and multilaterally (G8 Global Partnership) have worked to improve material accountancy in the Former Soviet Union and beyond. In addition, counterterrorism initiatives, not specifically nonproliferation-oriented, provide additional levels of assurances of responsible behavior or nonproliferation *bona fides*.

The U.S. and Russia have made some limited in-roads towards verifying parts of the nuclear weapons lifecycle. For example, transparency monitoring provisions under the 1993 United States-Russian Federation HEU Purchase Agreement allow for monitoring the down-blending of excess Russian weapons-origin highly enriched uranium to low enriched uranium; Plutonium Management and Disposition Agreement aims to dispose of excess weapons-grade plutonium monitored by inspectors, and the Plutonium Production Reactor Agreement allows for reciprocal monitoring of the 5 U.S. and 5 Russian shut-down plutonium production reactors. The START Treaty followed by New START, limits the numbers of strategic arms and provides verification and transparency via data exchanges/notifications and inspections/exhibitions in the U.S. and Russia. From 1996-2000, Russia, the U.S. and the IAEA worked to develop a system for verifying nuclear weapons disarmament and those who participated concluded that there were no technical obstacles to being able to implement such a regime (Trilateral Initiative).

4. Possibility of a State Level Approach

The IAEA has been improving its processes for safeguards implementation to ensure it is objectives-based and information-driven. The IAEA State-Level Concept (SLC)[3,4] outlines three phases:

1. Developing State-level safeguards approaches
2. Planning & conducting safeguards activities, and
3. Establishing knowledge & drawing conclusions

Decades of experience has taught the IAEA that integrating a wide variety of information in an objective way is the most effective way to analyze monitoring data and provide the information that States need to make their verification decisions.

To address the first phase, a methodology to implement a State-level Approach (SLA) allows State-specific approaches to nuclear safeguards, i.e. differentiation between States, taking into account all information available to the IAEA and being responsive to changes in risk assessment. It is not limited only to States with an Additional Protocol and it is applicable to all States with a safeguards agreement in force. This process is being implemented in three steps[5]:

- Identification of plausible acquisition paths,
- Specification and prioritization of State-specific technical objectives,
- Identification of safeguards measures to address the technical objectives.

The SLA outlines sequences of activities (acquisition paths, AP) that a State could consider to acquire weapons usable material. It analyzes all plausible APs aiming to determine whether a proposed set of safeguards measures will be sufficient. Mapping out the APs is essentially producing a state-specific network of process and material and flows with identified nodes for inter-connections[6]. The "relative attractiveness" of an AP, or usefulness in nuclear weapons, is considered in addition to the time it would take to implement such a process in a country. Currently, the IAEA is using this approach based on expert judgment, but a more transparent and reproducible method is needed[4].

A framework for collection and analysis of monitoring/verification information related to new arms control agreements could be formulated using the same characteristics being proposed for IAEA Safeguards[5]:

- objective – use the same method and criteria for all States;
- transparent - analysis should be open; understood methodologies;
- standardized - steps of the analysis have to be defined in detail;
- reproducible - conclusions not depending on who performs the analysis; and
- document - decisions made during the analysis have to be protocoled.

SLC Phases two and three would depend very much on the scope of the new agreements addressing the different parts of the nuclear weapons lifecycle. A common methodology cross the new agreements/initiatives could facilitate state-level analysis and conclusions. Table 1 presents steps that could be taken to developing such an approach and aid in design of a future program of research.

Phases		Focus & Questions
Develop approach	Analyze cheating pathways and level of risk	Taking into account governance, technology, cooperative measures, national technical means
	Monitoring & Verification Measures/technologies	Do stakeholders consider methods sufficient?
	Acceptable level of uncertainty	Bi-lateral, regional and/or global
Planning and conducting Activities	Existing treaties, agreements and regimes	Gaps in the network
	Identification of Verification Gaps	Existing technology
	Design new initiatives	Political feasibility
Establishing knowledge	Collection and analysis of data	Dealing with sensitive, classified and proprietary information
	Use of variety of data sources: NTM, unilateral, treaty-based and open source information	Managing types of data from different countries and regions in different time scales; data volumes
		Consultation & Clarification processes
Drawing conclusions	Influence of trust on data interpretation & objectivity	Lessons learned from the IAEA?
	Critical review/adjudication of varying interpretations	
	Presentation of data to analysts and decision-makers	

Table 1. Considerations on developing a state-level approach for achieving confidence, for possible future arms reductions.

5. Research and Development for Verification Technologies

Whatever governance and analytical framework is constructed, verification technologies are going to be needed for implementing any future regime(s). The R&D conducted to support IAEA safeguards and counterterrorism initiatives concentrate on materials detection and accounting. Verification mechanisms needed to monitor and verify the phases of the weapons lifecycle are at an earlier stage of development. Table 2 provides a list of possible research, development and deployment needs for possible cooperative measures that might be used in future verification initiatives.

6. Summary

It does not seem likely that a global arms reductions agreement could be achieved. It is more practical to work on a step-by-step approach to implement a web of complementary regimes that might ultimately achieve this goal. When the political challenges are overcome, technical and analytical capabilities will be needed to maintain confidence via increased transparency and technical verification. To build confidence in the ability to monitor and verify compliance, a consistent analytical framework, R&D advances, and demonstration projects will be needed. We have proposed a state-level analytical approach be considered in developing future arms reductions initiatives, which has been based on the IAEA's State-Level Approach, and technical R&D needed to support implementation.

Monitoring Objective	Possible Cooperative Measures	Research, Development & Deployment Needs
Non-deployed Monitored storage	Counting/Transparency Declarations Continuity of knowledge Routine inspections Remote monitoring	RDE – confirmation of warhead contained in container (attributes, imaging) (HEU, Pu) Information barriers/Managed Access; authentication Tags/unique identifiers for containers Remote monitoring
• Production • Weaponization	• Multiple steps with increasing intrusiveness • Declarations and Accountancy • Routine to short notice inspections • Continuity of knowledge	• Tags for warheads & components • Information barriers • Managed Access • Satellite Imagery • Environmental Monitoring • Forensics
• Dismantlement	• Done in multiple steps with increasing intrusiveness • Declarations • Transparency to counting to accounting • Continuity of knowledge • Routine to short notice inspections	• Tagging components & materials (to track from dismantled components fissile material) • Managed Access • Satellite Imagery • Warhead measurements using RDE

• State-level	• Cradle-to-grave tracking (State-level continuity of knowledge)
	• Inspections
		• Information analysis
		  • Sampling Statistics
		  • Propagation of Uncertainty
		  • Game theory
		• Societal Monitoring

Table 2. Proposal for the development of verification technologies

7. References

1. M. Dreicer, G. Stein, *Broader Perspectives on Nonproliferation and Nuclear Verification*, INMM/ESARDA Conference Working Group 3, Aix en Provence, 2011.
2. C. Listner, M.J. Canty, G. Stein, A. Rezniczek, *Can State-level Safeguards be applied to Nuclear Weapon States?* presented at DPG Conference, Dresden 2013.
3. J. Cooley, *Conceptual Framework for IAEA Safeguards Implementation*, presented at the INMM Workshop on Evolving the State-Level Concept, Charlottesville, Virginia, 2012.
4. J. Cooley, *The State-level Approach to International Safeguards*, JNMM, 2009,
5. C. Listner, M.J. Canty, G. Stein, A. Rezniczek, I. Niemeyer, *A Concept for Handling Acquisition Path Analysis in the Framework of IAEA's State-level Approach*, INMM Annual Meeting Proceedings, Orlando, 2012.
6. C. Reynolds, *Developing State-level Safeguards Approaches: Reflections from Select Country Case Studies* INMM Annual Meeting Proceedings, Orlando, 2012.

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344. LLNL-CONF-636653