Working Group 3 - Deliverable Ten

Summary

A mapping of existing and potential technical capabilities necessary to enable monitoring and verification at different stages of a nuclear weapon dismantlement process, and the level of confidence the technology brings to monitoring the dismantlement process, with a list that identifies capability gaps and weaknesses to inform future research.

Working Group 3: Technical Challenges and Solutions

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In order to identify and map existing and potential technologies applicable to monitoring and verification at various stages of a nuclear weapon dismantlement process, the Working Group on Technical Challenges and Solutions (Working Group 3) documented various technologies, described in more than 20 technology data sheets, and listed for each technology:

- Its physical principle and methodology;
- Potential monitoring use cases (pre-dismantlement, dismantlement, post-dismantlement, storage stage);
- The physical description of the technology (e.g., approximate size, weight);
- Time constraints (e.g., time to install equipment, measurement time including distance to object);
- Consideration regarding its applicability in the presence of shielding;
- Technology complexity (e.g., hardware, software, and ease of use by personnel);

- Infrastructure requirements (e.g., electricity, liquid nitrogen, etc.);
- Limitations (e.g., detection limits for nuclear material, operational temperature range, difference in technology detector materials, etc.);
- Information collected by the technology (used to help determine if an information barrier is required for use);
- Safety, security, deployment concerns;
- Technology development stage (technology readiness level, TRL);
- Additional system functionality; and
- Examples of existing equipment, and where and how they are used, including references.

The applicable technologies identified were hereafter divided into several categories and put together in technology tables (Working Group 3 Chain of Custody Technologies Mapping Table and the Working Group 3 Nuclear Explosive Device and Component Monitoring Technologies Tables), including:

- Technologies that can identify attributes of a nuclear weapon and provide confidence that the measurements taken of the item in the container are consistent with those of a nuclear weapon;
- Technologies that can be used to detect special nuclear material (SNM) in a container after dismantlement;
- Technologies that can be used to detect high explosives in a container after dismantlement;
- Technologies that can be used to maintain the chain of custody of the items being monitored; and
- Technologies that can be used to maintain the chain of custody of the facilities and locations that are part of the nuclear weapon dismantlement and storage process.

Within each category, key parameters and limitations for each technology were identified, to allow differentiation between technologies and methods and to allow the selection of the best technologies that fit the requirements given for the various steps of the monitoring scenario.

Furthermore, as a result of the technologies identified, the Working Group concluded that many of the technologies and methods used for nuclear safeguards are potentially applicable for monitoring nuclear weapons and the dismantlement of nuclear weapons. The issue with using many of these technologies “as is” is that much of the data obtained when used on a nuclear weapon, or parts thereof, is proliferative. Therefore, procedures and additional technical requirements are necessary to protect the information, so as not to violate Article I of the Nuclear Non-Proliferation Treaty.

To better understand some of the proliferation concerns, a food-for-thought paper on equipment authentication was put together. In short, equipment authentication is a process by which parties to a treaty or agreement obtain confidence that the information reported by the monitoring equipment accurately reflects the true state of a monitored item. Thus, the authentication techniques aim to provide assurance that systems function as designed, are assembled as designed, exhibit only expected functionality, and contain no hidden controls. The equipment authentication and certification needs of the host and inspector are interdependent, and the balancing of these needs is a challenge for a nuclear disarmament monitoring regime.

Factors affecting equipment authentication techniques to establish validity and confidence include:

- Design information of each system (including hardware and software);
- Functional and operational testing of each system's hardware and software;
- Inspection procedures to meet treaty obligations and perform authentication of the systems; and
- Chain of custody measures implemented throughout the lifecycle of authentication activities.

On June 27, 2017, representatives of all three Working Groups conducted a one-day Walkthrough Exercise of Phase I's Basic Dismantlement Scenario. The purpose of the exercise was to explore the application of technologies and procedures identified by the three Working Groups.

In order to come well prepared for the exercise, members of Working Group 3 composed an internal food-for-thought paper with questions to consider at the Walkthrough, taking into account all the findings from the work within the group. The paper was mainly composed of various questions to consider at the different steps of the dismantlement process, with the main aim of addressing issues that should be clarified in order to make use of appropriate technologies at the respective dismantlement step. The paper also included conceptual questions regarding the number of containers leaving the dismantlement station, i.e., whether materials in containers other than those containing Special Nuclear Material (SNM) and high explosives ought to be verified.

Additionally, during the Walkthrough the concept of nuclear weapon templates stood out as an area of potential technical significance. In theory, it should be technically possible to take a "snapshot" of a nuclear weapon within its container by measuring specific aspects or characteristics. With an information barrier to protect classified information, use of such a template could help build confidence in inspection/monitoring of nuclear weapon dismantlement. In practice, although this concept is potentially attractive, additional detailed work is needed on template methods (including what would be measured and how), ultimate feasibility, strengths and limitations, and how such a template would be used.

Finally, based on the technology requirements identified by Working Group 3 for the Basic Dismantlement Scenario, including the findings from the Walkthrough Exercise, several areas for which technologies either need to be developed or re-engineered to be used specifically for this type of activity were found. The technologies and methodologies that need to be developed are:

- Detection of explosives in a closed container using a method that is not a technology based on swipe samples or be destructive to the container or its contents;
- Quantification of the threshold mass of explosives in a closed container that may contain additional contents; and
- Passive measurement of uranium isotopics and threshold mass in a closed container.

The technologies and methodologies that need additional development or engineering are:

- Methods for detecting explosives in a room from a distance;
- Development of additional nuclear weapons template methods beyond the radiation-based ones that currently exist;
- Development of information barrier methods that can be used with various monitoring methods; and
- Evaluation of potential nuclear weapon intrinsic signatures before and after dismantlement.

To conclude, while tough challenges remain, potentially applicable technologies, information barriers, and inspection procedures provide a path forward that should make possible multilaterally monitored nuclear warhead dismantlement while successfully managing safety, security, non-proliferation, and classification concerns in a future nuclear disarmament agreement.

International Partnership for Nuclear Disarmament Verification

The International Partnership for Nuclear Disarmament Verification (IPNDV), is an ongoing initiative that includes more than 25 countries with and without nuclear weapons. Together, the Partners are identifying challenges associated with nuclear disarmament verification, and developing potential procedures and technologies to address those challenges. Learn more at www.ipndv.org.

About Working Group 3: Technical Challenges and Solutions

Throughout Phase I, the IPNDV Technical Challenges and Solutions Working Group has investigated effective technologies, methods, and procedures that can be used for the specific technical challenges in the dismantlement process, such as identifying a nuclear device, maintaining chain of custody, and protecting proliferation sensitive material. This group is co-chaired by Sweden and the United States.