International Partnership for
Nuclear Disarmament Verification

Walkthrough Exercise Summary

November 2017

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Foreword

A critical feature of any nuclear weapon reduction or disarmament agreement is the ability to verify that all parties to the treaty are meeting their obligations, but there are technical and political challenges to overcome in doing so. More than five years ago, NTI launched a Verification Pilot Project that gathered together international experts to develop technical and procedural solutions to these challenges. The project's final report in 2014 recommended developing capacity and creating a dialogue between countries with and without nuclear weapons.

This key recommendation developed into the International Partnership for Nuclear Disarmament Verification (IPNDV), a unique public-private partnership between the Nuclear Threat Initiative and the U.S. Department of State, which has brought together more than 25 countries over the past three years. The Partnership has identified many of the complex challenges of verifying nuclear disarmament and explored potential options for technologies and procedures to overcome those challenges. In so doing, we are also building national and international capacity in understanding those challenges and options. We believe there is enormous value in the process of sharing knowledge, challenging assumptions, and building capacity between countries with and without nuclear weapons. And through this work, the IPNDV is preparing for a future that can be more peaceful and secure.

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During its first phase, the Partnership and its three Working Groups focused on how to verify the actual dismantlement of a nuclear weapon, or what the Partnership has called the "basic dismantlement scenario." Verifying the actual dismantlement of nuclear weapons is a central, technically complex, and highly challenging aspect of nuclear disarmament. Confidence that nuclear weapons actually are being dismantled is essential for negotiated disarmament.

Verification of nuclear weapon dismantlement also requires striking the right balance between using monitoring and inspection technologies and procedures to build confidence and protecting proliferation-sensitive and other classified data. At the same time, safety and security requirements must be met.

In June 2017, participants from the Partnership's Working Groups conducted an exercise to walk through the essential multilateral monitoring and inspection tasks of the basic dismantlement scenario and how to carry them out. This Walkthrough Exercise was critical to begin integrating IPNDV's work—combining applicable technologies, information barriers, and inspection procedures that ensure both confidence that a weapon has been dismantled and protection against spreading sensitive information. The participants concluded that *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.*

The following report sets out the key themes and elements of the discussion at the Walkthrough Exercise. It explains the logic that underlies this important conclusion. In so doing, the report demonstrates how the Partnership contributes to the creation of critical verification building blocks for future nuclear disarmament.

We want to acknowledge and express deep appreciation to the Government of Canada for enabling NTI to undertake this important project through their generous financial contribution. NTI is proud to have helped initiate this effort, and we are pleased to be playing an integral role in supporting the ambitious goals of the Partnership.

Joan Rohlfing
President, NTI

Executive Summary

On June 27, 2017, representatives of the three Working Groups of the International Partnership for Nuclear Disarmament Verification (IPNDV) conducted a Walkthrough Exercise of their basic dismantlement scenario.

The purpose of this exercise was to explore the application of technologies and procedures identified by the Working Groups to achieve the monitoring/inspection objectives (and carry out the associated specific tasks) of the basic dismantlement scenario (Steps 6–10 of the 14-Step dismantlement graphic on page five).

The Walkthrough Exercise participants concluded that *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.*

This judgment reflected several working conclusions of the day's discussions, including:

- Established inspection technologies (e.g., unique identifiers, tags, and seals) and procedures (e.g., inspectors checking documentation, records, and other information) can be used to maintain chain of custody of containerized nuclear weapons and their component Special Nuclear Material (SNM) and High Explosive (HE) across the basic dismantlement scenario. This begins with the nuclear weapon in temporary storage at the nuclear dismantlement facility (Step 6) through dismantlement (Step 8) to temporary storage of separated SNM and HE components (Step 10). Some important safety, security, and classification issues will affect the specific technologies and approaches used.
- Multiple technology options (e.g., passive and active neutron and gamma interrogation techniques, accompanied possibly by development of nuclear weapon templates) exist to permit measurement for the presence of SNM in sealed containers, both before and after dismantlement; information barriers will be essential for SNM measurement; and for technical and safety reasons, greater confidence will be attainable in measurements of plutonium than uranium; and technology options still need to be validated beyond laboratory testing.
- Technologies can be identified that would show that HE could be present in a nuclear-weapon/HE container but sensitivity is limited; it is more challenging to confirm the presence of HE than to do so for SNM.
- Inspection technologies (e.g., surveillance and change detection techniques as well as portal monitoring and equipment to detect the presence of radiological materials or HE) and procedures (e.g., access to design information as well as inspectors' visual familiarization) exist or can be implemented to ensure the integrity of those areas within a dismantlement facility associated with initial storage pre-dismantlement, actual weapon dismantlement, and temporary storage of SNM and HE components after dismantlement—subject to limits set by safety, security, non-proliferation, and classification but sufficient to provide confidence that a nuclear weapon/SNM and HE components are not removed or moved without being authorized or observed.

IPNDV Phase I Working Groups

1. Monitoring and Verification Objectives: Co-chaired by The Netherlands and the United Kingdom
2. On-Site Inspections: Co-chaired by Australia and Poland
3. Technical Challenges and Solutions: Co-chaired by Sweden and the United States

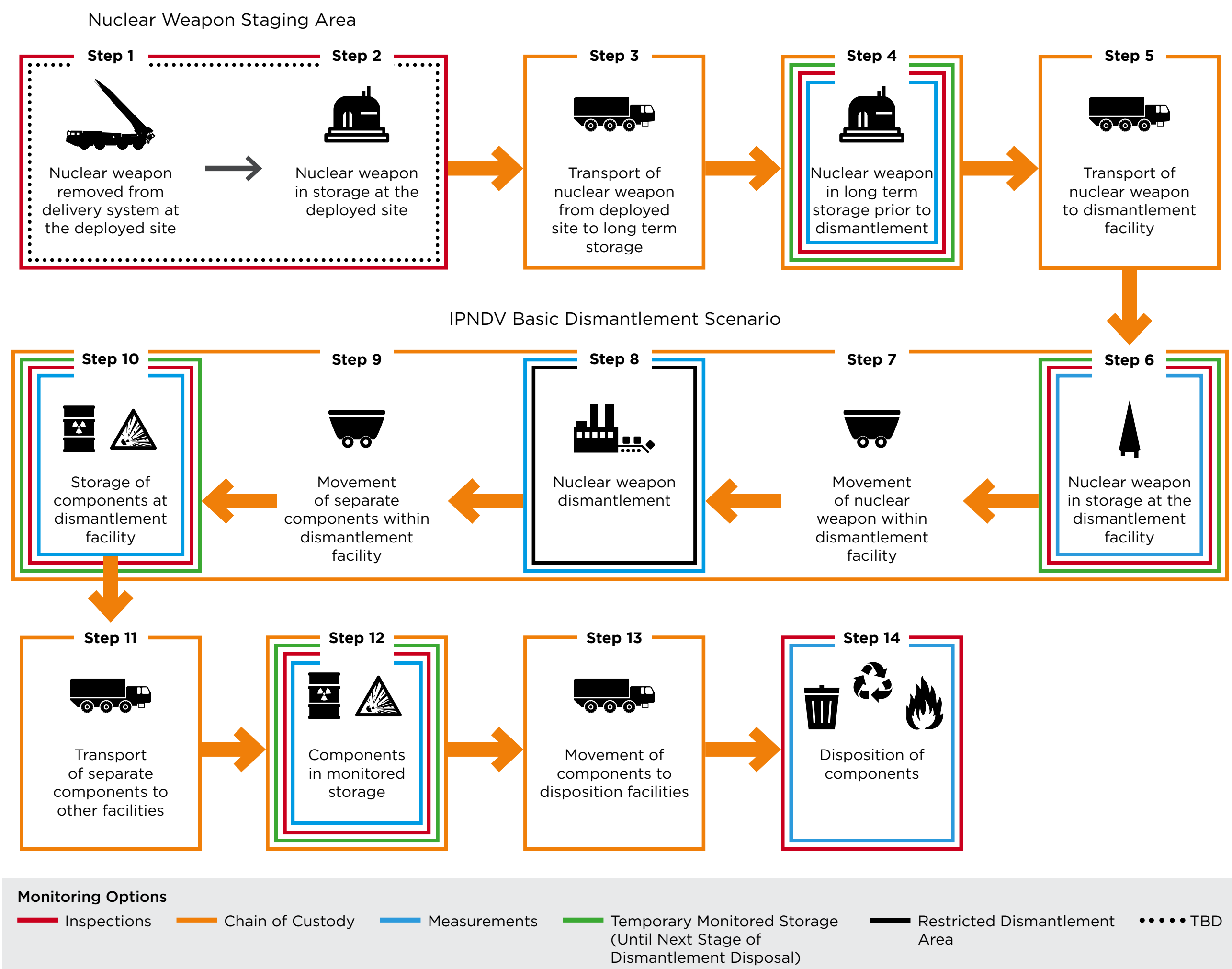
The Walkthrough Exercise also identified important cross-cutting issues and implications for ongoing IPNDV work, including:

- Uncertainty is unavoidable, both because inspectors will not be able to observe directly the dismantlement of the nuclear weapon and due to technology-inspection limitations at different steps in the process.
- Confidence that a nuclear weapon has been dismantled should be thought of as the result of many separate, mutually reinforcing, and cumulative monitoring/inspection activities over time.
- Monitoring/inspection of nuclear weapon dismantlement should be approached as a system in which the limitations of particular technologies/procedures can be compensated for by other technologies and procedures—at specific points and across the different steps.
- The work of the IPNDV is focused on developing a tool box of potential inspection technologies and procedures—the utility of specific sets of measures ultimately used will depend on their effectiveness with actual nuclear weapons, what is negotiated in a future disarmament agreement, and the unique characteristics of different facilities and programs of states with nuclear weapons.
- Information barriers will be essential; although promising technologies and concepts exist, more work needs to be done to turn those concepts into workable systems.
- Additional analysis is needed to determine the potential utility of documentation, declarations, records, and other information to buttress on-site inspections and technology chain of custody measures.
- Although inspection procedures were discussed for all steps, additional attention is needed to ensure that the fullest set of on-site inspection activities and preparations is integrated into a monitoring/inspection regime for nuclear weapon dismantlement; this may include activities related to visual familiarization and inspection of buildings/facilities designated to contain items subject to inspection, physical measurement, checking of records and documentation, and interviewing personnel.
- More detailed work on the concept of nuclear weapon templates should be a priority for Phase II of the Partnership, focused on what such templates would entail, their strengths and limitations, and their potential use in building confidence in measurements made to confirm the presence of a nuclear weapon prior to dismantlement or of the SNM component of a nuclear weapon either before or after dismantlement.

- More work also is needed on the technical limits of detection of containerized HE—and depending on that work, possible consideration of whether HE monitoring needs to be a requirement.
- Additional work should focus on data handling issues, which emerged as an important challenge (e.g., for data from technical monitoring and from on-site inspection activities).

Participants concluded the Walkthrough by agreeing that it had proved a valuable means to move toward integrating the results from the three Working Groups to show how the monitoring/inspection requirements of the basic nuclear weapon dismantlement scenario can be effectively met.

Monitoring and Verification Activities, as Identified by the IPNDV, for Key Steps in the Process of Dismantling Nuclear Weapons



*We make the assumption that there will be declarations at each step in the process.

The Walkthrough Exercise focused on Steps 6–10, which is the basic nuclear weapon dismantlement scenario.

Introduction

On June 27, 2017, representatives of the Working Groups of the International Partnership for Nuclear Disarmament Verification (IPNDV) conducted a one-day Walkthrough Exercise of their basic dismantlement scenario prior to the meeting of the Working Groups on June 28–30, 2017. This exercise explored the application of technologies and procedures identified by the Working Groups to the specific tasks involved in the multilateral monitoring/inspection of the dismantlement of nuclear weapons. The following report summarizes key points made in the discussion, including some cross-cutting issues and implications for the Partnership's future work. Every effort has been made to do so accurately. The author apologizes for any errors of omission or commission.

Scenario, Assumptions, and Structure of the Walkthrough Exercise

The scenario for the Walkthrough was a monitored dismantlement of the first of many nuclear weapons with inspection by a multilateral team, under a future multilateral nuclear disarmament agreement. The overall objective of the inspection team is to confirm that the nuclear weapon is dismantled into separate Special Nuclear Material (SNM) and High Explosive (HE) components and that those components are then placed in separate temporary storage to await further disposition.

The participants were given a set of assumptions to guide their discussion. Of particular importance, it was assumed that the inspectors would be presented with closed containers holding the nuclear weapon/SNM and HE; that inspectors would use agreed and authenticated inspection equipment stored under dual seal on site; and that the host, or Inspected State, would comply fully and cooperatively with the provisions of the agreement and within the limits set by health, safety, non-proliferation, and classification requirements.

The IPNDV basic dismantlement scenario was used to structure the Walkthrough, comprising Steps 6–10 of the figure on page five.[1]

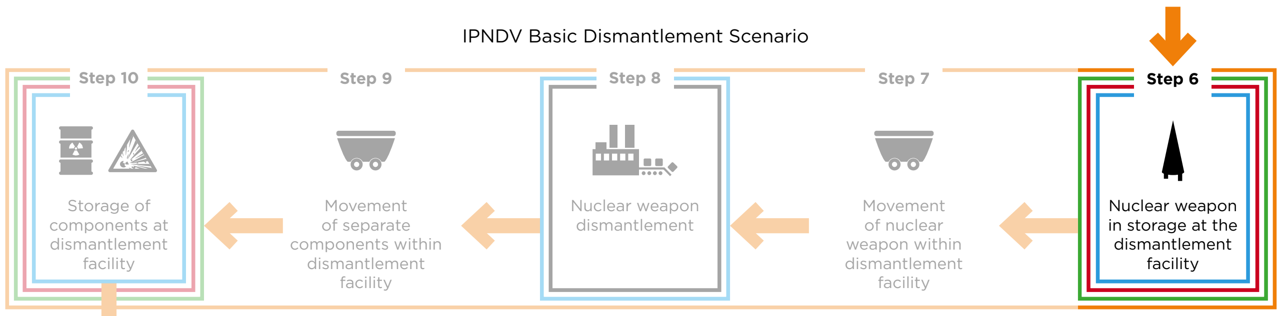
More specifically, during the exercise, the participants were asked to address a set of questions about how they would carry out specific monitoring/inspection tasks (reflecting the objectives of the Inspecting Party and the Inspected State) at different points in the dismantlement process. In addressing these questions, the participants were presented with lists of possibly applicable technologies and procedures that could be drawn upon to carry out specific tasks. Per the assumptions, it was stated that those lists were not intended to limit discussion. During the discussion, participants also were able to draw on inputs from a number of designated technical advisors and nuclear weapon state advisors, as well as their own Working Group experiences.

[1] During the exercise the facilitator also made use of a more detailed schematic of the dismantlement process prepared by the Japanese experts. See Annex on page 32.

Walkthrough Exercise Assumptions

- Dismantlement inspections are part of a comprehensive agreement with protocols providing specific procedures and equipment for implementation of various types of inspections
- A dismantlement record keeping and accountability process exists for tracking nuclear weapons through the duration of the agreement
- Dismantlement will take 14 working days per nuclear weapon
- All nuclear weapons/SNM and HE are presented for inspection in closed containers
- Approved inspection equipment is stored ready for use under dual seal at the dismantlement facility
- Inspected State complies fully and cooperatively with the provisions of the agreement and within the limits set by health, safety, non-proliferation, and classification requirements
- The technologies and procedures listed for participants are not an exhaustive list and are not intended to limit discussion

Step 6: A Nuclear Weapon in Temporary Storage at the Nuclear Dismantlement Facility



The exercise began with the nuclear weapon to be dismantled in the initial temporary storage area within a larger nuclear dismantlement facility. Per the assumptions, the nuclear weapon is in a closed container. Step 6 has two parts: Arrival of the nuclear weapon at the temporary storage site and initial measurement of the nuclear weapon in a sealed container, before transport to the area dedicated for dismantlement.

Arrival: Objectives

At this step, the monitoring/inspection objectives of the Inspecting Party were to first confirm that the item presented is as declared (or that an item randomly chosen by inspectors is as declared), to ensure the health and safety of inspecting personnel, and to ensure non-proliferation obligations are met. The latter objectives are applicable at all steps of the dismantlement process.

Throughout a dismantlement inspection, at every step, the objectives of the Inspected State were first, to demonstrate its compliance within applicable safety, security, and non-proliferation requirements; second, to ensure that no proliferation-sensitive or classified information is revealed while providing other inspection-relevant information, as provided for by an implementing agreement; third, to facilitate Inspecting Party activities, in accordance with applicable agreements; and fourth, to ensure the safety of all personnel.

Reflecting these objectives, two *specific monitoring/inspection tasks* were to be carried out at this step. These are to identify that the items presented for inspection are as declared and to apply chain of custody technologies and procedures for the inspection process going forward.

Arrival: Key Themes, Issues, and Findings

Use of Unique Identifiers, Tags, and Seals for Chain of Custody. Subject to the caveats discussed below concerning the importance of other complementary inspection activities, there was broad agreement in the utility of unique identifiers, tags, and seals applied to the container on its arrival at the dismantlement facility. Use of a unique identifier was seen as an essential element to sustain the chain of custody, that is, to build confidence that the same container is present at later steps in the dismantlement process; that it has not been altered or tampered with in moving between locations in the dismantlement facility; and that it has not been opened, except as provided for by the provisions of the agreement. That the overall dismantlement process would entail the dismantlement of multiple nuclear weapons over an extended period was seen to add to the importance of applying unique identifiers, tags, and seals to the containers stated to contain nuclear weapons for dismantlement.

Participants agreed that on-site inspectors could draw from various established technologies in applying unique identifiers, tags, and seals to the nuclear weapon container. However, the specific techniques used would need to consider safety and security concerns related to nuclear weapons. Thus, safety concerns could limit the use of electronic identifiers and seals that might impart energy to the nuclear weapon in the container. In turn, the specific techniques applied would need to be chosen and implemented in a

Potentially Applicable Inspection Technologies and Procedures

These options were presented to the participants.

Technologies—ensure items as declared

- Radiation-proof Radiofrequency Identification (RFID) tags
- 3D Container Identification
- Unique identifiers, tags, and seals

Technologies—ensure chain of custody

- Video, 3D surveillance, and laser surveillance to detect intrusion
- Portal monitors
- Accelerometers to detect movement
- Unique identifiers, tags, and seals

Inspection Procedures

- Visual observation (item counting, item identification, and checking via unique identifier)
- Physical verification
- Inspecting/inventorying relevant documentation and records
- Requesting clarification in connection with ambiguities

manner that would not delay access to the interior of the nuclear weapon container in the event of a safety emergency.

The issue of *when chain of custody would begin* was raised by several participants. In that regard, the possibility was raised by one participant of applying unique identifiers, tags, and seals prior to the arrival of the nuclear weapon container at the dismantlement facility, for example, when the nuclear warhead was removed from the delivery system at the deployment site and placed in a container for storage at the deployment site (see Steps 1 and 2).

Nonetheless, it was stressed by several participants in the discussion—and no one challenged this point—that use of unique identifiers, tags, and seals had to be *accompanied by other inspection/monitoring techniques/procedures to be of significance*. In particular, it was emphasized that without taking technical measurements to assess whether there was SNM and HE in a container presented for inspection, there would be no way to determine that the container contained a nuclear weapon within it. Thus, such technical measures are an essential adjunct to using unique identifiers, tags, and seals.

Continuing, the question was raised of *when such technical measurements for SNM and HE of the containerized nuclear weapon should take place*. The Walkthrough Exercise assumed that measurements would occur at a slightly later point in the process, as described in the next section. By contrast, some participants suggested that such measurements should be carried out as soon as the declared nuclear weapon in its container arrived at this initial temporary storage area—or at least, very soon thereafter. However, it also was pointed out that the timing for such technical measurements would depend partly on when the operational specifics of the actual dismantlement process and configuration would lend themselves to taking measurements—whether by the on-site inspectors or by the host country itself. In turn, it then was noted that the likelihood that measurements would be limited to certain locations and points in time in the dismantlement process increased the importance of using unique identifiers, tags, and seals and other inspection procedures to ensure a robust chain of custody.

Without taking technical measurements to assess whether there was SNM and HE in a container presented for inspection, there would be no way to determine that the container contained a nuclear weapon within it.

Inspector Access to Declarations, Documentation, and Records. Different types of declarations and access by inspectors to documentation and records were identified as important complements to using unique identifiers, tags, and seals. Specifically, some participants mentioned information about the Inspected State's nuclear weapon stockpile, including declarations of items to be dismantled; documents and other records for nuclear weapons in the dismantlement queue that could be checked against the container; and plans for the dismantlement process and how it would be conducted. Access to such information was seen as part of a cumulative process of building confidence that there was a nuclear weapon within the container (as declared) and of the overall chain of custody during the continuing dismantlement process. Another goal, it was suggested, would be to ensure no surprises for the inspectors regarding the site, the processes, or the movement of the nuclear weapon container (and later components containers with SNM/HE separated from the nuclear weapon) from initial arrival to eventual temporary storage at the dismantlement facility.

Verifying Design and Ensuring Integrity of the Storage Building. The importance of on-site inspection to verify the design and ensure the integrity of the storage building also was emphasized as a necessary adjunct to putting unique identifiers, tags, and seals on the container declared to contain a nuclear weapon. Various on-site inspection procedures and technical measures were highlighted to ensure facility integrity: access to design information of the facility in which the nuclear weapon container is to be stored and comparing that information with the actual room; inspectors' visual familiarization with that room to determine if there are pathways by which the container could be removed without inspectors' knowledge; and use of surveillance techniques to monitor exits and external walls but not the interior spaces. Concerns about access to classified information were seen to preclude inspectors from physically examining the internal walls. Possible equipment use by inspectors to detect the presence of any SNM or HE inside the room prior to the entry of the nuclear weapon container was also raised. But it was suggested that in a facility where activities other than monitored dismantlement occur, the value of such inspection activity within the room could be limited due to previous activities.

Participants recognized that ensuring facility integrity would be a more difficult challenge, compared to applying unique identifiers, tags, and seals and other means for ensuring chain of custody. That said, it also was noted that activities aimed at ensuring the integrity of the facility and the use of unique identifiers, tags, and seals are mutually reinforcing. Greater confidence that the container has not been altered or modified can compensate for uncertainties related to ensuring the integrity of the facility in which the container is present.

Participants recognized that ensuring facility integrity would be a more difficult challenge, compared to applying unique identifiers, tags, and seals and other means for ensuring chain of custody.

Some Additional On-Site Inspection Considerations.[2] Before the actual monitoring/inspection process, several preparatory activities would have been undertaken. These activities are relevant both to this specific step and across the other steps of the basic dismantlement scenario.

Within an overall verification agreement, the Inspected State would maintain a system of *accounting and control* to include records relevant to the dismantlement process. Some of these records could be provided to inspectors at this and other stages of the dismantlement process and checked for consistency with on-site observations. The agreement would likely require the Inspected State to make an *initial dismantlement declaration,* which could include, for example, descriptions of verifiable parameters and technical characteristics of nuclear weapons to be dismantled; specifications of the dedicated dismantlement area within a larger dismantlement facility and the types of information about the facility subject to inspection; and the timing and scope of the dismantlement campaign to be monitored/inspected. Such declarations of planned dismantlement activities would need to be updated periodically—or updated in the event of an operational change affecting planning to conduct monitoring/inspection activities.

[2] In drawing lessons from the Walkthrough, it was stated that the full set of inspection considerations had not been discussed during the Walkthrough. Drawing on the Working Group 2 draft deliverable ("2016–17 Output on inspection activities and techniques to verify compliance with future agreements" —June 9, 2017 draft), the author has taken the liberty to sketch here some additional considerations based on the Working Group 2 deliverable for carrying out the tasks of the basic dismantlement scenario, using the language of that report directly or in paraphrasing but without the cumbersomeness of quotation marks. Including this material in this Summary will help ensure a fuller discussion of on-site inspection procedures going forward. Here and below, the reader is directed to the actual Working Group 2 deliverable for details—and no attempt has been made to include all issues covered in that deliverable.

In turn, the Inspected State and the Inspecting Party (in this case a multilateral entity) would need to conclude a *facility agreement* that would include facility-specific monitoring/inspection procedures. The need for such an agreement reflects the unique characteristics of dismantlement activities in different States. Closely related, as part of such a facility agreement, procedures related to managed access would need to be set out. Negotiated on a site-specific basis, managed access would set out specific procedures for physical access of inspectors to particular locations as well as permitted observations and measurements in accordance with the provisions of the overarching agreement. It would be designed to meet monitoring/inspection objectives but not provide access to and would avoid disclosure of information and data unrelated to the purpose of the inspections process.

Although the Walkthrough explicitly set aside the issue of authentication of equipment used by inspectors, another preparatory activity by the Inspected State and the Inspecting Party would be the development of procedures for the authentication and certification of monitoring equipment as well as procedures for the inspectors to access equipment stored on-site and using that equipment during inspections. One purpose of such procedures would be to ensure confidence by both parties that the equipment would perform as agreed and required; another purpose would be to provide confidence against tampering with equipment once it is accepted for use by both the Inspected State and the Inspecting Party (e.g., by applying unique identifiers, tags, and seals).

Further, different types of routine or short notice inspections could be part of the overall on-site inspection process at different steps in the dismantlement process. Those inspections, for example, could be used to confirm that there were no undeclared changes in the overall dismantlement facility or key buildings. Routine or short-notice inspections could be carried out to check containment and surveillance of equipment stored on site, to maintain installed equipment in between monitoring/inspection activities, and to verify chain of custody of the components in temporary storage.

See the discussion of additional considerations below under "Initial Measurement" for a sketch of those issues related to confidentiality and data handling.

Initial Measurement: Objectives

Turning to the initial measurement of the declared nuclear weapon in its container (see Step 6), the principal monitoring/inspection objective of the Inspecting Party now would be to confirm that the nuclear weapon arriving at the dismantlement facility and presented for dismantlement (whether declared by the host or chosen by the inspectors) is indeed a nuclear weapon.

Three specific monitoring tasks were posited:

1. First, to measure for the presence of SNM—defined as determining that the quantity of either plutonium (Pu) or uranium (U) is greater than 500 g and determining that the isotopic composition is more than 90% Pu239 or 20% U235.
2. Second, to measure for the presence of HE—defined as determining that the quantity of HE is greater than X and determining that the chemical composition is consistent with HE.[3]
3. Third, to carry out any other activities to confirm presence of a containerized nuclear weapon.

[3] The precise percentage was not determined by the Partners and would require further evaluation of the detection limits for different HE detection methods.

Potentially Applicable Inspection Technologies and Procedures

These options were presented to the participants.

Technologies—presence of SNM

- Passive gamma detection and gamma ray imaging
- Nuclear Resonance Fluorescence
- Passive Neutron counting
- Active neutron techniques
- Fast neutron imaging
- Muon tomography
- Radiation templates
- Calorimetry

Technologies—presence of HE

- Raman Explosive Identification System
- Fast Neutron Interrogation System
- Compton Backscattering Cameras
- NQR-explosive Identification System
- Nuclear Resonance Fluorescence
- X-ray Computed Tomography

Inspection procedures—other

- Physical verification (linear measurements, weighing)
- NDA—Gamma/Neutron measurements
- Requesting clarification in connection with ambiguities

The Walkthrough assumed that these measurement tasks would be carried out after the monitoring/inspection activities already discussed above, e.g., after applying unique identifiers, tags, and seals to the nuclear weapon container. However, as already noted, there was some discussion at the Walkthrough of whether taking measurements for the presence of SNM and HE should be done first, before applying unique identifiers, tags, and seals to the container for its onward chain of custody in the dismantlement facility.

Initial Measurement: Key Themes, Issues, and Findings

Technologies Available to Measure for SNM. There was broad agreement among participants that technologies exist in principle for use by inspectors to measure for the presence of SNM. There also was agreement that it is easier to measure for plutonium than for uranium.

Still, participants judged that overall there are many options for measurement of radioactive materials to carry out the specific monitoring/inspection tasks. Specifically, they include using passive gamma ray and neutron counting technologies for plutonium measurement as well as active neutron interrogation techniques for uranium measurement. However, several participants stated that safety considerations stemming from imparting high energy into a container with a nuclear weapon would constrain the envelope for use of active interrogation techniques for determining the presence of uranium, while passive techniques also would be technically constrained. Thus, there remains further research to be done. Indeed, one technical advisor remained cautious about whether it ultimately would prove possible or not to use active interrogation techniques to assess the presence of uranium. More generally, the challenge remains to take technologies that have been validated in laboratory testing and prove them meaningful in the actual measurement of a nuclear weapon.

Given that techniques will provide a great deal of information about the containerized nuclear weapon, use of an information barrier to protect classified and proliferation-sensitive information was seen as essential.

Need for an Information Barrier. Given that techniques will provide a great deal of information about the containerized nuclear weapon, use of an information barrier to protect classified and proliferation-sensitive information was seen as essential. In that regard, one of the technology advisors stated that information barrier technology has been demonstrated and it is understood how they should work. But information barriers have not yet been tested against a nuclear weapon mock-up and more work is needed to turn concepts into workable systems.

Impact of the Container. The shielding inherent in the container (as well as the shielding provided by other materials in a containerized nuclear weapon) may constrain whether available technologies would be able to determine the presence (or absence) of plutonium or uranium and HE within the agreed specifications. This would need to be addressed in further development of those technologies. Still, until those technologies are tested on an actual nuclear weapon, some uncertainty will remain. Even so, the Inspected State will take measurements of its own objects and will have an interest in ensuring that the Inspecting Party uses techniques that will work.[4]

Possible Development and Use of Nuclear Weapon Templates. The concept was put forward by several participants of using nuclear weapon templates to increase confidence in inspectors' determination of the presence of a nuclear weapon/SNM in the container. There was considerable interest among participants in this concept.[5]

[4] The Working Group 2 deliverable suggested that states with nuclear weapons should "standardize" the types of containers used during monitored dismantlement so that inspectors would expect consistent results over multiple inspections.

[5] The use of nuclear warhead templates also was discussed later in the Walkthrough Exercise at the point of measuring for SNM after dismantlement. For readability and comprehensiveness, the technical points made there have been brought forward here.

In theory, it would be technically possible to develop what in effect would be a technical "snapshot" of a nuclear weapon within its container. There was some tentative speculation among participants about what different potential aspects could prove useful to measure, including isotopic composition of the SNM, total mass, geometry of the SNM/HE, and other unique warhead characteristics, recognizing that specific values related to such parameters may not be made available to inspectors. It was variously proposed that if practicable, using a nuclear weapon template at this step would help reduce uncertainty and build confidence in determining the presence of SNM; offer a means to detect a decoy; help recover if chain of custody procedures failed at the dismantlement facility; and by doing measurements repeatedly in an ongoing process of dismantlement of multiple nuclear weapons, build overall confidence. (Using a template also could support determining the presence of SNM after dismantlement. It also was suggested that using a template could help establish initial chain of custody if a template could be created once a warhead was removed from a delivery vehicle.)

Overall, the group thought that although the concept is attractive in principle, more work is needed on what specifically could be measured. Plus if states with nuclear weapons had produced the SNM used in their nuclear weapon in batches it would complicate, but not necessarily preclude, efforts to identify a unique characteristic of the nuclear weapon. An information barrier would be essential because the information acquired would be classified. Several other important technical constraints also were mentioned, including, for example, the need to do any such measurements exactly the same each time with measuring equipment positioned in precisely the same location and configuration from measurement to measurement on the outside of the nuclear weapon container and not changing the configuration of the room. Nonetheless, if these practical constraints can be overcome, as one of the technical advisors put it, using a nuclear weapon template potentially could be a very powerful technique to reduce uncertainty and build confidence in the dismantlement process. No one disagreed.

Greater Technical Difficulties in Measuring for HE. There are several technologies that can be used to detect the presence of HE in containers, including neutron interrogation. In that sense, measurement for HE in containers is possible. But questions also were raised about whether such technologies would only be able to allow inspectors to conclude that there could be—not that there is—HE present in the container. Safety concerns related to the use of neutron interrogation would need to be addressed.

These greater difficulties in measuring for HE led to a discussion of whether or not determining the presence of containerized HE should be a requirement in the monitoring/inspection of nuclear weapon dismantlement. Several participants suggested that what counts most is determining that SNM is present—and then gaining assurance by the end of the dismantlement process that the SNM has been separated from the HE and other components and placed into monitored storage pending its ultimate disposition. However, most participants still thought that there are good reasons to continue to include separation of the HE as part of the IPNDV definition of nuclear weapon dismantlement. Most important, doing so even if it only is possible to detect the possible presence of HE, was seen to provide a further increment in confidence that dismantlement had occurred. In any case, it was noted that the technical difficulties in determining with 100 percent confidence that the declared nuclear weapon container also contains HE increases the importance of complementing technical measurements with chain of custody procedures, e.g., the use of unique identifiers, tags, and seals as well as other visual and physical on-site inspection techniques.

Possible Physical Measurements of the Container by Inspectors. To complement technical measurements for SNM and HE, the possibility of taking physical measurements of the nuclear weapon container (e.g., weight and linear dimensions) by inspectors as part of its initial storage at the dismantlement facility was raised by several participants. In response to the question of what would be gained by weighing a container, it was suggested that doing so would allow inspectors to assess the consistency of multiple containers over time. The result would provide another increment of confidence. However, the practical difficulty of having inspectors actually pick up a container was posed as a constraint. Safety and security sensitivities also were raised by participants from states with nuclear weapons as were concerns about putting classified information at risk.[6] Still, this area appeared one for detailed concept development and assessment.

Some Additional On-Site Inspection Considerations. Inspectors' access to, analysis of, and checking/auditing *relevant records* could complement the preceding, more technical measurement activities as well as activities to ensure the integrity of the dismantlement area. Records directly related to monitoring/inspection activities could include those on management operations at the dismantlement process, for example, movement and in/out records at each of the monitoring checkpoints, in/out records of the dismantlement area, and records of incidents affecting monitoring/inspection. Subject to facility restrictions, there could be access to communications and data exchange networks for the facility. Again, any such use of records would take place within the framework both of managed access and of confidentiality procedures. (See below.)

At this step as well as across the basic dismantlement scenario, protection of sensitive security, non-proliferation, and classified information would be essential.[7] To meet that requirement, in advance of the inspection, the Inspected State and the Inspecting Party will need to develop an agreed format for *inspection reporting* to document what transpired during the inspection. There also will be a need to agree on:

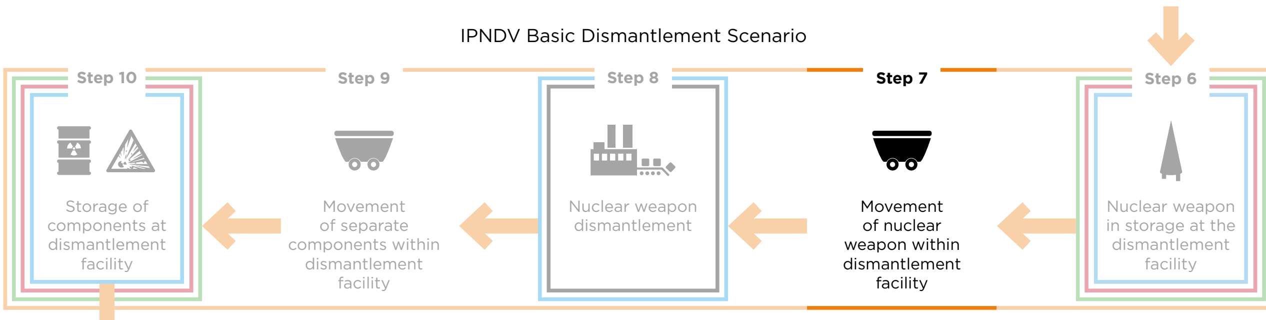
- How to handle inspectors' notes as well as electronic data from monitoring systems
- How the Inspected State will review inspectors' notes as well as the information being made available to inspectors for any unanticipated sensitivities
- How to ensure the integrity of the electronic and other data
- The kinds of information to be included in inspection reports
- The process for the Inspected State to comment on inspection reports
- Procedures for ensuring confidentiality of the information needed by inspectors as well as eventual reports of the Inspecting Party.

These elements would be part of a verification agreement. It also would be important to provide for a mechanism to resolve disputes that might arise in the conduct of the inspection.

[6] Safety and security procedures in states with nuclear weapons were said to restrict access by inspectors during the type of lifting and movement of nuclear weapons that would be involved. Classification concerns were said to result from the possible extrapolation of information about the containerized nuclear weapons based on visual assessment of the unique characteristics of the equipment used for lifting and weighing the container.

[7] The Working Group 2 On-Site Inspection deliverable also includes a full discussion of the safety, security, and non-proliferation concerns that underlie managed access as well as the issues of confidentiality and data handling.

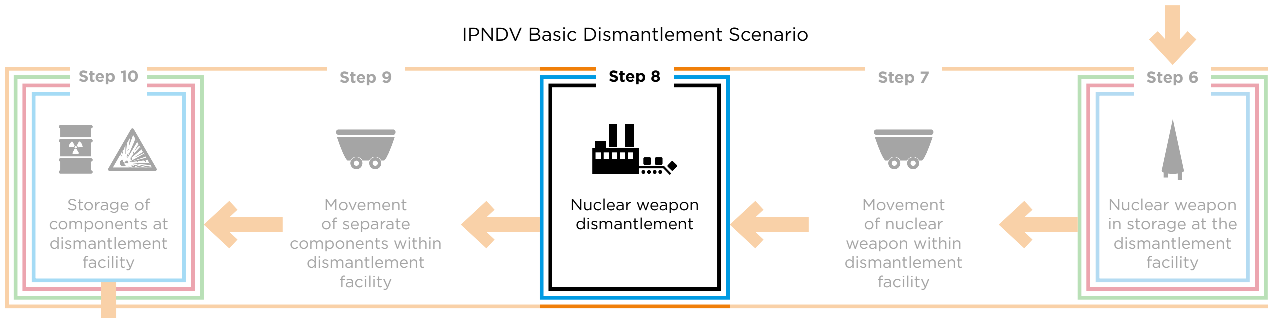
Step 7: Movement of Nuclear Weapons within the Dismantlement Facility



The Walkthrough Exercise addressed the movement of the containerized nuclear weapon from temporary storage within the dismantlement facility to its entry into the dedicated dismantlement area as part of its discussion in Step 6 of ensuring chain of custody. Those points apply here.[8] However, it also was noted in the discussion that visual monitoring/inspection of the nuclear weapon being moved likely would raise security issues. It also could raise proliferation-sensitivity issues if despite being in a container, visual access gave inspectors information about mass, size, and geometrical proportions.

[8] To recall, the participants' discussion of ensuring chain of custody following the arrival of the nuclear weapon at the dedicated dismantlement area included the application of unique identifiers, tags, and seals as well as other declarations, reporting, and record checking.

Step 8: Nuclear Weapon Dismantlement



During the actual dismantlement of the nuclear weapon, the Inspecting Party would not be able to observe directly the activities within the dedicated dismantlement area. They would undertake activities when the nuclear weapon container entered into that area and when the containers with the dismantled nuclear weapon component (SNM and HE) exited. Each set of activities is discussed separately below. Entry and exit from the dedicated dismantlement area, however, could be through a single portal.

Entry to the Dedicated Dismantlement Area: Objectives

The principal *monitoring/inspection objective* of the Inspecting Party now would be to confirm that the nuclear weapon or SNM or HE components of the nuclear weapon do not leave the dismantlement area unobserved.

Two specific *monitoring/inspection tasks* would need to be carried out: first, to ensure the unbroken chain of custody of the nuclear weapon following its initial measurement and second, to prepare the dismantlement station so that chain of custody can be maintained.[9]

Entry to the Dedicated Dismantlement Area: Key Themes, Issues, and Findings

Verifying Design and Ensuring Integrity of the Dedicated Dismantlement Area. As discussed above, various techniques and procedures could be used together by inspectors to ensure the integrity of the dismantlement area. These could include access by inspectors to design information on the dismantlement

[9] Working Group 1 deliverable 2, "Monitoring Objectives and Information Requirements for Each Step of the Dismantlement Process" proposes that before entering the dismantlement area, the Inspecting Party would again have the task "to confirm that the container declared to be a NED [nuclear explosive device] entering the dismantlement area is a NED. . . ." The Walkthrough was based on the assumption that the first measurement would be conducted before the nuclear weapon entered the dedicated dismantlement area. However, if once such confirmation had been done upon arrival at the overall dismantlement facility, chain of custody would suffice and there would be no need for the additional measurement before the nuclear weapon enters the dedicated dismantlement area.

Potentially Applicable Inspection Technologies and Procedures

These options were presented to the participants.

Technologies—ensure chain of custody and integrity of dismantlement station

- Video cameras
- 3D monitoring
- Change detection technology
- Radiation detection (gamma and neutron detectors)
- Portal monitoring
- Radiation-proof radiofrequency identification/3D container identification
- Unique identifiers, tags, and seals
- Containment and surveillance (tamper-indicating seals, unattended monitoring, optical surveillance)

Procedures—ensure chain of custody and integrity of dismantlement station

- Interviewing facility personnel
- Inspecting/inventorying documentation and records
- Visual observation
- Requesting clarification in connection with ambiguities

area and checking the area against that design information; inspectors' visual familiarization with that area to determine if there are pathways by which a nuclear weapon or its components could be removed unobserved; and use of surveillance technologies to monitor external walls (e.g., 3-D monitoring) but not the interior spaces and without actually touching the walls given concerns about access to classified information. In addition, ensuring the integrity of the dismantlement area—compared to ensuring the integrity of the temporary storage area—also could be more complicated because of the presence of many shrouded items to be used not only for nuclear weapon dismantlement but for other activities unrelated to dismantlement.

Portal Monitoring of Entry to Dedicated Dismantlement Area. Portal monitoring of any declared entry point also would take place. Readily available technologies and procedures for controlled access and monitoring could be used to monitor declared entry of personnel, equipment, and the containerized nuclear weapon. The location of portal monitors was seen as important near the gateway at which the host country would go in and out, but not inside the dedicated area where sensitive activities would be underway. (Technical issues related to portal monitors to look for unobserved withdrawals of SNM are discussed below as part of "Exit from the Dedicated Dismantlement Area.")

Inspection with Radiological/HE Detection Technologies of the Dedicated Dismantlement Area. In their discussion, participants assumed that before the nuclear weapon enters the dedicated dismantlement area, inspectors would use appropriate detection equipment to determine if there were any SNM or HE present in the dismantlement area and to establish a baseline for later re-inspection with such technologies after exit. At least for detection of the absence of SNM, one of the technical advisors stated that even with shrouding, it would be possible to do so. At the same time, the task would be considerably simplified if the Inspected State ensured that the dedicated area was not too large. By contrast, it was suggested that inspectors using technology to detect HE could be a considerably greater challenge.

The purpose of inspecting the dedicated dismantlement area with equipment to detect the presence of radiological materials or HE was seen to provide confidence that no undeclared SNM or HE was hidden in the area, including under shrouding. However, as one participant noted, any such hidden material would have value only if it could be removed unobserved from the dedicated dismantlement area. This comment again reinforced the broader point that the different techniques and procedures used to carry out specific monitoring/inspections tasks need to be viewed as a mutually reinforcing system of measures. Again, such inspection also would provide a baseline for re-inspection later.

Use of a Fully Dedicated Dismantlement Facility? At several points in this discussion, the question was raised as to why it would not be possible to use a facility completely dedicated to the dismantlement of nuclear weapons under a future disarmament agreement. Doing so was seen as a way to solve those problems stemming from both dismantlement and nuclear weapon refurbishment activities taking place in the same area or facility. One participant from a state with nuclear weapons responded that cost considerations, the differences among the states with nuclear weapons (including numbers of weapons to be dismantled), and other practical issues all would argue against a dedicated facility. However, it could become possible in a future disarmament agreement involving dismantlement of many nuclear weapons to do so in a batch mode. Still, assuming 14 days to dismantle one nuclear weapon (per the Walkthrough Exercise assumptions), the flow through would be approximately 20 nuclear weapons per year. Thus, beginning from existing nuclear weapon levels and positing substantial reductions-dismantlement, the outcome in practice could well be that any dismantlement facility would become a dedicated one.

Data Handling Issues for On-Site Inspections. In addition to the need for information barriers and the possible challenges of how to handle the information related to nuclear weapon templates, the discussion highlighted the importance of numerous data handling issues arising out of the monitoring/inspections process. Questions raised included the following: How much analysis would be done on-site and how much done elsewhere, including at the headquarters of any eventual monitoring/inspection organization? Would inspectors be permitted to do analysis on their own computers (adding to confidence in the results) and if so, how close to the actual dedicated dismantlement area would such computers be allowed? Would a dedicated room need to be set up for use by inspectors in assessing their notes and the data, and where? How would trusted copies be made of the data derived from technical monitoring? How would both the Inspected State and the Inspecting Party access and use the data? What data would be provided to the political body overseeing the monitoring/inspection process?

Some Additional On-Site Inspection Considerations. Inspectors' access to relevant records would complement the other monitoring/inspection measures at the dismantlement area. Specific management operations records could include those on entry-exit of the dedicated dismantlement area, for example, movement and in/out records of the area. (Also see discussion above of "Data Handling Issues for On-Site Inspections" with its data handling aspects.)

Exit from the Dedicated Dismantlement Area: Objectives

The Inspecting Party now would have two new *monitoring/inspection objectives*: to confirm that SNM and HE components or the nuclear weapon do not remain in the dedicated dismantlement area and to confirm that there has been no unauthorized removal of SNM and HE during dismantlement.[10]

The Inspecting Party's *specific task* now would be to ensure unbroken chain of custody of the SNM and the HE upon exit from the dedicated dismantlement area until measurement later.

To recall, the Walkthrough's assumptions set aside the question of any other containers existing from the dedicated dismantlement area, although this assumption became a point of discussion. As explained, the Walkthrough focused on measurement to confirm the presence of separated SNM and HE in containers that had exited the dismantlement area.

The Inspecting Party's *specific task* now would be to ensure unbroken chain of custody of the SNM and the HE upon exit from the dedicated dismantlement area until measurement later.

Exit from the Dedicated Dismantlement Area: Key Themes, Issues, and Findings

Ensuring Integrity of the Dedicated Dismantlement Area. The discussion above on ensuring the integrity of the dedicated dismantlement area also would apply to confirming that there was no unauthorized removal of SNM and HE during dismantlement.

Use of Unique Identifiers, Tags, and Seals. Ensuring chain of custody going forward on exit from the dedicated dismantlement area was now seen to require application by inspectors of new unique identifiers, tags, and seals on the SNM and HE containers on their exit from the dedicated dismantlement area. Again, established technologies could be used, perhaps now with fewer safety concerns about some electronic technologies, given that the nuclear weapon had now been separated into its SNM and HE components. Such unique identifiers, tags, and seals should be applied, according to one of the technical advisors, by inspectors as the SNM and HE containers are leaving the dedicated area or as physically close as possible to it.

[10] In its definition of the objectives at this step, the Working Group 1 paper, "Deliverable 2: Monitoring Objectives and Information Requirements for Each Step of the Dismantlement Process," proposes that on exit from the dedicated dismantlement area, the Inspecting Party also would have an objective "to confirm that the containers exiting the dismantlement facility contain NED components as declared." The Walkthrough was based on the assumption that such a required confirmation would be done later as a separate step. See the discussion below of "Second Measurement after Completion of Dismantlement," which addresses this objective.

Potentially Applicable Inspection Technologies and Procedures

These options were presented to the participants.

Technologies—ensure chain of custody and integrity of dismantlement station

- Video cameras
- 3D monitoring
- Change detection technology
- Radiation detection (gamma and neutron detectors)
- Portal monitoring
- Radiation-proof radiofrequency identification/3D container identification
- Unique identifiers, tags, and seals
- Containment and surveillance (tamper-indicating seals, unattended monitoring, optical surveillance)

Procedures—ensure chain of custody and integrity of dismantlement station

- Interviewing facility personnel
- Inspecting/inventorying documentation and records
- Visual observation
- Requesting clarification in connection with ambiguities

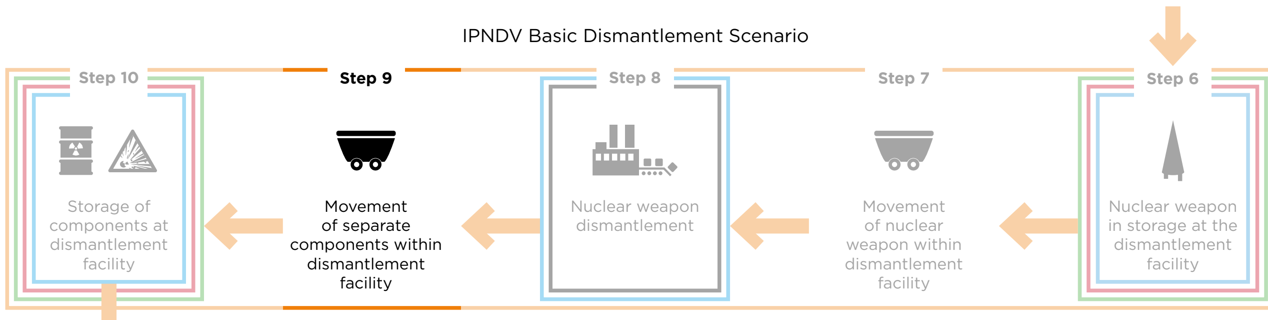
Portal Monitoring of Exit from the Dedicated Dismantlement Area. In addition to the points made above on portal monitoring of entry, there was considerable discussion now of whether the inspectors also should be concerned with the other containers not containing either SNM or HE that would exit from the dedicated dismantlement area. Those other non-SNM/HE containers could include, for example, containers with the electronic and other components of the nuclear weapon, with equipment used in the dismantlement of the nuclear weapon, and the original, now empty, nuclear weapon container.

Despite the day's focus only on the containers with SNM and HE (given the scenario assumptions), participants recognized that to detect any undeclared removal of SNM or HE from the dedicated dismantlement area, one approach could be to inspect all containers on their exit from the dismantlement facility. Techniques and procedures tentatively suggested included tagging and sealing of such containers; radiation monitoring to detect the absence of undeclared SNM; weighing of the containers; and checking of relevant documentation on all containers. However, participants also acknowledged that an alternative approach would be to confirm the absence of SNM and HE in the dedicated dismantlement area, after the exit of the containers with the SNM and HE.

Re-Inspection for Any Remaining SNM or HE in the Dedicated Dismantlement Area. Several participants proposed that inspectors should re-inspect the dedicated dismantlement area with radiological and HE detection equipment to confirm the absence of any SNM and HE from the dismantled nuclear weapon. In particular, it was proposed that such re-inspection of the area *after* the exit of the containers with SNM and HE but prior to the exit of other containers would be one way to increase confidence that the other containers would not be used to remove any undeclared SNM or HE. Again, however, detecting HE would be more difficult than detecting SNM.

Some Additional On-Site Inspection Considerations. As on entry, inspectors' access to relevant records and checking them against declared activities would complement the other monitoring/inspection measures at the dismantlement area. Specific records could include those on entry-exit of the dedicated dismantlement area, for example movement and in/out records of the area. Checking records could be an additional procedure to increase confidence that the other containers were as declared, and that no undeclared containers had been removed. As at other steps, ad hoc or routine inspections would be used to maintain and check the effective operation of installed monitoring equipment.

Step 9: Movement of Separate Components within the Dismantlement Facility



The Walkthrough addressed the movement of the now separated SNM and HE components to temporary storage as part of its consideration of chain of custody on exit from the dedicated dismantlement area.

Second Measurement after Completion of Dismantlement: Objectives

In the Walkthrough Exercise this measurement was a separate step. However, as already noted, it could take place as a sub-step of Step 8 as the SNM and HE containers exit the nuclear weapon dismantlement area. Or it could take place upon entry of the containers into temporary storage (Step 10), with necessary chain of custody procedures as discussed previously.

The principal monitoring/inspection objective of the Inspecting Party now would be to confirm that the two containers that exited the dismantlement station contain SNM and HE components as declared. The objectives of the Inspected State in a second measurement, done after dismantlement was completed, would remain the same as in all of the earlier steps.

The specific tasks would be the same as at the initial measurement step. In summary, these are first, to measure for the presence of SNM and HE in the designated containers and second, to carry out any other activities to confirm the absence of SNM and HE.

Potentially Applicable Inspection Technologies and Procedures

These options were presented to the participants.

Technologies—presence of SNM

- Passive gamma detection and gamma ray imaging
- Nuclear Resonance Fluorescence
- Passive Neutron counting
- Active neutron techniques
- Fast neutron imaging
- Muon tomography
- Radiation templates

Technologies—presence of HE

- Raman Explosive Identification System
- Fast Neutron Interrogation System
- Compton Backscattering Cameras
- NQR-explosive Identification System
- Nuclear Resonance Fluorescence
- X-ray Computed Tomography

Inspection procedures—other

- Physical verification (linear measurements, weighing)
- NDA—Gamma/Neutron measurements
- Requesting clarification in connection with ambiguities

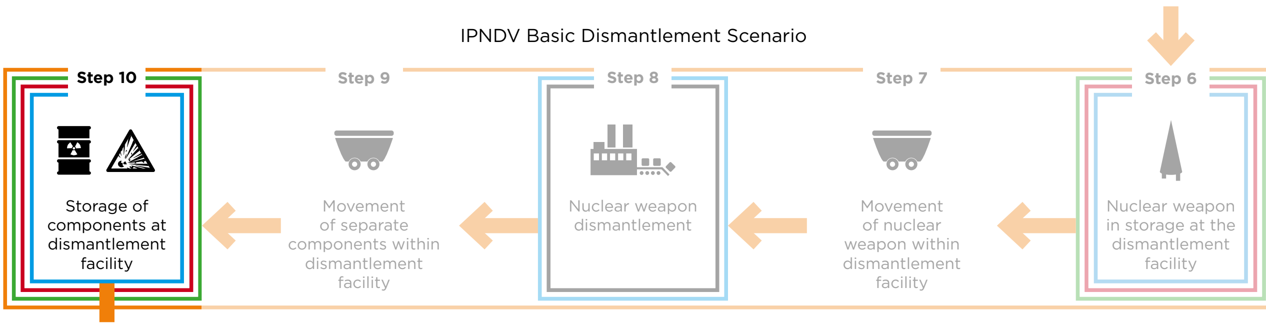
Second Measurement after Completing Dismantlement: Key Themes, Issues, and Findings

SNM and HE Measurement. Participants agreed that measurement by inspectors to confirm the presence of SNM overall would raise comparable technical issues to those present at the initial measurement. There is no need to repeat that discussion here. However, one of the technical advisors stated that, in the case of uranium, now that the uranium had been separated from the nuclear weapon, it would become easier to measure the isotopes of uranium. In turn, it was proposed that now that the HE had been separated from the SNM, measurement techniques thought too sensitive previously could possibly be used to provide augmented confidence in the presence of HE in its container. In this context, the idea was put forward that if confidence in the separation of HE is defined as important, yet another approach would be for inspectors to monitor the final disposition of the separated HE by the Inspected State's burning it.

Use of Nuclear Weapon Templates to Compare SNM Pre- and Post-Nuclear Weapon Dismantlement. Building on the earlier discussion, there was considerable interest among participants in exploring further the concept of nuclear weapon templates. As one technical advisor pointed out, were it possible to develop such a template, e.g., based on measuring the isotopic composition of the SNM, it would be possible for inspectors using an information barrier to compare the measurement before dismantlement with that taken after dismantlement. Assuming the information barrier confirmed a match, the result would be augmented confidence that the container exiting the dedicated dismantlement area contained the SNM separated from the original weapon.

Some Additional On-Site Inspection Considerations. See the discussion in Step 6 on "Initial Measurement," with its discussion of inspectors' access to relevant records and checking/auditing those records against declared activities to complement the above inspection activities.

Step 10: Temporary Storage of SNM and HE Components



The participants concluded the Walkthrough Exercise of the monitoring/inspection tasks of the basic dismantlement scenario by focusing on the temporary storage of separated SNM and HE components.

Arrival: Objectives

The principal monitoring/inspection objectives of the Inspecting Party now would be to confirm first, that the components in their containers arrive at the temporary storage area and are not diverted within the dismantlement facility, and second, to confirm that these items remain in temporary storage until moved to a long-term storage site or for final disposition. The objectives of the Inspected State would remain the same as in all of the earlier steps.

Specific monitoring/inspection tasks were seen by participants to be to:

- Ensure an unbroken chain of custody of the SNM and HE containers following exit from the dedicated dismantlement area to entry into temporary storage at the facility
- Ensure integrity of storage so that the SNM and HE once in storage are not moved without Inspecting Party knowledge in accordance with provisions of the applicable agreement.

Arrival: Key Themes, Issues, and Findings

Ensuring Chain of Custody. At this point in the Walkthrough, the participants did not explicitly address this issue. The implicit assumption was that the techniques and procedures previously identified in earlier steps, e.g., regarding application by inspectors of unique identifiers, tags, and seals as well as inspection/checking of relevant documentation and records, would apply here.

Potentially Applicable Inspection Technologies and Procedures

These options were presented to the participants.

Technologies—ensure chain of custody and integrity of storage

- Video cameras, 3D monitoring, laser surveillance, accelerometers, and other intrusion/change detection technologies
- Portal monitoring technologies
- Unique identifiers, tags, and seals

Procedures—ensure chain of custody and integrity of storage

- Visual observation (item counting, item identification with unique identifier)
- Containment and surveillance (with tamper-indicating seals, unattended monitoring—optical surveillance, gamma and neutron detectors)
- Requesting clarification in connection with ambiguities

Ensuring Integrity of the Temporary Storage Building. Ensuring that items remained in temporary storage was seen to be very manageable. It would be necessary, however, to take account particularly of the security and classification sensitivities associated with the fact that SNM from nuclear weapons is being stored. While doing so, the types of established techniques and procedures already discussed in the Walkthrough could be used, including unique identifiers, tags, and seals, containment and surveillance, inspector access to relevant documentation and records, and portal monitoring.

Some Additional On-Site Inspection Considerations. At this step, random or ad hoc inspections of containerized separated SNM or HE could be used to support the other chain of custody procedures above. Those inspections also could complement other technologies and procedures to build confidence in the integrity of the temporary storage facility for SNM and HE. They also would be used to maintain and check containment and surveillance and other monitoring equipment. Those inspections would be carried out under the agreed managed access provisions.

Cross-Cutting Issues and Implications

During the day's discussions, several cross-cutting issues and implications for the ongoing work of the IPNDV stood out. The most important of these issues are set out here.

Unavoidable Monitoring/Inspection Uncertainty

Participants acknowledged that even with use of the monitoring/inspection technologies and procedures discussed above, there would be some amount of unavoidable uncertainty as to whether a nuclear weapon actually had been dismantled as agreed in the disarmament agreement. In large part that uncertainty was seen to stem from the fact that given safety, security, non-proliferation, and classification requirements, the Inspecting Party would not be able to directly observe dismantlement of the nuclear weapon. Other constraints on inspectors' access as well as technology limitations also were seen as a source of uncertainty. Participants agreed that one important challenge would be managing and reducing both specific uncertainties at different dismantlement steps as well as overall uncertainty in the outcome of the process.

Confidence-Building in Nuclear Weapon Dismantlement

Given uncertainty, participants agreed on the importance of viewing confidence in monitoring/inspection activities of the nuclear weapon dismantlement process as the result of many separate, mutually reinforcing, and cumulative monitoring/inspection activities over time. Any one of those activities taken alone may not provide complete confidence that a nuclear weapon had been dismantled in accordance with the disarmament agreement. But taken together their goal should be to provide sufficient confidence in that outcome. This area was seen as a priority for future work, not least understanding the sources of confidence, the technical, inspection, and political difficulties that affect confidence, and how best to augment overall confidence through a set of activities. As for how much confidence is attainable at the end of the overall monitoring/inspection process and how much is necessary politically, none of the participants was prepared to hazard a judgment. Both questions also need to be explored further.

Think of Monitoring/Inspection for Nuclear Weapon Dismantlement as a System

Closely related, both at particular steps as well as overall across the dismantlement scenario, participants stated that the monitoring/inspection process should be viewed as a system. The limitations of specific techniques or procedures can be compensated for by other techniques or procedures. Mutually reinforcing measures can help to reduce uncertainty. From a different perspective, reliance on a set of such measures can make it harder to defeat the overall monitoring/inspection effort.

A Tool Box of Inspection Technologies and Procedures

Rather than trying at this stage in the IPNDV to identify "most promising" inspection technologies and procedures, parties should think in terms of developing a tool box of options, with a range of technologies and procedures. It is too soon to judge how specific options can best be applied to actual nuclear weapons, in actual dismantlement facilities versus in paper analyses or with simulated devices. In turn, it was noted that the specific sets of inspection technologies and procedures eventually used will depend on the context provided by a future disarmament agreement, as well as the need to adapt to the unique characteristics of the facilities and programs of different nuclear-weapon states. Those techniques and procedures also will be the result of political negotiations on what will be acceptable to all. In those negotiations, moreover, different states with nuclear weapons can be expected to be willing and able to allow different activities.

Information Barriers Will Be Essential

Protecting classified information will require the use of information barriers. Although work so far indicates that promising technologies and concepts exist, important work remains in turning concepts into workable systems.

Documentation, Declarations, Records, and Other Information

Closely related, additional analysis is needed on the contribution of specific types of information in building confidence in monitored/inspected nuclear weapon dismantlement. Consideration of how to balance the benefits for inspectors with the constraints on Inspected States would be an essential part of such analysis.

Fully Integrate Inspection Procedures and Activities

Though inspection procedures were discussed in the Walkthrough, they received somewhat less attention than some of the technology challenges. Going forward, it will be important to focus on how to integrate the full set of potential visual and other on-site inspection activities into the larger monitoring regime for nuclear weapon dismantlement. Some key areas for the different steps across the basic dismantlement scenario include greater specificity of the types of documentation, declarations, records, and other information that would build confidence; inspection activities in addition to applying unique identifiers, tags, and seals, confirming relevant records, and visually inspecting as part of chain of custody to ensure the integrity of relevant dismantlement facilities; interviewing personnel; and procedures for requesting clarification of anomalies and ambiguities.

Nuclear Weapon Templates

More detailed work on the concept of nuclear weapon templates should be a priority for future IPNDV work. This work should focus both on whether it is possible to develop such templates, their strengths and limitations, and how they might be used to build confidence in monitoring/inspecting nuclear weapon dismantlement.

The Need for Detailed Monitoring of HE—and Approaches to Do So

More work also is needed on how to confirm the presence of HE at different steps in the dismantlement process. If HE measurement proves too difficult—or provides too little confidence—it may be desirable to reassess whether it is a requirement, or how much confidence is necessary in doing so.

Data Handling Issues

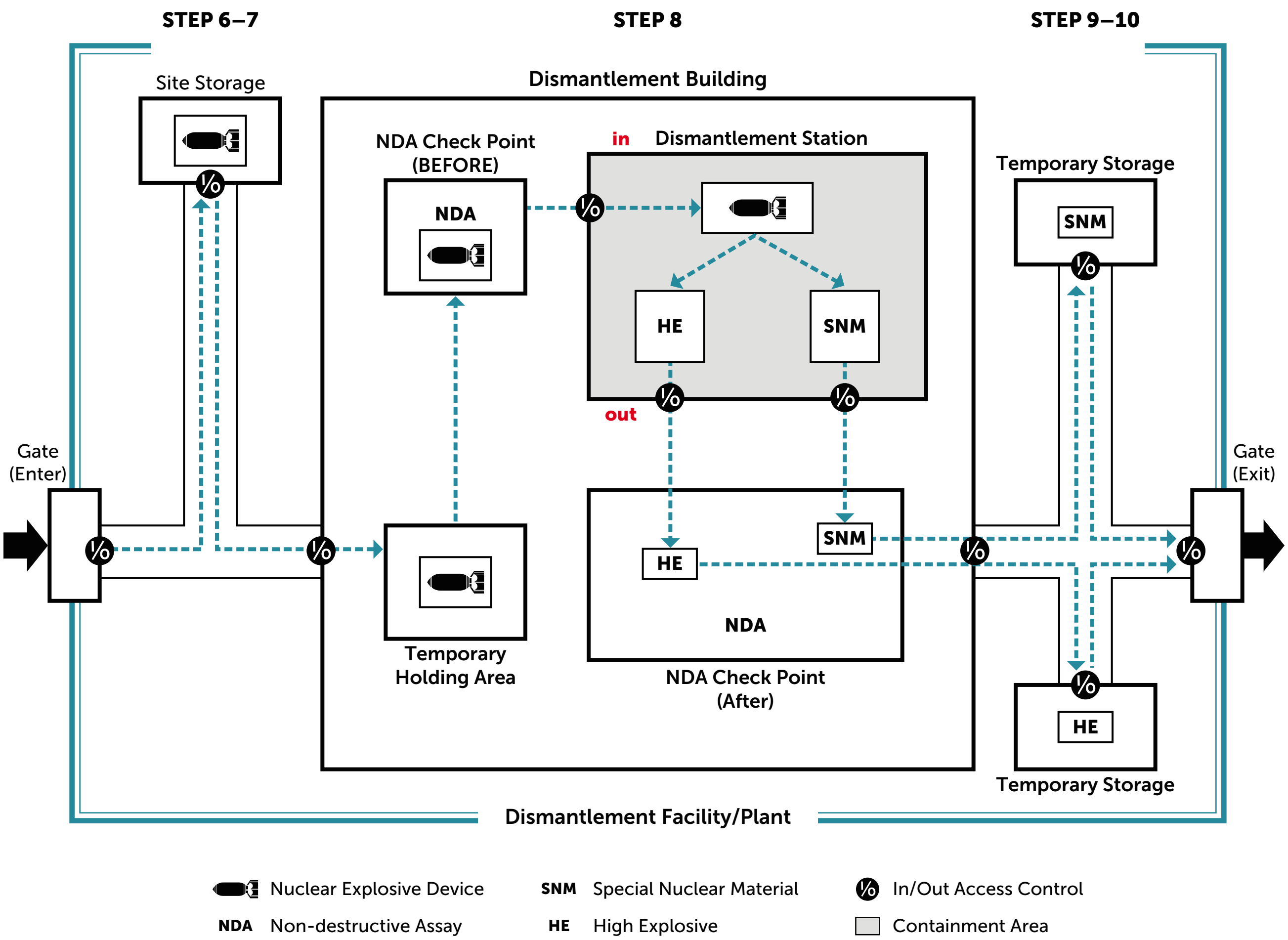
Data handling issues surfaced several times during the Walkthrough, from handling classified information in the case of a nuclear weapon template to how inspectors would analyze both data derived from technical monitoring and their own notes. This area also was seen to require additional work.

The Bottom-Line Judgment

At the completion of the exercise, the participants concluded that 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.

Annex

Schematic Diagram of Dismantlement Phase (Walkthrough Exercise)
Sequence of Events



This chart was created to facilitate potential monitoring and inspection options at each step of the dismantlement process.

About the 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. The IPNDV began in December 2014 when the U.S. Department of State announced that the U.S. government would lead the IPNDV in cooperation with the Nuclear Threat Initiative. Together, the Partners are identifying challenges associated with nuclear disarmament verification, and developing potential procedures and identifying potential technologies to address those challenges.

About the Author

Lewis A. Dunn, Ph.D. is an independent consultant to the Nuclear Threat Initiative (NTI) and participated in the IPNDV Walkthrough Exercise. For nearly three decades, he was a senior staff member at Science Applications International Corporation (SAIC), where he managed and contributed to projects on nuclear risk reduction, non-proliferation, and disarmament. He was the U.S. Ambassador to the 1985 Nuclear Non-Proliferation Treaty Review Conference and is a former Assistant Director of the U.S. Arms Control and Disarmament Agency. He has a Ph.D. from the University of Chicago.

International Partnership for Nuclear Disarmament Verification Walkthrough Exercise Summary

The International Partnership for Nuclear Disarmament Verification (IPNDV) works to identify challenges associated with nuclear disarmament verification, and to develop potential procedures and identify potential technologies to address those challenges. As part of this ongoing initiative, IPNDV representatives conducted a nuclear weapon dismantlement exercise to test how certain technologies and procedures can be applied to specific steps in the dismantlement process. This report summarizes the exercise and offers conclusions as to how identified technologies and procedures can potentially be used to monitor and verify nuclear weapon dismantlement multilaterally.

The International Partnership for Nuclear Disarmament Verification has a developed a series of papers and presentations, as well as an interactive infographic. All are available at www.ipndv.org.

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