Report of the Reductions Working Group

December 2025

1. Introduction: The Reductions Working Group

Phase III of the International Partnership for Nuclear Disarmament Verification (IPNDV) implemented a multi-year program of work to further develop, test, evaluate, and refine concepts and practical verification approaches to support future nuclear disarmament. The initial work in Phase III used a basic scenario that described a notional nuclear-armed state (Ipindovia), as well as its disarmament obligations derived from a notional nuclear disarmament agreement, the Nuclear Weapons Reduction Treaty (NWRT). The NWRT is a multilateral treaty that includes states with and without nuclear weapons as treaty parties. The reduction scenario entails reducing Ipindovia's nuclear arsenal from 500 to zero nuclear weapons within 20 years after entry into force of the treaty.

The reductions scenario was considered in parallel with the limitations scenario.[1] Some verification activities were similar for both scenarios (e.g., providing declarations and notifications, conducting on-site inspections, using remote monitoring equipment, etc.), along with the assumption that the number of certain types of inspections would be limited. Maintenance and production activities within the Nuclear Weapon Enterprise (NWE) would reduce over time in the reductions scenario and eventually cease altogether.[2] This was in contrast with the limitations scenario, where such activities would continue.

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[1] The Nuclear Weapon Limitation Treaty (NWLT) is a multilateral treaty of states with and without nuclear weapons. As a State Party to the NWLT, Ipindovia is obligated to limit its arsenal to no more than 500 nuclear warheads for 20 years from Entry Into Force (EIF). Its existing stockpile and the absence of undeclared warheads are to be verified during the process. The NWLT does not prevent Ipindovia from refurbishing existing warheads or producing new warheads, so long as the overall stockpile never exceeds 500. In both scenarios, inspections are carried out by a multilateral inspection entity (the Multi-State Verification Body (MSVB)).

[2] This would also apply to knowledge management regarding maintenance, production, and handling of nuclear weapons and the supporting infrastructure.

Table 1, lists examples of differences and similarities between the two scenarios. Each scenario had an impact on the set of verification activities that each working group chose, and also the emphasis on certain verification activities at different points in time over the 20-year life of the treaty.

Table 1: Similarities and Difference between the Limitations and Reductions Scenarios

	Limitations Scenario	**Reductions Scenario**
Ipindovia Activities and Facilities		
Declarations	Nuclear warheads, associated delivery vehicles, and associated facilities (maximum number of nuclear warheads is 500)	Nuclear warheads, associated delivery vehicles, and associated facilities (initial number of nuclear warheads is 500)
Dismantlement	As required (to balance production)	25 per year (average), 20 years
Maintenance Activities	Continuing	Declining and eventually ceasing
Production Activities	Continuing	Declining and eventually ceasing
Transport of Accountable Items	Active	Declining and eventually ceasing
Deployment Bases	Active	Closing
Nuclear Weapons Facilities/Storage	Active	Closing, declining activities
Former Bases/Facilities	Inactive (with respect to nuclear warheads)	Disassembling of nuclear weapons infrastructure
Nuclear Weapons-Related R&D	Continuing	Declining, and eventually ceasing
Multi-State Verification Body Verification Activities		
Initial Declaration (during negotiations)	No specific verification activities	No specific verification activities
Baseline Declarations	Verification	Verification
Periodic Declarations	Verification	Verification
Notifications	Verification	Verification
Dismantlement	If part of the treaty	Verification

The Reductions Working Group (RWG) examined elements of a coherent combination of verification activities in a multi-state, multi-warhead, multi-site environment over the lifetime of the NWRT.

The RWG formulated its approach across three workstreams that built on and informed each other:

- Exploring how a systems-based approach could be applied in order to develop and implement effective and efficient verification measures. This approach considers the nuclear weapons-related infrastructure and related technical capabilities of Ipindovia as a whole and analyzes how to verify that the NWE operates consistently with treaty requirements. The RWG studied potential diversion from undeclared activities across the 14-step model and potential undeclared activities within the NWE (cf. Section 2, The Importance of a Systems Approach).

- Identifying a comprehensive set of potential diversion steps and pathways from either declared activities or involving undeclared activities, as well as associated supporting activities (cf. Section 3, Identifying and Assessing Potential Diversion Pathways).
- Conducting a series of mini-exercises to refine the diversion pathway analysis and to examine the effectiveness of various processes, procedures, techniques and technologies, (PPTT) for detecting the diversion identified in the second work stream (cf. Section 4, Deterring Diversion by the Risk of Detection Using Multiple Verification PPTT). The focus was on diversion from within the 14-step dismantlement process and diversion involving undeclared retention of nuclear warheads, although some aspects of detecting undeclared production of nuclear warheads also were addressed. In the exercises, participants were asked how they would use various PPTT to maximize the risk of detecting the diversion.

2. The Importance of a Systems Approach

2.1 Defining a Systems Approach and Relationship to Work in the Reductions Working Group and Other Working Groups

The systems approach considers the state's nuclear weapons-related infrastructure and related technical capabilities as a whole and analyzes how to verify that the NWE operates consistent with treaty requirements. The NWE would encompass all treaty-accountable items (TAIs), including nuclear warheads, and the associated delivery vehicles and facilities that support them. Understanding how the NWE operates is the foundation of detecting undeclared activities, whether retention of nuclear warheads or undeclared production.

Assessing the NWE as a whole is necessary because inspection resources would be limited, and it is impossible to verify all items at all times. As an example, it may not be possible to verify all individual movements of items within the NWE; instead, periodic declarations coupled with a process of notifications and short-notice inspections could be part of the verification system. By identifying verifiable sub-systems and understanding their relationships, it should be possible to see behavior consistent with what has been declared across the system as a whole and build confidence in fulfilment of the full set of treaty obligations.

In addition, an understanding of the NWE as a whole is essential to verifying the absence of undeclared activities (the completeness of declarations). To assess possible diversion pathways involving undeclared activities, the systems approach should identify capabilities as sub-systems in the NWE. Each sub-system would have different diversion risks and could have its own implementation-specific verification objectives, activities, and priorities.

From this perspective, verifying the completeness of the treaty declarations would entail two different approaches: 1) looking for the absence of undeclared items and processes *within* the declared sub-systems and 2) looking for the absence of undeclared instances of sub-systems *outside* of the declared ones.

2.2 Defining and understanding the NWE in Ipindovia (Sites and Flows)

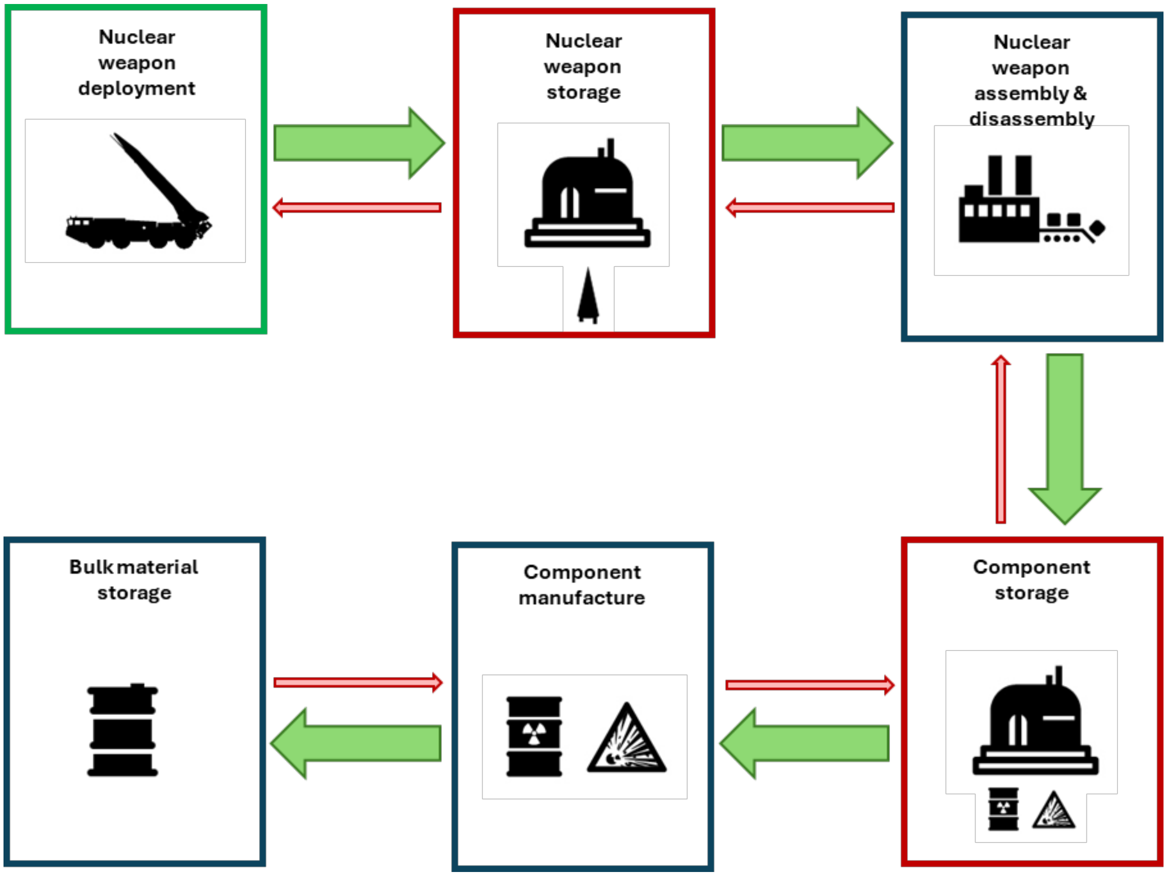
Looking at the whole NWE of Ipindovia (figure 1) as a system, it is possible to divide it into sub-systems representing the capabilities of the enterprise (table 2). These sub-systems do not necessarily represent a site. A nuclear weapons assembly and disassembly site may, for example, also contain storage facilities. A similar sub-system may exist in multiple places (e.g., Ipindovia has four deployment sites).

***Figure 1**: Map of Ipindovia, Including Its Nuclear-Related Bases and Infrastructure*

Table 2: Ipindovia Sub-Systems		
Sub-System	**Capability**	**Where in Ipindovia Scenario**
Nuclear Weapons Deployment	Deployment and handling of nuclear warheads and associated delivery vehicles	• Seastar SSBN Naval base • Westend road-mobile ICBM base • Northern Light silo ICBM base • Altitude bomber base
Nuclear Warhead Storage	Storage and handling of nuclear warheads	Central storage area at LADDU
Nuclear Warhead Assembly and Disassembly	Assembly, disassembly, and maintenance of nuclear warheads; handling of components	LADDU
Nuclear Warhead Component Storage	Storage and handling of nuclear warhead components	LADDU
Nuclear Warhead Component Manufacture	Manufacture and dismantling of nuclear warhead components	LADDU
Bulk Material Storage	Storage of special nuclear material (SNM), high explosives, and other nuclear weapon components	LADDU
Transportation	Transport of nuclear weapons and their components between sites	Between all sites

As illustrated in Figure 2, we can expect that in the reductions scenario, there will be a flow of items (almost unidirectional) from deployment through dismantlement to material storage. Due to the duration of the treaty, ongoing nuclear weapons operations would drive a need for items to also move the other way through the enterprise, toward deployment. From a systems approach, this also highlights how the sub-systems can represent diversion options. Diversion pathways can be illustrated by undeclared items flowing through the system toward deployment. Transportation is also a separate sub-system present throughout the NWE; all movements between sub-systems are using transportation, which represents its own diversion concern.

Figure 2: Sub-Systems in the Ipindovia Reductions Scenario



Note: Green arrows represent main flow of items during reductions. Due to length of treaty, some items may flow in the direction of the red arrows due to maintenance and refurbishment of operational nuclear weapons prior to completion of reductions to zero.

3. Identifying and Assessing Potential Diversion Pathways

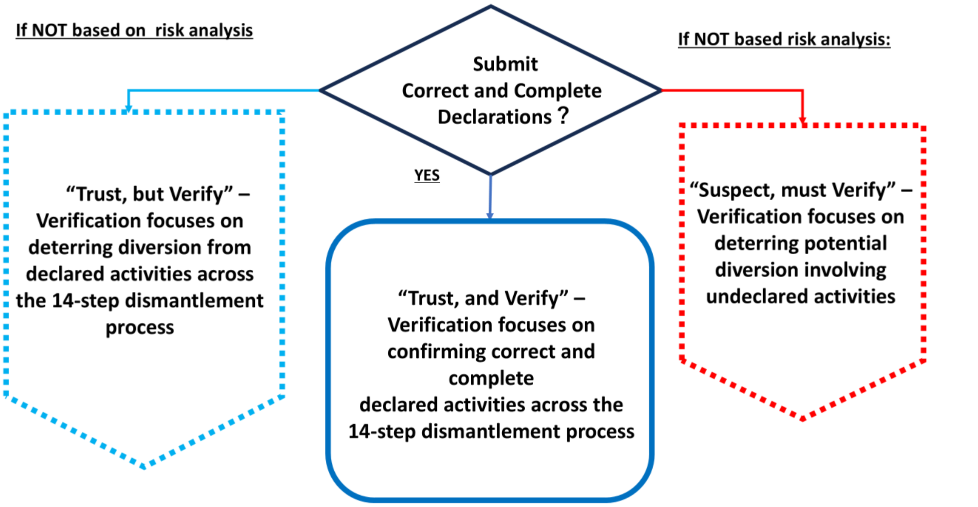
3.1 Basic Approach

The Reductions Working Group focused on potential pathways by which a party to a nuclear disarmament agreement could seek to divert nuclear warheads and/or components in violation of that agreement for four reasons:

1. To refine our understanding of specific verification objectives at different steps in the 14-step model of the overall dismantlement process
2. To test and refine specific monitoring and inspection PPTT
3. To assess the overall effectiveness of the PPTT options for deterring diversion by creating a credible risk of detection

4. To identify possible opportunities to strengthen verification measures and areas for additional IPNDV work

Figure 3: Three Layers of Verification



As shown in Figure 3, the three layers of verification are as follows:

- Confirm "correct and complete" statement of declared activities ("Trust, and Verify")
- Deter diversion from declared activities by the risk of detection ("Trust, but Verify")
- Deter diversion based on undeclared activities by the risk of detection ("Suspect, Must Verify")[3]

The RWG's work on diversion has focused on the latter two layers of verification.

The RWG followed a three-step approach to analyze diversion from either declared activities or involving potential undeclared activities. First, the group identified a comprehensive set of diversion pathways, including their associated supporting activities. Second, using a set of specific metrics, the group identified a more limited set of diversion pathways that could be more attractive to a potential diverting country. Third, the group conducted a series of mini-exercises to refine our understanding of the process of diversion and to assess the potential effectiveness of specific PPTT for detecting such diversion. This section summarizes the analysis of the process of diversion; the analysis of the potential effectiveness of the PPTT and any gaps identified are summarized in Section 4.

[3] For a more complete description of these three levels of verification and their implications for verification strategy, see Appendix 2.

Analyzing Diversion

Identify comprehensive set of potential diversion pathways and associated supporting activities.

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Use explicit metrics to evaluate options to identify higher credibility diversion pathways.

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Use mini-exercises to refine understanding of the process of diversion and to assess the effectiveness of specific PPTT to detect and deter such diversion by the risk of detection.

3.2 An Initial Set of Potential Diversion Pathways

Potential pathways to divert nuclear warheads during the dismantlement process or to carry out undeclared activities in violation of an agreement can be identified. These pathways are summarized across the elements of Ipindovia's NWE in Table 3. The diversion pathways involving undeclared activities, moreover, are of concern not only for the reductions scenario but also for the limitations scenario addressed by the Limitations Working Group.[4] In turn, the underlying analytic work is important for the conceptual and technical work of all of the IPNDV working groups.

For each of the potential diversion pathways, moreover, more specific activities need to be undertaken. In particular, virtually all the pathways considered require actions to avoid detection by the verification regime's monitoring and inspection PPTT.

Such attempts could include, for example, making false declarations/notifications concerning TAIs, substituting a simulated warhead for a real warhead, attempts to circumvent or defeat chain-of-custody techniques and technologies, taking advantage of treaty provisions that allow limiting inspectors' access on-site through managed access, and tampering with unattended monitoring equipment used to monitor in-out access to sites subject to inspection. Similarly, retention or production of undeclared nuclear warheads would need to be implemented by

[4] For the IPNDV scenarios, see "IPNDV Scenarios," February 9, 2024.

specific actions, from falsifying declarations of existing nuclear warheads to establishing a parallel production infrastructure and all associated accounting.

Table 3 : An Initial Set of Potential Diversion Pathways

Nuclear Enterprise Element	**Diversion Pathway—Basic Concept**
Nuclear Warhead Deployment	• Swap nuclear warhead with simulated warhead • Take credit for nuclear warhead presence in empty container—allow diversion of "real" warhead • Hide excess undeclared warheads at deployment site or at undeclared off-site location
Nuclear Warhead Storage	• Swap nuclear warhead with simulated warhead • Undeclared removal of nuclear warhead from storage bunker • Issue false notification of warhead shipment to dismantlement site—but retain in storage
Nuclear Warhead Dismantlement	• Swap nuclear warhead being dismantled with a simulated warhead • Provide false notification of nuclear warhead dismantlement • Divert components taken from dismantled nuclear warhead
Nuclear Warhead Component Storage and Manufacture	• Substitute simulated components to mask diversion of nuclear weapon components from storage • Removing components from storage without use of simulated components
Disposition of SNM (and other components)	• Diversion of SNM derived from processed warhead components by taking advantage of technical limits on fully accounting for all material during processing • Diversion of SNM during processing by denying inspectors' access on grounds of safety and sensitivity, defeating containment and surveillance means, and taking advantage of processing uncertainties
Transportation of Nuclear Warheads	• Swap warhead to be dismantled with a simulated warhead during or after transport—given no prior notification • Swap warhead in its container with empty container during or after transport • Substitute simulated components to mask diversion of nuclear weapon components after dismantlement • Swap component container(s) with empty container(s) during or after transport
Undeclared Activities	• Retain undeclared nuclear warheads • Produce undeclared nuclear warheads within declared elements of the NWE • Produce undeclared nuclear warheads at former NWE sites • Produce undeclared nuclear warheads at an undeclared site

3.3 Identifying a Narrower Set of Potential Diversion Pathways

Diversion risk exists at all points in the dismantlement process and across the different functional elements of the NWE model defined by the systems approach set out in Section 2 of this report. Potential diversion risk is never zero.

From the perspective of the inspecting entity, therefore, the verification regime must be designed to address all potential diversion pathways. This is so even if practical considerations may require the inspecting entity to focus more resources, not least inspection time, on some of the potential diversion pathways.

From the perspective of the potential diverting country, some potential diversion pathways are more attractive than others in terms of three key metrics:

- *Payoff to the Diverting Country:* After diversion, closeness to retaining a nuclear weapons capability, including delivery means.
- *Complexity and Ease to Implement:* Whether diversion requires a single successful activity or multiple successful activities; the extent of ancillary activities involved (e.g., technical preparation, post-diversion sustainment and maintenance, and use or not of a clandestine facility); and time required for up-front preparations, during diversion, and afterwards.
- *Verification Robustness or the Risk of Detection*: Whether or not there are multiple layers of verification measures; the frequency and scope of monitoring and inspection activities at declared facilities; the number of TAIs subject to inspection as well as the overall number of inspectable treaty partners, facilities, activities, and, therefore, the demands on the inspection entity's limited resources; and the reliability of technical monitoring means and the difficulty of spoofing them.

Applying these metrics, Table 4 sets out what the Reductions Working Group judges to be the more attractive potential diversion pathways and their possible accompanying activities in the reductions scenario.

In all of these cases, it is assumed that a diverting country also would be able to mate diverted nuclear warheads with some means of delivery. A stockpile of diverted warheads without means of delivery have a different significance militarily, although such diversion could have significant political impacts. This fact highlights the need to incorporate the elimination of delivery vehicles into any comprehensive nuclear disarmament agreement.

This result, moreover, is consistent with the results of an evaluation by the Concepts Working Group of the diversion pathways included in the more comprehensive listing set out in Table 3. The Limitations Working Group also identified retention of excess undeclared warheads and undeclared production of nuclear warheads as high-risk diversion pathways in the limitations scenario.

3.3.1 Some Analytic Propositions from the Initial Analysis

During the preceding analysis, several overarching propositions were put forward that are noted here and warrant further consideration. Specifically:

- Diversion risk may arise at any time during the implementation of a disarmament agreement if a party to an agreement later decides not to implement it in good faith (e.g.,

- because of regime change or changes of the regional or international security environment).

Table 4: More Attractive Diversion Pathways from Potential Diverting Country's Perspective

Concept	Examples of Possible Accompanying Activities
Swap nuclear warheads with simulated warheads—from delivery systems, in storage containers, during dismantlement	• Develop simulated warhead • Limit inspection access and activities • Tamper with/spoof tags/seals/UIDs • Tamper with/spoof inspection equipment • Tamper with/spoof portal monitoring systems deployed at storage and other sites • Use shielding to hide empty containers
Divert nuclear warheads during transport within or between sites	• Leverage limits on inspection activities, including only post-transport notification of movement • Tamper with/spoof tags/seals/UIDS and portal monitoring of in-out movement (including radiation measurement) • Swap with simulated warhead or use shielding to hide empty containers
Substitute simulated components to mask diversion of nuclear warhead components—during dismantlement, from storage	• Develop simulated components • Tamper with/spoof portal monitoring systems (including radiation measurement) • Use shielding to hide empty containers
Retain undeclared nuclear warheads	• Falsify baseline declaration of warheads required at entry into force (EIF) of agreement • Tamper with portal monitoring equipment • Limit inspection access • Use simulated warheads or shell game with "display" warheads
Undeclared production of nuclear warheads—declared site, undeclared site	• Falsify declarations/notifications of ongoing production activities • Tamper with monitoring equipment • Limit inspection access and activities • Establish parallel production infrastructure

- The relative attractiveness of different diversion pathways in the eyes of the diverting country will be influenced by the point in time of implementation of a nuclear disarmament agreement.
- The risk of diversion may be higher for retention or production of undeclared nuclear warheads, both because of the higher payoff of acquisition of multiple assembled nuclear warheads and the challenges of detecting such undeclared activities.
- Initially, the risk of diversion may be relatively less for diversion of either SNM or other components because of the need for more extensive follow-on activities to reassemble components into nuclear warheads or to manufacture components and then assemble them into nuclear warheads in the case of diversion of SNM.

- As the reductions to zero process advances, however, diversion of either SNM or other components could become relatively more attractive given more limited numbers and opportunities for diversion of assembled nuclear warheads.
- Excepting undeclared retention or production of nuclear warheads, the payoff of diversion during the dismantlement process is a single nuclear warhead; building up a number of diverted warheads in this way would take an extended period of time and require repeated successful deception.
- The earlier that diversion takes place, the higher risk that diversion will eventually be uncovered during the verification of the multi-year reductions to zero process.
- In addition, the risk of detection of diversion from declared dismantlement activities may increase as the process of reductions to zero continues, especially because of the higher possibility that anomalous activities will be detected against the backdrop and ground truth provided by many years of monitoring and inspection of those activities.
- There is a reciprocal dynamic relationship between the diverting country and the inspecting entity: the diverting country's choices of whether and how to divert will be shaped by the activities of the inspecting entity; the inspecting entity's allocation of resources will reflect its assessment of potential diversion pathways.
- The relative attractiveness of different diversion pathways is inseparable from the specific monitoring and inspection measures provided by the agreement and implemented by the inspecting entity.

3.3.2 Identifying Critical Nodes of Potential Diversion Pathways

The analysis of diversion pathways (Table 5) also explored whether specific operational activities or necessary processes—referred to as nodes of activity—recur across some or many of the different potential diversion pathways. Such nodes would provide opportunities for detection.

Table 5: Possible Nodes of Diversion: A Working Set

High Interest Diversion Pathways from the Diverting Country's Perspective	Falsify declarations/notifications	Develop simulated nuclear warhead-components; move to diversion site	Limit or deceive inspection activities	Tamper with/spoof tags/seals/UIDs	Deceive or tamper with Portal Monitoring	Use shielding in violation of an agreement	Move and hide diverted items on-site	Move diverted items off-site to declared or undeclared location(s)	Build parallel storage infrastructure	Build or restore undeclared maintenance infrastructure	Restore undeclared production infrastructure (less likely, build new undeclared production infrastructure)	Mate warhead with means of delivery
Swap nuclear warheads with simulated warheads—from delivery systems, in storage containers, during dismantlement		x	x	x	x	x	x	x	x	x		x
Divert nuclear warheads during transport within or between sites	x	x	x	x		x		x	x	x		x
Substitute simulated nuclear warhead components to mask diversion of components during dismantlement/ transport from storage		x	x	x	x	x	x	x	x	x		x
Retain undeclared nuclear warheads	x		x		x	x	x	x	x	x		x
Undeclared production of nuclear warheads—declared or undeclared site	x		x		x	x	x	x	x	x	x	x

3.3.3 Relying on Monitoring and Inspection Technologies

Several of the nodes of diversion identified in Table 5 require spoofing or tampering with verification technologies in order to successfully divert nuclear warheads or their components. With that in mind, the Reductions Working Group provided a set of questions to the Technology Track about the challenges and opportunities of doing so. The Technology Track's assessment is summarized in a separate report on spoofing and tampering with key monitoring and inspection technologies. The following are the key implications of that assessment:

- A potential diverter will confront both challenges to overcome and opportunities to exploit in carrying out successful spoofing or tampering with verification technologies.
- Considerable effort and logistics will be required over time for successful spoofing of the presence or absence of nuclear warheads in containers subject to verification. In particular:
- The challenge of spoofing a verification measurement depends greatly on the technology, analysis techniques, and signature types; equipment can be chosen to increase the difficulty of spoofing by bad actors. For example, certain measurable SNM signatures are challenging to replicate with non-SNM materials (e.g., gamma-ray spectral features), while others could be easily replicated with a fake object (e.g., weight).
- Continued spoofing of monitoring and inspection activities may become more challenging over time. Due to chain of custody, a simulated item may need to repeatedly spoof multiple layers of different monitoring and inspection measures across the overall disarmament process. This increases the number of times and ways that the simulated item must appear "real."
- The diverting state would need to treat the simulated item like a nuclear weapon and hide the diverted weapon. Doing so may involve breaking procedures, involving more and more workers in illicit activities, and falsifying more and more documentation—this likely becomes increasingly difficult to hide over time.
- Simulating the absence of highly enriched uranium may be easier than simulating the absence of plutonium due to the high gamma-ray and neutron emissions of plutonium.
- A specific spoofing strategy in some scenarios may itself create indicators of diversion (e.g., using shielding to simulate absence of a nuclear warhead will likely increase the size and weight of a container).
- Instead of creating a simulated item, a bad actor could tamper with equipment to support cheating efforts. Tamper-indicating tags and seals are important to increase the difficulty of undetected tampering with monitoring and inspection equipment stored under host custody. In addition, tamper indication strategies make equipment tampering more detectable, and/or require more direct action to impact the effectiveness of portal monitoring (PM) and closed-circuit television (CCTV) (e.g., cutting electricity).

- In some cases, relying on simpler technologies as well as avoiding wireless connectivity may reduce vulnerabilities and increase robustness against tampering (e.g., for PM, CCTV).
- Designing and implementing a verification regime can anticipate and build-in treaty-based counters to technology spoofing, including, for example, by designing/selecting PPTT with spoofing concerns in mind; agreed procedures for replacing/updating equipment (e.g., for tags and seals); authentication/certification of inspection equipment at the appropriate point in time; and addressing cyber-security risks (e.g., no wireless connectivity).

3.4 Diving Deeper: The Mini-Exercises

A series of six mini-exercises was conducted to explore the process of diversion (including possible accompanying activities) and associated verification measures as seen from both the diverting country and the inspecting entity. These exercises also examined the effectiveness of various PPTT options at detecting such diversion. The principal focus was on diversion from within the 14-step dismantlement process and diversion involving undeclared retention of nuclear warheads, although some aspects of detecting undeclared production of nuclear warheads also were addressed.

Diversion Mini-Exercises

- Identifying high-priority diversion pathways
- Storage site
- Deployment site—mobile ICBMs
- Assembly/disassembly site
- Transportation within and between sites
- Disposition of components from dismantled nuclear warheads

In each mini-exercise, participants were asked to consider how they would divert nuclear warheads in a given scenario. For each scenario, they also were asked to consider the relative merits of storing diverted nuclear warheads on-site or moving them to another declared or undeclared site. Next, participants were asked how they would use various PPTT to maximize the risk of detection of the diversion. Section 3.5 sums up some of the key points from the mini-exercises.

3.5 Potential Challenges Regarding the Process of Diversion

3.5.1 Diverting Country's Perspective

A diverting country would confront a number of choices related to the modality, timing, location, and implementation of its decision to divert. Consider each briefly.

Modality of diversion. The most fundamental choice for a diverting country would be whether to divert one or more nuclear warheads from declared activities subject to monitoring and inspection or to engage in undeclared retention or production of nuclear warheads. Undeclared retention or production offers a potentially higher payoff in terms of numbers of nuclear weapons to be retained. From one perspective, it also could be seen as having a lesser risk of detection due to the challenges of detecting such undeclared activities. That said, assuming retention of undeclared nuclear warheads prior to EIF, the diverting country would need to successfully avoid the detection of those warheads and their supporting infrastructure over an extended period of time. Without that infrastructure, diversion would not make much sense.

Timing of diversion. Retention of undeclared nuclear warheads would be easiest prior to the EIF of an agreement. Prior to EIF, none of the agreement's verification measures would be in place to detect such diversion. Any diversion after EIF would need to take those measures into account and attempt to defeat them. Prior to EIF, it also would be easier to divert a large number of nuclear warheads simply by not declaring them at all rather than attempting later to build up a stockpile one-by-one over time. Nonetheless, in the reductions to zero scenario, the relative payoff of diversion for the diverting country would increase as the process of reductions approaches zero. By contrast, the payoff from diversion of a few nuclear warheads is questionable as long as the potential diverter and other parties to an agreement still retain a large number of nuclear warheads that have not been dismantled and an active NWE to produce new nuclear warheads.

Actual v. Declared: Hiding a Discrepancy

- Initial false baseline declaration
- Ongoing false notifications
- Attempt to replace "real" warheads with "simulated" warheads
- Attempt to repeatedly present for monitoring and inspection the same "display" nuclear warhead
- Attempts to limit inspectors' access to declared or

Location of Diversion. A diverting country would also need to choose where diversion could most effectively occur. Its considerations could include, for example, whether a given site provided potential access to multiple nuclear warheads (a central storage facility); the need for follow-on activities (diversion of components as opposed to complete nuclear warheads); the specifics of its NWE, including the extent to which there were considerable ongoing routine maintenance of nuclear warheads and shipments among sites; and the robustness of monitoring and inspection measures.

By way of example, transportation of nuclear warheads could take place either within a site or between sites and raises special challenges. Unlike other dismantlement steps, safety and security requirements make it more difficult to achieve multiple levels of verification during actual physical transport of nuclear warheads, one to back up the other. Reliance needs to be placed primarily on effective tamper-indicating tags, seals, and UIDs, and to ensure chain of custody while containerized nuclear warheads are in transport. Security requirements will also impact the timeliness of notifications regarding movement of nuclear warheads by allowing only after-the-fact notifications of such movement. Those requirements may also delay access to portal monitoring data showing what goes in and out of given locations.

At the same time, there are possible ways to address those challenges after transport is completed. For example, there could be a process whereby transported nuclear warheads would be placed in segregated, controlled storage on arrival at their destination and not be moved onward until inspectors had an opportunity to confirm the integrity of tags/seals/UIDs, and potentially to do radiation measurements to confirm the presence of SNM in randomly selected containers.

Implementation of Diversion. The diverting country also would confront various specific choices in implementing a decision to divert either before or after EIF. These choices include, for example, whether to hide diverted nuclear warheads at the sites where they are located, to move them to another declared site, or to move them to an undeclared site; how to defeat monitoring and inspection means, from hiding the discrepancy between declared and actual numbers of nuclear warheads to circumventing possible radiation monitoring to confirm the absence or presence of SNM; and how ultimately to maintain an operational nuclear weapons capability (warheads, delivery vehicles, and supporting infrastructure) without detection.

Ensuring Safety and Security. Ensuring the safety and security of diverted nuclear warheads will continue to be a high priority for a diverting country. The need for robust safety and security infrastructure is likely to constrain where diverted nuclear weapons would be stored. Unless the diverting country is willing to accept reduced safety and security to reduce the risk of detection, it could create a preference for clandestine storage at a site that already had the needed infrastructure. Safety and security requirements provide a "footprint" that increases the likelihood of detection.

The Need for Successful Deception over Time. Even assuming diversion prior to EIF, diversion is not a one-time event. Retention of undeclared nuclear warheads, for example, would require maintaining two separate nuclear weapons enterprises, which would be complicated. The number of people needed to be complicit in the diversion scheme would raise the risk that the diverting country would make an error at some point that reveals the existence of undeclared nuclear weapons or infrastructure.

3.5.2 Inspecting Entity's Perspective

The inspecting entity also needs to make a number of choices in developing and implementing an inspection strategy to increase the risk that attempted diversion would be detected. Inspectors would need to decide how to allocate limited inspection resources and whether to adapt that allocation over time in light of the stage of implementation of the agreement.

Need for a Comprehensive Systems Approach. Through a series of mini-exercises, the group took a comprehensive systems approach to designing and implementing nuclear disarmament verification. Rather than thinking in terms of a series of discrete monitoring and inspection challenges, it is important to think in terms of a flow of nuclear warheads (and later SNM from dismantled warheads) through a multi-year, ongoing disarmament process. The different steps of the 14-step model are linked together. Effective application of monitoring and inspection measures at earlier steps reinforces verification at later steps (e.g., in establishing chain of custody). In turn, monitoring and inspection activities at later steps can provide added confidence and compensate for limits of earlier steps or a breakdown of verification during an earlier step (e.g., later use of radiation measurement to confirm the presence of SNM). A systems approach to verification also would reflect the fact that successful diversion would involve multiple nodes of activities across an entire diversion pathway. As such, there would be multiple opportunities for a system of monitoring and inspection activities to detect such diversion.

Allocating Overall Inspection Resources and Quotas. An inspection strategy will need to address how to allocate overall inspection resources across the different steps of the dismantlement process in any given party to an agreement. In that regard, in the Ipindovia reductions to zero scenario, the nuclear weapons assembly/disassembly site may be the highest priority target of verification because it combines multiple nuclear warhead-related operations, multiple diversion pathways, and locations at which diverted nuclear warheads could be hidden on-site. In practice, resource allocation also points to the utility of different types of inspections (routine "confirmation" inspections, formerly declared facility inspections, go-anywhere challenge inspections, etc.) each designed with a specific objective in mind. This variety of inspection types would be a key tool for deterring undeclared activities, whether at declared or undeclared sites.

Mixing Monitoring and Inspection Activities. In determining what PPTT to use for the particular verification task at hand, an effective verification regime should incorporate redundancy in verification activities and measures, making use of both remote monitoring technologies and relevant PPTT during on-site inspections. Ensuring two layers of verification with the use of multiple and different monitoring and inspection PPTT is an important means to increase the risk of detection of diversion. Multiple layers allow for leveraging the synergies between the different layers. Moreover, one layer is able to compensate for the possible shortcomings, or even unexpected breakdown, of another layer. The objective of ensuring two layers of verification may be most difficult to attain in the case of transport within or between sites.

The mini-exercises also highlighted that chain of custody using tags, seals, and UIDs, is a vital element of a nuclear disarmament verification system. These measures are relatively easy to apply, make use of reliable technologies, are least invasive, and are applicable across the verification system. Opportunities exist to enhance tags and seals with new technologies.

Radiation measurements to confirm the presence or absence of SNM during baseline inspections of nuclear warheads offer a potentially powerful tool to establish chain of custody early in the implementation of an agreement. However, the decision to measure all accountable nuclear warheads needs to balance considerations of cost, practicality, and time required.

More specifically, on the one hand, opportunities during downstream activities (e.g., entry of a nuclear warhead into central storage or prior to its dismantlement) to detect that diversion occurred earlier could argue for deferring such use. On the other hand, the importance of confidence that an item declared to contain a nuclear warhead did in fact contain such a warhead could argue at least for selective radiation measurement of randomly selected items presented for inspection at declared sites as part of baseline inspections. Consequently, use of radiation measurements (including template measurements to compare the signature of a containerized nuclear warhead with that of a previously made template) are best used where they provide the greatest value-added in strengthening or restoring chain of custody.

The "Analytic Layer." During the multi-year inspection process envisaged by the reductions scenario, the inspecting entity will build experience in implementing monitoring and inspection measures at specific sites, including how specific PPTT contribute to achieving verification objectives, their interaction, and how to respond to anomalies. In addition, it will gain an understanding of normal operations in the NWE at sites subject to inspections. The review of this data, information, and experience comprises an "analytic layer" in addition to the above two layers of actual verification measures. Its review can inform the next steps, identify issues of concern, and shape the strategy of an inspecting entity in making choices about resource allocation.

3.5.3 A Dynamic Process

Diversion is a dynamic process in which the payoffs, complexity, and risks of diversion will be shaped by many factors, including the actions of the inspecting entity. This means that any strategy to deter diversion by the risk of detection also needs to be a dynamic one. A well-crafted verification regime will facilitate the ability for such a strategy to adapt over time. In varying degrees, each of the higher credibility diversion pathways requires multiple accompanying activities to be implemented successfully. Each of these activities represents a potential point of detection.

In addition, except for pathways that involve retention of undeclared nuclear warheads, the payoff of diversion across the options above would be a limited number of nuclear warheads or nuclear warhead components. Thus, these diversion pathways would need to be used repeatedly to build up a large body of undeclared warheads.

4. Deterring Diversion by the Risk of Detection Using Multiple Verification PPTT

4.1 Declarations, Notifications, Monitoring, and Inspections

Declarations and notifications about activities covered by a nuclear disarmament agreement are the foundation of verification (Figure 4). Both an Initial Declaration made during negotiations and a baseline declaration made following an agreement's EIF provide essential information for carrying out verification measures. Recurring notifications provide information about specific changes in the status of TAIs and facilities, including their movement in the overall dismantlement process. Verification also draws on a comprehensive set of options for monitoring and inspection PPTT that can be used to confirm the information provided by the declarations and notifications, and, in so doing, build confidence that parties are implementing the agreement. For ease of reference, the IPNDV has referred to the set of options for declarations, notifications, and PPTT as a "verification toolkit." This toolkit provides options for consideration by negotiators when addressing verification in future nuclear disarmament agreements.

Figure 4: Foundational Elements of Verification

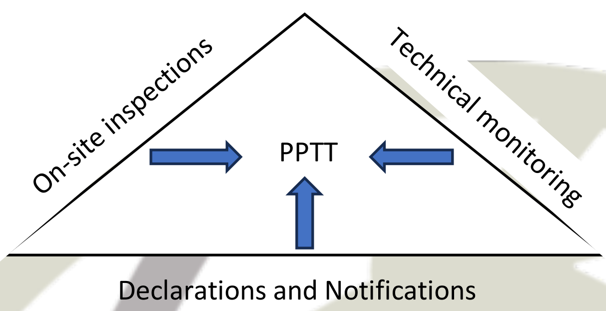
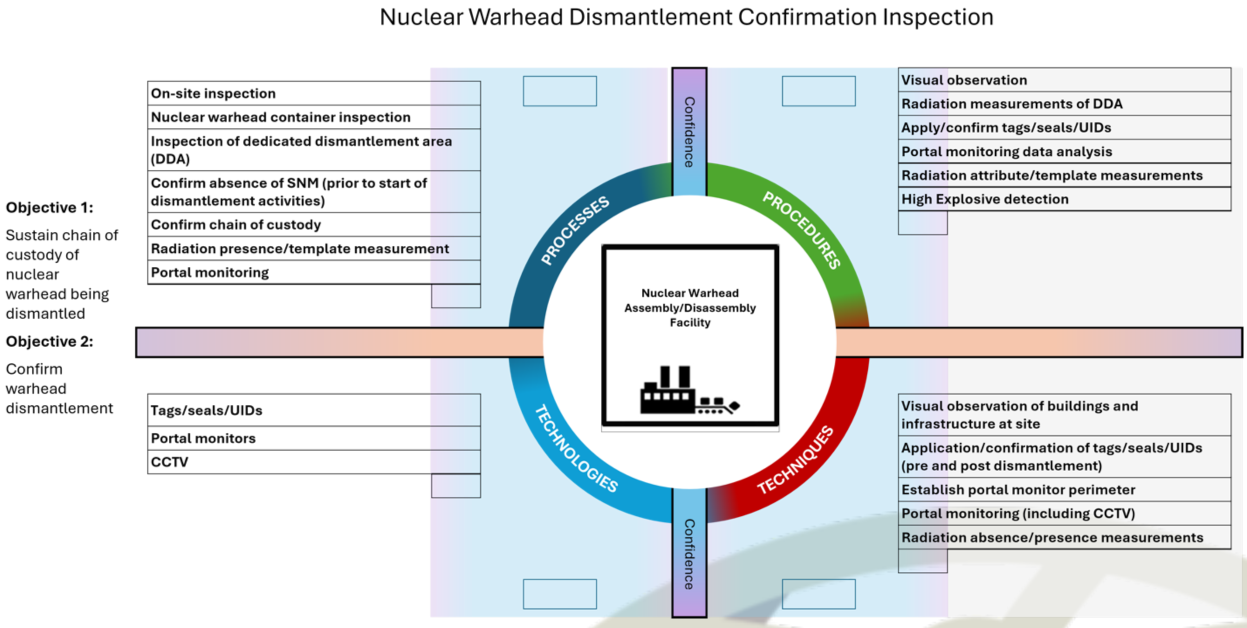


Figure 5 shows one set of PPTT that could be used at a nuclear warhead assembly/disassembly site to confirm the dismantlement of nuclear warheads. In this example and more generally, PPTT are related as follows:

- *Processes.* Monitoring and inspection activities tailored to a specific verification situation and needed to achieve verification objectives in that situation, in this example, confirming dismantlement of nuclear warheads at an assembly/disassembly facility
- *Procedures.* Necessary ways to deliver specific monitoring and inspection processes
- *Techniques.* Required operating procedures, user guides, checklists, and documents needed to operate the technologies to be used in that specific situation.
- *Technologies.* Means to fulfill the procedures identified for a specific situation

Figure 5



Comparable sets of PPTT can be tailored for use in monitoring and inspections across all the functional activities and related sites in the Ipindovia reductions scenario.[5]

4.2 Monitoring and Inspection PPTT to Deter Diversion: Some Insights from the Mini-Exercise Process

The mini-exercises confirmed that the PPTT in the toolkit offer a robust set of monitoring and inspection options to deter diversion by the risk of detection and to build verification confidence. The mini-exercises highlighted a number of these options and also identified a number of opportunities to strengthen PPTT and their implementation.

[5] For PPTT for all of the dismantlement steps and a discussion of their interrelations and potential applications, see *Exploring Processes, Procedures, Technologies, and Techniques (PPTT) for the Reductions Scenario,* Bucharest, April 2024.

4.2.1 PPTT Options and Their Implementation

The Centrality of Declarations and Notifications. In exploring the different diversion pathways, the mini-exercises underlined the importance of a comprehensive baseline declaration at EIF that provides detailed information about TAIs and facilities, their locations, and status. For specific sites, the baseline declaration should be accompanied by diagrams of the overall sites including locations and layout of buildings associated with TAIs and activities, and any areas on given sites without TAIs. By doing so the baseline declaration provides a foundation of "ground truth" needed for monitoring and inspection activities, develops an understanding of the overall nuclear weapons enterprise, and forms the background against which to detect anomalous activities that may indicate diversion. Regular updates (semi-annually for example) of the baseline declaration as well as extensive notifications of ongoing activities that involve TAIs and facilities also are essential to cue possible monitoring and inspection activities.

Tags, and Seals, and UIDs. Robust tamper-indicating tags, seals, and UIDs are important to help ensure chain of custody. Regardless of the specific point in the dismantlement process, they are the first line of defense against diversion. Their importance is even greater in deterring diversion during transport when security considerations will necessarily impede the chain of custody, allow for only after-the-fact notifications that transport has taken place, and create the types of unique challenges (and need for innovative complementary measures) discussed above.

Remote Monitoring Measures. Verification mechanisms like CCTV combined with portal monitoring is essential to track movements of TAIs in and out of specific sites to increase the risk that diversion would be detected. Portal monitoring could be used to monitor specified areas on a given site (e.g., storage, dismantlement, and other areas declared to contain items subject to an agreement). As a complement to notifications, it is important that portal monitoring be able to monitor both movement into and out of specified areas.

Different Options Exist for Conducting Portal Monitoring. These include ad hoc use during specified activities (e.g., dismantlement of nuclear warheads or delivery systems); a hybrid model that includes continuous monitoring, but only periodic access by inspectors to the monitored data (e.g., nuclear warheads in storage bunkers); or a monitoring presence with inspectors permanently on-site. Of these approaches, the personnel and resource cost clearly would be highest for a permanent on-site presence. The payoffs, limitations, costs, and value-added of different approaches warrant further assessment.

At the same time, the utility of portal monitoring varies depending on the specific site. For example, its value could be significantly less in the case of a road-mobile ICBM base in which standard operations entail continual movement of mobile launchers on and off base. Operational requirements also would limit the timeliness of any notifications from the monitoring system at such a base.

With regard to the overall strategy for using portal monitoring technologies, issues to explore further include multi-function portal monitors (e.g., confirming in-out movement but also specific characteristics of given items); how to create a network of technical monitoring means for a given site in which different means can communicate with each other (e.g., tags and seals on storage bunkers containing warheads awaiting dismantlement); and the optimal deployments of portal monitors at different sites. More broadly, it is important to think in terms of an integrated suite of verification measures (e.g., combining portal monitoring with CCTV, tags, seals, and inspections).

Specific Inspection Types. A mechanism for close-out, formerly declared facility, and challenge inspections is particularly important to increase the risk of detection of diversion involving undeclared retention or production of excess nuclear warheads. Close-out inspections of nuclear weapon facilities no longer active in a NEW take on special importance. By rendering their nuclear warhead-related infrastructure inoperable or putting in place monitoring measures to confirm non-use, such close-out inspections make it necessary for a diverter to recreate that infrastructure and, thus, reduce the relative attractiveness of such sites as part of a diversion strategy. Such close-out inspections, particularly when combined with Formerly Declared Facility Inspections, increase the difficulties for a state to attempt to reconstitute nuclear weapon facilities clandestinely.

In turn, the distinct safety and security "footprint" associated with storage of nuclear warheads as well as of nuclear warhead production provides a signature for use by an inspecting entity when allocating formerly declared facility and challenge type inspections. Procedures for these types of inspections would need to be based on a systems approach that took into account the complete NWE in a treaty party, the state of implementation of the treaty, past inspection activities, and other factors.

National and Multilateral Technical Means. In conjunction with a right to conduct formerly declared facility and challenge inspections, national and multilateral technical monitoring means have an important role to play in increasing the risks of detection of undeclared retention or production of nuclear warheads. Here, too, the distinct safety and security "footprint" associated with the operation and storage of nuclear warheads as well as of nuclear warhead production provides a signature for monitoring and inspection activities.

4.2.2 Possible PPTT Opportunities to Explore

Innovative Technologies for Tags, Seals, and UIDS. The group highlighted a number of areas to explore, including active tags/seals that monitor the integrity of a container and record when it's been sealed or opened. Also, use of UIDs that can be automatically read when an item passes a reader or is interrogated by a facility inventory system; and possible specialized "Buddy Tags" on nuclear warheads in containers to allow confirmation that items declared to contain a nuclear warhead in fact do.

Information Barriers and Container Weight. Closely related, the concept of information barriers could be broadened from its focus on radiation monitoring of nuclear warheads to

Buddy Tags

The concept of Buddy Tags envisages two tags, one on the inside of a nuclear warhead container and one on the outside. Data concerning the status of the warhead from the internal tag would be relayed to the external tag for reporting when queried by an inspector hand-held device, module or portal. It would relay only that the contents match or do not match the stored signature, that the container has/has not been opened and if so the time/date of such opening), and its combined UID and date of establishment.

consider possible options for use in conjunction with UIDs and other inspection activities. One possibility would be use of an information barrier as part of a system that would allow determinations that the weight of containers is consistent ("redlight/green light" based on a more than/less than criteria) with the presence or absence of a nuclear warhead within the container.

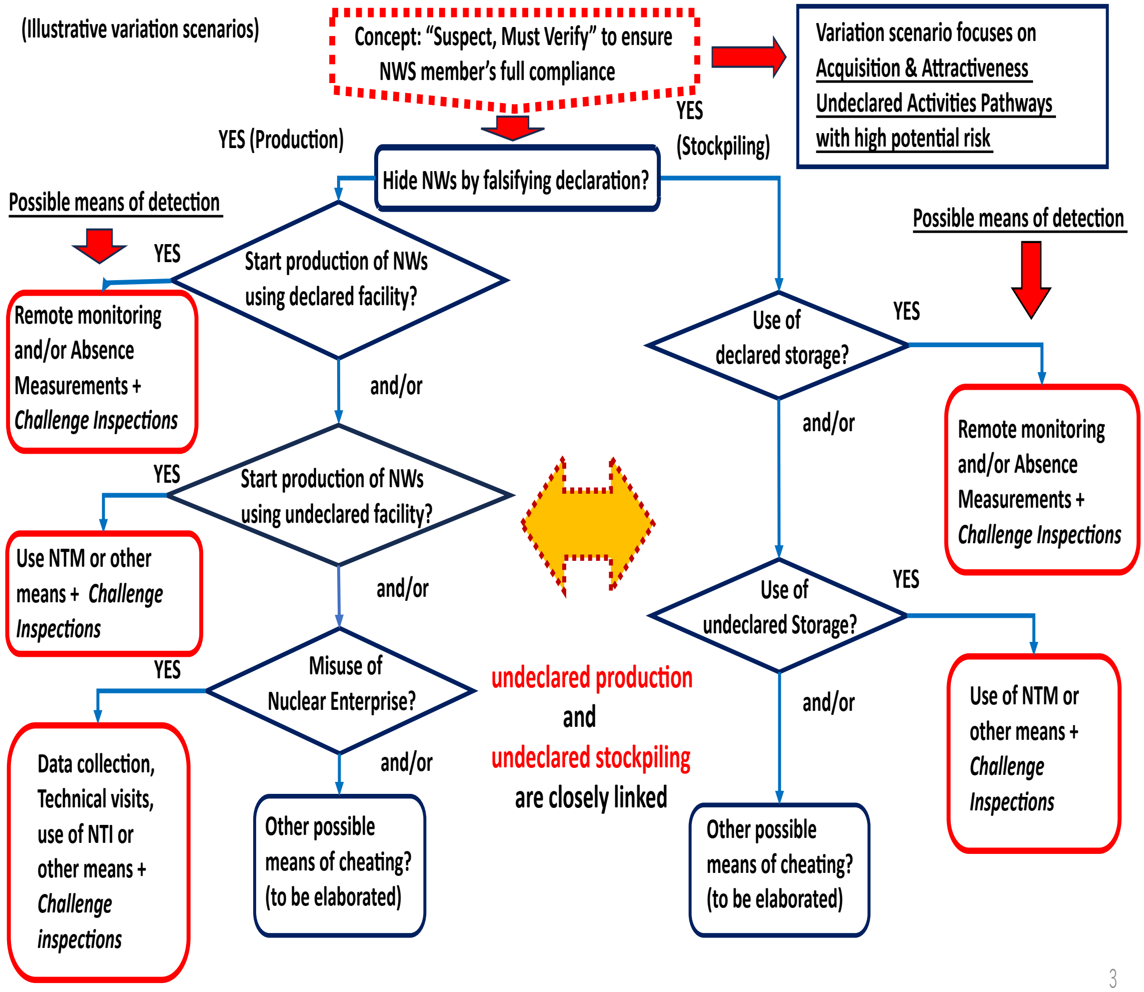
Comprehensive Declaration of TAIs. The list of items that are accountable under an agreement is vitally important to the effective verification of that agreement. Baseline and periodic declarations should include items beyond just nuclear warheads and their components but also delivery systems and associated hardware.

Restrictions on TAI Movement. Movement restrictions can strengthen deterrence of diversion, recognizing that such restrictions are most effective on items that can be monitored remotely. One possibility would be limits on movement of items (nuclear warheads and delivery systems) once an impending inspection has been notified. Another example is the implementation of continuous area monitoring with an access controlled, monitored boundary for stored nuclear warheads even if the data were only periodically reviewed by inspectors because of concerns about security of transport. Segregated areas could also be considered to help reduce the vulnerabilities of intra-site movement of nuclear warheads in storage at assembly/disassembly sites.

Dedicated Areas for Monitoring and Inspection Activities. Practical considerations (cost, construction time) rule out establishing new, purpose-built facilities for storage or dismantlement of nuclear warheads under a future nuclear disarmament agreement. However, the possibility exists of establishing and maintaining a dedicated area within an existing facility ("plant-within-a-plant") for carrying out treaty-related monitoring and inspection activities. This dedicated area would make it easier to detect undeclared activities or diversion of nuclear warheads during dismantlement operations by allowing for more effective monitoring of movement in and out of that facility. Similarly, segregating the space where treaty-accountable nuclear warheads are stored to keep them separate from non-accountable warheads would reinforce verification. This process may also help meet required security controls, by keeping all treaty-related inspection activities (outside of storage and transit) constrained to a single controlled location.

The Modalities of Close-out, Formerly Declared Facility, and Challenge Inspections. As the reductions process continues it will be important to explore what balance to strike between verification of the dismantlement and disposition of nuclear warheads and their components and the verification of infrastructure no longer used for nuclear weapon purposes. Dedicated inspections for the close-out or conversion of nuclear weapons infrastructure are likely to become increasingly important. Formerly declared facility and challenge inspections, as shown by Figure 6, serve as key measures to increase the risk of detection of undeclared retention or production of nuclear warheads at non-accountable sites. Key issues yet to be fully addressed include when and where such inspections add value, the modalities of their use, and how to blend challenge inspections into an overall inspection strategy.

Figure 6: Potential Risk of Cheating Posed by NWS by Undeclared Activities in Conjunction with Current 14-Step Verification Scenario



4.2.3 Some Implications for Further Work

During its three phases of work, the IPNDV has focused on three different verification scenarios: reductions from 1,000 to 500 nuclear warheads; reductions from 500 to zero nuclear warheads; and limitations of nuclear warheads at a level of 500 warheads. Both of the first two scenarios posited the dismantlement of nuclear warheads and the disposition of the resulting SNM and components.[6] To what extent do the results of the work of the Reductions Working Group on detecting diversion in a reductions to zero scenario offer potential insights for the other two scenarios as well as for the overall work of IPNDV? As a starting point for further discussion, the following propositions may be set out.

[6] For a description of these three scenarios, see *Verification of Nuclear Disarmament: Insights from a Decade of the International Partnership for Nuclear Disarmament Verification*, June 2024, pp. 10-11, 17.

First, given the comparable dismantlement activities involved in the scenario of reductions from 1,000 to 500 nuclear warheads, the results here are directly applicable in that case. This includes the importance of deterring diversion from declared activities by the risk of detection of comprehensive declarations and notifications and the use of multiple PPTT options to establish and sustain robust chain of custody.

Second, in all three scenarios, robust formerly declared facility and challenge inspection procedures are essential to detect undeclared activities. Thus, further work in this area would pay off for all three scenarios.

Third, the challenges of detecting diversion involving undeclared activities may be greater in the reductions from 1000 to 500 nuclear warheads and in the limitations to 500 nuclear warheads scenario than in the reductions to zero scenario. Particularly in the limitations scenario, the ongoing flows of nuclear warheads through the NWE as part of sustaining Ipindovia's operational nuclear weapons capability could provide greater "cover" for undeclared activities.

Fourth, particularly in the limitations scenario, those ongoing flows of nuclear warheads in an active deterrent posture could provide additional diversion pathways not explored in this report for retention of undeclared nuclear warheads or undeclared production.

5. Concluding Co-Chairs Observations and Reflections

5.1 Work of the Reductions Working Group

The Reductions Working Group examined the NWE of Ipindovia in its entirety using a systems-based approach. This approach turned out to be essential for effectively verifying compliance with treaty obligations and for rationally allocating resources. Within this framework, the group conducted a series of tabletop exercises to explore verification measures designed to counter potential diversion steps and pathways. These exercises provide further confidence that the work of the IPNDV has identified a set of declarations, monitoring, and inspection activities that with development activities, as needed, should contribute to a robust nuclear disarmament verification regime.

5.2 Implications Beyond the Reductions Scenario

The work of the group has implications that extend beyond the reductions scenario context. As shown in Table 1, the gradual reduction and eventual elimination/close-out of systems, activities, and facilities are at the core of the process of nuclear disarmament. Although not extensively discussed in Phase III, the Reductions Working Group has also identified the importance of thinking through the requirements for sustaining zero status once it is achieved. This includes considering other issues not yet addressed (e.g., residual latent nuclear weapons-related capabilities and related peaceful nuclear use) as well as the mechanisms necessary to ensure continued compliance and confidence in a world of zero nuclear weapons.

A comparison with the Limitations Scenario shows that both approaches have several common verification challenges and resource considerations, although the reductions to zero scenario has stricter irreversibility and long-term assurance demands. Therefore, insights gained from one scenario can inform the design of verification regimes under the other, strengthening the framework's overall robustness.

The systems approach applied throughout this analysis is also relevant to the reductions to zero scenario. Considering the NWE as an integrated system—including its facilities, processes, and potential diversion pathways—allows for better anticipation of interdependencies, reduction of vulnerabilities, and enhancement of deterrence and detection across different disarmament pathways.

5.3 Implications Crafting Effective Monitoring and Inspection Regimes for Nuclear Disarmament Verification

The work of the Reductions Working Group, especially related to deterring potential diversion by the risk of detection, also suggests a number of principles to be considered in the design of any monitoring and inspection regime for future nuclear disarmament verification. In summary, possible principles that would increase confidence in verification robustness, make diversion more complicated, and strengthen deterrence of diversion by the risk of detection include:

- Ensure robust baseline and periodic declarations and on-site inspections to establish a foundation for effective verification.
- Seek to identify and address potential diversion pathways.
- In a systems approach, understand all aspects of the NWE, its infrastructure, and its normal operations.
- In a systems approach also make use of different strategies for randomization in the allocation of monitoring and inspection resources.
- In any systems approach, take account of the shared steps or nodes of different diversion pathways in addition to the individual diversion activities.
- Ensure redundant layers of verification for each step in the dismantlement process, leveraging complementary monitoring and inspection measures to do so.
- Build flexibility into the allocation of monitoring and inspection resources as well as possible upgrades for new technologies to allow for a dynamic process in which more attractive diversion pathways may vary over time.
- Leverage existing experience with the monitoring, inspection, and elimination of delivery vehicles as an adjunct to verification of the elimination of nuclear warheads or the absence of undeclared activities in a reductions to zero regime.
- Incorporate an integrated approach with both in-country monitoring and inspection measures and national and multilateral technical monitoring means, including non-interference, to any verification regime.

5.4 Next Steps in Building Global Understanding and Capacity for Nuclear Disarmament Verification: An Agenda for Future Work

Future work in nuclear disarmament verification should focus on strengthening conceptual frameworks and practical measures to improve the global understanding of, and capacity for, nuclear disarmament verification. Several avenues for continued research and collaborative exercises have been identified.

One priority is exploring a sustaining zero scenario. This could include analyzing options for conducting close-out inspections, including rendering unusable former nuclear weapons infrastructure and examining irreversibility concepts across the scenario's different phases. Additional tabletop and scenario-based exercises, both in-person and virtual, would refine methodologies and test verification tools. Detecting undeclared activities should receive special attention, including more in-depth analyses, such as quad chart evaluations, and structured frameworks, such as the layered "Swiss cheese" model (in which different monitoring and inspection measures may overlap and in so doing compensate for the limitations of any one of them), to strengthen confidence-building measures.

Other areas for further technical investigation include alternatives to down-blending of SNM as an approach to disposition, their degree of irreversibility, and technological requirements. Building on the reductions to zero scenario, scenario development could incorporate elimination measures of categories of nuclear weapons, such as those in the Intermediate-Range Nuclear Forces (INF) Treaty. Still other specifics could include following up the initial analyses in Phase III of logistical and design options to support verification (including, e.g., segregated storage and sites-within-a-site), detection of undeclared activities, and time constraints on specific dismantlement activities.

Methodologically, Bayesian belief network models could provide a structured way to understand the NWE and select PPTT. This approach would also provide a framework for communicating verification choices to third parties.

Looking ahead, it will be especially important to clearly articulate areas where conceptual approaches to verification are mature, while also acknowledging unresolved challenges that require continued analysis and technical exploration. Developing a white paper or similar synthesis product could help consolidate achievements and outline a roadmap for future work.

5.5 Reductions Working Group in Phase III: A Closing Reflection

In the Reductions Working Group, our approach to Phase III emphasized the importance of a three-tiered analytical approach that considers systems-level factors, diversion pathways, and PPTT. Mini-exercises were useful for connecting these layers. The process also underscored the importance of cooperation among diplomats and technical experts, both from states with and without nuclear weapons. Building trust emerged as a central theme, with the IPNDV playing a pivotal role in fostering a comprehensive and shared appreciation of verification challenges—and in advancing our shared understanding of how to meet those challenges to advance the goal of nuclear disarmament.

About IPNDV the International Partnership for Nuclear Disarmament Verification

The International Partnership for Nuclear Disarmament Verification (IPNDV) convenes countries with and without nuclear weapons to identify challenges associated with nuclear disarmament verification and develop potential procedures and technologies to address those challenges. The IPNDV was founded in 2014 by the U.S. Department of State and the Nuclear Threat Initiative. Learn more at www.ipndv.org.