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Insights and Lessons from the IPNDV's Nuclear Disarmament Verification Exercises

IPNDV
INTERNATIONAL PARTNERSHIP FOR
Nuclear Disarmament Verification

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Belgian Director General for Multilateral Affairs and Globalisation Axel Kenes delivers opening remarks at JUNEX22.

Credit: Thomas Daems

Background

Now in its third multi-year phase, the International Partnership for Nuclear Disarmament Verification (IPNDV) continues to address the challenges and potential solutions involved with future nuclear disarmament verification. The IPNDV's work provides a critical conceptual and practical foundation for pursuit of a world without nuclear weapons.

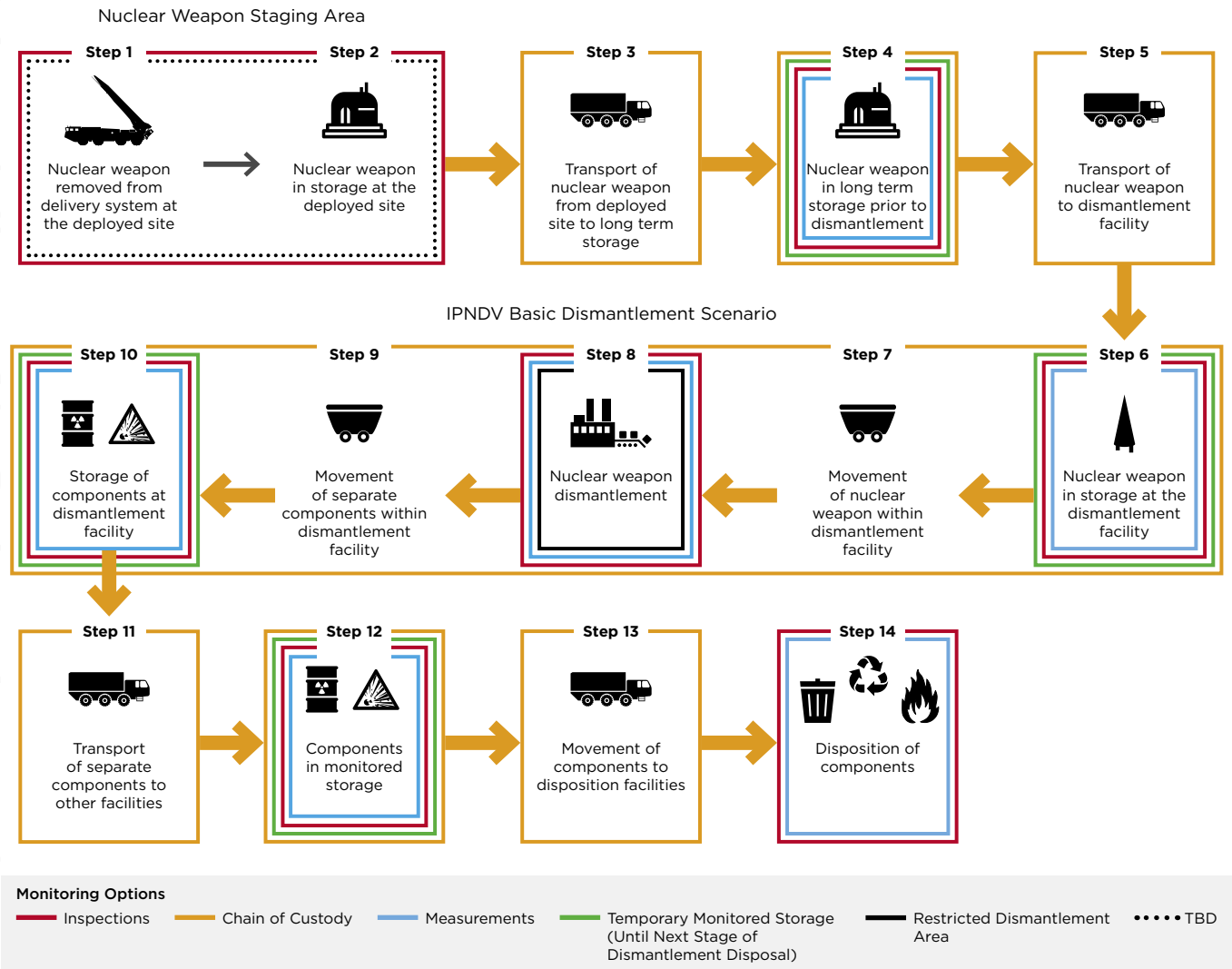
Phase III of the IPNDV began in January 2020. Shifting "from paper to practice," this phase emphasizes using a scenario-based approach to test and assess inspection processes, procedures, techniques, and technologies (PPTT) for verification of the different disarmament steps set out by the IPNDV's 14-Step model of the nuclear warhead dismantlement process.[1] The specific scenario posits a notional nuclear weapon-possessing country called Ipindovia that is obligated under a multilateral nuclear weapons reduction treaty to reduce and dismantle 500 of the 1,000 warheads in its nuclear arsenal with the reductions verified by a multilateral verification body. For verification, the treaty obligates Ipindovia to make different types of declarations about its nuclear-weapons enterprise and sets out specific inspection PPTT to be used for the associated verification activities. The scenario also provides detailed information on the nuclear weapons enterprise of Ipindovia, including related facilities and the locations of warheads.

Phase III also saw the creation of two task groups, the Inspector Task Group and Host Task Group, to glean additional understanding of the unique perspectives from hosts and inspectors involved in multilateral nuclear disarmament verification activities. Additionally, the Technology Track was established to continue the IPNDV's assessment of technologies to support nuclear disarmament verification as well as to provide expert technical guidance throughout the various Phase III exercises.

Despite the impacts of the COVID-19 pandemic, the Partners have conducted four major virtual or in-person exercises in Phase III thus far: the December 2020 "Inspection Planning" tabletop exercise, the June 2021 "Westend Base Inspection" tabletop exercise, the April 2022 Franco-German "Nuclear Disarmament

[1] Both the 14-Step model and the diverse PPTT are described in the Phase II Working Group 5 Report: *Verification of Each of the 14 Steps of Nuclear Weapon Dismantlement.*

Figure 1: Monitoring and Verification Activities for Key Steps in the Process of Dismantling Nuclear Weapons



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

Verification" exercise (NuDiVe22), and the June 2022 "Transport-Long-Term Storage Inspection" (JUNEX22) tabletop exercise.

The substantive reports prepared after each of these exercises highlight unique insights and lessons learned by organizers and participants. This report aims to cross-examine and highlight parallels across all the exercises. In so doing, it draws on the more specific exercise reports and also complements the Phase III interim report, *Building a Nuclear Disarmament Verification Tool Kit,* that documented the accomplishments of Phase III through the first two years. This report begins with a brief description of each exercise before turning to a discussion of cross-cutting insights and lessons learned from the exercise series.

The Exercise Series in Brief

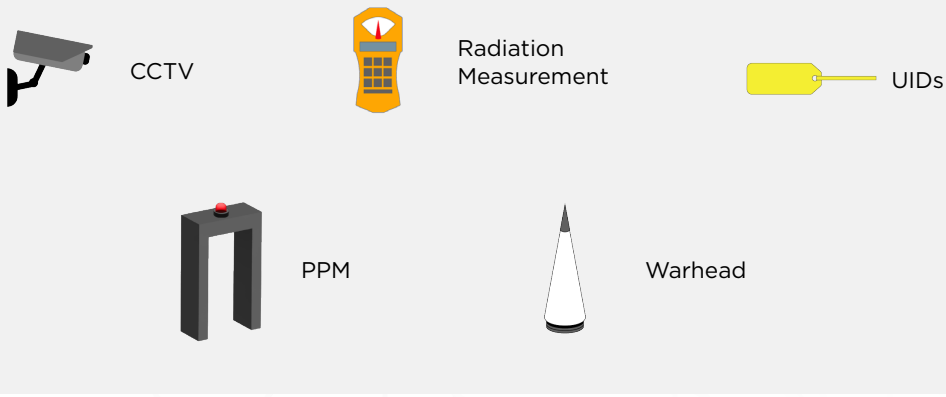
December 2020 Inspection Planning Tabletop Exercise. The series kicked off with a virtual tabletop exercise in December 2020. Unlike later exercises, this planning exercise did not focus on a specific step of the 14-Step model. Instead, within the framework of the scenario, it explored similarities and differences in the perspectives of inspectors from a Multi-State Verification Body (MSVB) and Ipindovia hosts as they each planned for initial implementation of the verification provisions of the notional Nuclear Weapons Reduction Treaty (NWRT). Particular attention focused on inspector and host objectives, what content Ipindovia should include in declarations about its nuclear weapons holdings and enterprise (numbers of nuclear warheads, locations, and related infrastructure), and the specific types and quantity of monitoring and inspection activities to verify those declarations.

June 2021 Westend Base Inspection Tabletop Exercise. The June 2021 exercise was designed to test and refine the relevant PPTTs for Steps 1 and 2 of the 14-Step nuclear dismantlement model: Step 1, the verified removal of a warhead from its delivery system and Step 2, the temporary storage of that warhead, as well as inspection of other warheads already designated for dismantlement and in storage at the Weapons Storage Area (WSA). Using the Ipindovia scenario, the exercise explored the process of on-site inspections under the NWRT at Ipindovia's Westend Mobile Intercontinental Ballistic Missile (ICBM) Base. Inspectors were tasked with observing the removal of one designated warhead from its associated delivery vehicle; initializing warhead verification under the treaty's accountability process, which included applying unique identifiers (UIDs), tags, and seals; transporting that warhead to a designated bunker at the base WSA; and confirming Ipindovia's declared number of warheads slated for dismantlement and in storage at the WSA.

April 2022 "NuDiVe22" Dismantlement Exercise. Inspectors, hosts, and technology advisors met in person in Germany for the April 2022 NuDiVe exercise co-hosted by France and Germany. Focused on Step 8 of the 14-Step model, NuDiVe22 simulated an inspection to confirm the dismantlement of a nuclear warhead subject to the

Dr. Irmgard Niemeyer, head of the Nuclear Safeguards and Security Division at Germany's Forschungszentrum Jülich research institution and organizer of NuDiVe22, in Brussels for JUNEX22.

Credit: Thomas Daems



Credit: Juliet Henry

Icons created for virtual game boards used in JUNEX22. The game boards helped participants track where inspection activities were taking place. For example, which tools inspectors were using, where they were using them, and which bunkers contained warheads.

NWRT at Ipindovia's primary nuclear weapons handling complex (the Lead Assembly/Disassembly Unit, or LADDU). The exercise used actual inspection tools (e.g., tags, seals, and closed-circuit TV [CCTV] monitors) and radioactive sources to simulate the nuclear warhead to be dismantled. NuDiVe22 built on the foundation of the first NuDiVe exercise, which was held in 2019. The two NuDiVe exercises partly explored the relationships and mutual trust that develop between the inspectors and hosts as a result of repeated verification work. Additionally, the NuDiVe exercises' iterative process allowed for inspectors and hosts to gain familiarity with the PPTT used in both exercises.

JUNEX22 Transport-Long-Term Storage Inspection Tabletop Exercise. In June 2022, the IPNDV met for an in-person tabletop exercise to test and assess the PPTT associated with Steps 3 and 4 of the 14-Step model: Step 3, confirming the periodic transport, receipt, and placement of nuclear warheads subject to a disarmament agreement in long-term storage and Step 4, confirming the declared number of nuclear warheads designated for dismantlement and in long-term storage. Specifically, inspectors were tasked with confirming the transport of four nuclear warheads from the Westend Mobile ICBM Base to long-term storage in the WSA located at LADDU. They also conducted an inspection of the WSA to verify storage of those four nuclear warheads in long-term storage and to initialize chain of custody on an additional 25 nuclear warheads declared by Ipindovia as subject to the NWRT.

Some Insights and Lessons Learned

Together, the more practical exercises conducted so far during Phase III have confirmed and refined the more conceptual analysis done by the IPNDV in its earlier phases and offered valuable insight into the challenges of planning and executing an effective nuclear disarmament verification regime. The lessons learned from the exercises also present a useful toolkit for developing future exercises and simulations. Five high-level themes emerged:

1

The IPNDV Is on the Right Track

The series of exercises covered, in varying levels of detail, almost all the spectrum of activities set out in the 14-Step model: overall inspector and host verification planning; verification of the initialization of nuclear warheads into the dismantlement process and their storage at a deployment base; transport of nuclear warheads from a deployment base to a central site for longer-term storage prior to dismantlement; longer-term storage of nuclear warheads prior to dismantlement; and dismantlement of nuclear warheads.

The results of the exercises *validated the overall set of inspection PPTT* developed in earlier phases—different types of declarations, on-site inspection procedures to confirm the information provided by those declarations, and use of relevant verification technologies (including radiation measurement options). The exercises also tested different types of managed access procedures that limit inspectors' access and activities to protect proliferation-sensitive and other sensitive information, and helped participants understand how to use those procedures effectively. Most broadly, the exercises confirmed the basic judgment of the IPNDV that multilateral verification of nuclear disarmament, with participation of personnel from countries with and without nuclear weapons, can be made to work while protecting sensitive information.

At the same time, the exercises *highlighted issues related to the more detailed implementation of the PPTT.* Such implementation issues have refined the IPNDV's understanding of the PPTT and how to implement them. These discoveries have become

Credit: Thomas Daems

JUNEX22 participants discuss the processes, procedures, techniques, and technologies examined in the hybrid exercise.

an input to additional work within the IPNDV, including work on more detailed inspection concepts in the Inspector Task Group and exploration by the Technology Track of inspection approaches that rely less on the use of verification technologies and, thereby, make it easier to protect sensitive information.

From the first December 2020 Inspection Planning tabletop exercise to JUNEX22, the exercises also repeatedly demonstrated the *shared interest of both inspectors and hosts in effective verification* of nuclear disarmament. Even so, the exercises also highlighted differences in the perspectives of inspectors and hosts with regard to their respective objectives, the scope and content of declarations made to support verification, and the implementation of different PPTT. In part, greater host circumspection often reflected the need to protect sensitive information and the overriding demands of ensuring the safety and security of nuclear weapons. The exercises, however, also provided an opportunity to explore ways to resolve inspector-host differences in a way that permitted effective implementation of verification activities (e.g., using perimeter-monitoring technology to confirm no unauthorized access to the nuclear-warhead storage bunkers at Ipindovia's long-term storage site without raising safety issues during JUNEX22).

2 The Centrality of Chain of Custody

The exercises highlighted the centrality of maintaining chain of custody over treaty-accountable items (nuclear warheads in the Ipindovia scenario) in the verification of any future nuclear disarmament agreement. In that regard, one insight identified in NuDiVe19, reaffirmed in NuDiVe22, and again in JUNEX22 was the concept of *reliance on "two layers of verification security."* That is, to ensure chain of custody, it is essential to put in place two independent means of verification (e.g., in each of these three exercises, relying on both unique identifiers and radiation detection measurements). Doing so avoids a single point of failure anywhere in the chain of custody of treaty-accountable items. With

two layers of security, if a problem occurs with one layer, the second layer will provide needed back-up and contribute to recovery from any breakdowns in chain of custody. Closely related, an additional conclusion from the exercise series is the importance of verifying as many attributes as possible of treaty-accountable items as soon as possible in the inspection process.

At the same time, the exercises also highlighted some of the *challenges of sustaining chain of custody through two layers of verification security.* By way of example, during NuDiVe22, on-the-spot adaptations to the inspector plan led to the movement of sensitive nuclear material with inadequate chain of custody measures. While a CCTV system was a key monitoring mechanism, an unforeseen problem with this technology resulted in decreased confidence in the inspection overall. Somewhat differently, one part of the JUNEX22 exercise dealt with 25 nuclear warheads declared by Ipindovia as having been moved from its active nuclear arsenal, placed in long-term storage, and made subject to the NWRT, all without any direct observation or prior confirmation of their movement by inspectors. Given time constraints on the use of radiation measurements to confirm the presence of fissile material, however, it proved difficult to fully implement a two-layer approach to establishing chain of custody over these newly declared warheads. Thus, both exercises underscored the importance of using future exercises, as well as other activities, to refine application of the two-layer concept, including challenges to its successful use and workarounds to such challenges.

In addition, the series of exercises also provided insights into how *unpredictable contingencies and events can impact inspections* by affecting equipment, disrupting timelines, and, often, undermining chain of custody. Such contingencies were intentionally built into later exercises, as with the extensive set of technical problems and weather-related occurrences explored in JUNEX22. Approaches to verification of future nuclear disarmament will need to take into account how to recover from such contingencies.

Finally, closely related to the criticality of sustaining chain of custody, the series of exercises highlighted the importance of thinking about *how to coordinate, integrate, and prioritize the discrete verification PPTT and inspection activities across the different steps of the 14-Step dismantlement model.* For example, during JUNEX22, the inspection team was required to choose between inspecting the treaty-accountable nuclear warheads prior to shipment from the

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Westend Mobile ICBM Base or after receipt at the WSA at LADDU. Although participants agreed that chain of custody was maintained within the scenario, based on a hypothetical earlier (or later) inspection, their discussion highlighted a shared hesitation to choose between critical inspection activities. It also highlighted the importance of continuing discussions about the requirements for fully maintaining the chain of custody of a treaty-accountable item during such transfers.

3 The Need for Strengthened Understanding of Inspection Technologies, Their Uses, and Implementation Procedures

The set of exercises *validated the overall set of inspection technologies identified* by the IPNDV as well as their potential contributions to verification of the dismantlement of nuclear warheads according to the 14-Step model. The exercises also refined initial thinking about how to use specific technologies to help achieve the verification objectives posited in the Ipindovia scenario. Partners also gained insights into how to blend and use mixes of verification technologies.

As was first highlighted after the June 2021 Westend Base Inspection exercise, the exercises also made clear that it is particularly important to *broaden understanding among all IPNDV participants of the specific technologies and equipment* needed for various inspection tasks. Familiarity with the array of technologies, equipment, and processes at play, as well as how long they may take to set up, operate, cool, and tear down, contributes to more robust exercise planning, prioritized inspection plans, and efficient, effective execution of exercises. It is also the basis for credible judgments about potential development priorities and future uses of verification technologies for nuclear disarmament.

Different exercises *addressed the challenge of knowledge of verification technologies and their implementation* in different

Credit: Forschungszentrum Jülich / Sascha Kreklau

Inspector team members preparing to examine tags and seals during NuDiVe22.

Writ large, the exercises made clear the importance of more detailed concepts for carrying out inspection activities in specific steps of the 14-Step model.

ways, all of which will be important to confront going forward. NuDiVe22 used a guide outlining specific steps to be carried out in verification of dismantlement. This guide gave a description of each inspection step, listed the required equipment, marked the facility or location where that step would take place, and the amount of host and inspector personnel required to execute it. Participants were also provided with procedure descriptions highlighting the key aspects of each step, and equipment manuals that detailed information on how each piece of equipment is initialized and operated. Pre-game briefings and more detailed summaries of different technologies were provided to participants in preparation for JUNEX22. JUNEX22 also had time built into the exercise for in-depth discussions among inspectors and hosts on how different technologies could be used to help ensure the integrity of a storage facility undergoing inspection and how to confirm the accuracy of host-supplied site diagrams.

The *importance of flexibility in planning for use and implementation of specific inspection technologies* also was highlighted through the exercise process. One of the insights from NuDiVe22 was that inspectors benefitted from having detailed guidance, but at the same time, effective and efficient use of specific technologies sometimes required flexibility when implemented in a specific situation. More broadly, the exercises highlighted the possible *tensions between use of specific verification technologies and time constraints.* This tension was particularly evident during JUNEX22, when the inspectors at the long-term storage site were unable to carry out all of their initially proposed radiation measurements within the time allotted for the inspection. Both the time required for opening and closing bunkers sequentially in moving a nuclear warhead to the designated measurement location and for setting up, operating, and tearing down certain types of gamma radiation detection equipment constrained inspectors' activities.

4 Some Outstanding Substantive Priorities for Future IPNDV Activities

The series of exercises highlighted issues and areas for further analytic and technical work by the IPNDV. Some of this work already is underway. Writ large, the exercises made clear the importance of *more detailed* concepts for carrying out inspection activities in specific steps of the 14-Step model. For example, the June 2021 Westend Base exercise raised

questions about how to allow inspectors to observe the removal of a warhead from a delivery vehicle or to observe hosts' application of tags and seals to containerized warheads on behalf of inspectors. As such, the exercises have provided input and served as a stepping-stone to the continuing work of the Inspector Task Group on inspection concepts of operations.

Similarly, the different perspectives between inspectors and hosts, first evidenced in the December 2020 Inspection Planning exercise, underlined the importance of efforts by both the Inspection and Host Task Groups to *identify the unique perspectives of each* and the implications of these differences for future nuclear disarmament verification. Parallel papers are now being prepared to do so.

The Technology Track has also moved forward to respond to the need for more detailed guidance on specific technologies and their effective use. Equally important, it has begun to explore possible *low-technology inspection options* as a means to lessen verification complexities and respond to constraints in the use of certain highly intrusive radiation detection verification technologies resulting from the need to protect sensitive information.

Different exercises also underlined the importance of the joint work of the Inspector and Host Task Groups to explore the elements of a *"Systems Approach"* to nuclear disarmament. A systems approach would help set inspection priorities, support necessary phasing of inspection activities, and optimize use of the different PPTT to achieve verification objectives, all among challenges highlighted by the exercise series. Now underway, the continued elaboration of the elements of a systems approach and its possible testing within the Ipindovia scenario would respond to the injunction from several of the exercises that the IPNDV needs to "think strategically."

Closely related, the series of exercises has highlighted the need to begin *thinking about nuclear disarmament verification conceptually as a multi-site, multi-year process.* In that way, synergies can be identified across inspection activities while exploring how overall verification confidence builds over time. Initial thinking is underway within the IPNDV on how to address this multi-site, multi-year dimension.

More narrowly, across the exercises, a number of *specific substantive topics* were identified as warranting future analysis or discussion within the task groups or the Technology Track, or as possible inputs into future exercises. Among these topics were:

- How to balance the verification of correctness of declarations and the verification of completeness of declarations by parties to a disarmament agreement
- The design and implementation of "Information Barrier Approaches" to provide needed technical information from use of verification systems without compromising sensitive information
- Further refinement of the "two layers of verification security" concept

- Identification of promising detection technology options for highly enriched uranium (HEU)
- The elements or dimensions of verification confidence and how to build verification confidence over time
- The impacts of the time available for inspections and to carry out specific PPTT on the planning and implementation of inspection and host approaches
- More detailed analysis of an inspection "sampling strategy" considering the concept of treaty-based inspection annual quotas, to shape decisions about how to allocate inspection resources, particularly as the number of treaty-accountable items subject to inspection increases significantly
- Additional analysis to identify possible diversion or cheating pathways in the Ipindovia scenario, how to address them, and their implications for overall inspection strategy
- Additional analysis of possible unexpected contingencies and their impact

Lastly, the exercises conducted during Phase III underline the importance, for both inspectors and hosts, of the need for familiarity with nuclear weapon sites and related activities as well as the unique safety and security requirements associated with those sites. Before several exercises, briefings on the inspection processes under the START and New START treaties were provided to exercise participants and improved PPTT and inspection-related knowledge among them. NuDiVe22 and JUNEX22 also underscored and provided insights into the many and sometimes unexpected ways that safety and security can impact the inspections.

5 Lessons for Future Exercise Planning, Design, and Implementation

The exercise series demonstrated that *active engagement by participants ahead of each exercise* can directly contribute to their successful outcome. Moreover, personal familiarity among participants, in advance of planned exercises, can heighten accountability and strengthen preparatory processes in many ways. For example, after NuDiVe22, evaluators and organizers observed that several participants appeared less prepared for the exercise than had been the case during the earlier NuDiVe19 exercise. They attributed this in part to the fact that prior to NuDiVe19, participants had engaged in planning activities on the sidelines of in-person IPNDV meetings. Another example comes from the June 2021 Westend Base exercise. In that case, the fact that identification of team leaders and team members was made only in the

Personal familiarity among participants, in advance of planned exercises, can heighten accountability and strengthen preparatory processes in many ways.

immediate run-up to the exercise reduced the time inspector and host teams spent planning for the exercise, revisiting PPTT, and developing inspection plans. By contrast, more timely identification of team leaders and members well ahead of the exercise facilitated discussion in JUNEX22. Relatedly, NuDiVe22 and NuDiVe19 organizers noted that preparation for each exercise could have included additional attention to the most important components of the exercise (in this case, the movement of treaty accountable items and sensitive nuclear material containers). Last-minute changes to the inspection plan executed during JUNEX22 similarly highlighted the importance of sufficient time for thinking through inspection priorities in advance, during the planning process.

Also, *building additional time for pre-exercise planning and coordination between inspectors and hosts into the exercise design* could facilitate the implementation of specific inspection PPTT. The impact of safety and security requirements on such implementation provides an example from JUNEX22. The inspector team was unable to use proposed containment and surveillance technologies due to a safety requirement that the WSA bunkers do not have any electrical power available. Inspectors were also unable to use battery-operated cameras due to fire hazards and they were restricted in their ability to use CCTV capabilities near the entrance to LADDU given security constraints. A candid conversation between the inspection and host teams ahead of JUNEX22, coupled with knowledge of the PPTT and exercise framework, could have avoided this confusion.

Demonstration of the Trusted Radiation Identification System (TRIS) during NuDiVe22.

Credit: Forschungszentrum Jülich / Sascha Kreklau

The use of sub-teams to carry out different inspection (and associated host) activities first in the June 2021 Westend Base exercise and then again during JUNEX22 proved effective for allocating personnel. But there was little *coordination between sub-teams* which diminished their ability to communicate effectively during the exercises and, more importantly, impeded efforts to link diverse inspection activities efficiently and cohesively. After the June 2021 exercise, a preference emerged for team leads to not be members of one of the sub-teams. But team leads were again members of the sub-teams during JUNEX22. Going forward, exercise planning needs to explicitly address how to achieve better sub-team coordination, with an aim to identify priorities, division of labor, and effective communication prior to initiation of the exercise.

Over time, the series of exercises became more realistic and detailed in terms of the information provided to the participants, the exercise tasks, and the flow of activities. Nonetheless, a continuing theme of the "hot washes" conducted after each of the exercises has been the *importance of making them even more detailed and realistic.* Looking back across the different exercises, various ways of doing so stand out and could be pursued further in future exercises. Operational or other limitations could be built into the inspection timeline provided to both hosts and inspectors (e.g., the time needed to remove and re-store inspection equipment while maintaining chain of custody as well as the impact of limits on the movement of nuclear warheads). Inspectors also could be provided with still more detailed information on the "inspection history" or "origin story" of

JUNEX21 participants gather virtually to conduct the tabletop exercise.

past inspections (e.g., existing knowledge on facility layouts, past measurements, chain of custody information, etc.).

Incorporation of a "game clock" during JUNEX22 to show the status of the inspection in light of the activities underway added an element of realism. It helped, moreover, to highlight temporal inconsistencies between the inspectors' proposed plan and its execution. How to use the game clock more efficiently should be a priority for future exercise planning. In particular, the game clock could be especially helpful in diving deeper into the impact of unforeseen events in disturbing inspection activities.

With regard to future in-person exercises at simulated sites, NuDiVe22 showed the value of providing inspectors and hosts with detailed inspection procedures for their background, in addition to equipment operating manuals. Inspectors and hosts were also given dedicated training sessions and were encouraged to behave as though they were on separate teams, including by staying in different hotels and meeting in separate rooms.

Finally, the exercise series has contributed to a shift from the IPNDV's earlier focus on identifying the specific steps required to verify the dismantlement of a single nuclear warhead to analyzing the implications of verifying the reduction and dismantlement of many nuclear warheads involving multiple sites, the movement of nuclear warheads between those sites, and multiple inspection activities, over multiple years. Going forward, IPNDV exercise planning should emphasize the *multi-year, multi-site dimension* of nuclear disarmament verification. One way to do so would be through a series of integrated exercises, each building upon the other as if engaged in real-world verification over time.

Credit: Thomas Daems

IPNDV participants at Egmont Palace in Brussels, Belgium for JUNEX22.

Next Steps

With its series of nuclear disarmament verification exercises, the IPNDV is fulfilling its Phase III goal of shifting "from paper to practice." The exercises have validated and highlighted the IPNDV's work, whether in developing an overall set of PPTT for application across the 14-Step model, identifying key concepts for nuclear disarmament verification such as "two layers of verification security," or identifying essential verification technologies while focusing attention on implementation issues. At the same time, this review of the insights and lessons learned from the Phase III exercises suggests both ways to make future exercises more effective and areas and issues for additional work by the IPNDV. Doing so will help ensure the IPNDV's continuing successful contribution to building the verification foundation for future nuclear disarmament agreements.

Jessica Bufford, program officer at the Nuclear Threat Initiative, addresses participants at JUNEX22.

Credit: Thomas Daems

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

The IPNDV is working to identify critical gaps and technical challenges associated with monitoring and verifying nuclear disarmament. To do this, the Partnership assesses monitoring and verification issues across the nuclear weapon lifecycle.

The IPNDV is also building and diversifying international capacity and expertise on nuclear disarmament monitoring and verification. Through the Partnership, more countries understand the process, as well as the significant technical and procedural challenges that must be overcome. At the same time, the Partnership is highlighting the importance of verification in future reductions of nuclear weapons.

For more information, **visit www.ipndv.org**.

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