Verifying the Absence of Nuclear Weapons – Results of a Field Exercise

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Abstract

One of the first steps toward nuclear disarmament will include separation of nuclear weapons from their delivery systems. In this arrangement nuclear weapons would be transferred to centralized storage facilities located at some distance from the bases where delivery systems are deployed or outside of a certain geographic region. This arrangement can include a verification mechanism that would allow parties to confirm the absence of nuclear weapons at certain storage facilities. To check the viability of this approach the UN Institute of Disarmament Research conducted a verification experiment that included a mockup on-site inspection at a former military facility in Menzingen, Switzerland. The exercise took place on 8 March 2023. The project was supported by the governments of Switzerland, Norway, and the Netherlands. Logistical support for the exercise was provided by the Swiss Armed Forces. The inspection included a visit to the site by an inspection team, accompanied by the host team. The inspection included confirmation of the accuracy of the site diagram, selection of an object of verification to be inspected, an inspection inside the selected object, and confirmation of the non-nuclear nature of objects located inside the object of verification. The non-nuclear nature of objects was confirmed by the means of visual inspection and by radiation measurements. The exercise also included an analysis of satellite imagery of the inspected site (with support of Open Nuclear Network). This paper provides an account of the exercise and discusses the lessons for future verification arrangements learned from the model inspection.

Introduction

This paper describes the Menzingen Verification Experiment that modeled a mock on-site inspection designed to verify the absence of nuclear weapons at a military facility. The experiment was organized by the UN Institute for Disarmament Research with the support of the Swiss Armed Forces, Spiez Laboratory, Princeton University's Program on Science and Global Security, and Open Nuclear Network in Switzerland on 8 March 2023.

The setup of the experiment assumed that the inspection would be conducted under an agreement that requires its parties not to have deployed nuclear weapons in storage facilities near military bases. The weapons would be removed to a central storage site. The agreement would cover all storage sites capable of permanently storing nuclear weapons within its area of application. These sites are readily identifiable by the presence of a security perimeter, hardened bunkers, and other support systems. The parties would declare such facilities and provide information about them during the initial data exchange. The parties will not exchange data on the numbers and types of nuclear weapons, but since the agreement would address weapons that can be deployed, the parties are expected to have a good understanding of the types of nuclear weapons that could potentially be stored at each site (e.g., gravity bombs, missiles, or missile warheads). The agreement's verification provisions then allow parties to

conduct on-site inspections of base-level storage facilities to verify the absence of nuclear weapons there.[1] In preparation for the experiment, UNIDIR developed a model protocol for the inspection activities and designed procedures to confirm the non-nuclear nature of the inspected items, including radiation measurements with active sources, and arranged for the acquisition of satellite imagery of the site. The procedures were adapted from those contained in the CFE Treaty and New START.

Preparation for the inspection

The site for the experiment was provided by the Swiss Armed Forces. It is a former air defense site known as the Bloodhound Missile Station BL-64 ZG located in the canton of Zug, about an hour drive from Lucerne or Zürich. Although the station is no longer active, it is still managed by the Swiss Army, which makes it a suitable facility for the exercise.

Figure 1. Satellite image of the Menzingen site and storage bunkers. Source: Google Earth (left).

The territory of the site is measured approximately 0.6 km by 0.4 km, which is comparable to that of secured areas of most active weapon storage sites. It includes 16 open launch pads, 32 hardened bunkers, a number of buildings and roads. The satellite image of the site and bunkers are shown in Figure 1.

The site diagram that would be submitted by the inspected party (Figure 2) shows the site boundaries, entrances, roads and all buildings and other structures, which are divided into two categories. Any building suitable for the storage of nuclear weapons, whether permanent or temporary, must be eligible for inspection. These buildings are classified as "objects of verification." This category includes dedicated storage bunkers as well as garages, hangars, or other similar facilities. Buildings and structures that cannot be used for nuclear weapons storage, such as office buildings or small structures, are identified as auxiliary buildings.

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[1] Pavel Podvig, "Verifying the Absence of Nuclear Weapons in a Field Exercise," *Proceedings of the INMM & ESARDA Joint Annual Meeting*, August 2021, https://resources.inmm.org/sites/default/files/2021-09/a1687.pdf; Pavel Podvig, Ryan Snyder, and Wilfred Wan, "Evidence of Absence: Verifying the Removal of Nuclear Weapons" (UNIDIR, 2018), https://www.unidir.org/sites/default/files/publication/pdfs/evidence-of-absence-verifying-the-removal-of-nuclear-weapons-en-722.pdf; Pavel Podvig and Javier Serrat, "Lock Them Up: Zero-Deployed Non-Strategic Nuclear Weapons in Europe" (UNIDIR, 2017), https://www.unidir.org/sites/default/files/publication/pdfs/lock-them-up-zero-deployed-non-strategic-nuclear-weapons-in-europe-en-675.pdf.

Elements of the inspection

The general sequence of the inspection followed the practice established in other treaties, specifically in the Conventional Forces in Europe (CFE) Treaty and New START. The exercise participants were divided into three groups of six: the inspectors, the hosts, and the observers. In order to facilitate access to various facilities at the site, the host group was led by representatives of the Swiss Armed Forces. The Armed Forces College in Lucerne provided a venue for the pre-inspection and post-inspection workshops. Lucerne was also identified as the point of entry for the purposes of the inspection.

The experiment did not replicate all elements of an inspection, but instead focused on the following key procedures:

- Confirmation of the accuracy of the site diagram,
- Inspection of selected objects of verification (storage bunkers),
- Inspection of non-nuclear items:
    - Visual inspection,
    - Radiation measurements,
- Use of satellite imagery to verify the lockdown.

Confirmation of the accuracy of the site diagram

When the inspectors arrived at the site, the host presented them with an updated diagram and explained the nature of the changes. In this scenario, the only change reported by the host was the addition of a training BL-64 missile, located at one of the launch pads. The site diagram used during the inspection is shown in Figure 2.

To confirm the accuracy of the site diagram, the inspectors divided into two sub-teams. Each sub-team, accompanied by hosts (and observers), examined its own area of responsibility. The goal of this part of the inspection was to confirm that the diagram correctly shows all buildings, structures, and roads. The inspectors also verified that the buildings that are marked as auxiliary cannot be used to store nuclear weapons, whether permanently or temporary. This procedure involved a visual inspection of the exterior of the building and access roads and, if necessary, the measurement of its entrances.

The inspectors identified several structures that were not shown on the diagram and suggested that the diagram should be amended. The inspectors also requested access to some of these structures to determine whether they should be classified as objects of verification. In accordance with the inspection protocol, the decision to grant access is at the discretion of the hosts. In several cases, the hosts granted access to the interior of the building. In some cases, the hosts provided a detailed explanation of the function of a structure or a building.

Following the inspection script developed in advance, the hosts refused access to two structures identified as auxiliary on the site diagram (see “Inspected building” in Figure 2). In these cases, the inspection protocol allowed the inspectors to raise a formal challenge. The inspectors documented the challenge by taking photographs and conducting measurements, which were included in the inspection report. The decision

to amend the site diagram or to change the classification of buildings and structures is left to the treaty implementation commission.

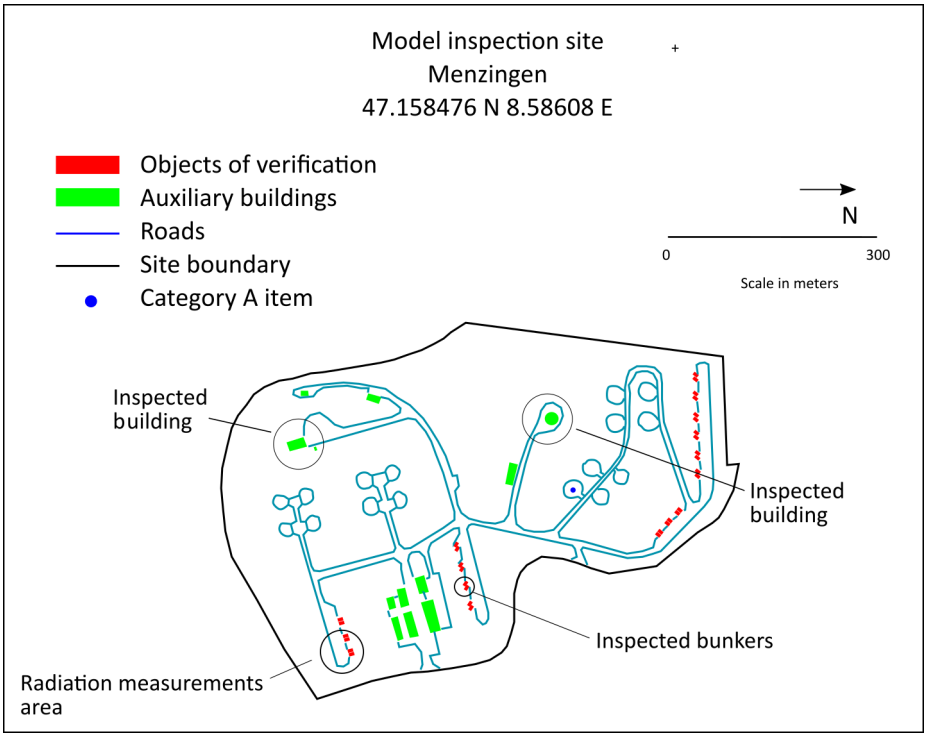

Figure 2. The site diagram used during the inspection with area markings added.

Inspection of an object of verification (bunker)

Once the inspectors established the accuracy of the site diagram and documented their challenges, they select one of the buildings (structure) identified as an object of verification for a detailed inspection. The inspection protocol then allows the host to prepare the selected object for an inspection, for example, by shrouding sensitive equipment. In the process, the hosts must provide the inspectors with an opportunity to observe that no items are removed from the building, for example by allowing them to observe the main entrances from a distance. This part of the protocol was not tested during this inspection as the objects of verification were selected and prepared in advance.

The objects of verification that were prepared for the inspection were the two bunkers, No. 212 and No. 213, located in the “inspected bunkers” area shown in Figure 2. Each bunker is about 4x7 meters in size, protected by a hardened door. During the preparation, several items were placed inside the bunker, as shown in Figure 3.

After completing the preparation and before the inspectors enter an object of verification, the hosts present the inspectors with a floor plan that shows the location of items inside. Each item is assigned a category that determines the procedure that the inspectors can use to confirm its non-nuclear nature. These procedures are negotiated in advance and included in the annex to the inspection protocol.

Figure 3. Bunker 213 prepared for the inspection and its floor plan.

The category definitions used in this exercise were notional as they reflected the availability of items to be examined rather than a judgment about the applicability of any particular method of examination:

- Category A: Items that can be examined visually. This includes small items and containers that can be opened to demonstrate that they are empty. It also includes items that are clearly marked as inert, training, etc.
- Category B: Items that can be examined by passive neutrons. This category would include relatively small containers that cannot be opened. In this exercise these items were containers of 240x32x32 cm in size.
- Category C: Items that can be examined by gamma measurements. This category is designed to include larger containers that cannot be opened and that may require some form of active radiation measurements to confirm their non-nuclear nature. In this exercise these were cylindrical containers 120 cm long and 32 cm in diameter.

The inspectors checked the accuracy of the floor plan and confirmed the absence of hidden doors and areas that are large enough to contain nuclear weapons. After that they examined the items located in the bunkers.

The Category A items in Bunker 213 (Figure 3) included two radiators and a climate control unit attached to the wall as well as two empty ammunition boxes stacked on top of each other (upper left corner on the floor plan). Since items in this category can be inspected visually, the inspectors asked the hosts to open the cover of the climate control unit (Figure 4, left) and demonstrate that the ammunition boxes are empty.

Figure 4. Inspection of individual items in Bunker 213.

The inspectors then examined the items marked as Category B and C (Figure 4, center). They confirmed that the dimensions of these items corresponded to those described in the annex to the inspection protocol and, in accordance with the protocol and the inspection script, "selected" these two items for an inspection with radiation measurements.

The inspectors also tested several additional inspection methods. The hosts explained that the Category B item is a plastic container that is used for training. Although the container cannot be opened, by lifting it and asking the hosts to tap on its surface, the inspectors were able to conclude with confidence that it was empty and could not contain a nuclear weapon. With the Category C item, the inspectors examined the markings that showed that it is clearly marked as a training munition (Figure 4, right. "Engin guidé antichar sol-sol BB 77 obus d'exercice 90").

According to the inspection sequence described in the inspection protocol, the inspectors would conduct radiation measurements to confirm the non-nuclear nature of the Category B and Category C items they selected for an inspection. In this experiment the radiation measurements were set up in a separate area of the site and were performed in parallel with the inspection of the objects of verification.

Radiation measurements

Radiation measurements were conducted in a separate area of the site, shown in Figure 2. The bunkers for the inspection were prepared in advance by the Swiss Armed Forces and by the Spiez Laboratory team. The detailed account of this part of the experiment is provided in a separate contribution at this conference.[2] This section provides an outline of the radiation measurements setup.

The items that were examined during this part of the experiment were identical to those that were selected for a radiation measurement inspection by the sub-team that conducted the inspection of the objects of verification in Bunkers 212 and 213. Two bunkers, 201 and 202, were used to place containers identical to the Category B item located in Bunker 213. In preparation for the experiment, the Spiez Laboratory team placed a californium-252 neutron source that represented plutonium, in one of these containers. Two other bunkers, 204 and 205, were used to place identical Category C containers, with depleted uranium projectiles, representing an HEU component of a

[2] Eric Lepowsky, Manuel Kreutle, Christoph Wirz, and Alexander Glaser, "Confirming the Absence of Nuclear Weapons. Neutron and Gamma Measurements During a Verification Experiment in Switzerland, INMM & ESARDA Joint Annual Meeting, Vienna, May 2023.

nuclear weapon, in one of them. Neither the hosts nor the inspectors knew which items contain radiation sources.

The neutron measurement protocol followed that of the New START Treaty, using the LB 6414 Neutron Survey Meter provided by the Spiez Laboratory. The gamma measurements used the Absence Confirmation Experimental (ACX 2.0) device developed at Princeton University's Laboratory for Science and Global Security. The gamma measurement protocol required the use of a strong (cesium-137) reference source, which allowed to test the possibility of using active radiation sources during an absence inspection.

In both cases, the measurements correctly identified the containers with radiation sources inside. These were reflected in the inspection report as anomalies. Neutron measurements also detected the anomaly on the empty container. Additional measurements showed that it was a result of a neutron leakage from the adjacent bunker with neutron source. Overall, the experiment demonstrated the possibility of using passive and active radiation measurements to confirm the non-nuclear nature of items and identified a number of ways to improve the experimental setup.

Satellite imagery and lockdown verification

According to the inspection protocol, the inspectors submit a notification of the intent to inspect at least 24 hours before arriving at the point of entry. The specific site to be inspected is designated later, closer to the time the inspectors arrive at the site (one hour in this experiment). Once selected, the inspected site must go into a lockdown to ensure that no items are removed from the site or that no items are moved from dedicated storage bunkers to temporary storage facilities on site.

The inspecting party can use a variety of means to monitor the inspected site during the window of interest – the period of time between the notification of the inspection and the arrival of the inspectors on site. In this experiment, the notification of the intent to inspect was submitted at 13:00 on 6 March 2023. The notification identified Lucerne as the point of entry. The inspectors arrived on site at 09:20 on 8 March 2023.

To test the capability to monitor the site during the window of interest, Open Nuclear Network acquired optical and SAR satellite images of the site from several commercial providers. A detailed account of this part of the experiment is provided in a separate presentation at this conference.[3] It has been shown that the inspected party cannot have high confidence in its ability to conceal equipment movement on the base during the lockdown period, especially since the inspected party has control over the timing of the inspection and access to a wide range of imagery providers.

Conclusion

The Menzingen Verification Experiment demonstrated the viability of the approach to nuclear disarmament based on the removal of nuclear weapons from their delivery systems. The inspection protocol and verification procedures developed and tested during the experiment can serve as a basis for designing verification arrangements that will demonstrate the absence of nuclear weapons in a storage facility. The key advantage of this approach is that it does not require access to nuclear weapons. The

[3] Jaewoo Shin, Veronika Bedenko, and Pavel Podvig, "Use of Satellite Imagery in Support of On-Site Inspections. Lessons from a Field Exercise," INMM & ESARDA Joint Annual Meeting, Vienna, May 2023.

absence of nuclear weapons expands the range of verification tools and techniques that can be used during inspections and addresses concerns about sensitive weapons-related information. The experiment provided valuable lessons that will be used to further improve the inspection procedures and develop new tools of verification.

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