Verifying the Absence of Nuclear Weapons in a Field Exercise

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Abstract
Robust verification is an essential element of the nuclear disarmament process. Each stage of this process presents its own verification challenges and requires the development of technical tools and organizational arrangements adapted to its specific circumstances. One of the disarmament steps includes a verifiable removal of nuclear weapons from operational bases, so they are no longer mated to delivery vehicles, such as missiles, and are not stored at the base-level storage facilities. Since it is the absence of weapons that is verified, the verification procedure in this case does not require access to information about weapons or their classified characteristics. Nevertheless, the verification arrangements still have to take into account practical aspects of an inspection that would be conducted at a military base. These include the procedures for obtaining access to an inspected facility, the inspection protocol, the tools available to inspectors and the types of measurements they would be allowed to perform. This paper presents a scenario of a field exercise that could be used to test these procedures in practice. The scenario considers a simulated inspection at a military facility that would confirm the absence of nuclear weapons. It discusses all elements of the inspection procedure that is built to take into account the experience of the past arms control and disarmament treaties, such as START, New START, the INF Treaty, and the CFE Treaty. The scenario is designed to be implemented during an actual field exercise at an active military base.

Introduction
Verification arrangements are an essential element of most arms control and disarmament agreements. They allow parties to demonstrate compliance with their obligations and help build confidence and trust that is required to sustain the disarmament process. While specific verification provisions are always determined by the obligations imposed by the agreement, it is important to consider new disarmament verification technologies and organizational arrangements that could create political space for new arms control and disarmament initiatives.

One of the challenges facing future US-Russian nuclear arms control and disarmament process is the issue of non-strategic nuclear weapons, which have not been covered by the bilateral strategic nuclear disarmament agreements. One approach to this problem involves a withdrawal of non-strategic nuclear weapons away from the military bases where their delivery systems are deployed.[1] While this kind of agreement alone would

[1] Rose Gottemoeller, "Eliminating Short-Range Nuclear Weapons Designed to Be Forward Deployed," in *Reykjavik Revisited: Steps Toward a World Free of Nuclear Weapons: Complete Report of 2007 Hoover Institution Conference*, ed. George P. Shultz et al. (Hoover Press, 2013); Alexei Arbatov, "A Russian Perspective on the Challenge of U.S., NATO, and Russian Non-Strategic Nuclear Weapons," in *Reducing Nuclear Risks in Europe: A Framework for Action*, ed. Steve Andreasen and Isabelle Williams (NTI, 2011), https://media.nti.org/pdfs/NTI_Framework_Chpt8b.pdf; Pavel Podvig and Javier Serrat, "Lock Them Up:

not reduce the number of non-strategic weapons, it can significantly reduce the risks associated with these weapons and create conditions for their subsequent elimination. Further steps could include verified dismantlement of the weapon deployment infrastructure, conversion of delivery systems, and, eventually, elimination of weapons. One significant advantage of this approach is that since it is the absence of weapons that is verified none of these steps would require access to information about nuclear weapons—from their numbers and locations to their technical characteristics.[2]

Even though the verification of absence of weapons is conceptually simple, its implementation requires addressing a range of practical issues. These include determining what kinds of facilities should be subject to verification, what data should be included in declarations and data exchange, and what kind of access to a facility would be necessary. Some of these issues have been explored in various contexts, such as comprehensive nuclear disarmament or US-Russian confidence-building process.[3]

This paper describes a scenario of a field exercise that would be used to consider practical aspects of verifying the absence of weapons. The exercise will model an inspection at a military base that would aim to verify the absence of deployed non-strategic nuclear weapons.

Zero-deployed non-strategic nuclear weapons

The scenario outlined in this paper assumes that Russia and the United States commit to transfer their non-strategic nuclear weapons to storage facilities that are located away from the bases where their delivery system are deployed. This can be described as a "zero-deployed" arrangement since neither party will have its non-strategic weapons ready for immediate use.

The focus on the absence of deployed weapons, as opposed to the one on limiting the total number of non-strategic weapons or their delivery systems, significantly simplifies verification arrangements while still providing meaningful contribution to disarmament. The choice of the real-world circumstances of nuclear weapons deployed in Europe allows a closer examination of the challenges facing future verification arrangements. Furthermore, once the existing non-strategic weapon storage and deployment procedures practiced by Russia and the United States are taken into

Zero-Deployed Non-Strategic Nuclear Weapons in Europe" (UNIDIR, 2017), http://unidir.org/files/publications/pdfs/lock-them-up-zero-deployed-non-strategic-nuclear-weapons-in-europe-en-675.pdf.

[2] Pavel Podvig, Ryan Snyder, and Wilfred Wan, "Evidence of Absence: Verifying the Removal of Nuclear Weapons" (UNIDIR, 2018), http://www.unidir.org/files/publications/pdfs/evidence-of-absence-verifying-the-removal-of-nuclear-weapons-en-722.pdf; Pavel Podvig and Ryan Snyder, "Watch Them Go: Simplifying the Elimination of Fissile Materials and Nuclear Weapons" (UNIDIR, August 2019), http://unidir.org/files/publications/pdfs/watch-them-go-simplifying-the-elimination-of-fissile-materials-and-nuclear-weapons-en-817.pdf.

[3] Keir Allen et al., "Selection and Deployment of Verification Technologies. Lessons Learned from the Quad Nuclear Verification Partnership and the LETTERPRESS Simulation" (Quad Nuclear Verification Partnership, March 2019), 11–13, https://quad-nvp.info/wp-content/uploads/2020/06/QUAD-Selection-and-deployment-of-verification-technologies_-March-2019.pdf; "IPNDV Working Group 4: Verification of Nuclear Weapons Declarations" (IPNDV, June 2019), 34–35, https://www.ipndv.org/wp-content/uploads/2020/04/WG4_Deliverable_FINAL.pdf; James M. Acton, Thomas D. MacDonald, and Pranay Vaddi, "Revamping Nuclear Arms Control: Five Near-Term Proposals" (Carnegie Endowment for International Peace, December 2020), https://carnegieendowment.org/files/Acton_McDonald_Vaddi_Arms_Control.pdf.

account, it becomes possible to design verification procedure that can be tested in practice.

The United States has about 230 nuclear weapons, of which about 100 are deployed in Europe. All US non-strategic weapons are variants of the B-61 gravity bomb delivered by aircraft.[4] Russia is believed to have about 2000 weapons assigned to a range of non-strategic delivery systems as well as various defense systems.[5] While the weapon storage and deployment arrangements are very different, Russia's non-strategic nuclear weapons as well as the US weapons in Europe are stored at a small number of known secure sites and are never mated to their delivery systems in peacetime.

US weapons in Europe

The United State and NATO never officially disclosed the locations, or the number of nuclear weapons deployed in Europe. There are five air bases that are believed to host nuclear weapons – Kleine Brogel in Belgium, Volkel in the Netherlands, Aviano and Ghedi in Italy, Büchel in Germany, and Incirlik in Turkey.[6] Nuclear-certified aircraft that can deliver the weapons are deployed at all these bases, except for Incirlik.

Nuclear weapons are deployed in Protective Aircraft Shelters, which are equipped with Weapons Storage and Security Systems (WS3). These systems include vaults where the weapons are actually stored. A Weapon Storage Vault (WSV) is a structure recessed into the floor of the shelter that can contain up to four B-61 bombs.[7] At all bases but Volkel the shelters that contain nuclear weapons are surrounded by a security perimeter that visible on satellite images. It appears that at least some shelters outside the security fence also have vaults.[8] These, however, are not used for storing nuclear weapons.

In principle, aircraft that are assigned nuclear missions could be stationed in "hot" shelters during peacetime day-to-day operations. In any event, they are likely to be moved there at the heightened state of alert, so bombs can be quickly loaded on the aircraft. At the highest readiness level, known as a quick-reaction alert, weapons are loaded on aircraft, which stay in the shelter awaiting an order to launch. An aircraft on a quick-reaction alert can get into the air in "less than 15 minutes."[9] The time it takes to load weapons stored in a vault onto an aircraft is definitely longer. and is likely to be measured in hours.

Russia

Compared to the United States and NATO, Russia has a much wider range of nuclear-capable delivery systems. This section focuses on air-delivered weapons and on ground-

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[4] Hans M. Kristensen and Matt Korda, "United States Nuclear Weapons, 2021," *Bulletin of the Atomic Scientists* 77, no. 1 (January 2, 2021): 43–63, https://doi.org/10.1080/00963402.2020.1859865.
[5] Hans M. Kristensen and Matt Korda, "Russian Nuclear Weapons, 2021," *Bulletin of the Atomic Scientists* 77, no. 2 (March 4, 2021): 90–108, https://doi.org/10.1080/00963402.2021.1885869.
[6] Kristensen and Korda, "United States Nuclear Weapons, 2021," 56.
[7] Hans Kristensen, "Kleine Brogel Nukes: Not There, Over Here!," *Federation Of American Scientists*, February 12, 2010, https://fas.org/blogs/security/2010/02/kleinebrogel2/.
[8] The story about US weapons in Volkel suggests that in 2019 six out of eleven shelters were used to store nuclear weapons. "US Soldiers Expose Nuclear Weapons Secrets Via Flashcard Apps," Bellingcat, May 28, 2021, https://www.bellingcat.com/news/2021/05/28/us-soldiers-expose-nuclear-weapons-secrets-via-flashcard-apps/.
[9] "30 Years Past: 20th FW Role in Victor Alert," accessed August 4, 2021, https://www.acc.af.mil/News/Features/Display/Article/1020423/30-years-past-20th-fw-role-in-victor-alert/; "Safe Skies: 60 Years of NATO Air Policing," NATO, accessed August 4, 2021, http://www.nato.int/cps/en/natohq/news_185683.htm.

launched road-mobile missiles (whether ballistic or cruise missiles). The key principles of operations, however, remain the same across all nuclear delivery systems.

Russia has repeatedly stated that in peacetime all its non-strategic nuclear weapons are "concentrated at centralized storage bases." There are two kinds of facilities that fit that definition—twelve large national-level storage sites and about 35 base-level storage facilities.[10] Base-level facilities could contain weapons that are assigned to delivery systems at the base they are collocated with or to other bases in the region. For example, a storage facility known as Kolosovka can store nuclear weapons for all nuclear-capable delivery systems in the Kaliningrad region. Each base-level facility has a "parent" national-level storage site that stores nuclear weapons assigned to the respective base or region. All weapons that are not mated to their delivery systems are handled by the troops of the 12th Main Directorate of the Ministry of Defense (12 GUMO).

If nuclear weapons are stored at the base-level facility, the standard weapon deployment procedure appears to include several steps that depend on the specific delivery system and the weapon type. In Russia's practice, weapons are stored separately from their delivery systems. The base-level storage facilities are located at a distance from airfields or missile bases. If the weapons in question are warheads of ballistic or cruise missiles, each of them is stored in a specialized container, only to be mated with the missile as part of the deployment procedure. Gravity bombs are stored in their containers assembled.

Once the units receive an order to bring nuclear delivery systems to a higher state of readiness, the 12 GUMO units must take the weapons, still in containers, out of storage and load them on specialized trucks. When this procedure is completed, the trucks deliver the containers to a designated point, where weapons are removed from containers and mated with their delivery systems.

In the case of air-delivered weapons, such as bombs or ALCMs, this point is normally a designated area of an airbase where the 12 GUMO troops carry out the final assembly of a weapon, if necessary, and prepare it for loading on the delivery aircraft. Fully assembled weapons at the airbase remain in the custody of the 12 GUMO troops until the very moment they are loaded on an aircraft that is ready to take off, at which point the custody is transferred to the aircraft crew.

Warheads of land-based ballistic and cruise missiles could probably be delivered to the missile base. However, the standard procedure appears to involve transporting the warheads to a designated rendezvous point away from the base where they would be mated with missiles and then loaded on launchers. The 12 GUMO troops apparently have the necessary equipment to conduct these operations in the field.

It appears that the 12 GUMO troops can keep nuclear weapons outside of the storage facility for some time, probably days and maybe even weeks. However, at some point

[10] The description of nuclear weapon storage and deployment procedures is based primarily on Pavel Podvig and Javier Serrat, "Lock Them Up: Zero-Deployed Non-Strategic Nuclear Weapons in Europe"; *Рожденные атомной эрой. История создания и развития 12 Главного Управления Министерства Обороны Российской Федерации. т. 1* (Москва: Наука, 2007); László Becz, Szabolcs Kizmus, and Tamás Várhegyi, *OKSNAR - Fully Assembled State - Soviet Nuclear Weapons in Hungary 1961-1991* (Becz László, 2019).

the weapons must be returned to the base-level facility that provides conditions for a long-term storage.

An outline of a possible arrangement

The verification arrangement described here assumes that Russia and the United States agree to withdraw their non-strategic nuclear weapons to some central storage facilities from the bases where they are prepared for deployment. In practical terms that would mean that Russia would transfer all its weapons to national-level storage sites while the United States would move its weapons either to its national territory or to some storage facilities in Europe. The base-level facilities would then be open to inspections to verify that the weapons have indeed been removed.

One significant advantage of this arrangement is that it does not require revealing any information about nuclear weapons. For example, neither side would have to disclose the number of non-strategic weapons, their types, or specific characteristics of individual weapons. This drastically simplifies the verification procedures as they do not have to include measures that protect classified information about weapons or their design.

It is also important to emphasize that this arrangement would be different from a disarmament scenario in which parties would agree to eliminate some or all nuclear weapons. In the disarmament case, the verification procedure must address a very difficult problem of confirming the absence of nuclear weapons in a state, which would require making virtually any facility subject to a challenge inspection.[11] In contrast, the zero-deployed arrangement could limit verification activities to a small number of sites.

The key reason why this is possible is that the parties can be assumed to be responsible custodians of nuclear weapons. This means that deployed weapons are stored in conditions that provide proper maintenance, security, and reasonable degree of readiness. This requires storing them in dedicated facilities, which is, in fact, the standard practice in Russia and the United States. As described earlier, apart from ICBM and SLBM warheads, in peacetime neither of them keeps nuclear warheads mated to missiles or air-delivered weapons loaded on aircraft. While it is possible to move weapons outside of their secure facilities or indeed mate them with their delivery systems, this would be done only in extreme circumstances of a crisis.

Initial declarations

The approach to the selection of facilities that would be subject to inspection could follow the practice that was accepted in the INF and START/New START treaties. In New START the parties provide a list of declared sites, which includes "site diagrams [...] for each facility at which inspection activities may be conducted."[12] The facilities covered by this obligation are ICBM, SLBM, and bomber bases as well as maintenance facilities. Information about a facility must include its geographic coordinates as well as a site diagram that should depict "structures and locations at which items of inspection may be located."[13]

For the purposes of the non-deployment agreement, a declared site eligible for inspection would be defined by a security perimeter around the nuclear weapon storage sites. The diagram must identify objects of verification, which are the structures

[11] "IPNDV Working Group 4: Verification of Nuclear Weapons Declarations."
[12] New START Protocol, Part Two, Section I, para 2.
[13] New START Protocol. Annex on Inspection Activities, Part Four.

where nuclear weapons might be stored, as well as auxiliary buildings within the perimeter of the declared site.

It should be noted that START and New START (as well as the INF Treaty) allowed inspections at declared sites and did not have provisions for challenge inspections to verify the absence of undeclared treaty-relevant items or facilities. This approach could be used in the zero-deployed agreement as well since nuclear weapon storage facilities have very distinct signatures and their locations are well known. Russia submitted information about its weapon storage facilities to the United States as part of a program that improved security at these sites. Even though the United States and NATO have never officially disclosed the locations where nuclear weapons are deployed, these sites are easily identifiable as well. To resolve potential disputes, the agreement can introduce a category of former storage facilities that would be subject to a one-time close-out inspection to confirm the absence of infrastructure for nuclear weapon deployment. Disputes could also be resolved in a bilateral commission that would be established by the agreement. At the same time, the experience of the INF and START/New START treaties suggests that this mechanism is not essential. Despite the absence of a challenge inspection mechanism, neither party attempted to conceal its facilities that would be subject to inspection.

Inspection procedures

The general sequence of an inspection could also follow the practice established in earlier treaties.[14] The agreement would have to identify points of entry that would be used by inspectors to enter the inspected country. After arrival to the point of entry inspectors identify the facility to be inspected. The inspected party must transport the inspection team to the designated facility within a specified period, probably on the order of 24 hours.

Once the inspected facility is identified, the inspected party must implement certain restrictions at the designated site to ensure that no nuclear weapons are removed from the facility. In New START, these measures include a ban on a removal of closed vehicles or covered objects that are "large enough to contain an item of inspection." Movements within the inspected site are limited as well. These restrictions should be implemented no later than one hour from the moment the designation of the inspected site.[15]

It should be noted that an item of inspection in New START, defined as either a heavy bomber or an ICBM or SLBM, is a large object, which makes the lockdown easier to monitor. It may appear that in the case of nuclear storage sites movements of items of inspection would be difficult to detect since a nuclear weapon, especially one removed from a transport container, could be a very compact object. At the same time, in the zero-deployed arrangement an item of inspection is, in effect, not a single weapon or a container, but rather all nuclear weapons that could be stored on site. Removal of these weapons would involve movement of at least several vehicles or aircraft, which would be extremely difficult to conceal.[16]

[14] New START Protocol. Annex on Inspection Activities, Part One and Part Three.
[15] New START Protocol. Annex on Inspection Activities, Part Seven, Section I.
[16] The movement of security convoys that accompany transfer of nuclear weapons can be detected by satellites. See, for example, Hans M. Kristensen, "Urgent: Move Us Nuclear Weapons Out of Turkey," *Federation of American Scientists*, October 16, 2019, https://fas.org/blogs/security/2019/10/nukes-out-of-turkey/.

Upon arriving at the inspected facility, inspectors verify the accuracy of the site diagram that was submitted as part of the initial declaration. They should have the right to request an examination of one of the auxiliary buildings to confirm that it cannot be used to store nuclear weapons, even if only temporarily. This procedure would involve a visual inspection of the exterior of the building and access roads and, if necessary, the measurement of its entrances. In practice, only sufficiently large buildings, such as garages or aircraft hangars, would have to be examined this way. However, these are normally not located within the security perimeter.

If inspectors believe that the auxiliary building can be used as nuclear weapon storage, whether permanent or temporary, they could request the in-country escort to provide a clarification. If the issue cannot be resolved on site, the inspecting team notes its concerns in the inspection activity report. This concern will then be considered by the bilateral commission that can decide to designate the building as an object of verification that is eligible for inspection.

Once inspectors established the accuracy of the site diagram, they select one of the buildings identified as an object of verification for an inspection. Once the building is selected, the inspected party should be allowed to prepare it for an inspection, for example, by shrouding sensitive equipment. Dedicated weapon-storage structures, such as the Weapon Storage Vaults, should be raised above ground and shrouded in a way that permits confirmation of the absence of weapons by a visual inspection. The host should also provide inspectors with an opportunity to observe that no items are removed from the building.

When the building is selected for an inspection, the inspected party should provide the inspectors with a simplified floor plan of the building. In its simplest form, the inspection would consist of a visual inspection of empty interior halls (and of empty vaults). This inspection would also check the accuracy of the floor plan to confirm the absence of hidden doors and areas that are large enough to contain nuclear weapons.

Non-nuclear items

In practice, the inspected building may not be completely empty as it is likely to contain objects that the inspected party would claim to be non-nuclear. These objects could be the support equipment or non-nuclear armaments for the delivery systems deployed at the base. The inspection protocol must include a procedure that can confirm the non-nuclear nature of objects that may be present in the inspected building.

Most proposals that have explored potential verification measures suggested following the START/New START procedure to confirm the non-nuclear nature of inspected objects.[17] This procedure gives the inspecting party the right to use radiation detection equipment to measure the total neutron count in the vicinity of the inspected object, which is then compared to the separately measured neutron background.[18] This procedure, however, relies on certain assumptions about nuclear weapons, namely on the presence of a certain mass of plutonium. More importantly, it cannot be reliably used if the inspected item is placed in a container. The New START inspection protocol, in fact, explicitly specifies that "the use of containers shall not be permitted while

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[17] James M. Acton, Thomas D. MacDonald, and Pranay Vaddi, "Revamping Nuclear Arms Control: Five Near-Term Proposals," 14; Keir Allen et al., "Selection and Deployment of Verification Technologies," 12.
[18] New START Protocol. Annex on Inspection Activities, Part Five, Section VI. See also Alexander Glaser, "Ceci N'est Pas Une Bombe. Toward a Verifiable Definition of a Nuclear Weapon" (58th Annual Meeting of the Institute of Nuclear Materials Management, Indian Wells, California, USA, July 2017).

conducting the procedures [described here]."[19] The reason for this limitation is that the procedure is designed to deal with objects that are "located on the front section" of a deployed missile or "located on or in the heavy bomber." This guarantees that the object does not have shielding that could mask the radiation level emitted by the fissile material that it might contain. A container, on the other hand, can contain shielding material that significantly attenuates the signal. This suggests that the New START procedure would be unsuitable for verifying the non-nuclear nature of an object in a container.

It is, however, possible to confirm the absence of a nuclear object even if the object is placed in a container. For example, passive gamma-ray measurements could determine whether the amount of fissile material in a container exceeds a certain threshold, even in the presence of a shielding material.[20] If it is possible to make certain assumptions about nuclear weapons whose absence is verified, this technique could be used to confirm the absence of weapons.

It should also be possible to develop a protocol that would not rely on any assumptions about nuclear weapons, whether it is the amount of material they contain or the type of fissile material. In this approach, the parties would exchange information about the types of non-nuclear objects that can be present at the object of inspection. For each of these types of objects the parties will record a so-called "non-nuclear template" that could then be used to confirm that the inspected item is non-nuclear.[21]

For the purposes of the field exercise described here, it is assumed that the parties exchange a list of non-nuclear items that may be present at the inspected facilities. These could be containers, assembled conventional weapons, or even large stationary items that could be in the inspected areas. For each item on the list, the parties develop an agreed procedure that confirms its non-nuclear nature.

If the inspecting party detects any listed non-nuclear items in the inspected area, it should have the right to select one of them for a detailed inspection in accordance with the procedure agreed for these kinds of items. Depending on the procedure, the item could be examined in place or moved to a designated area for examination.

The inspection procedure could be simplified if the parties agree to exclude certain items from consideration. For example, it should be possible to agree that objects with dimensions that are smaller than a certain threshold should be automatically considered non-nuclear. While strictly speaking determining this threshold would require some knowledge nuclear weapons, this can be done without revealing any information about weapons, the way it was done in START/New START. For example, the parties could agree that items with the minimum dimension not exceeding, say, one meter should not be considered nuclear. In any event, inspectors should be able to declare any item non-nuclear regardless of whether it fits any of the agreed formal criteria.

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19 New START Protocol. Annex on Inspection Activities, Part Five, Section VI, para 16(l).

20 Eric Lepowsky, Jihye Jeon, and Alexander Glaser, "Confirming the Absence of Nuclear Warheads via Passive Gamma-Ray Measurements," *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment* 990 (February 21, 2021): 164983, https://doi.org/10.1016/j.nima.2020.164983.

21 Pavel Podvig and Ryan Snyder, "Verifying the Non-Nuclear Nature of Objects," *Proceedings of the 60th Annual Meeting of the Institute of Nuclear Materials Management, Palm Desert, CA*, July 2019.

Once the visual inspection of the object of verification and the examination of the nuclear items selected for detailed inspection are completed, the inspection team prepares an inspection activity report that is submitted to the bilateral commission for consideration and, if necessary, follow-on actions.

Conclusions and outlook

Even though verifying the absence of nuclear weapons is a conceptually simple task, designing an inspection protocol that could be implemented in practice presents several challenges. The protocol described in this paper suggests an arrangement that would verify the withdrawal of non-strategic nuclear weapons from the bases where their delivery systems are deployed. It also takes into account weapon storage and deployment practices accepted by Russia and the United States for their non-strategic weapons stationed in Europe. This allows to simplify the verification arrangements and to develop a protocol that does not require disclosure of information about nuclear weapons.

This model protocol will be used to organize an exercise that would test the conceptual approach described in the paper in the conditions of a military base. The exercise will be used to assess the applicability of the suggested solutions and, if necessary, correct the verification procedures.