Highlights of the Quad Multilateral Nuclear Arms Control Research Initiative LETTERPRESS Simulation

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Abstract

The US, UK, Sweden and Norway have formed the Quad Nuclear Verification Partnership and have been working together as the 'Quad' to ensure non-nuclear weapon states (NNWS) and nuclear weapon states (NWS) collaborate to overcome the challenge of nuclear arms control verification. The Quad aims to complement and inform the work of other multinational initiatives such as the International Partnership for Nuclear Disarmament Verification (IPNDV).

The initial engagement of the Quad was the development and execution of a role-playing, in-field verification simulation, named LETTERPRESS. A benefit of role-playing events is the capacity they have to allow researchers to engage critically with a challenge from multiple perspectives. This paper will introduce LETTERPRESS and the process the Quad followed to develop and execute the multilateral simulation. The paper will highlight the in-play objectives of the verification regime, the site hosting the on-site inspection, and the verification technologies and their roles with respect to the objectives. The paper will include lessons learned from LETTERPRESS and their contribution to a successful monitoring result. The paper will conclude by highlighting the in-play success of a multilateral verification body and the ability of both NNWS and NWS to contribute to the verification process within LETTERPRESS.

Keywords: Quad, LETTERPRESS, multilateral, arms control

1. Introduction to the Quad

The Quad is a multilateral nuclear disarmament verification partnership bringing together representatives from two non-nuclear-weapon states (NNWS), Norway and Sweden, and two nuclear weapon states (NWS), the United States and United Kingdom. The Quad builds upon previous experiences, such as the UK-Norway Initiative [1] and US-UK arms control exercises [2], to collaborate and explore technical and policy solutions to help solve verification and monitoring challenges related to nuclear disarmament. The Quad also aims to complement and inform the work of other multinational initiatives such as the International Partnership for Nuclear Disarmament Verification (IPNDV) [3].

One objective of the Quad is to enhance and extend previous work by the Quad partners and investigate how NWS) and NWS may participate together to demonstrate how multilateral nuclear disarmament verification could work and be implemented in the real world. This objective directly supports Nuclear Nonproliferation Treaty (NPT) Article VI, ***Each of the Parties*** *to the Treaty undertakes to pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament, and on a treaty on general and complete disarmament* ***under strict and effective international control*** [4]. The key section of Article VI impacted by the Quad engagement is highlighted in bold. Complementarily, the engagement also impacts Article I and Article II of the NPT to provide assurance that disarmament activities can include effective international control without revealing or proliferating sensitive weapon design information.

2. Introduction to the LETTERPRESS Simulation

2.1 LETTERPRESS Scope and Objectives

LETTERPRESS was the name of the simulation executed in October 2017 at Royal Airforce (RAF) base Honington in the UK, and represented the first activity undertaken by the Quad. It included approximately 50 representatives from all four countries who acted as planners, i.e. for logistics, simulation execution, support, and simulation evaluation, and players, i.e. host and inspection team members. At a high-level, the exercise examined one on-site inspection activity, as part of a broader treaty regime, at an interim storage facility. The fictitious site where the interim storage facility was located was called Notinghon, and is represented in Figure 1. The in-play objective was to confirm the correctness and completeness of the host declaration, and establish chain of custody (CoC) over treaty accountable items (TAI) destined for dismantlement. There were confirmation measurements to confirm the authenticity of the declared TAI, absence measurements to confirm the absence of undeclared TAIs at declared locations, and CoC measures, i.e. surveillance, tamper indicating devices and enclosures (TIDs/TIEs), and unique identifiers (UIDs) to maintain the integrity of equipment, facilities, and TAIs.

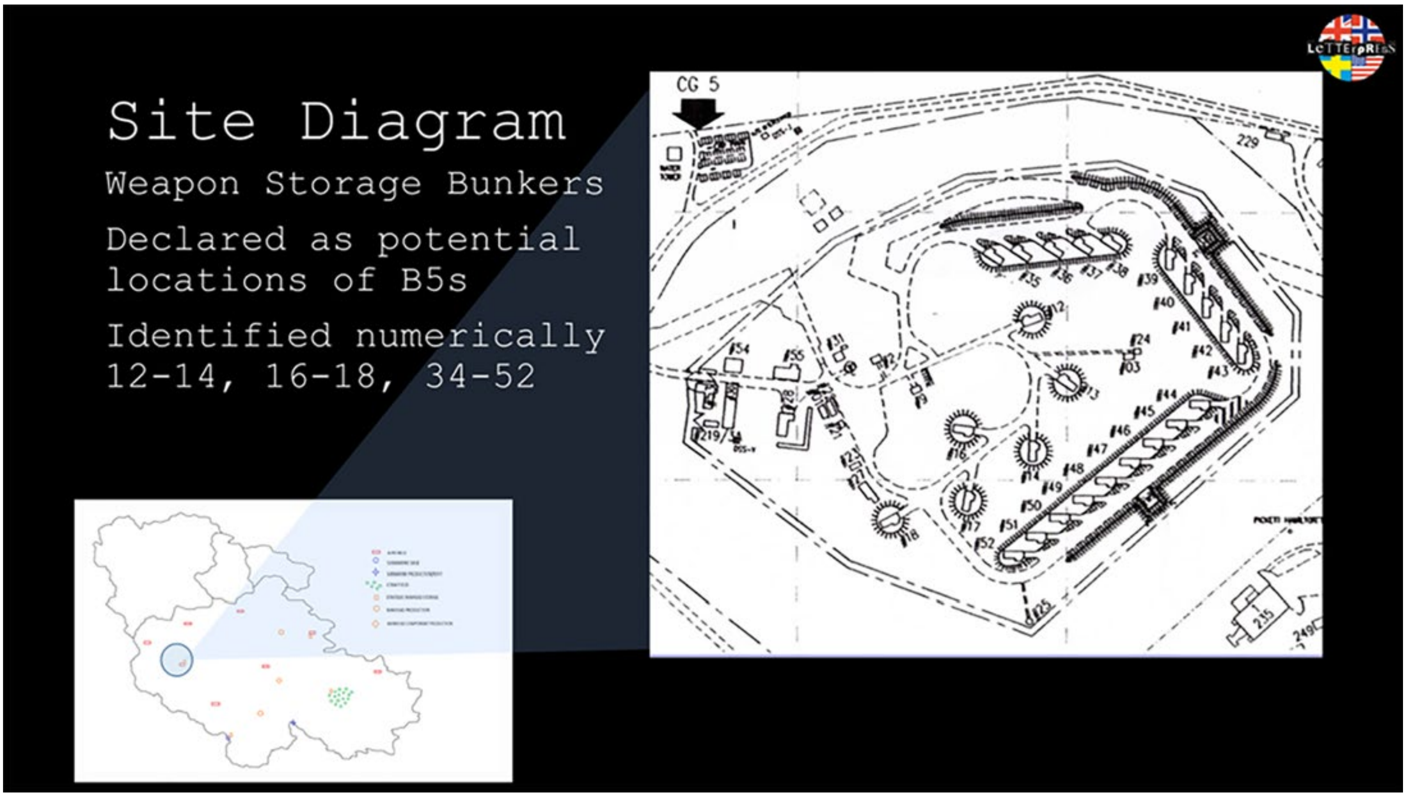

Figure 1: ‘Notinghon’, the interim storage facility that featured in LETTERPRESS, was just one declared site in the fictitious state. The site contained multiple locations and facilities.

Out of play, the research objectives of LETTERPRESS were to evaluate technical options for collecting and analyzing treaty relevant information and data, and to explore the minimum information necessary for the inspectors to achieve their inspection objectives. Additionally, LETTERPRESS included learning objectives to immerse a diverse set of technical experts from the four countries into a realistic monitoring and verification scenario. Together, the participants would gain a greater appreciation for the challenges present in verification of nuclear arms control/reduction treaties, and to gain experience and knowledge to continue to work together in the future to address these challenges.

3. LETTERPRESS Treaty and Verification Regime

In order to achieve the stated learning objectives, it was important to develop a realistic scenario. Toward that end, the Quad partners pulled from previous and current treaties and agreements, specifically New START, and leveraged the expertise of the partners in arms control, nonproliferation and international safeguards. The following formed the foundation of the verification regime.

3.1 LETTERPRESS Background and High-Level Declarations

Two NWS agreed to a significant reduction in their respective stockpiles. As part of the significant reduction in nuclear weapons, the two countries agreed to include the two neighboring NNWS to be part of the inspectorate tasked with confirming the technical aspects of the monitoring regime. The ‘B5’, as called out in the scenario as the Treaty Accountable Item and referred to throughout this paper and shown in Figure 2, was represented by a WE177 weapon case. The WE177 was a historical UK gravity bomb. As part of the agreement to this treaty, the following high-level declarations were made:

a) All B5s will be removed from the active stockpile over the lifetime of the treaty. The operationally deployed B5s will be reduced over time through the dismantlement process.
b) B5s selected to enter the dismantlement process will be declared and transported from their respective operational bases to the interim storage site where they will be stored until ready for dismantlement at the just-in-time dismantlement facility.
c) B5s remaining operationally deployed may require refurbishment over the lifetime of the treaty. These items will be transported from their respective operational bases to the interim storage site where they will be stored until ready for refurbishment.

New START is a current nuclear arms control treaty between the US and Russia which limits each party’s strategic delivery vehicles and warheads with an inspection protocol detailing the content, structure, and requirements for providing notifications and declarations of treaty

Figure 2: A B5 bomb sits outside its container during the LETTERPRESS simulation. Inspectors (in white) and host personnel discuss the next step in the verification procedure.

accountable items to each treaty partner [5]. Leveraging New START type notifications and declarations, a number of assumptions were made for LETTERPRESS with respect to the protocol and agreement. These included:

a) Per the agreed protocol, there is an agreed number of inspections allowed per year at the interim storage site and the dismantlement facility.
b) The host country will provide post-departure and post-arrival notifications of inter-site movement to all treaty partners no later than five days after the movement is complete.
c) The host country will notify the treaty partners of its intent to send a batch of treaty accountable items, previously declared for dismantlement, from interim storage to the dismantlement facility.
d) The host country will provide only post-departure and post-arrival notifications of movement for B5s requiring refurbishment.
e) The inspecting party may request to initiate an on-site inspection after any number of notifications of movement, or an intent to send items to the dismantlement facility have been provided.

This last assumption served as the impetus for the LETTERPRESS exercise.

At a high-level, the verification activities simulated in LETTERPRESS were the following:

1. Upon arrival on-site, the inspectors confirmed CoC over a storage bunker serving as treaty monitored storage for all B5s declared for dismantlement and which were initialized into the monitoring regime. They also confirmed CoC over a bunker where they performed agreed measurements and stored equipment.
2. Upon establishing CoC over the storage bunkers, the inspectors declared that they were ready to accept and initialize the B5(s) into the regime.
3. A confirmation measurement was performed on each declared B5 (*to address the 'correctness' element of the protocol and confirm the declared treaty accountable item attributes*).

- o An agreed UID was initialized and confirmed for each B5.
- o An agreed confirmation measurement was performed on each B5. It was radiation-based and confirmed an agreed set of attributes and compared against a trusted template. The trusted template was generated by performing a reference measurement on an active stockpile B5 declared on-site. Subsequent measurements were compared against that reference template.

4. As agreed in the protocol, the inspectors exercised their right to perform monitoring of items and activities at other declared locations at the site. Therefore, the inspectors requested to inspect a random storage bunker declared as empty.
5. The inspectors performed an absence measurement on the container(s) to confirm lack of a radiation (neutron) signature and noted visual observations (*to address the 'completeness' of the element of the protocol*).
6. Inspectors performed the following CoC measures on the selected B5(s) transported to the dismantlement facility.
   - o The inspectors confirmed the UID of each B5 selected for transport to the dismantlement facility.
   - o The inspectors installed agreed TIDs to secure the B5 and container during transport.
7. Upon arrival at the dismantlement facility, the inspectors confirmed the authenticity and integrity of the CoC measures and performed a reconfirmation measurement.
   - o The host presented each B5 which was transported from the interim storage site to the dismantlement facility.
   - o Inspectors reconfirmed the UID of each B5.
   - o Inspectors performed confirmation measurements for each B5. The agreed confirmation measurements were radiation-based and confirmed an agreed set of attributes and compare against a trusted template (*agreed to in the protocol*).

Once confirmation measurements were complete and successfully passed/matched, the item(s) were released by the inspectors and processed through dismantlement. *At this point, LETTERPRESS was complete.*

3.2 Rights, Responsibilities and Protocol

LETTERPRESS simulated an on-site inspection, where the role of the inspection team was to carry out an inspection at Notinghon to verify that the declaration made about the status and location of a number of B5 nuclear bombs was 'correct' and 'complete'. The role of the host team was to help facilitate the inspection team in their mission on site, while also ensuring the site security and national security are not compromised. Together these formed the overarching obligations of the inspection and host teams respectively and the biggest challenge in the development and execution of a robust verification regime: how can the inspection team collect sufficient data to confirm correctness and completeness while the host team protects sensitive, classified, or information otherwise outside of the treaty agreement?

Within LETTERPRESS, the completeness objective was simulated by allowing the inspection team to randomly select a facility bunker and perform an absence measurement to confirm the absence of a B5 to provide confidence that undeclared weapons are not stockpiled or deployed on-site. This activity is captured in Figure 3. This seemingly simple activity raised a number of questions and posed many challenges that, while not solved in LETTERPRESS, helped the Quad partners to better understand the techniques and challenges in this area.

A few simple examples of challenges are highlighted in the context of managed access, the host process to control site access and protect information. These include, defining the criteria for selecting inspection locations, how to lockdown the site, and the immediacy of allowing inspections versus protecting facility operations that cannot be stopped immediately. These examples reinforce the high-level LETTERPRESS objective to explore the minimum information necessary for the inspectors to achieve their inspection objectives. The project team worked hard to create a balance to simulate the realistic facility and on-site inspection constraints at a nuclear weapon facility and the flexibility to evaluate technologies and complete monitoring activities to explore what and how much information give inspectors adequate confidence towards their inspection objectives.

Within LETTERPRESS, the correctness objective was simulated through attribute and template measurements on declared B5s, both active stockpile and those declared for dismantlement. The confirmation technologies used included the UK-Norway Initiative Information Barrier (UKNI IB) with a high-purity germanium (HPGe) detector and the Trusted Radiation Identification System (TRIS). The use of TRIS to generate a trusted reference is shown in Figure 4. To facilitate these measurements, the treaty required the declaration of certain details about the basic design and stockpile characteristics of the B5. In the end, the declarations stated that all B5s contained plutonium below a threshold ratio of Pu-240 to Pu-239, and all B5s exhibited a very similar radiological profile. Together these declarations met the technical needs for the UKNI IB and TRIS respectively, and allowed the Quad to evaluate the correctness objective.

Figure 3: Radiation detection Equipment (RDE) is used to measure the local neutron count rate within a storage bunker that had been declared not to contain any B5 bombs as part of the absence verification procedure on a randomly selected location.

Figure 4: The Trusted Radiation Identification System (TRIS) is used to ensure the radiation profile of a B5 bomb is similar to a 'template' profile of another B5, collected earlier.

In the TRIS concept of operations, the initial trusted template would be generated on the first measured active stockpile B5 and use that template to compare all other B5s; if the template matched then it was declared a B5 and was initialized into the regime. From a policy perspective, this raised a number of interesting issues. First, it required the declaration of additional information about the B5 design and overall stockpile, e.g. the similarity of all B5s. If the profile of the B5s was not consistent throughout the stockpile, then the weapon owner could be forced to declare sub-populations upfront, or ensure the profile was sufficiently broad to cover all differences between B5s. The monitoring of how those sub-populations are used over time could impact operational security, while an overly broad profile could impact inspector confidence in the correctness of the initial declaration. Additionally, a template by itself does not directly relate to a weapon system. Since the spectrum from a template is never seen, it must initially be combined with an alternate method to gain confidence that the spectrum is truly from a declared weapon, e.g. using agreed attributes of a declared weapon. Lastly, the trusted template now needs to be protected and controlled throughout the timeframe of the treaty. This creates additional CoC requirements, e.g. key management and dual containment, from the inspector perspective and information and physical security requirements for the host.

In total, there are technical and policy challenges which exist in the use of TRIS, and templates in general. However, the huge benefit of templates is that, assuming a trusted template, the inspector can have high confidence in the authenticity of all other weapons declared to be of the same type, that match the reference template.

In the context of exploring the minimal amount of information necessary for inspectors to achieve their objectives, and in this case for the host to ensure protection of sensitive information, these discussions and the ultimate simulation of TRIS as a warhead confirmation tool proved valuable.

LETTERPRESS also focused on CoC, the process to maintain confidence in the integrity of inspection facilities, treaty accountable items, i.e. B5s, and inspection equipment. Issues that were explored included how to maintain confidence in the above between inspection visits, while on-site performing confirmation measurements and intra-site movements, and inter-site movements from Notinghon to the dismantlement facility. Technologies trialed during LETTERPRESS included an applied UID using the reflective particle tag (RPT) and an intrinsic UID produced using the eddy current tagging (ECT) system. In addition, the Chain of Custody Item Monitor (CoCIM) active loop seal and passive adhesive seals were applied to maintain control over monitored areas. Video cameras were notional.

Figure 5: An applied Unique Identifier (UID) Tag is applied to the container of the B5 to ensure the individual item can be accounted for and tracked throughout the treaty lifetime.

As an interesting note, during the planning process, there was significant discussion regarding the use of TRIS and the potential impact on the quality and quantity of information that must be included in the declaration. One of the early ideas was to utilize TRIS as a CoC tool. In this way, a template would be generated on a B5 declared for dismantlement prior to it leaving Notinghon. Upon arrival at the dismantlement facility, the template would be reconfirmed, and the inspectors would have confidence in the integrity of the B5 through transport and prior to it entering the dismantlement process. This process would be repeated for every B5 declared for dismantlement. With this concept of operations, there is no need to generate and store, for a long period of time, a trusted template because it was only valid through the transportation process. Additionally, there was no need to declare any information about the B5, e.g. the similarity of all B5 radiological profiles, to utilize TRIS because each B5 would have its own unique template. Discussions regarding the use of TRIS as either a CoC tool or warhead confirmation tool proved valuable to the team and highlighted a number of lessons learned surrounding the impact of technology on policy. As mentioned earlier, ultimately the decision was made to utilize TRIS as a warhead confirmation tool in LETTERPRESS.

In LETTERPRESS, the combination of declarations and CoC allowed the inspectors the opportunity to track declared items over time and between locations, and to know when monitored areas were accessed outside of inspector's presence. There were two techniques trialed to review data and ensure data security. The first was through physical security, and the second through cryptographic security. In the former, data from digital cameras used to confirm CoC seals was collected on secure digital memory cards (SD cards), stored in a tamper-indicating enclosure (TIE), and transported outside of the secure area under inspector visual observation and host control, as prescribed by applied host managed access. Upon receipt in the inspection station, the data was uploaded and manually reviewed. In the latter case, data was protected by cryptographic keys on the CoCIM, used to secure doors to monitored areas, and TRIS, as a confirmation tool. In each case, the integrity of the seal and template could be verified in-situ. The importance of data review for CoC and for maintaining overall confidence in the regime was made very clear throughout LETTERPRESS. However, the difficulty and time-consuming nature of physical security and manual review of data was also made very clear. And contrary to the comments on physical security and manual review, the immediate confirmation of cryptographic data was highlighted as a huge benefit to the inspectors.

At the end of LETTERPRESS, the importance and frustration of CoC was mentioned nearly unanimously by the players. In the context of the amount of information necessary for inspectors to achieve their objectives, this was a significant lesson. The LETTERPRESS team explored the balance between how much data is enough to have confidence but not overwhelm the inspectors and syphon precious time and resources away from the inspection to data review.

4. Lessons Learned

The impact of the lessons learned, and the experience gained will last well beyond LETTERPRESS. In conclusion, a few of the high-level and impactful lessons learned are provided here.

- The inspection objectives of confirming correctness and completeness are complementary. In the context of useful information and achieving inspection objectives, the combination of correctness and completeness may provide greater overall confidence while minimizing the amount of information required by the inspector or released by the host. Thinking of these as a system helped to identify key control points and allowed all parties to better understand the impact of any one action, decision, or activity on the host and inspector, and in the context of minimization of information.
- The technologies were instrumental in the success of LETTERPRESS. The implementation of the technologies within their defined roles were selected to trial various techniques and capabilities of interest to the Quad partners. Each technology also highlighted potential opportunities and challenges regarding its use in a verification regime similar to LETTERPRESS. One aspect that was left out of LETTERPRESS was equipment authentication. This was recognized as a key part of technology deployment but was not on the critical path with respect to Quad learning objectives for LETTERPRESS.
- The implementation of managed access within LETTERPRESS highlighted the challenges of performing verification activities at a treaty partner nuclear weapon facility. Host operation of all equipment and data, and the use of personal protective equipment (PPE) for inspectors, in conjunction with continuous escorting, within monitored areas highlight the scope of managed access in LETTERPRESS. These examples were implemented within LETTERPRESS to evaluate the impact of managed access and information protection without the need to focus ont guards, gates and guns. Output from LETTERPRESS made it clear that managed access has a big impact on both inspector and host in positive and negative ways.
- LETTERPRESS highlighted technical and policy implications stemming from decisions made during the exercise/simulation regime development effort. Technical solutions require certain information to be successful. This information may directly impact policy decisions regarding the quality and quantity of information that may need

to be released regarding a country's nuclear stockpile and weapon characteristics. The regime development process must be considered from a system point of view to capture the cost-benefit analysis and achieve the desired balance between verification and information protection.

5. References

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