

38 NORTH

SPECIAL REPORT

IAEA Safeguards in North Korea

Possible Verification Roles and Mandates



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March 2020

STIMSON

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IAEA Safeguards in North Korea: Possible Verification Roles and Mandates

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Executive Summary

In current circumstances, the possibility of IAEA (International Atomic Energy Agency) engagement in verification in North Korea may seem remote. Negotiations between the United States and North Korea have not progressed, and Kim Jong Un has [stated](#) that “if the US persists in its hostile policy toward [North Korea] there will never be denuclearization on the Korean Peninsula.” This statement might sound negative, but it contains an important implication—that the direction taken by North Korea will depend on the actions of the US. This suggests that a resumption of negotiations, if not on the immediate horizon, cannot be ruled out.

The starting point for any agreed process for reducing North Korea’s nuclear capabilities and associated infrastructure should be a freeze on the production of fissile material, followed by a commitment to permanently cease these activities and to disable and dismantle the facilities involved through a step-by-step process, with the ultimate objective of denuclearization of the Korean peninsula. This process would include: application of safeguards to all peaceful nuclear activities; progressive rollback of the nuclear arsenal, with fissile materials transferred irreversibly to safeguarded peaceful use or disposal; and verification measures for possible undeclared nuclear activities. The advantage of this process is that confidence and trust can be built progressively in support of each succeeding step.

The approaches set out in this paper to accomplish these tasks may seem unduly complicated, but all parties must recognize that effective verification is absolutely essential to the credibility, and therefore the sustainability, of any negotiating process for North Korea’s denuclearization. The IAEA would have the key verification role and full cooperation with its verification activities will be essential to building confidence that the parties to any denuclearization agreements are fulfilling their commitments at every stage of the process. This paper focuses on these activities and the verification role of the IAEA. It reaches the following key judgments:

- North Korea’s willingness to declare all enrichment and reprocessing facilities, and to negotiate mutually acceptable verification arrangements, is a basic threshold for cooperation and trust, without which *any* agreement is likely to be short-lived. However, for any future agreement or agreements with North Korea, the key point for all parties to appreciate is that the IAEA’s verification mandate is determined by the terms of the relevant agreements, and can be as wide or as limited as the parties agree.

- Pyongyang can be expected to resist the idea of international inspectors having rights of access around the country. However, it might be possible to assuage some of its fears, stressing that the scope of any new safeguards agreements will be limited to what the parties accept in these agreements.
- Some intrusive inspections will be required, but exactly what is needed to ensure effective verification will depend on what has to be verified (as set out in the relevant agreement). Under a step-by-step approach, the IAEA and all main actors will have to accept the reality that North Korea will have some nuclear materials and items outside the scope of verification (namely, nuclear materials in the military program), and IAEA inspectors will not have a general mandate to look for all “undeclared” nuclear material and activities.
- Continued enrichment operations would become a major issue in the negotiations; thus, if enrichment is agreed to it will be essential to place North Korea’s enrichment plant and its low enriched uranium (LEU) product and supporting activities under the most rigorous safeguards. Limits would also have to be agreed upon for the permissible level of enrichment and LEU stocks. If continuation of enrichment is a red line for North Korea, operating enrichment facilities under multilateral arrangements could be considered. A better approach would be to establish multilaterally guaranteed fuel supply arrangements.
- Successfully resolving all these issues highlights the importance of establishing the right mandate for the IAEA. In any agreement on safeguards and related verification measures, clarity is essential. Any misunderstandings could be disastrous, potentially resulting in a loss of trust amongst the parties, the collapse of the agreement and a long and difficult path to reaching any further agreement. Consequently, it is imperative to set out precisely the rights and obligations of North Korea and the IAEA, to ensure that the expectations of the parties correspond, and to define precise verification objectives to ensure there is a shared understanding of what these objectives involve.

Background

In current circumstances, there might seem little point in considering the potential role of the IAEA in North Korea. Negotiations between the United States and North Korea have not progressed, and Kim Jong Un has stated that “if the US persists in its hostile policy toward [North Korea] there will never be denuclearization on the Korean Peninsula.”¹ While this may sound as if efforts to resolve the nuclear problem have failed, the statement contains a significant implication—that the direction taken by North Korea will depend on the actions of the US. Thus, there is still a basis for negotiations—and engagement to this end is more important than ever.

It is no surprise that the US approach of “maximum pressure” has not worked. A process of trust building is needed between the two sides—in these circumstances, North Korea’s “action-for-action” approach is a much more realistic basis for negotiations. If the two sides are able to proceed on a step-by-step basis, verification would be an essential part of building the confidence and trust required. Such an approach requires both agreement on meaningful steps and credible verification that the steps are being fulfilled.

The IAEA would have a key role in providing verification. It is commonly assumed North Korea will be reluctant to accept the return of the IAEA. It is important for North Korea to reflect on the benefits of IAEA involvement: its impartial verification should not be seen as an affront to North Korean sovereignty but rather a mechanism to build confidence in North Korea's good faith, while at the same time protecting North Korea against unfounded accusations that it is violating the terms of relevant agreements.

In my paper [*Denuclearizing North Korea: The Case for a Pragmatic Approach to Nuclear Safeguards and Verification*](#), I outlined the range of commitments and verification approaches that could be involved in a negotiated process for addressing North Korea's nuclear weapon program. In the present paper, I discuss the possible verification roles for the IAEA and how they could be reflected in the IAEA's formal mandate.

It is expected that the starting point for any agreed process for addressing international concerns over North Korea's nuclear weapon program will be an agreement to cease production of fissile material, nuclear testing and production and testing of nuclear-capable missiles. The immediate step would be a freeze of these activities, together with a commitment that the facilities involved will be disabled and dismantled. The freeze would be followed by negotiation of incremental steps, with the ultimate objective of denuclearization of the Korean peninsula, recognizing that the total elimination of nuclear weapons is likely to take some time.

The details and timing of the rollback of North Korea's nuclear arsenal would be major issues for negotiation. It can be expected North Korea will want to retain what it considers a minimum credible nuclear deterrent until it is convinced that the risks and opportunity costs of possessing nuclear weapons are outweighed by the perceived benefits of relinquishing them. There would need to be a commitment at the outset to the principle of the eventual elimination of North Korea's nuclear weapons, but agreement at this stage to a specific deadline is unlikely. Progress towards elimination might be described in terms of agreed milestones rather than specific dates.

To be credible, an agreement for a freeze will need to include effective verification arrangements to provide assurance that the terms of the agreement are being met. This is also the case for the negotiation of follow-on agreements: effective verification arrangements will be essential for each stage.

It is the international expectation that multilateral verification agencies with relevant responsibilities will be involved in verification of an agreement or agreements with North Korea. This means the IAEA for commitments related to fissile material and nuclear activities and to the verification role of this agency.

The IAEA's Safeguards Mandate

The IAEA's mandate refers to the legal basis for applying safeguards (including monitoring arrangements). The mandate involves two aspects: the scope of verification and the procedures the IAEA applies (with which the state is required to cooperate).

Essentially, the IAEA’s mandate is to implement safeguards in accordance with its Statute and relevant safeguards agreements or, where applicable, United Nations Security Council resolutions. The IAEA’s Statute authorizes the Agency “...to apply safeguards, at the request of the parties, to any bilateral or multilateral arrangement.”² Where the parties to an arrangement request the IAEA to apply safeguards, the scope of the safeguards and the procedures applied will depend on the requirements of the arrangement.

Regarding scope and procedures, generically there are three basic possibilities:

Comprehensive safeguards: What used to be described as “full-scope safeguards,” based on agreements concluded between the IAEA and *non-nuclear-weapon states* pursuant to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT).³ The NPT requires the state concerned to accept safeguards in accordance with the IAEA’s Statute and *the Agency’s safeguards system* on all its nuclear material, existing and future. The safeguards system is described in the standard comprehensive safeguards agreement (based on IAEA document INFCIRC/153) and associated documentation (including the safeguards additional protocol, based on IAEA document INFCIRC/540). The agreement sets out detailed procedures for matters such as records, reporting, inspections and monitoring. The agreement gives the IAEA both the right and the obligation to ensure that safeguards apply to all the state’s nuclear material.⁴ This includes ensuring that the state has no undeclared nuclear material. Hence, in addition to inspections and monitoring at declared locations, the IAEA has authority to investigate possible safeguards violations at undeclared locations.

Item-specific safeguards, applying only to specified materials, facilities or items: This form of safeguards is set out in an agreement between the IAEA and the state based on IAEA document INFCIRC/66. This document also refers to *the Agency’s safeguards system*, with detailed procedures for records, reporting, inspections and monitoring, but the scope is limited to the items specified in the agreement. INFCIRC/66 agreements apply in non-NPT states—India, Israel and Pakistan. North Korea also had an INFCIRC/66 agreement prior to joining the NPT. As will be discussed, legally this agreement should have revived when North Korea withdrew from the NPT, but the agreement remains inoperative.

Situation-specific arrangements: Examples include: monitoring the freezes under the 1994 US-North Korea Agreed Framework and the 2007 Six Party arrangements; verification in Iraq under the mandate given by the Security Council following the Gulf War; and the Iran Joint Comprehensive Plan of Action (JCPOA), which contained safeguards procedures based on Iran’s comprehensive safeguards agreement and additional protocol, together with qualitative and quantitative limits and transparency measures monitored by the IAEA. The JCPOA was endorsed by Security Council resolution 2231.

As regards a future agreement or agreements with North Korea, the key point for all parties (the US, North Korea, the IAEA and any others involved) to appreciate is that the IAEA’s verification mandate is determined by the terms of the agreement, and can be as wide or as limited as the parties agree.

Outline of past IAEA Safeguards and Monitoring in North Korea

A list of North Korea's known nuclear facilities, showing the status of these facilities under the 1994 and 2007 freeze arrangements, is given in [Attachment 1](#) of this paper.

IAEA Safeguards Agreements

In 1977, North Korea concluded an INFCIRC/66 agreement covering the Soviet-supplied IRT research reactor at Yongbyon. Subsequently, in 1985, North Korea joined the NPT. Under the NPT, North Korea was obliged to conclude a comprehensive safeguards agreement covering all its nuclear material within 18 months but did not do so until 1992. The INFCIRC/66 agreement was suspended when the 1992 agreement came into force. Soon after commencing inspections under the 1992 agreement, the IAEA found North Korea had failed to declare a quantity of plutonium. Pyongyang refused to cooperate in clarifying this situation and in 1993, the IAEA determined that North Korea was in noncompliance with its safeguards agreement. The DPRK reacted by ceasing all cooperation with IAEA inspectors.

1994 Agreed Framework Freeze (1994-2002)

In 1994, North Korea and the US [concluded](#) the Agreed Framework. North Korea undertook to freeze operations at key facilities at Yongbyon, and to allow IAEA inspectors to monitor this freeze. At the end of 2002, North Korea ended the freeze and ordered IAEA inspectors to leave the country. In 2003, North Korea declared it was withdrawing from the NPT. Consequently, the comprehensive safeguards agreement concluded pursuant to the NPT lapsed.⁵ Legally, the INFCIRC/66 agreement covering the IRT reactor should then have been revived, but this agreement remains dormant.

Under the Agreed Framework North Korea undertook to freeze operations at key facilities at the Yongbyon site—the 5 MWe reactor, the Radiochemical Laboratory (reprocessing plant), the fuel fabrication plant and the partially built 50 MWe power reactor. The freeze also applied to the 200 MWe power reactor under construction at Taechon. IAEA inspectors were tasked with [monitoring](#) this freeze. The IAEA maintained a continuous presence at Yongbyon for this purpose from 1994 to 2002. In addition, the IAEA continued to apply safeguards to other facilities at the Yongbyon site that were not subject to the freeze, namely, the IRT Research Reactor, the Critical Assembly, the Sub-Critical Assembly and the Nuclear Fuel Rod Storage Facility. The IAEA's mandate for monitoring the Agreed Framework freeze was based on:

- North Korea's comprehensive safeguards agreement, which remained in legal force until North Korea's withdrawal from the NPT (2003), although during the freeze the agreement was only partially implemented. The IAEA considered its monitoring activities to be a subset of the safeguards activities that would normally apply; and
- The [request](#) of the Security Council for the IAEA to take all steps necessary to monitor the freeze and to continue reporting to the Council on the implementation of the safeguards agreement.

The Agreed Framework was silent on the issue of whether there might be nuclear material or facilities at locations other than Yongbyon. There was an understanding, not recorded in the

Agreed Framework text, that during the freeze North Korea would not construct any further nuclear facilities. However, under the monitoring arrangements, the IAEA was not authorized to conduct verification activities away from Yongbyon (other than the Taechon reactor) until a significant portion of the light water reactor project under the Agreed Framework was complete. North Korea undertook that it would come into full compliance with its comprehensive safeguards agreement at that time, including taking all steps required by the IAEA to verify the accuracy and completeness of North Korea's declared nuclear material. This would have restored the IAEA's right to investigate locations outside Yongbyon, including undeclared locations, if necessary. However, at the end of 2002, after US accusations that it had an undeclared enrichment program, North Korea ceased all cooperation with the IAEA. This history reinforces that the monitoring arrangements under the Agreed Framework cannot be considered an adequate model for any new freeze. The Agreed Framework did not specifically address the possibility of undeclared enrichment and reprocessing facilities, and it collapsed on this very issue.

2007 Six Party Freeze (2007-2009)

In 2005, as part of the Six Party process, North Korea committed to abandon all nuclear weapons and existing nuclear programs and to return at an early date to the NPT and IAEA safeguards, in exchange for economic and security guarantees. In 2006, however, North Korea conducted its first nuclear weapon test. In 2007, as part of the Six Party process,⁶ North Korea [agreed](#) to "... shut down and seal, for the purpose of eventual abandonment, the Yongbyon nuclear facility, including the reprocessing facility, and invite back IAEA personnel to conduct all necessary monitoring and verifications as agreed between IAEA and the DPRK." Under the ad hoc agreement North Korea and the IAEA reached for monitoring and verifying this freeze (set out in [Attachment 2](#) of this paper), the freeze was applied to the same five facilities as the 1994 freeze, namely, the 5 MWe reactor, the Radiochemical Laboratory, the fuel fabrication plant and the 50 MWe reactor at Yongbyon and the 200 MWe reactor at Taechon. The IAEA observed disablement activities at the first three facilities and confirmed there had been no construction at the 50 MWe and 200 MWe reactors since 2002. The IAEA was also able to maintain surveillance at the Nuclear Fuel Rod Storage Facility. Unlike the 1994 freeze, the IAEA was not permitted to apply safeguards at the other facilities at Yongbyon, which remained operational outside the freeze.

As with the 1994 freeze, the arrangements made no reference to nuclear activities outside Yongbyon apart from the Taechon reactor. The basis of this omission seemed to be the expectation that the freeze would be the first step towards a complete declaration of all nuclear programs and the disablement of all existing nuclear facilities in North Korea. These further steps, however, were never taken. In April 2009, North Korea announced it had decided to reactivate all facilities and resume reprocessing, and to cease all cooperation with the IAEA. After the IAEA left, North Korea conducted its second nuclear test.

Lessons for the Future?

Given North Korea is a closed society, and with limited exposure to international inspections—its comprehensive safeguards agreement operated for only a short period—North Korea can

be expected to resist the idea of international inspectors having rights of access around the country. However, it can be pointed out to North Korea that it is a long way from returning to comprehensive safeguards, and for some time any new safeguards agreements are likely to be of limited scope. The IAEA's mandate under these agreements will be limited to what the parties agree.

North Korea has practical experience with the IAEA operating under a limited safeguards mandate. This was the case with the pre-NPT INFCIRC/66 agreement, and also with the 1994 and 2007 freezes. Thus, North Korea *should* be familiar with the concept of IAEA inspectors working under an agreed mandate and it has no reason to believe IAEA inspectors will exceed this mandate. Some intrusive inspections will be required, but exactly what is needed to ensure effective verification will depend on what has to be verified (as set out in the relevant agreement). Under a step-by-step negotiating process, it is assumed that North Korea would possess some nuclear materials and items outside the scope of verification (namely, nuclear materials in the military program), and IAEA inspectors would not have a general mandate to look for all “undeclared” nuclear material and activities.

Future IAEA Role in North Korea—A Suggested Framework

To date, there have been no negotiations on nuclear verification arrangements in North Korea; thus, discussion of what these might involve can only be speculative. For the purposes of discussion, it is assumed in this paper that these arrangements might include a freeze on production of highly enriched uranium (HEU) and separated plutonium, which would also establish the baseline for the denuclearization process; application of safeguards to all peaceful nuclear activities; and a progressive rollback of the nuclear arsenal, with the fissile materials released by this process transferred irreversibly to safeguarded peaceful use or disposal.

What Might Be Involved with a New Freeze—A Baseline Mandate

The term *freeze* does not fully convey what is meant. A freeze could imply something temporary, such as a moratorium, but what is really intended is a permanent cessation of the activities concerned.

Nuclear warheads: Ideally, a freeze would apply to production of further nuclear warheads; however, such a freeze would not be verifiable in current circumstances: It is not known how many warheads North Korea has now, nor what quantities of HEU and plutonium it currently holds. Therefore, there is no way of knowing if North Korea produces further warheads using available fissile material. A ban on further production of nuclear warheads cannot be verified unless North Korea is prepared to declare all relevant sites and activities and all existing fissile material stocks, and to allow extensive verification activities. It is extremely unlikely, however, that North Korea would agree to all this until a substantial level of confidence and trust has been built, which will take some time.

Fissile material production: Meanwhile, a freeze on fissile material production—enrichment and reprocessing—would at least put a finite cap on the number of additional warheads that *could* be produced. Analysts can estimate how much HEU and plutonium North Korea *may* have

produced to date, and thereby calculate an upper limit on how many warheads it may be capable of producing. If there is a verifiable freeze on producing further fissile material, then the number of warheads will be bounded by existing fissile stocks. At a minimum, a freeze on fissile material production would require a freeze on all high enrichment and all reprocessing (separation of plutonium from irradiated fuel or targets). This would be followed by disabling and dismantling of the facilities involved. To enable the freeze and subsequent actions to be verified, the IAEA will need to know the location of all of North Korea's enrichment and reprocessing facilities and to have access to these to monitor compliance with the freeze.

Nuclear weapon-related activities: An issue to be considered is whether a freeze should apply to weapon-related activities such as tritium production and subcritical testing. These should be regarded as *second-order* issues: they are not essential to an initial freeze but would need to be considered as part of the progressive rollback of the nuclear weapon program.

The details of a freeze have yet to be negotiated, and there are various forms this might take. For the purpose of discussion, this paper suggests the following approach:

Step A: A freeze of enrichment and reprocessing at Yongbyon

There would be an immediate freeze on enrichment and reprocessing at Yongbyon, with a commitment to disable and dismantle the facilities involved under a timetable to be determined. IAEA inspectors would be admitted quickly to begin monitoring operations. A possible variation on this is for low enrichment to continue at Yongbyon if the parties are able to agree to this. As discussed below, this is a difficult issue. Continued enrichment would require the immediate application of safeguards on all relevant materials and activities at Yongbyon. The facilities at Yongbyon critical to fissile material production are the reprocessing and centrifuge enrichment plants.

- **Reprocessing and associated facilities should be closed without question since North Korea has no peaceful use for separated plutonium.** Also, the 5 MWe reactor, which has been the source of most of North Korea's plutonium, should be shut down. In addition, it would be essential to ensure irradiated fuel is not removed for weapons production.
- **Uranium enrichment would be a potentially major complication.** Ideally, the centrifuge enrichment plant would be closed, and any enriched uranium held at Yongbyon should be monitored to ensure it is not removed for further enrichment. (It is assumed North Korea will have removed any HEU from Yongbyon and only LEU will be present there.) In addition, there is a strong argument for monitoring stocks of uranium hexafluoride (UF₆) held at Yongbyon—if there is a freeze on enrichment, there would be no legitimate reason for North Korea to have UF₆ outside monitoring arrangements.

North Korea might not be prepared to dismantle the Yongbyon enrichment plant until it has sufficient confidence in the denuclearization process; Pyongyang may also argue that it needs to continue operating the enrichment plant to produce LEU to fuel the Experimental Light Water Reactor (ELWR) and future power reactors.

Continued enrichment operations in North Korea would be highly problematic, and would become a major issue in the negotiations. If North Korea continues to operate an enrichment plant it will have the capability to quickly resume production of HEU for weapons. The breakout time would be shorter still if significant LEU stocks are available for high enrichment feedstock. Further, the supporting operations for an enrichment program—uranium mining, uranium conversion and centrifuge component manufacture—could also be used to support undeclared enrichment facilities located away from Yongbyon. Accordingly, if continuing enrichment is agreed to, it would be essential for the enrichment plant and its LEU product and supporting activities to be placed under the most rigorous safeguards—and limits would have to be agreed for the level of enrichment and the quantity of LEU stocks.

A further issue is that operating an enrichment program for civilian use would provide a rationale for substantial expansion of enrichment capacity, dramatically reducing breakout time. The current capacity of the Yongbyon plant is believed to be at least 8,000 separative work units (SWU)⁷, which is broadly consistent with the fuel requirements of the ELWR, a very small reactor (30 MWe). If used for high enrichment, this capacity could produce enough HEU for one-two warheads a year. However, if North Korea established a nuclear power program of the scale of just one of the reactors proposed under the Agreed Framework (1,000 MWe), the enrichment capacity required for fuel production would be around 120,000 SWU. This would be sufficient for around 25 warheads a year. These figures illustrate the case for having no enrichment in North Korea. If continuation of enrichment is a red line for North Korea, operating enrichment under multilateral arrangements could be considered. A better approach, likely to be more cost-effective for North Korea itself, would be to establish multilaterally guaranteed fuel supply arrangements.

Summing up, the freeze must include either monitored shutdown of the centrifuge plant and monitoring of LEU and UF₆ stocks or application of rigorous safeguards and limits to the plant and related materials and operations. If the enrichment plant continues to operate, the baseline freeze would have to go beyond a freeze and include safeguards and transparency measures on this facility and related operations. Finally, it would be surprising if North Korea did not want to proceed with the ELWR, which is nearing completion. North Korea is also likely to want to operate the IRT research reactor, the Critical Facility and Sub-Critical Facility and possibly also the fuel fabrication plant, all of which were outside the previous freezes. Safeguards on continuing nuclear activities will be discussed in the next part of this paper.

Step B: Declaration and freeze of all enrichment and reprocessing activities elsewhere

To be credible, a freeze on fissile production will have to encompass, at a minimum, all of North Korea's enrichment and reprocessing plants. Confining previous freezes to the Yongbyon site (and the Taechon reactor) led to the collapse of the Agreed Framework. It is possible to envisage a limited freeze, applying only to the Yongbyon site, as an immediate step, while negotiations proceed on inclusion of other sites,

but the suspicion that fissile production may be continuing elsewhere will be highly corrosive to the effort to build trust.

If the parties decide to first establish a freeze at Yongbyon, it would be imperative to extend the freeze to all other enrichment and reprocessing facilities within a short period (say, less than a year). There is a suspected enrichment plant at Kangson, southwest of Pyongyang. Some analysts believe there may be a further enrichment plant elsewhere. There are no suggestions of reprocessing plants outside Yongbyon, at least on the public record. North Korea would have to be prepared to declare all its enrichment and reprocessing plants and negotiate necessary verification arrangements, both to monitor a freeze at the declared facilities and to resolve any indications of undeclared enrichment or reprocessing facilities.

North Korea has previously [said](#) it would not reveal undeclared nuclear facilities as this would amount to providing the US with a target list. However, if North Korea is genuinely committed to a cessation of fissile production, it should have no reason to maintain secrecy over nuclear facilities. To do so would suggest it intends to produce more fissile material. Preparedness to declare all enrichment and reprocessing facilities, and to negotiate mutually acceptable verification arrangements, is a basic threshold for cooperation and trust, without which *any* agreement is likely to be short-lived.

Step C: Commence negotiation of arrangements for addressing possible undeclared enrichment and reprocessing activities

Compared with negotiation of steps A and B, it is expected to be much more difficult to persuade North Korea to agree to arrangements to enable investigation of suspected undeclared facilities. However, North Korea should be left in no doubt this will be an essential aspect of any credible verification arrangement. For this reason, negotiations on addressing possible undeclared activities should be initiated at the outset, when step A is negotiated, recognizing, however, that implementation of step C might be delayed, partly because of the time needed for negotiations and partly because such arrangements would work best after safeguards are extended to all ongoing fuel cycle activities.

Two points can be made to North Korea to persuade it to accept such arrangements. First, in this context, “undeclared” has a specific meaning. It does not mean *anything* North Korea has not declared. Rather, the term “undeclared” refers to something required to be declared in accordance with the terms of specific agreements concluded between North Korea and the IAEA. If the agreement requires only the declaration of enrichment plants and reprocessing plants, the IAEA will have no authority to look for other kinds of facilities or nuclear material holdings. Just as the scope of verification would be widened in a step-by-step process, the scope of arrangements to address possible undeclared activities would be introduced in corresponding steps.

Second, all standard IAEA safeguards agreements give inspectors a right of access to locations outside declared nuclear facilities in order to resolve questions or investigate

possible violations. Comprehensive safeguards agreements provide for special inspections, which allow inspectors to conduct investigations at any location if the “information made available by the State...is not adequate for the Agency to fulfil its responsibilities under the Agreement” concerned.⁸ INFCIRC/66 agreements also provide for special inspections.⁹ Under the additional protocol, inspectors have the right of *complementary access* at any location where necessary to resolve any question or inconsistency regarding information available to the Agency.¹⁰

North Korea may not be happy to be reminded of special inspections since the IAEA sought to conduct a special inspection in 1993, but the availability of this mechanism is a normal part of safeguards practice. North Korea can be assured this does not mean IAEA inspectors are free to roam the countryside at will. In fact, under a safeguards agreement, if the IAEA considers a special inspection is needed it must first seek the state’s agreement. If there is no agreement the matter must be referred to the Board of Governors to resolve.¹¹ In the case of complementary access under the additional protocol to resolve a question or inconsistency, the state is to be given an opportunity to clarify and facilitate the resolution of the matter,¹² and the activities that can be undertaken during access are specified.¹³

Because of the expected sensitivity of this issue, in the absence of a formal safeguards agreement with North Korea (or maybe even if there is such an agreement), it may be necessary to establish a mechanism involving all relevant parties for resolving any concerns about undeclared nuclear material and activities, along the lines of the mechanism provided in the Iran JCPOA.¹⁴ This could involve establishing a joint commission comprised of North Korea plus the other parties to the overall political agreement. Where information provided by North Korea is not sufficient to resolve the IAEA’s concerns, the Joint Commission may determine, by a specified majority, the necessary means for resolving the matter.

Formalizing a Baseline Mandate

Given the potential for major disputes, it is essential for any verification arrangement to be clearly documented. This applies both to the IAEA’s formal mandate and the description of the relevant verification activities and procedures. This documentation should set out the rights and obligations of both the IAEA and North Korea. In normal circumstances, this would be done through a safeguards agreement between the IAEA and the state concerned. The arrangements for monitoring the 1994 freeze were underpinned by North Korea’s 1992 comprehensive safeguards agreement which was still legally in force at that time. Although the agreement was not being fully implemented, the basic safeguards procedures—of which the monitoring activities were a subset—were described in it.

By the time of the 2007 freeze, there was no safeguards agreement actually in force in North Korea. The 1977 INFCIRC/66 type agreement should have been revived but in practice, this did not happen—and in any event, this agreement applies only to the IRT research reactor, so it would not be helpful with regard to safeguards activities at other facilities. The 2007 monitoring

arrangement was considered informal and ad hoc by the IAEA because it does not require any particular form or substance for safeguards arrangements.¹⁵

For a new freeze, it is assumed that initially its key parameters would be set out in an agreed document between North Korea, the US and possibly other parties. While the ad hoc arrangement for the 2007 freeze (see Attachment 2) could be the starting point for developing the mandate for a new freeze, it is inadequate for today's circumstances and cannot simply be replicated. Issues to be addressed include:

- (i) The Yongbyon centrifuge enrichment facility, which did not exist in 2007. Clearly it must be covered now, either by a freeze or, if continued operation for production of LEU is agreed, by rigorous safeguards. Verification must also be applied to stocks of LEU and UF₆, to provide assurance these materials are not removed for use as feed for high enrichment elsewhere;
- (ii) Enrichment and reprocessing facilities elsewhere: North Korea must be prepared to declare these and to extend the freeze and verification measures to them;
- (iii) Verification measures to address the issue of possible undeclared enrichment and reprocessing facilities—if agreement cannot be reached on dealing with this subject in the initial arrangements, both sides need to work on establishing the necessary arrangements as soon as possible thereafter;
- (iv) Preservation of records, materials and items necessary to enable the IAEA to establish historical nuclear material flows in due course (*nuclear archaeology*). This may have been intended under paragraph (g) of the 2007 arrangement, but needs to be made explicit;
- (v) Safeguards at other operating facilities at Yongbyon and elsewhere.

It would be preferable for any new arrangement to be given legal force. This could be done through a Security Council resolution, calling on North Korea and the other party or parties to act in accordance with the arrangement. The resolution would authorize the IAEA to implement the necessary verification measures and would call upon North Korea and the other parties to cooperate with and support the IAEA.

A Progressive Verification Mandate—Application of Safeguards to All Peaceful Nuclear Activities

Following the introduction of the freeze, the next phase would involve extending the application of safeguards to all ongoing fuel cycle operations at Yongbyon and elsewhere. A key question to consider would be the scope of nuclear activities in North Korea following the establishment of the initial freeze. Unlike historical situations elsewhere, where states with nuclear weapons operate both peaceful and military nuclear programs, a commitment to cease producing fissile material would mean there is no legitimate reason for North Korea to maintain any nuclear

fuel cycle activities outside safeguards. As long as North Korea retains nuclear weapons there will be nuclear material outside safeguards, in the form of warheads and fissile material stocks. However, when North Korea ceases fissile material production it would not require fuel cycle facilities (mines, conversion, enrichment, fuel fabrication, reactors and reprocessing) for military purposes. North Korea may argue that it needs to maintain activities such as tritium production, and special purpose facilities, for example, for dismantling warheads, perhaps for plutonium clean-up (removal of americium build-up) and for refabricating warhead pits. These matters are discussed below.

Safeguarding All Peaceful Nuclear Activities

If North Korea continues to operate the Yongbyon enrichment plant to produce LEU for power reactor fuel, it is essential for the plant and associated nuclear material flows—UF₆ feed and LEU output—to be covered by IAEA safeguards. Any new process for addressing North Korea's nuclear programs should include the objective of making Yongbyon a fully safeguarded site. More broadly, all routine IAEA safeguards measures apply not only to enrichment and reprocessing facilities and their output, but to all upstream materials and facilities including uranium mines and uranium conversion plants used for enrichment and uranium mines, fuel fabrication plants and associated uranium conversion plants and reactors used for reprocessing.

If a state is producing upstream materials outside safeguards it raises the obvious question of whether these materials are intended for undeclared enrichment or reprocessing operations. Verification of nuclear material flows through these upstream processes is required to provide assurance there are no such undeclared activities. For an initial fissile production freeze in North Korea, these upstream activities could be omitted, but without them, assurance that there are no undeclared enrichment or reprocessing facilities is limited; it would be important, therefore, to extend safeguards to all peaceful nuclear activities in North Korea as quickly as possible. As previously discussed, with the cessation of fissile material production, North Korea will not require fuel cycle facilities for military purposes, so any continuing fuel cycle activity should be under safeguards. Nuclear-related locations, as set out in the additional protocol, should be declared and included in safeguards implementation. These include uranium mines and mills, enrichment research and development, manufacturing of enrichment components and matters covered by the additional protocol annexes. As discussed below, at this stage this would not include non-fuel cycle nuclear activities in the military program.

There are three kinds of safeguards agreement that could be used: a comprehensive safeguards agreement (based on INFCIRC/153); an item-specific agreement (based on INFCIRC/66); and a situation-specific agreement prepared for North Korea.

INFCIRC/153 agreement: North Korea had a comprehensive safeguards agreement when it was a party to the NPT. Although the previous freezes included calls for North Korea to come into compliance with that agreement and rejoin the NPT, clearly this is not possible while North Korea has nuclear weapons. Thus, the standard INFCIRC/153 agreement cannot be used for North Korea in current circumstances. The same is true for a modified version of INFCIRC/153 as used for nuclear-weapon states parties to the NPT.

INFCIRC/66 agreement: North Korea has such an agreement legally, although it is not operational and applies only to the IRT reactor. This form of agreement was developed in the

1960s (pre-NPT) to meet the circumstances where a state may have nuclear materials and facilities outside safeguards but was required (usually by a nuclear supplier) to accept safeguards on specific materials, facilities or items. Today, however, it is anachronistic and cannot be considered appropriate for North Korea's circumstances.

A specially written agreement: This modality seems the most satisfactory approach for North Korea. There is a strong case for using INFCIRC/153 as a starting point, but with necessary modifications. INFCIRC/153 is the current expression of the IAEA safeguards system together with the additional protocol. The provisions of INFCIRC/153 are supplemented by detailed *subsidiary arrangements* and *facility attachments*. Through this documentation, the IAEA has developed a system which is both rigorous and adaptable to changing circumstances. A great strength of this system is that its acceptance is almost universal—the only states with nuclear activities but outside INFCIRC/153 agreements are the four states outside the NPT (India, Israel, Pakistan and North Korea)—so the possibility of disputes over safeguards procedures should be minimal.

Modification of INFCIRC/153 for application in North Korea would include omitting the reference to the NPT, changing it from *comprehensive* scope to specified nuclear material and facilities (making it clear this means all existing and future nuclear materials and facilities in peaceful use), and incorporating the principle of irreversibility. It would also be possible to incorporate provisions of the additional protocol since it is not essential to maintain the additional protocol as a separate document. All this would be a significant drafting exercise, but it is important to have an agreement that is optimized for North Korea's circumstances.

Additional Protocol

The additional protocol (INFCIRC/540) is usually thought of as being for comprehensive safeguards states, so at first blush, it might seem that the additional protocol could not be applicable to North Korea. However, the additional protocol can be, and has been, modified for nuclear-weapon states and INFCIRC/66 states. The five NPT nuclear-weapon states and India have additional protocols, modified to varying degrees.¹⁶

The additional protocol is important for strengthening the IAEA's ability to detect indicators of possible undeclared nuclear activities. As previously discussed, as long as North Korea maintains nuclear weapons it will have undeclared nuclear material and specialized facilities, including fissile material storage and possibly warhead refabrication and plutonium clean-up (if these activities are agreed to). However, if North Korea has ceased producing fissile material—a fundamental condition for any agreement dealing with its nuclear weapon program—it will have no need for fuel cycle facilities outside safeguards, so an additional protocol, suitably modified to clarify what is meant by “undeclared” in North Korea's context, is both appropriate and necessary. Additional protocol provisions will be particularly important if North Korea continues with uranium enrichment. For example, the IAEA will need to monitor the scale of manufacturing centrifuge components for consistency with declared enrichment operations. Reporting on, and access to, uranium production will also be important.

Progressive Dismantlement of North Korea’s Nuclear Weapons and Irreversible Transfer of Fissile Materials to Safeguarded Nuclear Activities or Disposal

The final phase, likely to involve a series of agreements and steps over an extended period, is the commitment to roll back North Korea’s nuclear arsenal, involving progressive dismantlement of warheads and the irreversible transfer of the fissile materials released by this process to safeguarded nuclear activities or disposal. As there have been no negotiations on this subject, this discussion is necessarily speculative.

Nuclear Weapon-Related Activities

As part of the negotiations, it needs to be considered whether weapon-related activities should be terminated at the outset, or whether some such activities could be maintained for a period and phased out later during the progressive rollback of the nuclear weapon program. These activities include:

Tritium production: This is a potentially challenging issue. North Korea may seek to maintain tritium production capabilities, involving irradiation of lithium targets (requiring use of a suitable reactor) and tritium extraction from the irradiated targets. Analysts believe there is a tritium extraction facility at Yongbyon. North Korea may argue that tritium is required to maintain a credible nuclear deterrent rather than to produce further warheads.¹⁷ However, it would be difficult to reconcile ongoing tritium production with the principle of a nuclear weapon freeze and a commitment to their elimination. The most satisfactory solution is for North Korea to build up, before the freeze takes effect, stocks of tritium sufficient for a minimum credible deterrent so as not to need further production.

Subcritical testing: Such testing would run counter to the commitment to denuclearization and should be terminated.

Manufacture of new warheads: As part of maintaining a credible nuclear deterrent, North Korea may want the option of manufacturing new warheads: Either dismantling warheads withdrawn from service and replacing them with newer models, or refabricating warheads after plutonium clean-up operations (as discussed below). There is no convincing rationale for replacing warheads: The North Korean arsenal is very new and is unlikely to have obsolete warhead models. Arguments for maintaining warhead manufacturing facilities should be rejected.

Plutonium clean-up: The negotiations may need to address whether existing plutonium can be chemically treated to remove americium build-up. This has been a practice of nuclear-weapon states at various times—warhead “pits” are withdrawn for “reconditioning” to restore them to their original specifications. North Korea may argue it needs this option to maintain a minimum credible deterrent. On the other hand, this would imply an intention to maintain nuclear weapons over a considerable period (decades), which runs counter to the commitment to denuclearization. Accordingly, arguments for undertaking plutonium clean-up should be rejected.

Verification Stages

Broadly speaking, the verification activities involved would break down into the following stages.¹⁸

- Stage 1—North Korea ceases production of fissile materials.
- Stage 2—North Korea declares all nuclear material and all nuclear facilities, and nuclear-related activities, items and materials. With the cessation of all fissile material production, North Korea should have no nuclear fuel cycle facilities outside safeguards, other than storage facilities.

All facilities related to tritium production, subcritical testing, warhead manufacture and plutonium clean-up should be declared and dismantled. Appropriate verification and monitoring arrangements will be required to establish that these facilities are not being operated and are dismantled.

Fissile materials in warheads or military custody would be black-boxed—the total quantities of HEU and plutonium within the military program would be declared, but without any breakdown by forms and locations. Fissile materials in warheads would not be available for verification until the warheads are dismantled.

- Stage 3—Inspections of declared facilities and related nuclear materials.
- Stage 4—North Korea declares excess nuclear materials in the military program, and these are irreversibly transferred to the safeguarded program or disposed of.
- Stage 5—Progressive reduction in warheads. This is likely to involve a series of agreements, probably over an extended period.

The verification arrangements in support of progressive reductions may take some time to establish. The US has suggested that North Korea might relinquish a number of warheads early in the process as a confidence building measure. The absence of verification arrangements need not delay any such action, but verification will become increasingly important as reductions proceed (to provide assurance that warheads and fissile materials are not being withheld contrary to agreements).

- Stage 6—Verification activities to provide assurance against the existence of undeclared nuclear facilities and nuclear materials.

An important aspect will be prohibiting or monitoring of dual-use activities having potential nuclear weaponization application, similar to arrangements in the Iran JCPOA.¹⁹ In addition, items from the Nuclear Suppliers Group dual-use list should be covered, e.g., high explosive containment vessels (relevant to subcritical testing) and specialized high explosive materials.²⁰ Another aspect of this stage would be establishing a historic nuclear materials balance, drawing on declared material flows, facility operating records, sampling and analysis of materials, interviews of personnel and related activities. This will be essential for supporting a conclusion that there are no undeclared materials.

- Stage 7—End of the disarmament process. North Korea is shown to meet the requirements for a non-nuclear-weapon state. At this point, it is envisaged that North Korea would rejoin the NPT and conclude a comprehensive safeguards agreement (and additional protocol). The IAEA would complete any remaining safeguards activities necessary to draw the “broader conclusion” that all nuclear material in North Korea is under safeguards and accounted for.

The role of the IAEA in these various stages and activities remains to be determined. Some of these are encompassed in normal safeguards activity or are closely parallel to safeguards, and it can be expected they will be undertaken by the IAEA, with a special mandate to be established where necessary—for example, to cover fissile materials with non-classified attributes or to protect fissile material in classified form.

Conclusions

Although the approaches set out in this paper may seem unduly complicated, all parties need to recognize that effective verification is absolutely essential to the credibility and, therefore, the sustainability, of any process seeking to address the North Korean nuclear situation. If one party thinks the other is violating the agreement, the agreement will not only fail; the situation could end up being far worse than if there had been no agreement at all. Apparent violations, whether real or not, will lead to escalating tensions and the risk of military conflict.

Clearly both negotiation and verification of a series of agreements addressing North Korea’s nuclear program will involve major challenges for all parties. North Korea can be expected to resist the introduction of IAEA safeguards and related verification activities, especially those required to provide assurance of the absence of undeclared nuclear material and activities. North Korea can be assured that IAEA inspectors will not have authority to go everywhere and look at everything, and that they will be operating under a precise mandate which will be determined by agreement between North Korea itself and the other parties involved.

Obviously North Korea will not be willing to freeze its nuclear weapon program and to commit to eventual denuclearization unless it is persuaded this is in its national interest. The same applies for the US and the other parties: They will not remain committed to the process if it appears North Korea is not fully committed. Full cooperation with IAEA verification activities will be essential to building confidence that both sides are committed to fulfilling their obligations under the agreement.

All this highlights the importance of establishing the right mandate for the IAEA. In any agreement on safeguards and related verification, clarity is essential. Any misunderstandings could be disastrous, potentially resulting in a loss of trust amongst the parties, the collapse of the agreement and a long and difficult path to reaching any further agreement. Accordingly, it is imperative to set out precisely the rights and obligations of North Korea and the IAEA, and to ensure that the expectations of the parties correspond. It is essential to define precise verification objectives and to ensure there is a shared understanding of what these objectives involve. Effectively verified denuclearization is essential to building the confidence and trust needed to achieve lasting peace and security on the Korean peninsula.

Attachment 1

North Korea's Known Nuclear Facilities

Facilities Frozen and Monitored Under 1994 (Agreed Framework) and 2007 (Six Party) Freezes	
<i>Yongbyon</i>	<ul style="list-style-type: none"> • Experimental Nuclear Power Plant (5 MWe) • Radiochemical Laboratory (reprocessing plant) • Nuclear Fuel Fabrication Plant • Yongbyon Nuclear Power Plant (50 MWe) (never completed; subsequently abandoned)
<i>Elsewhere</i>	<ul style="list-style-type: none"> • Taechon Nuclear Power Plant (200 MWe) (never completed; subsequently abandoned)
Facilities That Operated under Safeguards during the 1994 Freeze (<i>Note: Safeguards were not applied to these facilities during the 2007 freeze</i>)	
<i>Yongbyon</i>	<ul style="list-style-type: none"> • IRT Research Reactor • Critical Facility • Sub-Critical Facility • Nuclear Fuel Storage (irradiated fuel) <p><i>Note: The latter facility operated under IAEA monitoring, but not safeguards, during 2007-09.</i></p>
Known Facilities Post-Dating the Freezes	
<i>Yongbyon</i>	<ul style="list-style-type: none"> • Centrifuge Enrichment Facility (located in Nuclear Fuel Fabrication Plant) • Experimental Light Water Reactor (30 MWe) (nearing completion)
Suspected Facilities	
<i>Kangson</i>	<ul style="list-style-type: none"> • Centrifuge enrichment facility*
<i>Elsewhere*</i>	<ul style="list-style-type: none"> • Another centrifuge enrichment facility*

<i>Yongbyon</i>	<ul style="list-style-type: none"> • Uranium conversion plant* • Tritium extraction facility* <p>(some analysts suggest the Radioisotope Production Facility could include either uranium conversion or tritium extraction operations)</p>
Uranium Production	
<i>Pyongsan</i>	<ul style="list-style-type: none"> • Uranium mine • Uranium concentration plant
<i>Wolbisan</i>	<ul style="list-style-type: none"> • Uranium mine
<i>Pakchon</i>	<ul style="list-style-type: none"> • Pilot uranium concentration plant

*unconfirmed

For a detailed study see: Chaim Braun, Siegfried Hecker, Chris Lawrence, and Panos Papadiamantis, “North Korean Nuclear Facilities After the Agreed Framework,” *Center for International Security and Cooperation*, Stanford University, May 27, 2016, https://fsi-live.s3.us-west-1.amazonaws.com/s3fs-public/khucisacfinalreport_compressed.pdf.

Attachment 2

2007 IAEA Ad Hoc Monitoring and Verification Plan

- (a) The Agency will receive from the DPRK a list of facilities that have been shut down and/or sealed, and subsequently, the Agency will be kept informed of their status with a view to monitoring and verifying the shutdown and/or sealing of the declared facilities;
- (b) The Agency will have access to all facilities and equipment that have been shut down and/or sealed for the purpose of its monitoring and verification activities;
- (c) The Agency will install, and service as necessary, appropriate containment and surveillance (C/S) and other devices to monitor and verify the status of the shutdown and/or sealed facilities and equipment. If C/S measures cannot be applied because of practical reasons, the Agency and the DPRK will agree on the implementation of other appropriate verification measures;
- (d) The Agency will examine and verify information on the design of the shutdown and/or sealed facilities and document the status of these facilities photographically or through video recordings. Reverification of such information will be performed periodically;
- (e) The Agency will be informed in advance if the DPRK intends to change the design and/or status of facilities and equipment so that consultations can be held with the DPRK about the impact such changes may have on the Agency's monitoring and verification work;
- (f) The Agency will be informed in advance if the DPRK intends to move or remove any nuclear-related equipment or other essential equipment or components from the shutdown nuclear facilities or decommission any of these facilities. The Agency will be provided appropriate access to verify such equipment, components and/or activities;
- (g) The DPRK will maintain all records relevant to the Agency's monitoring and verification activities;
- (h) The Agency will be provided the necessary visas for Agency personnel, and will be extended the same privileges and immunities as those set out in the relevant provisions of the Agreement on the Privileges and Immunities of the International Atomic Energy Agency ([INFCIRC/9/Rev.2](#)) for Agency property, funds and assets, its personnel and other officials in exercising their functions under this arrangement;
- (i) The Agency will be provided with full information on the health and safety procedures at the relevant facilities;
- (j) The Agency and the DPRK will consult on issues related to the costs of implementation; and
- (k) The above measures will be subject to periodic review by the DPRK and the Agency.

See: IAEA, *Monitoring and Verification in the Democratic People's Republic of Korea*, GOV/2007/36, July 3, 2007, <https://www.isis-online.org/publications/dprk/IAEAReportonDPRK.pdf>.

Endnotes

- ¹ Christy Lee, “Experts: Kim Suggested Road to Denuclearization Has Come to an End,” *VOA*, January 3, 2020, <https://www.voanews.com/east-asia-pacific/experts-kim-suggested-road-denuclearization-has-come-end?utm>; see also: Michelle Nichols and David Brunnstrom, “North Korea’s U.N. envoy says denuclearization off negotiating table with United States,” *Reuters*, December 7, 2019, <https://www.reuters.com/article/us-northkorea-usa/north-koreas-un-envoy-says-denuclearization-off-negotiating-table-with-united-states-idUSKBN1YB0FG>.
- ² IAEA, *IAEA Statute*, Article III.A.5., December 28, 1989.
- ³ Comprehensive safeguards agreements are based on IAEA document IAEA, *The Structure and Content of Agreements Between the Agency and States Required in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons*, INFCIRC/153, June 1972, <https://www.iaea.org/sites/default/files/publications/documents/infcircs/1972/infcirc153.pdf>.
- ⁴ *Ibid*, paragraph 2.
- ⁵ The validity of North Korea’s withdrawal from the NPT has not been definitively determined. The IAEA sought guidance from NPT parties on the legal status of the withdrawal, but such guidance has not been forthcoming. See: IAEA, *Application of Safeguards in the Democratic People’s Republic of Korea*, GOV/2011/53-GC(55)/24, September 2, 2011, https://www-legacy.iaea.org/About/Policy/GC/GC55/GC55Documents/English/gc55-24_en.pdf.
- ⁶ The Six Parties comprised North Korea and the US, China, Japan, South Korea and Russia.
- ⁷ Chaim Braun, Siegfried Hecker, Chris Lawrence, and Panos Papadiamantis, “North Korean Nuclear Facilities After the Agreed Framework,” *Center for International Security and Cooperation*, Stanford University, May 27, 2016, https://fsi-live.s3.us-west-1.amazonaws.com/s3fs-public/khucisacfinalreport_compressed.pdf.
- ⁸ IAEA, INFCIRC/153, paragraph. 73.
- ⁹ IAEA, *The Agency’s Safeguards System (1965)*, INFCIRC/66, paragraph. 53, December 3, 1965, <https://www.iaea.org/sites/default/files/publications/documents/infcircs/1965/infcirc66.pdf>.
- ¹⁰ IAEA, *Model Protocol Additional to the Agreement(s) Between State(s) and the International Atomic Energy Agency for the Application of Safeguards*, INFCIRC/540, Article 4.a.(iii), September 1997, <https://www.iaea.org/sites/default/files/infcirc540.pdf>.
- ¹¹ IAEA, INFCIRC/153, paragraph. 77.
- ¹² IAEA, INFCIRC/540, Article 4.d.
- ¹³ *Ibid*. Articles 5.c and 6.d.
- ¹⁴ See: *Joint Comprehensive Plan of Action*, Annex I, section Q, Vienna, July 14, 2015, <https://www.europarl.europa.eu/cmsdata/122460/full-text-of-the-iran-nuclear-deal.pdf>.
- ¹⁵ IAEA, *Monitoring and Verification in the Democratic People’s Republic of Korea*, GOV/2007/36, July 3, 2007, <https://www.isis-online.org/publications/dprk/IAEAReportonDPRK.pdf>.
- ¹⁶ In India’s case the additional protocol has been modified to the point of having no application to nuclear material and facilities in India, so is not a suitable precedent for North Korea.

- ¹⁷ The half-life of tritium is approximately 12.4 years; tritium stocks decay by around 5.5 percent a year.
- ¹⁸ A detailed discussion can be found in my paper: John Carlson, “Verification of DPRK Nuclear Disarmament: The Pros and Cons of Non-Nuclear-Weapon States (specifically, the ROK) Participating in this Verification Program,” *The Nautilus Institute*, May 19, 2019, <https://nautilus.org/napsnet/napsnet-special-reports/verification-of-dprk-nuclear-disarmament-the-pros-and-cons-of-non-nuclear-weapon-states-specifically-the-rok-participating-in-this-verification-program>.
- ¹⁹ The JCPOA prohibits computer simulation of nuclear explosives and explosively driven neutron sources, and permits multipoint detonation systems and explosive diagnostic systems for non-nuclear purposes with Joint Commission approval and monitoring.
- ²⁰ IAEA, *Communication received from the Permanent Mission of the Republic of Korea to the International Atomic Energy Agency regarding Certain Member States’ Guidelines for Transfers of Nuclear-related Dual-use Equipment, Materials, Software and Related Technology*, NSG Part 2 Guidelines – INFCIRC/254/Rev.10/Part 2* (Corrected), paragraphs 5.B.7 and 6.C.1, respectively, February 5, 2018, <https://www.iaea.org/sites/default/files/publications/documents/infcircs/1978/infcirc254r10p2c.pdf>.