DEFUSING THE BOMB

A PHASED APPROACH FOR A VERIFIED DENUCLEARIZATION OF NORTH KOREA

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There remain about 15,000 nuclear weapons in the world today.
Denuclearizing North Korea: A verified, phased approach

A verified, phased approach

The process must reflect existing levels of trust at each stage

By Alexander Glaser and Zia Mian

At the June 2018 Singapore Summit, North Korea agreed to the goal of “complete denuclearization” in exchange for “security guarantees” by the United States, including an end to sanctions (1). Like earlier efforts in the 1990s and 2000s, the current round of diplomacy may well fail because of the challenges of balancing North Korean insistence on the primacy of building trust and cooperation with U.S. demands for progress on denuclearization. Any successful attempt to balance these priorities will have to resolve the thorny question of verification. Here, we propose a phased approach for verified denuclearization that relies on technical measures and tools to allow for the scope, pace, and intrusiveness of denuclearization to reflect progress in political confidence building. More broadly, successfully bridging the goals of denuclearization and political judgments by the international community about how to approach verified disarmament for other states that currently have nuclear weapons will underwrite the purpose of the treaty.

Moving forward, eliminating North Korea’s nuclear weapons program and related facilities will need a freeze on current weapons-related activities; an agreed baseline of current stockpiles of nuclear weapons, fissile materials, ballistic missiles, and key components; and verified reduction of these stockpiles and dismantling of North Korea’s weapons complex. There are already several proposals for drawn-out, perhaps decade-long, step-by-step approaches that lead to eventual denuclearization, in contrast to demands from Trump administration officials that North Korea “dismantle all of their W.M.D. and ballistic missile programs in a year,” but in neither case is attention paid to how verification might assist or hinder such efforts (2). To be sustainable for other states that currently have nuclear weapons.

Although the process of “denuclearization” has not been spelled out explicitly in the current United States–North Korea talks, the two sides seem to have settled on the phrase “complete denuclearization.” For the purposes of this analysis, this is taken to include the key nuclear weapons-related obligations agreed on in the 1992 Joint Declaration of South and North Korea on the Denuclearization of the Korean Peninsula, namely to “not test, manufacture, produce, receive, possess, store, deploy or use nuclear weapons” and that these commitments would be verified (3).

In March 2018, North Korea announced a moratorium on nuclear weapons and ballistic missile testing. Maintaining this moratorium is seen as the foundation for moving forward with talks and implementing whatever is eventually agreed as the denuclearization process. A more formal commitment to not carry out further nuclear weapon tests would be for North Korea to join the Comprehensive Nuclear Test Ban Treaty (CTBT). Even though the CTBT is not in force, under customary international law, programs of an international treaty concerning the obligations to not take actions that would undermine the purpose of the treaty.

To establish a basis for moving forward, North Korea could add to its freeze on nuclear weapon and ballistic missile tests a freeze on fissile material production. This can be verified primarily through agreed-on nonintrusive provisions. Originally, North Korea launched its first plutonium production program with plutonium recovered from the spent fuel of the graphite-moderated (5 MW-electric) plutonium production reactor at Yongbyon. The shutdown of its cooling tower in 2008 temporarily made reactor operation impossible and constrained plutonium supply in the following years, but plutonium production at Yongbyon appears to have resumed more recently. In the meantime, North Korea may have shifted the emphasis of its program to uranium enrichment and uranium-based weapons. Today, North Korea likely produces both plutonium and HEU and may have available material for dozens of nuclear weapons. The question now is how such a freeze could be monitored for both plutonium production and uranium enrichment. North Korea (and South Korea) could permanently refrain from plutonium separation and uranium enrichment, as agreed in their 1992 Joint Declaration.

In the case of plutonium, satellite imagery can be used to observe heat signatures, vapor plumes, cooling water discharges, and other activities near the reactor (4). All these indicators would provide good evidence for a suspension of plutonium production at Yongbyon. Regional cryptanalysis monitoring, ideally with a small number of detectors placed around the Yongbyon site, could confirm that remaining spent fuel is not reprocessed (5). There are also simple measures to permanently disable the Yongbyon reactor—for example, by blowing boron dust through the core’s cooling channels—but North Korea may not agree to such actions until the later stages of the denuclearization process.

The situation with regard to uranium enrichment is more difficult. It may be possible to confirm remotely the shutdown status of the Yongbyon enrichment plant and a possible second plant suspected to

FREEZE ON FISSILE MATERIAL

Since North Korea’s withdrawal from the Nuclear Non-Proliferation Treaty (NPT) in 1992, there have been essentially no international inspection efforts in North Korea. At the same time, North Korea has expanded the scale and complexity of its nuclear weapons program. On the basis of information available via open sources, it is not clear how many nuclear weapons North Korea possesses today, of what kind (including possibly thermonuclear weapons), and whether they use plutonium or highly enriched uranium (HEU) or both as fissile material. Nor is there reliable information on its ballistic missile capabilities. We assume that a new framework agreement would establish a freeze on fissile material production. This can be verified primarily through agreement on nonintrusive provisions.
**MILESTONES TOWARD DENUCLEARIZATION**

1. **MORATORIUM ON NUCLEAR WEAPON AND BALLISTIC MISSILE TESTING**
   - North Korea announced such a moratorium in March 2018; it could now also join the CTBT

2. **(VERIFIED) FREEZE ON FISSILE MATERIAL (AND BALLISTIC MISSILE) PRODUCTION**
   - Ideally, such a freeze could rely primarily on remote-monitoring techniques

3. **BASELINE DECLARATIONS OF WARHEAD AND FISSILE MATERIAL INVENTORIES**
   - Confirming correctness and completeness would be a longer-term objective

4. **(VERIFIED) REDUCTIONS IN THE NUCLEAR ARSENAL**
   - Different options and approaches depending on priorities/preferences

*Source (from top to bottom): KCNA, Urenco, Chung Sung-Jun/Getty Images, Sandia National Laboratories*
THREE LEVELS OF ACCESS FOR POSSIBLE INSPECTIONS

REMOTE MONITORING
Satellite imagery in particular could be an important tool to confirm the operational status of nuclear facilities or observe (the absence of) related activities.

STANDOFF DETECTION
For facilities where onsite access is considered too intrusive, at least initially, nearby sensors could provide reassurance of compliance with agreed provisions.

ONSITE INSPECTIONS
Direct inspector access to declared sites and (upon request) to other sites access offers the greatest level of reassurance; but they may only become relevant in longer term.

Source: DigitalGlobe (top), NASA (middle), IAEA (bottom)
Monitoring a Suspension of Fissile Material Production
MONITORING A FREEZE ON FISSILE MATERIAL PRODUCTION

**PLUTONIUM PRODUCTION**

Satellite imagery can be used to observe heat signatures, vapor plumes, cooling water discharges, and other onsite activities; these provide good evidence for a suspension of plutonium production at Yongbyon.

Regional krypton-85 monitoring could provide further evidence of a freeze.

**NON-PRODUCTION OF HIGHLY ENRICHED URANIUM**

Shutdown status of enrichment plant could (possibly) be monitored remotely; if plant is allowed to operate, then unattended measurement systems (OLEM, C/S, and perhaps even environmental sampling) could confirm non-production of HEU.

Source: Google (top) and Urenco (bottom)
Making Declarations
POSSIBLE BASELINE DECLARATIONS
OF NUCLEAR WARHEAD AND FISSION MATERIAL INVENTORIES

<table>
<thead>
<tr>
<th>WARHEAD DECLARATION</th>
<th>Inventory</th>
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</thead>
<tbody>
<tr>
<td>Total number of warheads as of [DATE]</td>
<td>..........</td>
</tr>
<tr>
<td>Warheads, by type/designation</td>
<td>..........</td>
</tr>
<tr>
<td>Additional warhead components in storage, by type/designation</td>
<td>..........</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>FISSILE MATERIAL DECLARATION</th>
<th>Plutonium</th>
<th>HEU</th>
<th>(Tritium)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inventory as of [DATE]</td>
<td>..........</td>
<td></td>
<td>..........</td>
</tr>
<tr>
<td>Of this, material currently in weapons or weapon components</td>
<td>..........</td>
<td></td>
<td>..........</td>
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</tbody>
</table>
DATA EXCHANGE
AS A BASIS FOR A MORE ROBUST VERIFICATION FRAMEWORK

In May 2008, North Korea made available about 18,000 pages of operating records with information on operation of its plutonium production reactor and the associated reprocessing facility since 1986.
NUCLEAR ARCHAEOLOGY COULD BE USED TO VERIFY A NORTH KOREAN PLUTONIUM DECLARATION

The banner reads: “Let’s protect Dear General Kim Jong Il desperately!”
Credit: CNN/Brian Rokus, 2008

Unit cell of the DPRK Yongbyon reactor
ESTIMATING LIFETIME PLUTONIUM PRODUCTION

BASED ON THE MEASUREMENT OF A SINGLE (BORON) ISOTOPE RATIO

UNDERSTANDING URANIUM SUPPLY

URANIUM MINING IN NORTH KOREA
Mining activities at few (perhaps only one or two) locations;
ore grade previously reported as 0.26%, but can be expected to vary;
it takes several hundred tons of ore to extract one ton of uranium

Jeffrey Lewis, August 12, 2015, www.38north.org/2015/08/jlewis081215/

RECONSTRUCTING NORTH KOREA’S URANIUM SUPPLY HISTORY
About 2000 tons of ore are required to make 25 kg of weapon-grade HEU
or 5 kg of weapon-grade plutonium
Understanding historic uranium production in North Korea could help dispel concerns
about undeclared enrichment plants and/or undeclared stocks of fissile material
Enabling Verified Reductions
PHASED (AND “SECURE”) VERIFIED REDUCTIONS

1. DEMATING AND (JOINT) CONTAINERIZATION OF NUCLEAR WARHEADS
   - May need some type of confirmation measurement
   - Warheads are then placed in containers, sealed, and prepared for long-term storage

2. MONITORED LONG-TERM STORAGE OF NUCLEAR WARHEADS (AND MISSILES)
   - Storage location of containerized warheads can remain unknown/secret
   - Possibility of confirming integrity of seals and containers remotely

3. STEPWISE REDUCTIONS IN THE ARSENAL
   - Based on agreed schedule for reductions, DPRK would offer warheads for verified dismantlement (or specified amounts of fissile material for safeguards)

Source: U.S. Department of Energy (top), Sandia National Laboratories (middle), KCNA (bottom)
UNCONVENTIONAL APPROACHES
(SIMPLE, NON-INTRUSIVE, QUICKLY IMPLEMENTABLE)

Entrance to Storage Magazine at Pantex, Zone 4
Uses massive concrete blocks to prevent unauthorized access
Credit: U.S. DOE

Tethered balloons for 24/7 site surveillance
Widely used for civilian and military applications
Credit: Altave Omni, www.altave.com.br
NEXT STEPS / WAY FORWARD

SHORT-TERM GOALS
- Declarations and freeze of fissile material production
- Confirmed storage and stepwise reductions (several options)
- Emphasis on verification approaches that are non-intrusive
  (e.g. using remote-monitoring techniques) and quickly implementable

LONGER-TERM GOALS
- Disposition pathways for fissile materials and/or weapon components
- Return to NPT and/or accession to Ban treaty (before or after
  elimination of North Korea’s weapons program)

Source: W. Keith Luse, CISAC (top) and author (bottom)