VERIFIED DENUCLEARIZATION OF NORTH KOREA
ELEMENTS OF A PHASED APPROACH

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MILESTONES TOWARD DENUCLEARIZATION

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

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

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

(VERIFIED) REDUCTIONS IN THE NUCLEAR ARSENAL
Different options and approaches depending on priorities/preferences
Suspension of Fissile Material Production
(REMOTE) MONITORING
OF A FREEZE ON FISSION 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

WARHEAD DECLARATION

<table>
<thead>
<tr>
<th></th>
<th>Inventory</th>
</tr>
</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>
</tr>
</tbody>
</table>

FISSION MATERIAL DECLARATION

<table>
<thead>
<tr>
<th></th>
<th>Plutonium</th>
<th>HEU</th>
<th>(Tritium)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total material produced</td>
<td>............</td>
<td>............</td>
<td>............</td>
</tr>
<tr>
<td>Removals and losses (including material consumed in weapon tests)</td>
<td>............</td>
<td>............</td>
<td>............</td>
</tr>
<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>
</tr>
</tbody>
</table>

(Several options: public, private, cryptographic escrow)
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

FORENSIC ANALYSIS OF GRAPHITE SAMPLES COULD CONFIRM TOTAL PLUTONIUM PRODUCTION IN NORTH KOREA WITHIN AN UNCERTAINTY OF ±3 KG

The banner reads: “Let’s protect Dear General Kim Jong Il desperately!”
Credit: CNN/Brian Rokus, 2008
UNDERSTANDING URANIUM SUPPLY TO GAIN CONFIDENCE IN THE ABSENCE OF UNDECLARED PRODUCTION

URANIUM MINING IN NORTH KOREA
Mining activities at few (perhaps only one or two) locations; ore grade previously reported as 0.26%, i.e., it takes 300–400 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
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 stocks of fissile material

Source: Google (top) and Rio Tinto (bottom)
Ways to Approach Verified Reductions
(COMPLEMENTARY) APPROACHES TO VERIFIED REDUCTIONS

MONITORED STORAGE OF NUCLEAR WARHEADS (AND MISSILES)
Storage location of containerized items can remain unknown/secret
May need some type of confirmation measurement

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

STEPWISE DOWNSIZING OF THE WEAPONS COMPLEX
Footprint of weapons complex would “shrink” over time, and additional sites would
then be offered for inspections; see also “Deferred Verification” concept (UNIDIR)

Source: Sandia National Laboratories (top), KCNA (middle), fws.gov (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