Plan for This Session

Question

Next session, Thursday, 2-3.20pm, March 16th:
Midterm Exam in 103 Talbot Lab

Multiple Choice (partial credit) + Essay Question

Office hours: Wednesday noon to 6pm in 401 Grainger

News

Module 6: Nuclear Arsenals
How US nuclear force modernization is undermining strategic stability: The burst-height compensating super-fuze

Hans M. Kristensen, Matthew McKinzie, Theodore A. Postol

The US nuclear forces modernization program has been portrayed to the public as an effort to ensure the reliability and safety of warheads in the US nuclear arsenal, rather than to enhance their military capabilities. In reality, however, that program has implemented revolutionary new technologies that will vastly increase the targeting capability of the US ballistic missile arsenal. This increase in capability is astonishing—boosting the overall killing power of existing US ballistic missile forces by a factor of roughly three—and it creates exactly what one would expect to see, if a nuclear-armed state were planning to have the capacity to fight and win a nuclear war by disarming enemies with a surprise first strike.

targeting with old fuze

Kill probability for hardened silo
Increases from 50% to 86%

Number of deployed Trident warheads (W67-1/MK4A) with ability to kill hardened targets.

⇒ results in significant imbalance in nuclear deterrent + possible Russian concerns with regards to US first strike capabilities.
AMF&F Firing System (Arming, Fusing and Firing) for W67-1Mk4A warhead

**Our conclusions.** Under the veil of an otherwise-legitimate warhead life-extension program, the US military has quietly engaged in a vast expansion of the killing power of the most numerous warhead in the US nuclear arsenal: the W76, deployed on the Navy’s ballistic missile submarines. This improvement in kill power means that all US sea-based warheads now have the capability to destroy hardened targets such as Russian missile silos, a capability previously reserved for only the highest-yield warheads in the US arsenal.

The capability upgrade has happened outside the attention of most government officials, who have been preoccupied with reducing nuclear warhead numbers. The result is a nuclear arsenal that is being transformed into a force that has the unambiguous characteristics of being optimized for surprise attacks against Russia and for fighting and winning nuclear wars. While the lethality and firepower of the US force has been greatly increased, the numbers of weapons in both US and Russian forces have decreased, resulting in a dramatic increase in the vulnerability of Russian nuclear forces to a US first strike. We estimate that the results of arms reductions with the increase in US nuclear capacity means that the US military can now destroy all of Russia’s ICBM silos using only about 20 percent of the warheads deployed on US land- and sea-based ballistic missiles.
Part 1: Overview of Programs and Arsenals

Part 2: Arsenals of the NPT Nuclear-Weapon States:  
The United States, Russia, the United Kingdom,  
France, and China

Part 3: Arsenals of non-NPT and Emerging Nuclear-Weapon States:  
India, Pakistan, Israel and North Korea

Part 4: Threat Perceptions
Module 6: Programs and Arsenals

Part 1: Overview of Programs and Arsenals
Module 6: Nuclear Arsenals and Proliferation

The New York Times

A Chain Reaction of Proliferation

"The Nuclear Express," a new book on the history of the atomic age, describes the interlocking web of influence and espionage behind the proliferation of nuclear technology. This diagram gives a summary of the authors' tracking of the transfers of nuclear technology and secrets.

Connections show the flow of information and technology, by intended transfer, leak or espionage. Some were one-way transfers; others were two-way.

Sources: Thomas C. Reed and Danny B. Stilman

Nuclear states
Circles represent nuclear states, arranged on the timeline by the year of first nuclear detonation (or, for Israel and South Africa, the year they could have tested).

Abandoned nuclear programs
Hexagons represent states that have abandoned their nuclear weapons programs. Other states, not shown, that have ended their weapons programs include Sweden (1970), Switzerland and Taiwan (1988), and Argentina and Brazil (1994).

Aspiring states
Squares represent states that the authors say have embryonic nuclear weapons programs. All the nations deny any ambitions to develop atom bombs.

This article has been revised to reflect the following correction:

Correction: December 15, 2008
A chart last Tuesday with an article about the proliferation of the atomic bomb, showing the exchange of nuclear information and technology between countries, misidentified the type of reactor that India acquired from Canada, which allowed India to make fuel for its first nuclear test. It was a CIRUS reactor, not a CANDU reactor.
Rising, then Pulling Back from a Peak
Having reached a peak in the late 1980s, the number of nuclear warheads has dropped significantly. But more countries now possess them.


9,920 total nuclear weapons in 2014
World Nuclear Weapon Stockpiles 1945–2014

Rising, then Pulling Back from a Peak
Having reached a peak in the late 1980s, the number of nuclear warheads has dropped significantly. But more countries now possess them.


USA and Russia
World Nuclear Weapon Stockpiles 1945–2014

World Nuclear Weapon Stockpiles 1945–2014

Source: The Bulletin of the Atomic Scientist
Nuclear Notebook, written by Hans M Kristensen and
Robert S. Norris, Federation of American Scientists

Other Nuclear Weapon States
Plan for This Session

Midterm grades before the end of the week

RE4v1 due Thursday March 30th

RPv1 will be due Thursday April 6th

News and Discussion

Module 6: Nuclear Arsenals (cont’d)
27 March 2017 – At the start of a United Nations conference to negotiate a legally binding instrument to prohibit nuclear weapons, a senior UN official highlighted that creating a world free of such weapons is a common obligation of all States – both nuclear and non-nuclear – and called for their inclusive engagement.

“Let us all work harder and more creatively, so that we can achieve our common goal of a world, safer and more secure, without nuclear weapons, and better for all,” said Kim Won-soo, the UN High Representative for Disarmament Affairs.

Speaking on behalf of UN Secretary-General António Guterres, he also expressed hope that the instrument will also strengthen the Nuclear Non-Proliferation Treaty (NPT) and advance the world closer to the total elimination of nuclear weapons and that it would make important contribution to nuclear disarmament and to our ultimate objective of general and complete disarmament.

Yet he acknowledged that defeatism and dismissiveness now permeate international deliberations on disarmament, and cautioned that the public at large seems to be losing interest in the issue. Indeed, it is hard to imagine these days a gathering of one million people in the street in support of nuclear disarmament, as the world witnessed in the 1980s.
The United States, Britain and France are among almost 40 countries that will not join talks on a nuclear weapons ban treaty starting at the United Nations on Monday, said U.S. Ambassador Nikki Haley.

Haley told reporters the countries skipping the negotiations are instead committed to the Non-Proliferation Treaty, which entered into force in 1970 and is aimed at preventing the spread of nuclear weapons and weapons technology.

The Trump administration is reviewing whether it will reaffirm the goal of a world without nuclear weapons, a White House aide said last week, referring to an aim embraced by previous Republican and Democratic presidents and required by a key arms control treaty.

Britain's U.N. Ambassador Matthew Rycroft said: "The UK is not attending the negotiations on a treaty to prohibit nuclear weapons because we do not believe that those negotiations will lead to effective progress on global nuclear disarmament."
States With Nuclear Weapons in 2014

NPT States
- China
- France
- Russia
- UK
- USA

Non NPT States
- India
- Israel
- North Korea
- Pakistan
Global Nuclear Weapon Inventory 2014 (Important)

NPT Nuclear Weapon States (Total Weapons)

China: ~ 250
France: ~ 300
Russia: ~ 4,300
UK: ~ 225
US: ~ 4,760

Global Nuclear Weapon Inventory 2014
(Important)

Non-NPT Nuclear Weapon States
(Total Weapons)

Pakistan: ~ 120
Israel: ~ 80
India: ~ 110
North Korea: < 10

States With Nuclear Weapons in 2012
## Table 1. Estimated alert nuclear forces, 2012

<table>
<thead>
<tr>
<th>Country</th>
<th>Stockpiled warheads</th>
<th>Alert warheads</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>5,000</td>
<td>920</td>
<td>Split more or less evenly between ICBMs and SLBM s</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>4,500</td>
<td>890</td>
<td>Mainly warheads on ICBMs; alert levels vary greatly depending on type</td>
</tr>
<tr>
<td>France</td>
<td>300</td>
<td>80</td>
<td>One SSBN on patrol</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>225</td>
<td>48</td>
<td>One SSBN on patrol</td>
</tr>
<tr>
<td>China</td>
<td>240</td>
<td>0</td>
<td>Warheads are not mated with delivery systems or in military custody</td>
</tr>
<tr>
<td>Pakistan</td>
<td>100</td>
<td>0</td>
<td>Warheads are not mated with deployed delivery vehicles</td>
</tr>
<tr>
<td>India</td>
<td>90</td>
<td>0</td>
<td>Warheads are not mated with deployed delivery vehicles</td>
</tr>
<tr>
<td>Israel</td>
<td>80</td>
<td>0</td>
<td>Warheads are not mated with deployed delivery vehicles</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>~10,540</td>
<td>~1,940</td>
<td></td>
</tr>
</tbody>
</table>

*This includes warheads in the military stockpile, assigned to nuclear forces. Additional retired, but still intact, warheads may be in storage awaiting dismantlement. The United States and the Russian Federation each have several thousand warheads in this category.*

**Warheads are considered on alert if they are deployed on a delivery system that is deployed and ready to launch the weapons within minutes or hours.**

**Although deployed and fully operational, SLBMs on French and British SSBNs are thought to require longer preparation to launch than US and Russian alert weapons.**
Module 6: Programs and Arsenals

Part 2: Arsenals of the NPT Nuclear-Weapon States

Will cover impact of New Start in Arms Control Module

The United States, Russia, the United Kingdom, France, and China
Evolution of US and SU-Russian Nuclear Stockpiles

Evolution of US and SU-Russian Strategic Nuclear Warhead Numbers

Source: NRDC (Nov. 2002)
Evolution of US and SU-Russian Strategic Nuclear Launcher Numbers

Source: NRDC (Nov. 2002)
U.S. and Russian “Tactical” Weapons in Europe

• The U.S. is thought to have 150 tactical nuclear weapons based in Europe, in the form of aerial bombs.

• Most are based in Italy and Turkey, but some are based in Germany, Belgium, and the Netherlands.

• Russia is thought to have about 2,000 operational “tactical” nuclear weapons in its arsenal.

• At the peak in 1971, 7100 U.S. tactical weapons were stationed in Europe: removed for concerns with regards to decision process of escalating conventional conflict and for security risks arising from political terrorism in Europe.
The long-standing position of Washington is that its air-to-surface weapons in Europe connect the security of NATO and the United States. Still, the tactical arms are not intended for use against any particular nation and the infrastructure required to employ the weapons no longer stands at combat readiness.

A December 2008 report by an advisory panel to the U.S. Defense Department found that the time required to bring the aircraft that would fire the nuclear weapons into battle mode was "now measured in months rather than minutes."

The report detailed different views within the alliance, with some high-level U.S. officials at NATO headquarters in Belgium described as not being supportive of keeping the tactical weapons in Europe. An anonymous U.S. general was quoted to say that the nuclear bombs were no longer required as Washington could extend its nuclear umbrella to cover European allies from outside the continent.
## Evolution of US Nuclear Bomber Forces – 1

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>B-52 Stratofortress</td>
<td>94</td>
<td>94</td>
<td>94</td>
<td>94</td>
<td>94</td>
</tr>
<tr>
<td>B-2 Spirit</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td><strong>Total (Bombers)</strong></td>
<td><strong>115</strong></td>
<td><strong>115</strong></td>
<td><strong>115</strong></td>
<td><strong>115</strong></td>
<td><strong>115</strong></td>
</tr>
</tbody>
</table>

Source: NRDC
### Evolution of US Nuclear Bomber Forces – 2

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bombers Weapons (Force Loadings) [12]</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bombs [13]</td>
<td>516</td>
<td>516</td>
<td>516</td>
<td>516</td>
<td>1,286</td>
</tr>
<tr>
<td>ALCM (AGM-86B) [16]</td>
<td>430</td>
<td>430</td>
<td>430</td>
<td>430</td>
<td>45</td>
</tr>
<tr>
<td>ACM (AGM-129A) [17]</td>
<td>430</td>
<td>430</td>
<td>430</td>
<td>430</td>
<td>45</td>
</tr>
<tr>
<td><strong>Total (Force Loading Weapons)</strong></td>
<td>1,376</td>
<td>1,376</td>
<td>1,376</td>
<td>1,376</td>
<td>1,376</td>
</tr>
</tbody>
</table>

* The 2007 figure is a goal of the Bush administration's 2001 Nuclear Posture Review
** The 2012 figure is a limit of the Treaty of Moscow signed on May 24, 2002

Source: NRDC
## Evolution of US SSBN Nuclear Forces

<table>
<thead>
<tr>
<th>SSBN Forces</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2007*</th>
<th>2012**</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SSBNs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trident [3]</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td><strong>Total SSBNs</strong></td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td><strong>SLBM Launchers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trident with C4 [9]</td>
<td>192</td>
<td>168</td>
<td>168</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trident with D5 [10]</td>
<td>240</td>
<td>264</td>
<td>264</td>
<td>336</td>
<td>336</td>
</tr>
<tr>
<td><strong>Total Launchers</strong></td>
<td>432</td>
<td>432</td>
<td>432</td>
<td>336</td>
<td>336</td>
</tr>
<tr>
<td><strong>SLBM Warheads</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W76 (C-4) [14]</td>
<td>1536</td>
<td>1008</td>
<td>1008</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W76 (D-5)</td>
<td>1536</td>
<td>1728</td>
<td>1728</td>
<td>1560</td>
<td>1300</td>
</tr>
<tr>
<td>W88 (D-5) [15]</td>
<td>384</td>
<td>384</td>
<td>384</td>
<td>384</td>
<td>380</td>
</tr>
<tr>
<td><strong>Total Warheads</strong></td>
<td>3456</td>
<td>3120</td>
<td>3120</td>
<td>1944</td>
<td>1680</td>
</tr>
</tbody>
</table>

Source: NRDC
# Evolution of US ICBM Nuclear Forces

<table>
<thead>
<tr>
<th>ICBM Forces</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2007*</th>
<th>2012**</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Launchers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MINUTEMAN III [8]</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>MX (PEACEKEEPER) [9]</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td><strong>Total Launchers</strong></td>
<td>550</td>
<td>550</td>
<td>550</td>
<td>550</td>
<td>550</td>
</tr>
<tr>
<td><strong>ICBM Deployed Warheads</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W62 (MM III) [16]</td>
<td>600</td>
<td>300</td>
<td>300</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>W78 (MM III) [17]</td>
<td>900</td>
<td>900</td>
<td>900</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>W87 (MX) [18]</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td><strong>Total (Deployed)</strong></td>
<td>2000</td>
<td>1700</td>
<td>1700</td>
<td>500</td>
<td>500</td>
</tr>
</tbody>
</table>

Source: NRDC
Obama Limits When U.S. Would Use Nuclear Arms

By DAVID E. SANGER and PETER BAKER

WASHINGTON — President Obama said Monday that he was revamping American nuclear strategy to substantially narrow the conditions under which the United States would use nuclear weapons.

But the president said in an interview that he was carving out an exception for “outliers like Iran and North Korea” that have violated or renounced the main treaty to halt nuclear proliferation.
The document to be released Tuesday after months of study led by the Defense Department will declare that “the fundamental role” of nuclear weapons is to deter nuclear attacks on the United States, allies or partners, a narrower presumption than the past. But Mr. Obama rejected the formulation sought by arms control advocates to declare that the “sole role” of nuclear weapons is to deter a nuclear attack.

“We are going to pursue opportunities for further reductions in our nuclear posture, working in tandem with Russia but also working in tandem with NATO as a whole,” he said.

An obvious such issue would be the estimated 200 tactical nuclear weapons the United States still has stationed in Western Europe. Russia has called for their removal, and there is growing interest among European nations in such a move as well. But Mr. Obama said he wanted to consult with NATO allies before making such a commitment.
iClicker Question

About when did the total worldwide nuclear arsenal peak?

(A) 1955
(B) 1965
(C) 1975
(D) 1985
(E) 1995
About when did the total worldwide nuclear arsenal peak?

(A) 1955
(B) 1965
(C) 1975
(D) 1985
(E) 1995
About how many nuclear weapons were there at the peak?

(A) 10,000
(B) 30,000
(C) 50,000
(D) 70,000
(E) 90,000
About how many nuclear weapons were there at the peak?

(A) 10,000
(B) 30,000
(C) 50,000
(D) 70,000
(E) 90,000
About how many nuclear weapons are in the global inventory today?

(A) 5,500
(B) 8,500
(C) 13,500
(D) 15,700
(E) 17,300
About how many nuclear weapons are in the global inventory today?

(A) 5,500  
(B) 8,500  
(C) 13,500  
(D) 15,700  
(E) 17,300
About how many nuclear weapons does China now have *in total*?

(A) 50
(B) 100
(C) 240
(D) 3,000
(E) 5,000
About how many nuclear weapons does China now have *in total*?

- (A) 50
- (B) 100
- **(C) 240**
- (D) 3,000
- (E) 5,000
iClicker Question

About how many nuclear weapons does France now have in total?

(A) 50
(B) 100
(C) 300
(D) 1,000
(E) 5,000
About how many nuclear weapons does France now have in total?

(A) 50
(B) 100
(C) 300
(D) 1,000
(E) 5,000
Major nuclear facilities
Nuclear weapon assembly/disassembly sites
Strategic nuclear weapon site
Nuclear test site
SU-Russian Nuclear Warheads

Source: NRDC (Nov. 2002)
# Russian Nuclear Forces (2011)

<table>
<thead>
<tr>
<th>Type/name</th>
<th>Russian designation</th>
<th>Year</th>
<th>Warheads x yield (kilotons)</th>
<th>Total warheads</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strategic offensive weapons</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ICBMs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SS-18 M6 Satan</td>
<td>RS-20V</td>
<td>50</td>
<td>10 × 500/800 (MIRV)</td>
<td>500</td>
</tr>
<tr>
<td>SS-19 M3 Stiletto</td>
<td>RS-18</td>
<td>50</td>
<td>6 × 400 (MIRV)</td>
<td>300</td>
</tr>
<tr>
<td>SS-25 Sickle</td>
<td>RS-12M (Topol)</td>
<td>120</td>
<td>1 × 800</td>
<td>120</td>
</tr>
<tr>
<td>SS-27 Mod 1</td>
<td>RS-12M2 (Topol-M)</td>
<td>51</td>
<td>1 × 800</td>
<td>51</td>
</tr>
<tr>
<td>SS-27 Mod 1</td>
<td>RS-12M1 (Topol-M)</td>
<td>18</td>
<td>1 × 800?</td>
<td>18</td>
</tr>
<tr>
<td>SS-27 Mod 2</td>
<td>RS-24</td>
<td>6</td>
<td>3 × 400? (MIRV)</td>
<td>18</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td></td>
<td>295</td>
<td></td>
<td>1,007</td>
</tr>
<tr>
<td><strong>SLBMs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SS-N-18 M1 Stingray</td>
<td>RSM-50</td>
<td>4/64</td>
<td>3 × 50 (MIRV)</td>
<td>192</td>
</tr>
<tr>
<td>SS-N-23 Skiff</td>
<td>R-29RM</td>
<td>1/16</td>
<td>4 × 100 (MIRV)</td>
<td>64</td>
</tr>
<tr>
<td>SS-N-23 M1</td>
<td>RSM-54 (Sineva)</td>
<td>5/80</td>
<td>4 × 100 (MIRV)</td>
<td>320</td>
</tr>
<tr>
<td>SS-N-32</td>
<td>RSM-56 (Bulava)</td>
<td>(1/16)</td>
<td>6 × 100 (MIRV)</td>
<td>(96)</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td></td>
<td>10/160</td>
<td></td>
<td>576</td>
</tr>
<tr>
<td><strong>Bombers/weapons</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bear-H6</td>
<td>Tu-95 MS6</td>
<td>32</td>
<td>6 × AS-15A ALCMs, bombs</td>
<td>192</td>
</tr>
<tr>
<td>Bear-H16</td>
<td>Tu-95 MS16</td>
<td>31</td>
<td>16 × AS-15A ALCMs, bombs</td>
<td>496</td>
</tr>
<tr>
<td>Blackjack</td>
<td>Tu-160</td>
<td>13</td>
<td>12 × AS-15B ALCMs or AS-16 SRAMs, bombs</td>
<td>156</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td></td>
<td>76</td>
<td></td>
<td>844²</td>
</tr>
<tr>
<td><strong>Subtotal strategic offensive forces</strong></td>
<td></td>
<td></td>
<td></td>
<td>~2,430</td>
</tr>
</tbody>
</table>

---

17p280 Programs and Arsenals, p. 50
Russian Nuclear Forces
Russian Nuclear Forces

Russian SS-27 Road-Mobile Launcher
### Russian Nuclear Forces (2010)

#### NONSTRATEGIC AND DEFENSIVE WEAPONS

**ABM/Air defense**

<table>
<thead>
<tr>
<th>System</th>
<th>Type</th>
<th>Number</th>
<th>Year</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>53T6</td>
<td>Gazelle</td>
<td>68</td>
<td>1986</td>
<td>1 x 1,000</td>
</tr>
<tr>
<td>SA-10</td>
<td>Grumble</td>
<td>1,900</td>
<td>1980</td>
<td>1 x low</td>
</tr>
</tbody>
</table>

**Land-based air**

<table>
<thead>
<tr>
<th>Category</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bombers/fighters</td>
<td>~524</td>
</tr>
</tbody>
</table>

**Naval**

<table>
<thead>
<tr>
<th>Category</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Submarines/surface ships/air</td>
<td>~700</td>
</tr>
</tbody>
</table>

### SUBTOTAL NONSTRATEGIC AND DEFENSIVE FORCES

~2,000

### TOTAL

~4,600

---

1. The Sineva probably carries at least four MIRVed warheads. U.S. intelligence in 2006 estimated that the missile can carry "up to 10" warheads.

2. All Gorgon missiles apparently have been removed from the ABM system.

3. We estimate that an additional 3,300 nonstrategic warheads are in reserve or awaiting dismantlement, leaving a total inventory of approximately 5,300 nonstrategic warheads.

4. We estimate that an additional 7,300 intact warheads are in reserve or awaiting dismantlement, for a total inventory of approximately 12,000 warheads.
Recent Evolution of Russian Nuclear Forces

Evolution of Russian total warheads is very similar to the evolution of US nuclear forces (because of START and New START limits).

Unlike the US, for geopolitical reasons Russia deploys more warheads on its ICBMs than on its SLBMs.
China’s Nuclear Infrastructure


Possible warhead assembly and production facility.

Headquarters of the North Sea Naval Fleet: Probable location of China’s Xia class ballistic missile submarine.

Shanghai Institute of Nuclear Research: Engaged in ballistic missile and nuclear weapon development.

Chinese Academy of Engineering Physics: This is a duplicate of the nuclear weapon research and design facility at Haigang.

Nuclear Fuel Component Plant: Used for producing and processing plutonium for nuclear weapons.

Northwest Nuclear Weapon Research and Design Academy (Qinghai Academy)


Guangyuan: Site of China’s largest plutonium production reactor and plutonium separation (reprocessing) plant. Facilities are not thought to be producing fissile material.

Lop Nur Nuclear Weapon Test Site: Also possible site of nuclear weapon stockpile.

Heping: Site of gaseous diffusion uranium enrichment plant can produce between 750 and 2,950 kg of weapons-grade uranium per year.

Total Chinese Nuclear Warheads vs Time

Traditional Chinese nuclear posture:
No first strike use – limited assured 2\textsuperscript{nd} strike capability

Source: The Bulletin of the Atomic Scientist
Nuclear Notebook, written by Hans M Kristensen and Robert S. Norris, Federation of American Scientists
Chinese Nuclear Forces (2008):

Currently: Modernizing nuclear forces to strengthen assured 2nd strike capability
- road mobile ICBM launchers
- submarine based missiles

See for example:
**China’s Transition to a More Credible Nuclear Deterrent: Implications and Challenges for the United States**
Michael S. Chase in Asia Policy, July 2013
French and British Nuclear Forces

# French Nuclear Forces

## THE FRENCH ARSENAL

<table>
<thead>
<tr>
<th>Aircraft Type</th>
<th>No.</th>
<th>Year Operational</th>
<th>Range (Kilometers)</th>
<th>Warheads x Yield (Kilotons)</th>
<th>Active Warheads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land-Based Aircraft</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mirage 2000N/ASMP</td>
<td>50</td>
<td>1988*</td>
<td>2,750**</td>
<td>1 TN81 x VARIABLE TO 300</td>
<td>50</td>
</tr>
<tr>
<td>Rafale F3/ASMP-A</td>
<td>?</td>
<td>2008</td>
<td>2,000</td>
<td>1 TNA x VARIABLE TO ?</td>
<td></td>
</tr>
<tr>
<td>Carrier-Based Aircraft</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Super Étendard/ASMP</td>
<td>10</td>
<td>1978</td>
<td>650**</td>
<td>1 TN81 x VARIABLE TO 300</td>
<td>10</td>
</tr>
<tr>
<td>Rafale MK3/ASMP-A</td>
<td>?</td>
<td>(2010)</td>
<td>2,000</td>
<td>1 TNA x VARIABLE TO ?</td>
<td></td>
</tr>
<tr>
<td>SLBMs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M45***</td>
<td>48</td>
<td>N/A</td>
<td>4,000+</td>
<td>4–6 TN75 x 100</td>
<td>240</td>
</tr>
</tbody>
</table>

* The ASMP first became operational on the Mirage IV in 1986.
** Maximum range of the ASMP is 300 kilometers; for the ASMP-A it is 500 kilometers.
*** Three sets of 16 M45 missiles are deployed on three of four SSBNs in the operational cycle.

### TOTAL: 300

---

## FRENCH SSBNs

<table>
<thead>
<tr>
<th>Name/SLBM</th>
<th>Year Operational</th>
<th>Missile Range (Kilometers)</th>
<th>Warheads x Yield (Kilotons)</th>
<th>Total Warheads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Le Triomphant/M45</td>
<td>1997</td>
<td>4,000+</td>
<td>4–6 TN75 x 100</td>
<td>80</td>
</tr>
<tr>
<td>Le Téméraire/M45</td>
<td>1999</td>
<td>4,000+</td>
<td>4–6 TN75 x 100</td>
<td>80</td>
</tr>
<tr>
<td>Le Vigilant/M45</td>
<td>2005</td>
<td>4,000+</td>
<td>4–6 TN75 x 100</td>
<td>80</td>
</tr>
<tr>
<td>Le Terrible/M51.1**</td>
<td>(2010)</td>
<td>6,000</td>
<td>4–6 TN75 x 100</td>
<td>0</td>
</tr>
</tbody>
</table>

* Three sets of 16 M45 missiles are deployed on three of four SSBNs in the operational cycle.
** Its first deployment is scheduled for 2010.

SSBN: Nuclear-power ballistic missile submarine
SLBM: Submarine-launched ballistic missile
The United Kingdom and France (largely) rely on a nuclear deterrent in form of a naval submarine based nuclear arsenal.

<table>
<thead>
<tr>
<th>Weapon System</th>
<th>Warheads</th>
<th>Type</th>
<th>No. in stockpile</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLBMs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trident II D-5</td>
<td>64</td>
<td>1994</td>
<td>7,400</td>
</tr>
</tbody>
</table>

# average loading five warheads per missile, some missiles carry one warhead, various yield options

Source: NRDC (Nov. 2002)
Module 6: Programs and Arsenals

Part 3: Arsenals of non-NPT and Emerging Nuclear-Weapon States

India, Pakistan, Israel and North Korea
Estimates for Arsenals in India, Israel, North Korea and Pakistan


North Korea < 10

India ~ 110

Israel ~ 80

Pakistan ~ 120

17p280 Programs and Arsenals, p. 62

MGP, Phys. Dep. © 2017
Khan Research Laboratory—Kahuta
Large-scale uranium enrichment plant designed to produce enough weapons-grade uranium for a number of nuclear devices per year; not subject to IAEA inspection.

Possible uranium enrichment R&D facility/pilot plant; not subject to IAEA inspection.

Pakistani Institute of Nuclear Science and Technology (PINSTECH)
Laboratory and pilot-scale plant for plutonium extraction; neither subject to IAEA inspection. PARR-1 (9 MWe) and PARR-2 (30 KWe) research reactors, subject to IAEA safeguards.

Missile production factory

40-50 MWe research and plutonium production reactor operational; not under IAEA inspection. In conjunction with the nearby large plutonium extraction plant at Chasma and the pilot-scale plant at Rawalpindi, the reactor could be the source of a significant inventory of unsafeguarded weapons usable plutonium.

- 1998 nuclear test sites

Large plutonium extraction plant; civil works complete; not subject to IAEA inspection. Chinese-supplied 300-MWe nuclear power reactor operational; subject to IAEA inspection. Additional 310-MWe nuclear power reactor planned.

Canadian-supplied KANUPP nuclear power reactor; subject to IAEA inspection.

Bhabha Atomic Research Center (BARC)
Location of India’s nuclear weapon program including research, plutonium production using the Dhruva and Cirrus research reactors, associated plutonium extraction plant (none subject to IAEA inspection), and manufacture of implosion devices. Pilot-scale uranium enrichment plant, not subject to IAEA inspection.

Indira Gandhi Atomic Research Center
Site of fast-breeder test reactor (FBTR) and pilot-scale and large-scale plutonium extraction plants. Also location of Madras 1 and 2 nuclear power reactors—not subject to IAEA inspection and therefore available to produce plutonium for nuclear weapons.

Kudankulam India and Russia have signed an agreement to construct two 1,000-MWe civilian nuclear power reactors at this site, subject to IAEA safeguards.

Italicized names represent nuclear-related sites. See table 11.1

Italicized names represent nuclear-related sites. See table 12.1
India’s nuclear weapons use plutonium

• India’s first nuclear explosive device used explosive material diverted illegally from a civilian nuclear reactor provided by Canada

• Estimated to have produced 225–370 kg of weapons-grade plutonium

• Estimated to have produced a smaller, but publicly unknown, quantity of weapons-grade uranium

• This quantity of plutonium is thought to be enough for India to produce ~50-90 nuclear weapons

• The FAS estimates that India has about 110 warheads

• India is thought to have the components to deploy a small number of nuclear weapons within days

• No nuclear weapons are known to be deployed among active military units or deployed on missiles
## India’s nuclear weapon tests

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 18, 1974</td>
<td>02:34:55</td>
<td>27.095 N</td>
<td>71.752 E</td>
<td>2-5 kt</td>
</tr>
<tr>
<td>May 11, 1998</td>
<td>10:13:42</td>
<td>27.102 N</td>
<td>71.857 E</td>
<td>12 kt*</td>
</tr>
</tbody>
</table>

Local time is 5 and one-half hours later than GMT

* The Indian government announced that three nuclear devices were detonated simultaneously in two shafts, about one kilometer apart. We count this as two tests.

** Seismic records do not discriminate the explosions of two devices (announced by Indian scientists as being 0.2 kt and 0.6 kt), one or both of which may not have detonated.

Source: NRDC
India’s Nuclear and Missile Programs – 3

**India’s nuclear delivery capability**

- India has developed several types of ballistic missiles capable of carrying and delivering a nuclear payload.

- Three versions of the short-range, liquid-propellant, road-mobile Prithvi have been developed —
  - Army (range = 150 km, payload = 500 kg)
  - Air Force (range = 250 km, payload = 500–750 kg)
  - Navy (range = 350 km, payload = 500 kg)

- India has developed and successfully tested 3 medium range missiles Agni I-III, with a declared range of up to 3,000 km. The payload for the Agni III missile is assumed to be 1.5 tons.

- Longer range missiles Agni IV and V are under development.

- Prior to 2010 the main delivery vehicles where bomber planes
Indian Nuclear Forces (2008)

<table>
<thead>
<tr>
<th>AIRCRAFT</th>
<th>RANGE (KILOMETERS)</th>
<th>PAYLOAD (KILOGRAMS)</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mirage 2000H/Vajra</td>
<td>1,800</td>
<td>6,300</td>
<td>Squadron 1 or 7 at Gwalior Air Force Station.</td>
</tr>
<tr>
<td>Jaguar IS/IB/Shamsher</td>
<td>1,600</td>
<td>4,775</td>
<td>At Ambala Air Force Station.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LAND-BASED MISSILES</th>
<th>RANGE (KILOMETERS)</th>
<th>PAYLOAD (KILOGRAMS)</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prithvi I</td>
<td>150</td>
<td>1,000</td>
<td>Nuclear version entered service after 1998 with the 333rd and 355th Missile Groups. Will be converted from liquid fuel to solid fuel.</td>
</tr>
<tr>
<td>Agni II</td>
<td>2,000</td>
<td>1,000</td>
<td>Under development. Tested August 29, 2004. Deployed with army's 335th Missile Group.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SEA-BASED MISSILES</th>
<th>RANGE (KILOMETERS)</th>
<th>PAYLOAD (KILOGRAMS)</th>
<th>COMMENT</th>
</tr>
</thead>
</table>
Pakistan’s current nuclear weapons mainly use HEU

- Pakistan stole uranium enrichment technology from Urenco; has since supplied it to many other countries of concern
- Is estimated to have produced 585–800 kg of highly enriched uranium
- FAS estimates that it could have 120 HEU nuclear weapons
- May possess enough weapon-grade plutonium to produce 3–5 nuclear weapons
- Nuclear weapons are thought to be stored in component form, with the fissile core stored separately from the non-nuclear explosives
- Thought to possess enough components and material to assemble a small number of nuclear weapons in a matter of hours or days
Plan for This Session

Questions

Extra Credit Opportunity:
Governing Globalization, Challenges for Democracy and Global Society
Panel #2: Armed Conflict, Terrorism, and Nuclear Proliferation
Illini Union Room 210, Saturday, April 1st.

News

Module 6: Nuclear Arsenals (cont’d)

Video Presentation: Kim’s Nuclear Gambit
North Korea might be preparing for another nuclear test, satellite images suggest

By Anna Fifield  March 30 at 9:53 AM

TOKYO — North Korea appears to be getting ready for another nuclear test, according to new satellite images that show a prolonged and heightened level of activity at its underground testing site.

It was not immediately possible to tell whether North Korea is putting on a performance for the satellites — a ploy it has sometimes used to raise tensions — or whether a sixth nuclear test is imminent. But analysts agree that North Korea is determined to make progress on its nuclear and missile programs.

“They are trying to get a working arsenal, so the more they test, the more they learn,” said Jon Wolfsthal, a senior nonproliferation adviser in the Obama administration who is now at the Carnegie Endowment for International Peace.

“It’s likely that they’re trying to make a device small enough to achieve their goal of putting a nuclear warhead on a long-range missile,” Wolfsthal said.

North Korea has made no secret of its ambitions to build a missile capable of reaching the continental United States, and Kim Jong Un said in a Jan. 1 address that his regime had “entered the final stage of preparation for a test launch of an intercontinental ballistic missile.”
“The North Koreans know when commercial satellites are passing overhead and typically try to avoid activities during that time. The fact these formations can be seen suggests that Pyongyang is sending a political message that the sixth nuclear test will be conducted soon,” Bermudez and fellow analyst Jack Liu wrote for 38 North.
Pakistan’s Nuclear and Missile Programs – 2

Pakistan’s nuclear weapon tests

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Yield (kt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 28, 1998</td>
<td>10:16:15</td>
<td>28.862 North</td>
<td>64.818 East</td>
<td>9-12 kt#</td>
</tr>
</tbody>
</table>

Local time is 5 hours later than GMT

# Pakistani officials announced that five nuclear devices were tested. Seismic records do not discriminate these and possibly only one device was detonated.

last revised 11.25.02

Source: NRDC
Pakistan’s nuclear delivery capability

• Thought to have about 30 nuclear-capable short-range Chinese M-11 surface-to-surface missiles, which have a range of 280–300 km

• Announced deployment of the Shaheen I in 2001

• Tested Ghauri I (range > 1,300 km, payload = 700 kg)

• Tested Ghauri II (range = 2,000 km, payload = 850 kg)

• Displayed but never tested the 2,000-km Shaheen II

• Primary nuclear capable aircraft is the F-16, which can deliver a 1,000-kg bomb to a distance of 1,400 km
We estimate that Pakistan has produced 70-90 nuclear warheads that can be deployed on the following delivery vehicles:

<table>
<thead>
<tr>
<th>TYPE</th>
<th>RANGE</th>
<th>PAYLOAD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(kilometers)</td>
<td>(kilograms)</td>
</tr>
<tr>
<td><strong>Aircraft</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F-16A/B</td>
<td>1,600</td>
<td>1 bomb (4,500)</td>
</tr>
<tr>
<td>Mirage V</td>
<td>2,100</td>
<td>1 bomb (4,000)</td>
</tr>
<tr>
<td><strong>Ballistic missiles</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ghaznavi (Hatf-3)</td>
<td>~400</td>
<td>Conventional or nuclear (500)</td>
</tr>
<tr>
<td>Shaheen-1 (Hatf-4)</td>
<td>450+</td>
<td>Conventional or nuclear (1,000)</td>
</tr>
<tr>
<td>Shaheen-2 (Hatf-6)*</td>
<td>2,000+</td>
<td>Conventional or nuclear (1,000)</td>
</tr>
<tr>
<td>Ghauri (Hatf-5)</td>
<td>1,200+</td>
<td>Conventional or nuclear (1,000)</td>
</tr>
<tr>
<td><strong>Cruise missiles</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Babur (Hatf-7)*</td>
<td>320+</td>
<td>Conventional or nuclear (n/a)</td>
</tr>
<tr>
<td>Ra’ad (Hatf-8)*</td>
<td>320+</td>
<td>Conventional or nuclear (n/a)</td>
</tr>
</tbody>
</table>
Pakistani Ra’ad Air-Launched Cruise Missile
Summary of India’s and Pakistan’s Ballistic Missile Systems

With India and Pakistan both possessing nuclear weapons and the means to deliver them great distances, a possible war could result in millions of deaths in both countries. The following illustrates the range of missiles:

Source: CNN (May 2003)
Israel’s Nuclear Weapons Complex

Negev Nuclear Research Center
Dimona is the location of Israel’s nuclear weapon program, including plutonium production using IRR 2 research reactor (40-150 MWt) and associated plutonium extraction plant; and related uranium purification, uranium conversion, and fuel fabrication facilities. Site of small-scale laser and centrifuge uranium enrichment programs and discontinued lithium-6 and lithium deuteride production activities. No activities at Dimona are subject to IAEA inspection.
Israel’s nuclear weapons primarily use Pu

- Is thought to have completed its first nuclear device by late 1966 or early 1967, probably using HEU stolen from the United States.
- Is reported to have hurriedly assembled deliverable devices just before the 1967 six-day war.
- Is estimated to have produced ~ 400–700 kg of weapons-grade plutonium.
- Is thought to have enough plutonium to fabricate ~ 100–200 nuclear weapons.
- Is thought to have ~ 75–200 fission weapons, FAS estimate: 80. (Some sources disagree, claiming much more capability, including modern thermonuclear weapons.)
Israel’s Nuclear and Missile Programs – 2

Israel’s nuclear delivery capability


• Jericho II: medium-range, solid-propellant (range = 1,500 km, payload = 1,000 kg). Developed with the French. Deployed in 1990; currently has ~ 100. Land- and rail-mobile.

• Jericho III: intermediate-range, solid-propellant (range approx. 4,000 km, payload = 1,000 kg). Indigenous. Tested.

• Israel could also deliver nuclear weapons using its U.S.-supplied F-4E and F-16 aircraft.

• Israel could also deliver nuclear weapons using its cruise missiles (the U.S.-supplied Harpoon, range = 120 km, payload = 220 kg, or a new 1,200-km cruise missile).
## Summary of Israel’s Nuclear Delivery Systems

<table>
<thead>
<tr>
<th>Strategic forces</th>
<th>Year deployed</th>
<th>Range (kilometer)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aircraft</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F-16A/B/C/D/I Fighting Falcon</td>
<td>1980</td>
<td>1,600</td>
<td>Bombs possibly stored at Tel Nof, Nevatim, Ramon, Ramat-David, and Hatzor</td>
</tr>
<tr>
<td>F-15I Ra’am (Thunder)</td>
<td>1998</td>
<td>4,450</td>
<td>Could be used for long-range strike role</td>
</tr>
<tr>
<td><strong>Land-based missiles</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jericho I</td>
<td>1972</td>
<td>1,200</td>
<td>Possibly 50 at Zekharyeh</td>
</tr>
<tr>
<td>Jericho II</td>
<td>1984–85</td>
<td>1,800</td>
<td>Possibly 50 at Zekharyeh, on TELs in caves</td>
</tr>
<tr>
<td><strong>Sea-based missiles</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dolphin-class submarines</td>
<td>2002 (?)</td>
<td>?</td>
<td>Modified Harpoon missiles for land-attack</td>
</tr>
</tbody>
</table>

## Non-strategic forces

| Artillery and landmines | | | Reports of these weapons cannot be confirmed |


Dolphin class submarines, if nuclear armed, provide secure nuclear 2\textsuperscript{nd} strike capability.
iClicker Question

Based on the range of its delivery systems the nuclear weapons arsenal in Pakistan responds to strategic threats from

A. China
B. India
C. China and India
D. China, India and Russia
E. Russia
iClicker Question
Based on the range of its delivery systems the nuclear weapons arsenal in Pakistan responds to strategic threats from

A. China
B. India
C. China and India
D. China, India and Russia
E. Russia
Which countries have Uranium enrichment plants that are monitored by the IAEA?

A. Pakistan and India
B. The Netherlands and Germany
C. Pakistan
D. India
iClicker Question
iClicker Question

Which countries have Uranium enrichment plants that are monitored by the IAEA?

A. Pakistan and India
B. The Netherlands and Germany
C. Pakistan
D. India
Yongbyon Nuclear Research Center  Site of a 5-MWe experimental nuclear power reactor; a partially completed plutonium extraction facility; a fuel fabrication plant; fuel storage facilities; and a Soviet-supplied IRT research reactor and critical assembly. ** 50-MWe power reactor previously under construction.

Under the Oct. 21, 1994, U.S.-North Korean Agreed Framework, activities at the 5-MWe gas-graphite reactor, the fuel fabrication facility, and the reprocessing plant have been frozen; construction also has been halted on the 50-MWe gas-graphite reactor. U.S. intelligence agencies believe that North Korea has used the 5-MWe reactor and extraction plant to produce plutonium (possibly enough for 1 or 2 nuclear weapons). Wastes from the extraction process are believed to be stored at two undeclared sites near the center.

200-MWe nuclear power reactor; construction halted under U.S.-N.K. Agreed Framework.

North Korea

Huaedae-Gun missile testing range and production facilities.

Site of two 1,000-MWe, light-water reactors financed by KEDO according to the terms of the Agreed Framework; construction began in August 1997.

Uranium mining, and uranium concentrate production plant.

Pyongyang

Subcritical assembly. Soviet-supplied laboratory-scale hot cells, which may have been used to extract small quantities of plutonium. (Similar cells may exist at other locations.)

* Subject to IAEA safeguards as of May 1992 and pursuant to North Korea's obligations under the Non-Proliferation Treaty (NPT); future application of safeguards uncertain.

** Under IAEA safeguards pursuant to NPT obligations and a trilateral USSR-North Korean-IAEA agreement.
Kim’s Nuclear Gambit

Video Presentation:
Kim’s Nuclear Gambit
History —

• 1950s: NK nuclear research reportedly begins.

• At this time NK was a Soviet Client state and its nuclear engineers were largely trained at Soviet scientific institutes.

• 1965: NK begins operating a small research reactor it received from the USSR.

• mid-1980s: Concerns over NK’s nuclear weapons program grow when US intelligence satellites reportedly photograph construction of a research reactor and the beginnings of a reprocessing facility at Yongbyon.
History (cont’d) —

• 1985 April: NK accedes to the NPT after a concerted sales effort by the USSR, which hopes to sell light-water reactors (LWRs) to NK for electrical power generation. These are never built, in part due to the collapse of the Soviet Union.

• 1986: NK publicly makes withdrawal of US nuclear weapons from SK a condition of its completion of the safeguard agreement required by the NPT, completes negotiation of the safeguard agreement with the IAEA within 18 months after acceding to the NPT, as the NPT requires.

• 1991: US signals it will withdraw its nuclear weapons from SK as part of its global return of tactical nuclear weapons to United States territory. (The United States had stationed a large number — sometimes more than 700 — nuclear weapons in SK as part of its alliance with SK and its Cold War strategy of flexible response to a possible attack by the USSR or its allies.)
History (cont’d) —

- 1989: NK is reported to have shut down its main research and plutonium production reactor for approximately 100 days.

- The US Intelligence Community judges that this was enough time for NK to extract enough nuclear material to build a nuclear device and to refuel the entire reactor

- Neither the US nor any other country takes any direct action in response to this development.

- Instead, the international community presses NK to join the NPT and come into full compliance with its obligations under the NPT and makes this a condition for further progress on diplomatic issues.

- NK is believed to have extracted enough Pu for 1 or 2 nuclear bombs.
### APPROXIMATE FISSION MATERIAL REQUIREMENTS FOR PURE FISSION NUCLEAR WEAPONS

<table>
<thead>
<tr>
<th>Technical Capability</th>
<th>Yield (kilotons)</th>
<th>Technical Capability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Plutonium</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Weapon-Grade</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Medium</td>
<td>1.5</td>
<td>4</td>
</tr>
<tr>
<td>High</td>
<td>1</td>
<td>2.5</td>
</tr>
<tr>
<td>(kilograms)</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>2.5</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>1.5</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>4</td>
</tr>
</tbody>
</table>

Source: NRDC (April 2003)
History (cont’d) —

- 1992 April 9: NK finally approves its NPT safeguard agreement.
- 1992 May: Inspections to verify the accuracy of NK’s initial declaration begin. NK informs the IAEA it conducted a one-time Pu extraction experiment on “damaged” fuel rods removed from the reactor at Yongbyon in 1989 but extracted only 90 grams of Pu (< 1/40 of the amount needed to produce a nuclear device).
- IAEA chemical analysis indicates NK had separated plutonium in four campaigns over a 3-year period beginning in 1989 and that NK possesses more Pu than it had declared to the IAEA or to the international community.
- 1993: NK announces it is withdrawing from the NPT.
- 1994: US threatens war with NK. President Carter flies to NK and negotiates a nuclear agreement to avoid war.
# Key Elements of the 1994 Agreed Framework

<table>
<thead>
<tr>
<th><strong>North Korea</strong></th>
<th><strong>United States</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>North Korea freezes its operation and construction of nuclear facilities under IAEA supervision.</td>
<td>The United States agrees to provide heavy fuel oil to replace the electrical production potential of the shutdown 5-MW reactor.</td>
</tr>
<tr>
<td>North Korea allows the canning and nonreprocessing of spent fuel from its 5-MW reactor under IAEA monitoring. Fuel to be removed from North Korea.</td>
<td>The United States agrees to establish an international consortium to construct two modern, light-water reactors in North Korea.</td>
</tr>
<tr>
<td>North Korea agrees to provide all necessary information and access, “including taking all steps that may be deemed necessary by the IAEA” to determine the accuracy of North Korea’s initial declaration on past plutonium production.</td>
<td>International consortium agrees to complete a significant portion of the reactor complex, not including key components.</td>
</tr>
<tr>
<td>North Korea agrees to begin dismantling its finished and incomplete nuclear facilities and to begin removal of spent fuel upon delivery of key reactor components for first light-water reactor.</td>
<td>International consortium to deliver key components for first light-water reactor.</td>
</tr>
<tr>
<td>North Korea agrees to complete dismantling of its nuclear facilities and removal of its spent fuel upon delivery of key components for second reactor.</td>
<td>International consortium to deliver key components for second light-water reactor.</td>
</tr>
</tbody>
</table>
History (cont’d) —

• 1994 October: The US and NK sign the 1994 Agreed Framework. A key goal of the Agreed Framework is for NK to replace its indigenous gas-graphite reactors with imported LWRs, which are good for electrical power generation but less useful for making bomb material.

• 1994 November: The new Republican majority in the US Congress rejects the Agreed Framework and refuses to fund its execution.

• 1994–1998: Execution of the Agreed Framework is plagued with political and technical problems and fails to make much progress.

• 1998 August: NK launches a 3-stage Taepo Dong-1 rocket with a range of 1,500–2,000 km; 3rd stage explodes at ignition.

• 1999 September: NK agrees to a moratorium on testing of long-range missiles as long as arms talks with the US continue.
History (cont’d) —


- 2000 October: US and NK issue Joint Communique:
  - Neither government has hostile intent toward the other.
  - Both commit to building a new relationship free from past enmity.

- 2000 October: NK states that it will not further test the Taepo Dong-1 missile; President Clinton announces he will travel to NK.

- 2000 December: Clinton announces he will not leave US to travel to NK during the constitutional crisis created by the Presidential election dispute; time runs out.
History (cont’d) —

• Secretary of State Colin Powell says President Bush will continue the engagement with NK currently in progress.

• 2001 June: President Bush announces desire for “serious discussions” with NK.

• 2002 January (post 9-11): President Bush labels NK part of “an axis of evil”.

• 2002 October: Visiting US official publicly challenges NK, US claims NK has uranium enrichment effort that violates the 1994 Agreed Framework.

• 2002 November: KEDO (Korean Energy Development Organization) consortium suspends fuel oil deliveries to NK, alleging NK has violated the Agreed Framework.
North Korea’s Nuclear Program – 9

History (cont’d) —

• 2002 December: NK announces it is restarting its reactor because US violated the Agreed Framework, ends its cooperation with the IAEA, orders inspectors out.

• 2003 January: NK announces it is withdrawing from the NPT.

• 2004: NK tells visiting US experts it has separated the Pu in the spent reactor fuel at Yongbyon and is making nuclear weapons, shows “Pu” to visiting experts. NK is believed to have extracted 24–42 kg of Pu, enough for 6–12 nuclear bombs.

• 2006 October 9: NK tests a Pu nuclear explosive device.

• 2007 February 28: New 6-party agreement announced (see separate slide).

• 2009 April 5: NK launches a long-range rocket, is condemned by the UN, announces it will build its own LWR without outside help.

• 2009 May 25: NK tests a second nuclear explosive device.
Six-Party Agreement (2007 Feb 28)

An important first step toward complete, verifiable, and irreversible denuclearization of the Korean peninsula and the establishment of a more stable, peaceful, and prosperous Northeast Asia.

The D.P.R.K. agreed that it will, within 60 days:

• Shut down and seal Yongbyon nuclear facility for eventual abandonment
• Invite IAEA to conduct necessary monitoring and verifications
• Discuss with the other parties a list of all its nuclear programs, including plutonium extracted from used fuel rods, that would be abandoned

The other Parties agreed that they will:

• Provide emergency energy assistance to North Korea in the initial phase
• Make an initial shipment of emergency energy assistance equivalent to 50,000 tons of heavy fuel oil (HFO) within the first 60 days of the agreement

Five working groups will be established to carry out initial actions and formulate specific plans to implement the agreement, leading to a denuclearized D.P.R.K. and a permanent peace.
History (cont’d) —

- 2011 Dec 17 Kim Jong-un ascends to Supreme Leader of NK
- 2012 Feb 29: NK agrees to freeze nuclear program in exchange for energy and food relieve.
- 2012 Apr. 12: Unsuccessful NK missile test leads to cancellation of food and energy relieve agreement.
- 2012 May 4: Reports that NK has resumed construction of LWR for Pu production at Yongbyon.
- 2012 Dec. 12: Successful test of long range missile launching satellite into orbit
- 2013 Feb. 12: NK tests third nuclear explosive device.
- 2017 Jan. 6: NK tests fourth nuclear war head, 7-9kt, claimed thermo nuclear device
- 2017 Feb. 7: NK tests long range missile launching a satellite into orbit.
North Koreans Agree to Freeze Nuclear Work; U.S. to Give Aid

By STEVEN LEE MYERS and CHOE SANG-HUN

WASHINGTON — North Korea announced on Wednesday that it would suspend its nuclear weapons tests and uranium enrichment and allow international inspectors to monitor activities at its main nuclear complex. The surprise announcement raised the possibility of ending a diplomatic impasse that has allowed the country’s nuclear program to continue for years without international oversight.

The Obama administration called the steps “important, if limited.” But the announcement seemed to signal that North Korea’s new leader, Kim Jong-un, is at least willing to consider a return to negotiations and to engage with the United States, which pledged in exchange to ship tons of food aid to the isolated, impoverished nation.

240,000 metric tons of food aid
Famine in North Korea 1995 – 1998
unknown number of victims
estimates  600,000 – 3,000,000
in a population of 23 million
North Korea’s Nuclear Program – 11

Recent situation (see the assigned reading written by Hecker) —

• 2010 November: NK showed visiting U.S. experts (Carlin, Hecker, and Lewis)
  — An openly constructed, recently completed small but industrial-scale centrifuge uranium-enrichment facility
  — An experimental light-water reactor (LWR) under construction

• NK claimed 2,000 P-2 centrifuges in 6 cascades in the modern facility at Yongbyon (build with external help from Khan)

• Publicly displayed facility is sufficient to produce
  — 2 tons of LEU/year, enough to supply the LWR under construction
  — 1 bomb/year of HEU, if slightly reconfigured

• Experts believe NK has undisclosed centrifuge facilities at other sites, probably producing weapon-grade HEU. NK has fundamentally changed its nuclear strategy.

• New leadership under Kim Jong-un appears to continue nuclear weapons program aggressively.
North Korea’s Nuclear Program – 12

• NK’s new nuclear strategy —
  — Appears to have abandoned its Pu program, shutting down its 5 MWe gas-graphite reactor and giving up on external assistance for LWRs
  — Is attempting to construct an experimental 25-30 MWe LWR of indigenous design as part of an electrical power program (probably not for bomb Pu)

• Major concerns about NK’s new nuclear strategy —
  — Can NK construct its own LWR safely?
  — Will NK’s enrichment program lead to additional weapons or export?
Can NK construct its own LWR safely?

— NK appears to have no experience with key LWR design and safety issues.
— Radiation-resistant steels and stringent construction are needed to withstand the intense, long-term radiation produced by LWRs.
— NK has little experience with uranium oxide fuels and fuel-cladding alloys.
— The concrete reactor foundation is insufficiently robust.
— The concrete containment shell is being poured in small sections from a small concrete mixer.
— These safety concerns will increase dramatically if NK builds larger LWRs, because the risks would extend well beyond NK’s borders.
North Korea’s Nuclear Program – 14

• Will NK’s enrichment program lead to additional weapons or export?
  — Bomb-grade HEU can be produced by slightly reconfiguring the existing centrifuge cascade
  — NK has indigenous U ore and all the know-how and equipment needed to make feedstock for its centrifuge cascades

• NK can ratchet up the current nuclear threat by
  — Greatly expanding its HEU production at undisclosed sites
  — Increasing substantially the size of its nuclear arsenal
  — Conducting additional nuclear tests to increase the sophistication of its nuclear weapon designs
  — Exporting nuclear weapon materials or technology

• NK’s categorical denial of any earlier enrichment activities, when they clearly existed, complicates diplomatic reengagement
What to Do About NK’s Nuclear Program?

• Top priority: prevent NK from expanding its arsenal or exporting its nuclear technologies

• Long-term goal: denuclearize the Korean peninsula

• Few options but to reengage NK diplomatically

• Hecker advocates 3 No’s supported by 1 Yes:
  — No more bombs
  — No better bombs (which means no more testing)
  — No export of bombs or bomb technology and materials
  — Yes to meeting NK’s fundamental security concerns

• What are NK’s fundamental security requirements?
  — Normalization of relations with the United States
  — Energy and economic aid / Regime survival
North Korea’s Ballistic Missile Capabilities

<table>
<thead>
<tr>
<th>NORTH KOREAN BALLISTIC MISSILES</th>
<th>Range (kilometers)</th>
<th>Payload (kilograms)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scud B</td>
<td>320</td>
<td>1,000</td>
<td>Reverse-engineered Soviet Scud B</td>
</tr>
<tr>
<td>Scud C</td>
<td>500</td>
<td>770</td>
<td>Conventional explosives, chemical, and cluster warheads</td>
</tr>
<tr>
<td>Nodong</td>
<td>1,350–1,500</td>
<td>770–1,200</td>
<td>Test fired in May 1993; flew 500 kilometers. Close to 100 deployed. Designed to carry a nuclear warhead</td>
</tr>
<tr>
<td>Taepodong-1</td>
<td>1,500–2,500</td>
<td>1,000–1,500</td>
<td>Test-launched August 31, 1998</td>
</tr>
<tr>
<td>Taepodong-2</td>
<td>3,500–6,000</td>
<td>700–1,000</td>
<td>Not yet tested</td>
</tr>
<tr>
<td>Taepodong-2 (three-stage)</td>
<td>up to 15,000</td>
<td>several hundred</td>
<td>More than a decade away</td>
</tr>
</tbody>
</table>

Source: NRDC (April 2003)
Ranges of North Korea’s Missiles
End of Module 6: Programs and Arsenals