North Korean nuclear crisis: What, how, when and why – and what to do now?

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Bay Area Strategic Engagement Seminar
Sandia National Laboratories Livermore
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Is there a North Korea nuclear crisis?

Nov. 10, 2016 briefing: Obama tells Trump North Korea is greatest security threat

UN General Assembly
September 19, 2017


"…we will have no choice but to totally destroy North Korea. Rocket man is on a suicide mission"


Gen. John Kelly's reaction

UN General Assembly
September 19, 2017

Kim's Reply
Sept. 22, 2017

Yes – we have created a political crisis

But, what does the DPRK have?

- Most difficult part
- Reactors or enrichment

Hydrogen bombs
- Tritium
- Li-6D

- Physics, computers
- High explosives
- Detonators
- Initiators
- Machining
- Assembly
- Explosives tests
- Arming, fuzing, firing

- Plane
- Boat
- Van
- Missile

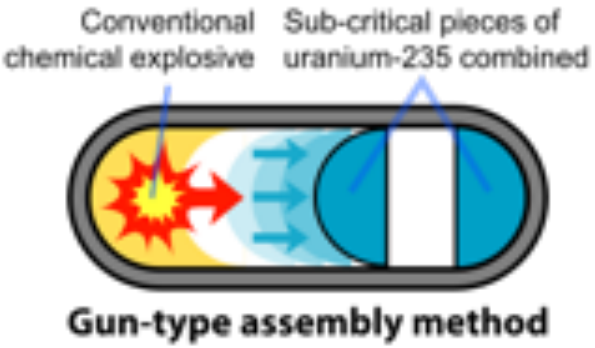
But, what does the DPRK have?

Governs size of arsenal	Governs sophistication of arsenal	Governs threat arsenal poses
Bomb-grade Pu or HEU →	**Weaponization** →	**Delivery system**
•Most difficult part •Reactors **(Pu)** or enrichment **(HEU)** Hydrogen bombs - **Tritium** - **Li-6D**	•Physics, computers •High explosives •Detonators •Initiators •Machining •Assembly •Explosives tests •Arming, fuzing, firing	•Plane •Boat •Van •Missile

Two paths to the bomb

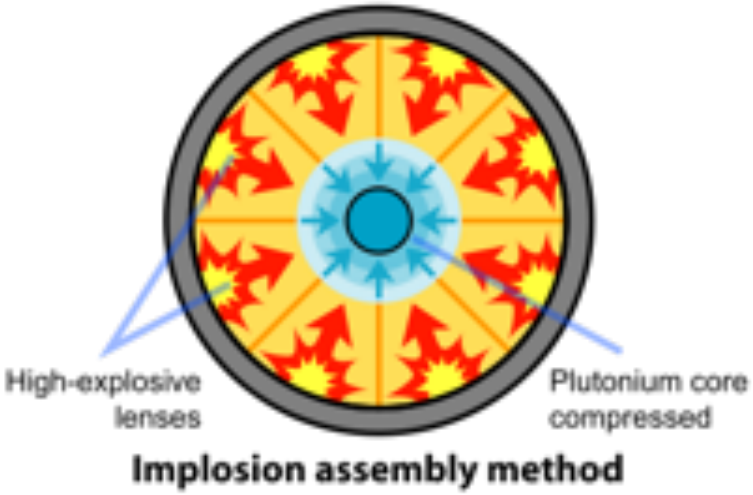
- **Uranium-235 (Produced by enrichment)**
- Natural uranium is 99.3% U-238 and 0.7% U-235
- >20% HEU is weapons usable
- A few tens of kg of 90% U-235 required for a bomb

Hiroshima – Aug. 6, 1945



- **Plutonium-239 (Produced in reactors)**
- Pu-239 metal, typically >93% Pu-239 for bombs
- < 10 kg required for a bomb

Trinity – July 16, 1945
Nagasaki – Aug. 9, 1945



Hydrogen bomb?

Nuclear materials production

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Estimates – how do we know? What is confidence level?

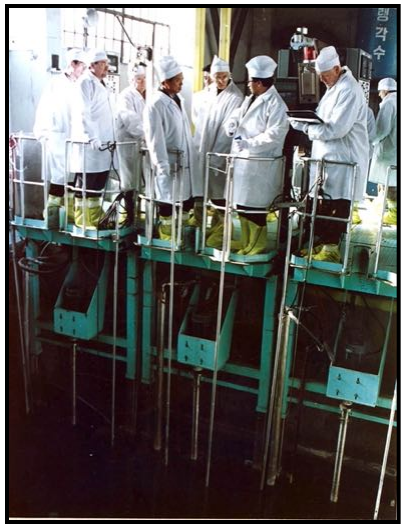
Commercial overhead imagery

Yongbyon, North Korea
39.770027 N 125.750307 E
Image Date: 3 February 2014 / Pleiades Satellite

The fuel fabrication facility is the largest of the functional areas in the southern half of the Centre. Visible is a new centrifuge building with an expected capacity of 2,000 centrifuges.

Looking from the inside

Site visits and technical discussions provide valuable information



Jan. 2004 Yongbyon

Aug. 2005 Pyongyang

Nov. 2006 Pyongyang

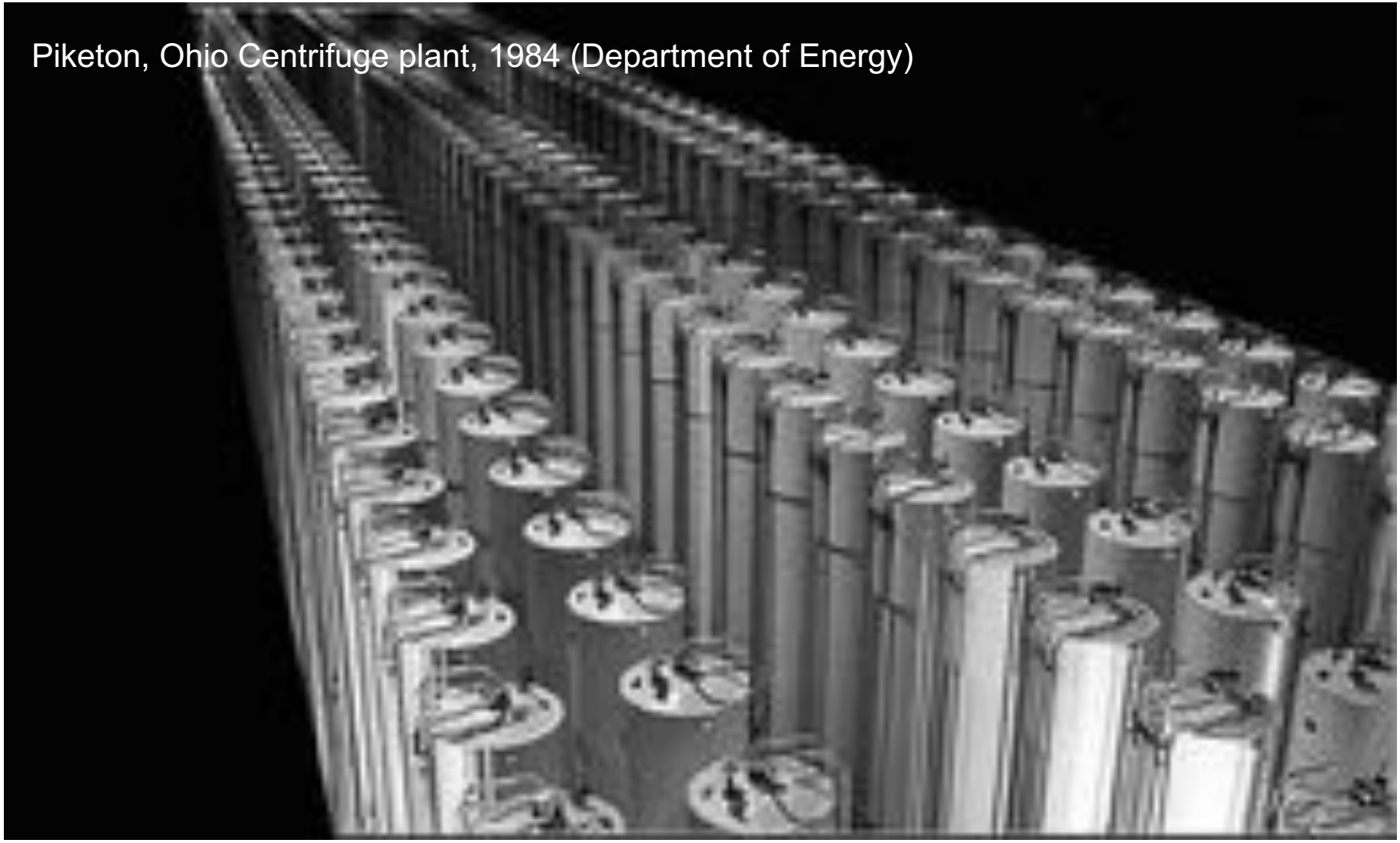
August 9, 2007, Yongbyon

Feb. 14, 2008, Yongbyon

Feb. 27, 2009, Pyongyang

The seventh visit brought a big surprise

Purely illustrative - this is not Yongbyon, but close to what we saw (Nov. 12, 2010).



No outsiders have been in Yongbyon since Nov. 2010


KCNA Publicity – what they show us


Another Kim Jong-un site visit on KCNA in March 2016

Plutonium production in North Korea

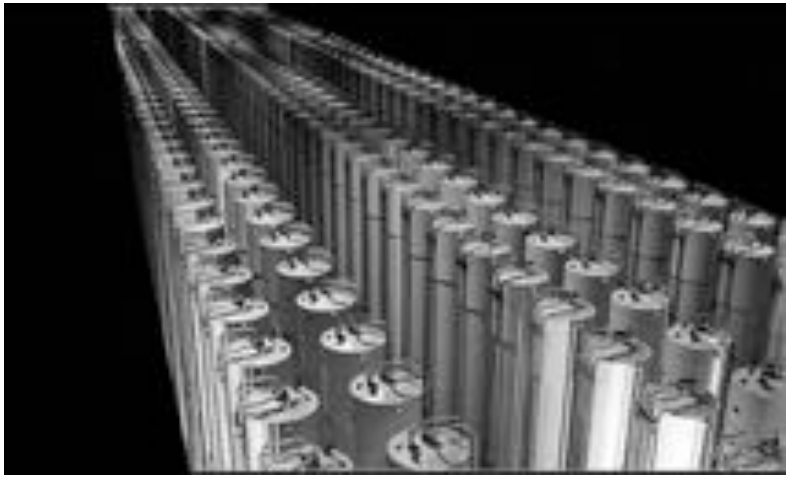
- **Uranium ore, mining, milling**
- **Fuel fabrication (U metal fuel)**
- **Reactor operation (5 MWe)**
  - Gas Graphite – natural U fuel
- **Reprocessing (extract Pu)**
- **Plutonium fabrication/machining**

- **Capacity < 6 kg/yr (1 bomb)**
- **Inventory ~ 20 – 40 kg by 12/2016**
- **Estimated confidence: High**
- **Observability: High**


What is current centrifuge capacity?
How much imported and how much indigenous?

HEU production

- **Uranium ore, mining, milling**
- **Conversion to UF6**
- **Centrifuges for enrichment**
  - LEU for LW Reactor
  - HEU for bombs
- **Uranium metal fabrication/ machining**
- **Capacity ~ 150 kg/yr (6 bombs)**
- **Inventory ~ 200-450 kg by 12/2016**
- **Estimated confidence: Low**
- **Observability: Very low**



Tritium

- **Li-6**
  - Have capability
  - Marketing for sale
- **Tritium production**
  - IRT-2000 Reactor (unlikely)
  - 5 MWe Reactor (likely)
  - ELWR (future?)
- **Tritium extraction**
  - Hot cells at IRT-2000 site
  - New construction (likely)

Li-6D (lithium deuteride)

- **Capacity ~ Likely small for now**
- **Inventory ~ Not known**
- **Estimated confidence: Very low**
- **Observability: Very low**

ELWR for future?

New hot cells?

Weaponization

Governs size of arsenal

Governs sophistication of arsenal

Governs threat arsenal poses

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We have few details, but –
Bottom line is they conducted 6 nuclear tests

Nuclear tests critical to sophistication

- Oct. 9, 2006: Close to1 kiloton
  - Likely Pu
- May 25, 2009: ~ 2 to 7 kilotons
  - Likely Pu
- Feb. 12, 2013: ~ 7 to 14 kilotons
  - Either Pu or HEU
- Jan. 6, 2016 – deeper than others, ~ 7 to 14 kilotons
  - Either Pu or HEU. Claim of H bomb not likely.
- Sept. 9, 2016 – ~ 15 to 25 kilotons
  - Likely made progress in miniaturization
- Sept. 3, 2017 > 100 kilotons, possibly 250 kilotons

March 2016 Kim with “disco ball”

KCNA claim of hydrogen bomb a few hours before test

September 3, 2017 nuclear test

September 3, 2017 nuclear test

September 3, 2017 nuclear test

Ri Hong-sop: Director of Nuclear Weapons Institute

Will the tested device fit into DPRK missiles?

- We do not know if they tested the device shown
- Possible for the short-range; more difficult for ICBM
- Much work remains to be done to survive the launch-flight-reentry requirements for ICBMs

More missile tests and nuclear tests will be required

Delivery systems

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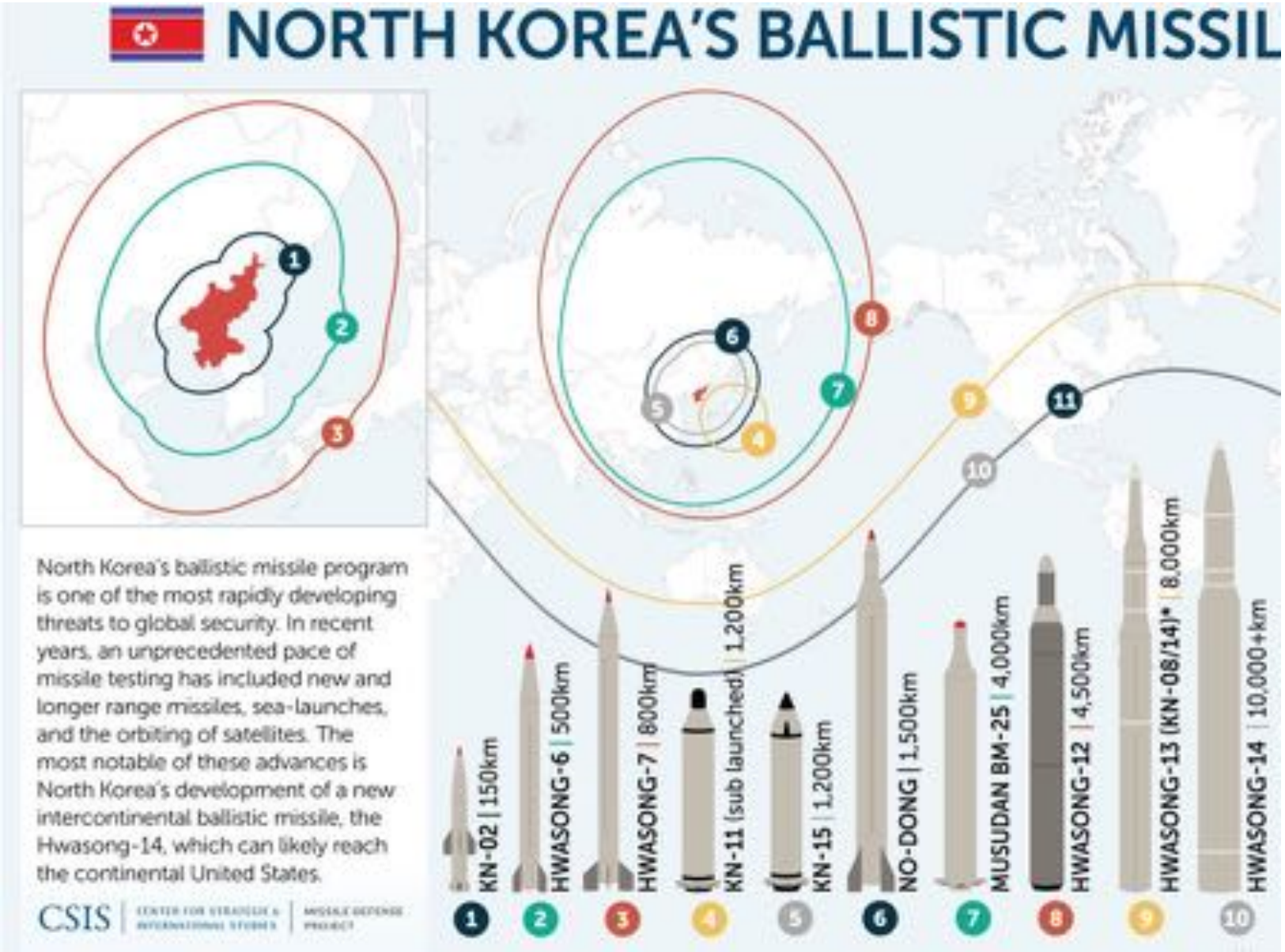
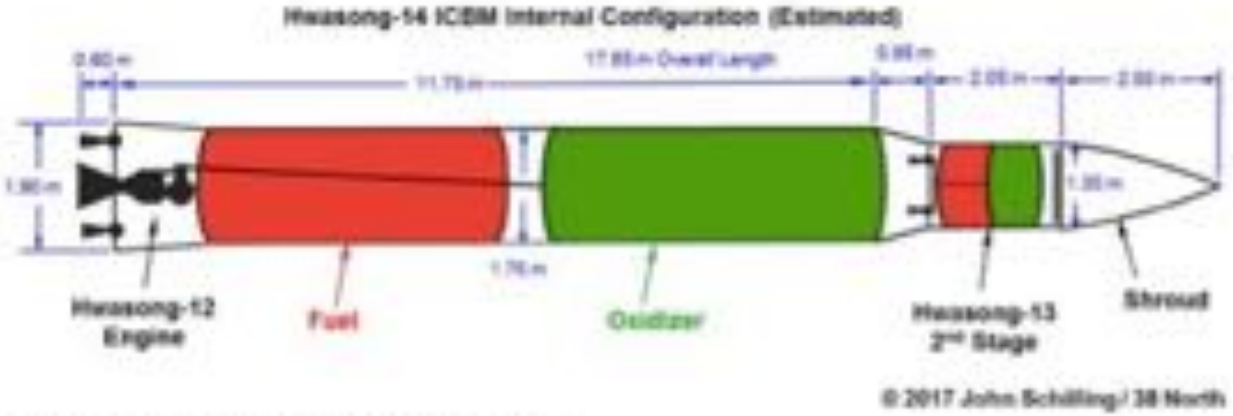
Missile Names, Ranges and Coverage



July 4, 2017 Hwasong-14 ICBM-capable



(Image: John Schilling / 38 North.)

Hwaysong-14, July 4, 2017


“We will launch from anywhere at any time”
Kim Jong-un (2017)

Estimates of DPRK nuclear program

Nuclear Capability	January 2003	September 2017 Rough estimates
Plutonium	0 to 10 kg	20 to 40 kg
HEU (Highly enriched U)	Likely zero	Possibly 250-500 kg Possibly 150 kg/yr
Nuclear tests	Zero	6
Nuclear weapons	Likely zero Pu Zero HEU	**Possibly material for 25-30 bombs**
Rockets	One failed Taepodong-1 launch (1998)	Significant progress in 2016 & 2017 HW-12 and HW-14

How did North Korea build the bomb?

Kim Il-sung
- Soviet Atoms for Peace
- Indigenous reactor program
- Built the option for the bomb
- Agreed to freeze program in 1994

Kim Jong-il
- Likely built the bomb in 2003
- Signed denuclearization deal 2005
- Continued with bomb, tested 2006, 2009

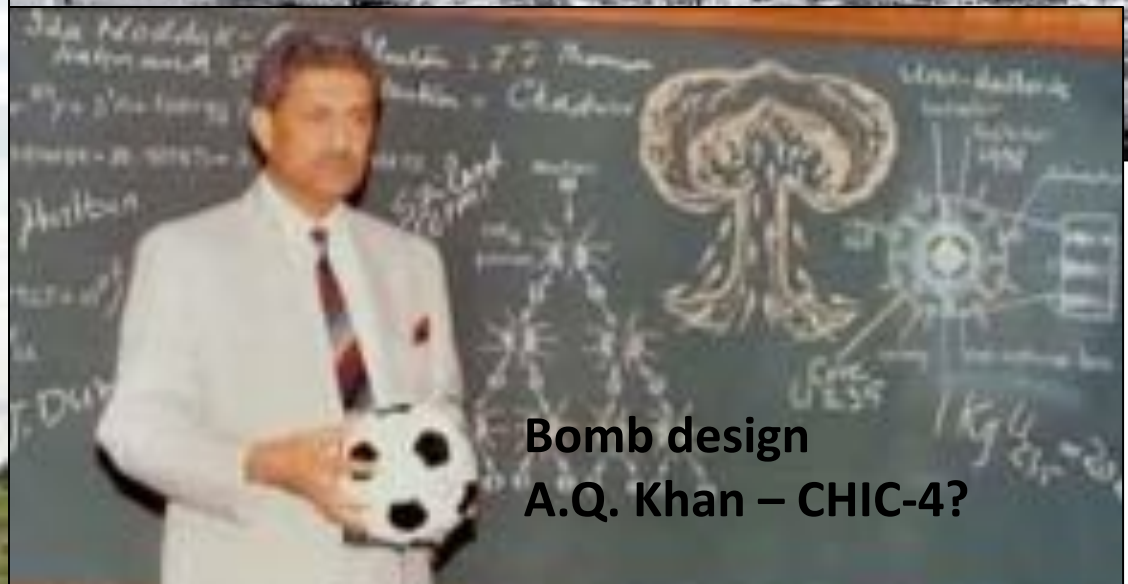
Kim Jong-un
- 2012, first successful space launch, increased missile launches
- Third, fourth, fifth and sixth nuclear tests, 2013 through 2017
- Nukes in constitution, threatened to nuke US and the South

How did North Korea build the bomb?

- **Early Soviet assistance with civilian technologies**
  - Education and IRT-2000 research reactor
- **Reverse engineering and technical competence**
- **International black market**
  - Europe, Russia, A.Q. Khan, China
- **Indigenous engineering and manufacturing**
  - Remarkable resilience

No direct assistance from Russian or Chinese governments

Masters of reverse engineering



Extensive Foreign Procurement Network Centrifuges (non-Pakistani supply) – D. Albright (ISIS)

- **Materials**: Aluminum tubes (low strength for outer casings), ring magnets for use in a centrifuge upper bearing, epoxy resins used in assembling centrifuge parts (sold commercially as Araldite), raw materials and additive alloys;
- **Vacuum Equipment:** A range of equipment important to operating centrifuges individually or in cascades, such as vacuum pumps, valves, specialized uranium hexafluoride resistant oils. Also pressure transducers, which are used to measure the vacuum pressure in individual centrifuges and cascades;
- **Other Equipment:** Uranium hexafluoride cylinders, uranium hexafluoride flow meter, He leak detectors, and whole frequency converters and their key subcomponents, implying that North Korea assembles frequency converters from subcomponents purchased abroad. Also computerized control equipment, including software and updates, used to run a plant composed of centrifuge cascades. (The equipment is the same as that acquired by Iran to control its centrifuges.)
- **Manufacturing Equipment:** Flow-forming machine usable to make centrifuge rotors. an electron beam welder for centrifuge assembly, equipment to make ring magnets. State-of-the-art computer numerically controlled (CNC) machines for making centrifuge parts, and measuring equipment;
- **Spare parts** for centrifuge-related equipment.

Indigenous training, design, production and testing

"Working Notes" – with running annotations of the buildings within the Fuel Fabrication Facility / Fuel Enrichment Plant at Yongbyon

When did North Korea build the bomb?

- **1965 – 1985** **Built the foundation** (education, research)
- **1986 – 1994** **Nuclear weapon option developed**
- **1995 – 2003** **Plutonium freeze (AF), HEU hedge**
- **2003 – 2006** **Built and tested the bomb (Test #1)**
- **2007 – 2008** **Disabled Pu complex, continued HEU**
- **2009 – 2010** **Test #2, also revealed HEU option**
- **2010 – 2017** **Test #3, 4, 5 & 6 expanded nuclear arsenal – likely H-bomb test**
  Long and intermediate missile tests

Why did North Korea build the bomb?

- **Security**
  - Particularly security of the regime
- **International prestige or leverage**
- **Domestic leverage**

But motivation and capabilities are interdependent.
One will affect the other

Concerns about nuclear technology exports

- **Pakistan – DPRK nuclear for missile swaps**
- **Libya – export of uranium hexafluride (2002-3)**
- **Syria – construction of plutonium reactor**
  - 2000 – 2007: close to operation
  - Destroyed by Israeli bombing – Sept. 2007
- **Possible marketing of Li-6 in 2016**

These were some of DPRK's most egregious actions

Nuclear Capability	China nuclear official	S. S.Hecker	D. Albright (ISIS)
Plutonium	30-40 kg	20-40 kg	~30 kg
HEU	500 kg	250 - 500 kg	250 – 650 kg
Nuclear devices (sufficient material)	30	25-30	15-32
Fit on SCUD & Nodong	Yes	Yes	Yes
Fit on HW-12 & HW-14 (ICBM) A-bomb	No No more NT	No Need more NT	?

What now?

The North Korea Challenge for U.S. Presidents

Don't build the bomb
Succeeded – but NK built a hedge

Don't build the bomb
Failed. ~ 6 nukes by end of term.
No successful missile tests

Don't build a nuclear arsenal.
Denuclearize
Failed. ~ 20 – 25 bombs by end of term
Successful missile tests

Trump Challenge:
Prevent use of nuclear weapon
Denuclearization comes later

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Trump Challenge:
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Denuclearization comes later

But war of words has prevented much needed dialogue

“…fire and fury, like the world has never seen.”
August 8, 2017

“…we will have no choice but to totally destroy North Korea. Rocket man is on a suicide mission”

"The world has received North Korea's latest message loud and clear ... All options are on the table."

“ I told Rex … he is wasting his time trying to negotiate with Little Rocket Man...”

“Save your energy Rex, we'll do what has to be done!”

About foreign minister – “If he echoes thoughts of Little Rocket Man, they won't be around much longer!”

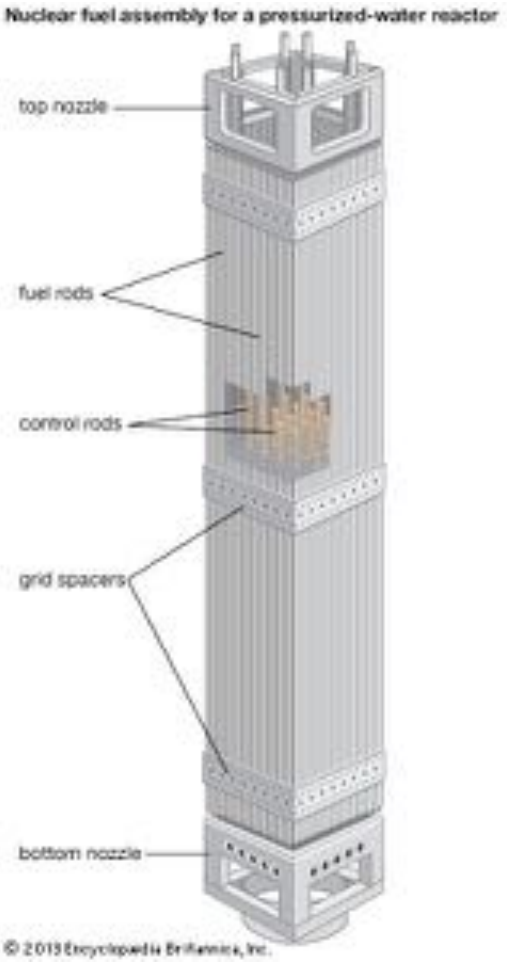
”It’s the calm before the storm.”

“Sorry, but only one thing will work!” When questioned – “you’ll see – soon.”

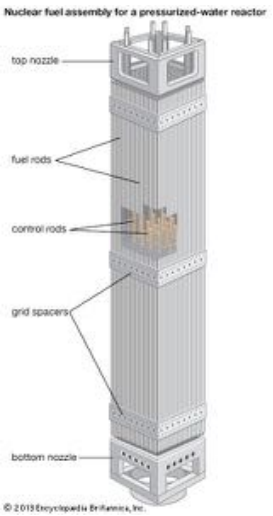
How to prevent a runaway nuclear reaction and meltdown?

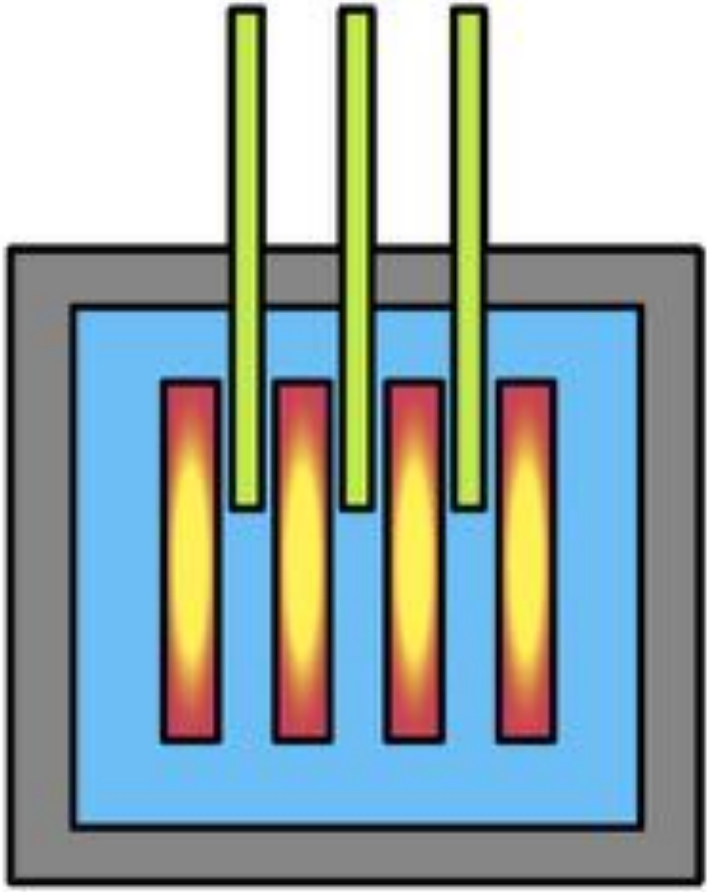
How to prevent a runaway nuclear reaction and meltdown?

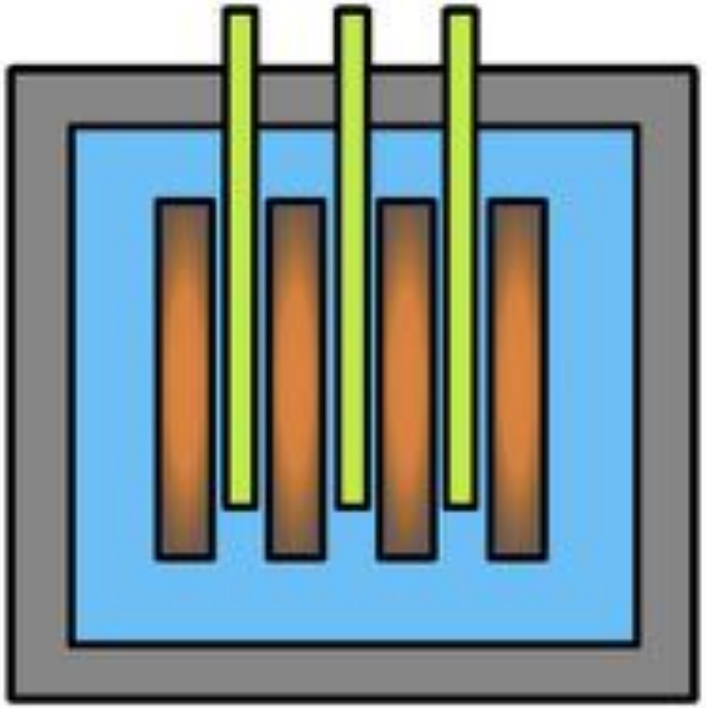
Control Rods



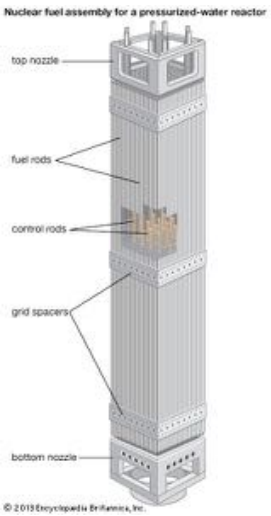
It’s time to lower the control rods

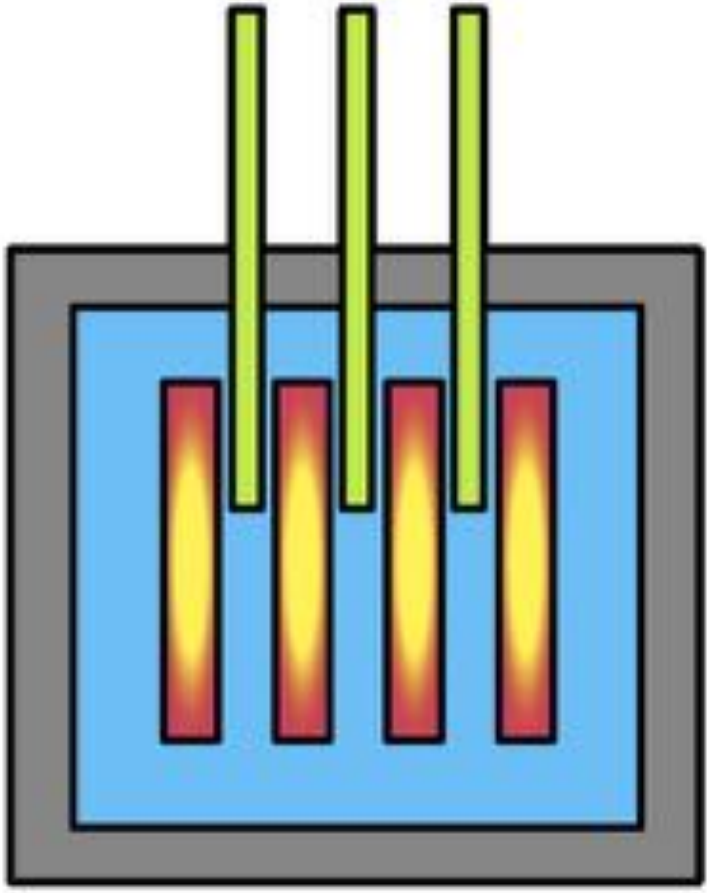


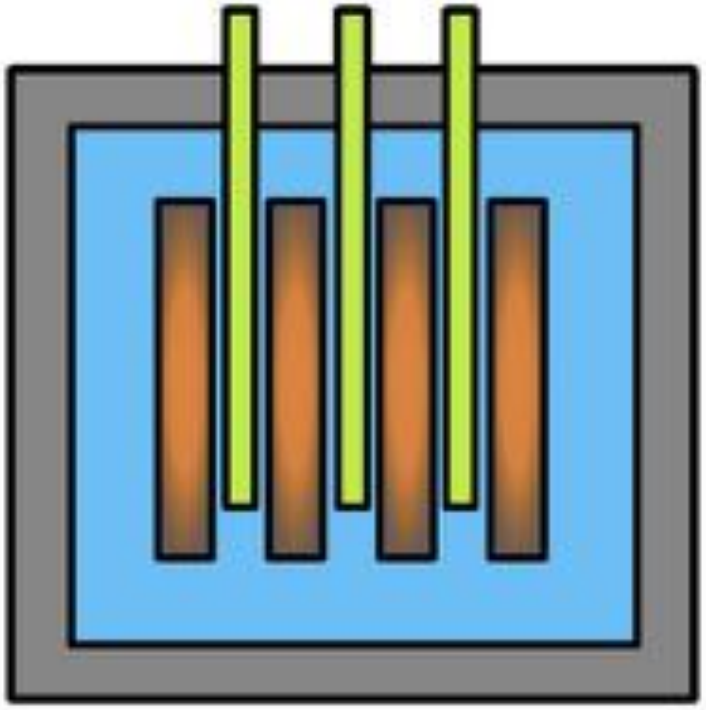




The diplomatic equivalent to control rods







Are there control rods in North Korea?

How will this crisis end?

- **Peaceful surrender of nukes**
  - Sanctions and Chinese pressure
- **Regime collapse**
  - External or internal causes – who controls nukes?
  - How to render weapons safe? Secure nuclear materials
- **Military action**
  - Can escalation to nuclear be prevented?
- **Regime transformation**
  - Talks to prevent use of nuclear weapons
  - Halt, roll back and long-term denuclearization

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Or rely on deterrence and decay from within