Can the North Korean nuclear crisis be resolved?

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PACOM WMD/DPRK SEMINAR
U.S. Pacific Command Headquarters
April 16, 2015

Outline

- What does North Korea have?
- A short nuclear primer
- How did it get there?
  - A close look at 6 years ago
  - Post 2010
- What now?

DPRK nuclear facilities

Yongbyon nuclear complex

- **Fuel fabrication facility – uranium fuel**
  - Fuel for reactor and feed for uranium centrifuges
- **5 MWe reactor – Magnox (gas – graphite)**
  - 6 kg plutonium/year
- **Reprocessing facility – plutonium separation**
  - Large scale capability, small plutonium laboratory
- **50 MWe and 200 MWe reactors – not salvageable**
  - Would represent major threat (~ 300 kg Pu/year)
- **IRT-2000 research reactor – very little fuel remains**
  - Used for medical isotope production
- **Uranium centrifuge facility**

Other facilities outside Yongbyon

- Covert uranium facilities and weaponization facilities

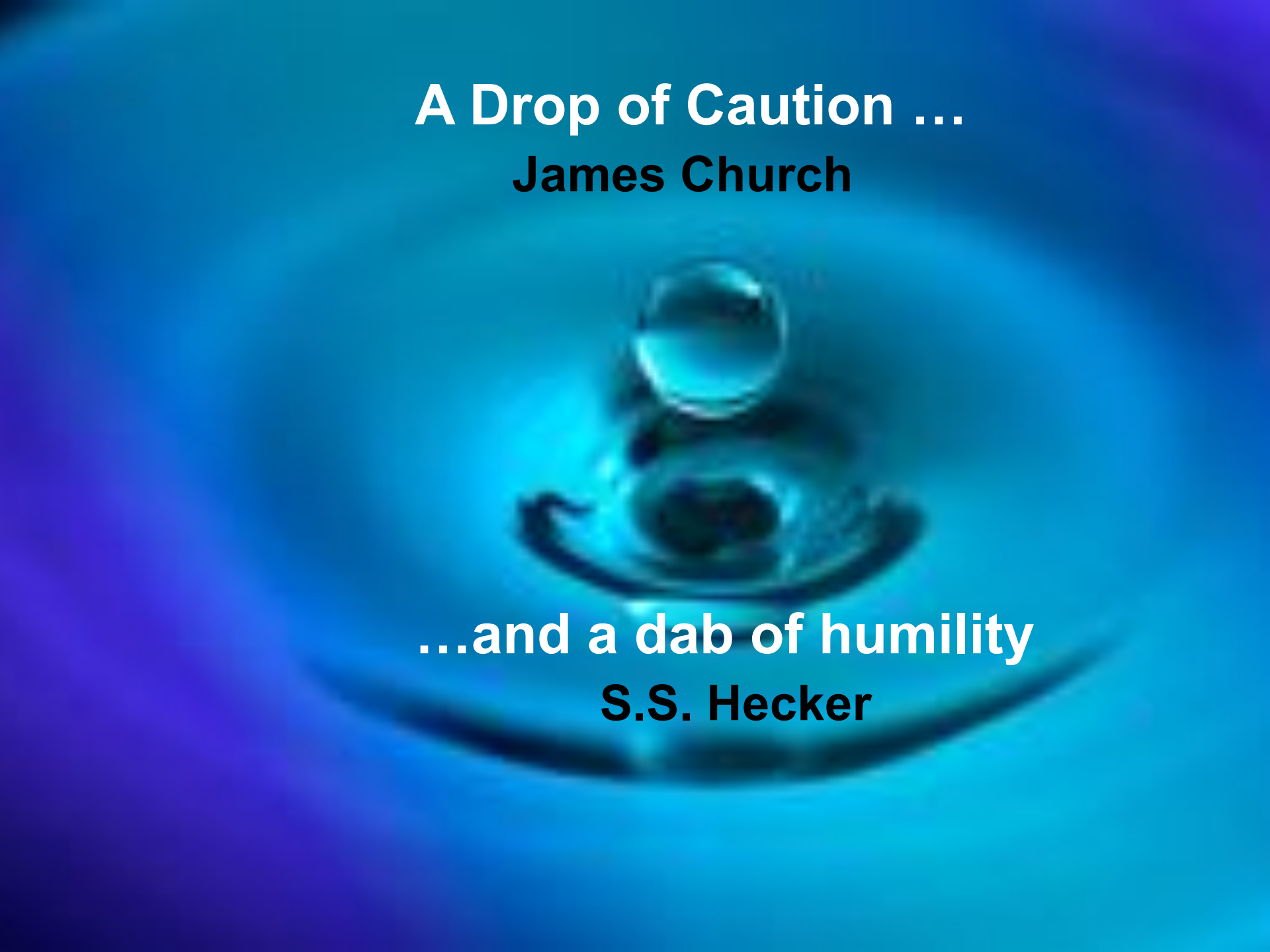
DPRK nuclear program

Nuclear Capability	January 2003
Nuclear reactors	5 MWe – standby 50 MWe – standby 200 MWe - abandoned
Fuel fabrication	Standby – corroding U conversion - operating
Uranium enrichment	DPRK – denied US – Oct. 2002 accusation
Nuclear export	UF6 to Libya Reactor to Syria
Political	Kim Jong-il No mention of nukes

Plutonium production halted. Uranium enrichment – building capacity.
No nuclear weapons, no successful long-range rockets.

A Drop of Caution …

James Church



…and a dab of humility

S.S. Hecker

DPRK nuclear program

Nuclear Capability	January 2003	December 2014
Nuclear reactors	5 MWe – standby 50 MWe – standby 200 MWe - abandoned	5 MWe restarted ELWR near completion
Fuel fabrication	Standby – corroding U conversion - operating	Reactivated Fuel for ELWR
Uranium enrichment	DPRK – denied US – Oct. 2002 accusation	YB centrifuge facility Covert facilities ?
Nuclear export	UF6 to Libya Reactor to Syria	Any customers?
Political	Kim Jong-il No mention of nukes	Kim Jong-un New constitution declares DPRK nuclear state

DPRK nuclear program

Nuclear Capability	January 2003	December 2014
Plutonium	0 to 10 kg	24 to 42 kg China est.: 30-35 kg
HEU (Highly enriched U)	Likely zero	Possibly 150 kg Possibly 500 kg
Nuclear tests	Zero	3 (possible 4th)
Nuclear weapons	Likely zero Pu Zero HEU	~ 6 Pu + 6 HEU = 12 ~ 6 + 14 = 20
Long-range rockets	One failed Taepodong-1 launch (1998)	Successful Unha-3 launch (Dec. 2012)

Potential DPRK nuclear program by 2020

Nuclear Capability	December 2016 Estimates	2020
Plutonium	34 – 52 kg 30 – 35 kg	Possibly 70 kg 30 – 35 kg
HEU (Highly enriched U)	Possibly 450 kg China: Possibly 500 kg	~150 kg/yr China: HEU 200 kg/yr
Nuclear tests	3 or 4	Possibly 4
Nuclear weapons	Possibly 8 Pu + 18 HEU China: ~ 6 + 34	~10 Pu + 42 HEU China: Possibly 70
Long-range rockets	Unha-3 Possibly more tests	Musudan or KN-08 tests

Potential DPRK nuclear program by 2020

Nuclear Capability	Albright 2020	2020
Plutonium	50 – 154 kg	Possibly 70 kg China 30 - 35
HEU (Highly enriched U)	280 – 1230 kg	Possibly 1000 kg Possibly 1300
Nuclear tests	4 to 8	Possibly 4
Nuclear weapons	20 – 100	Possibly 50 Possibly 70
Long-range rockets	Musudan and KN-08	Musudan or KN-08 tests

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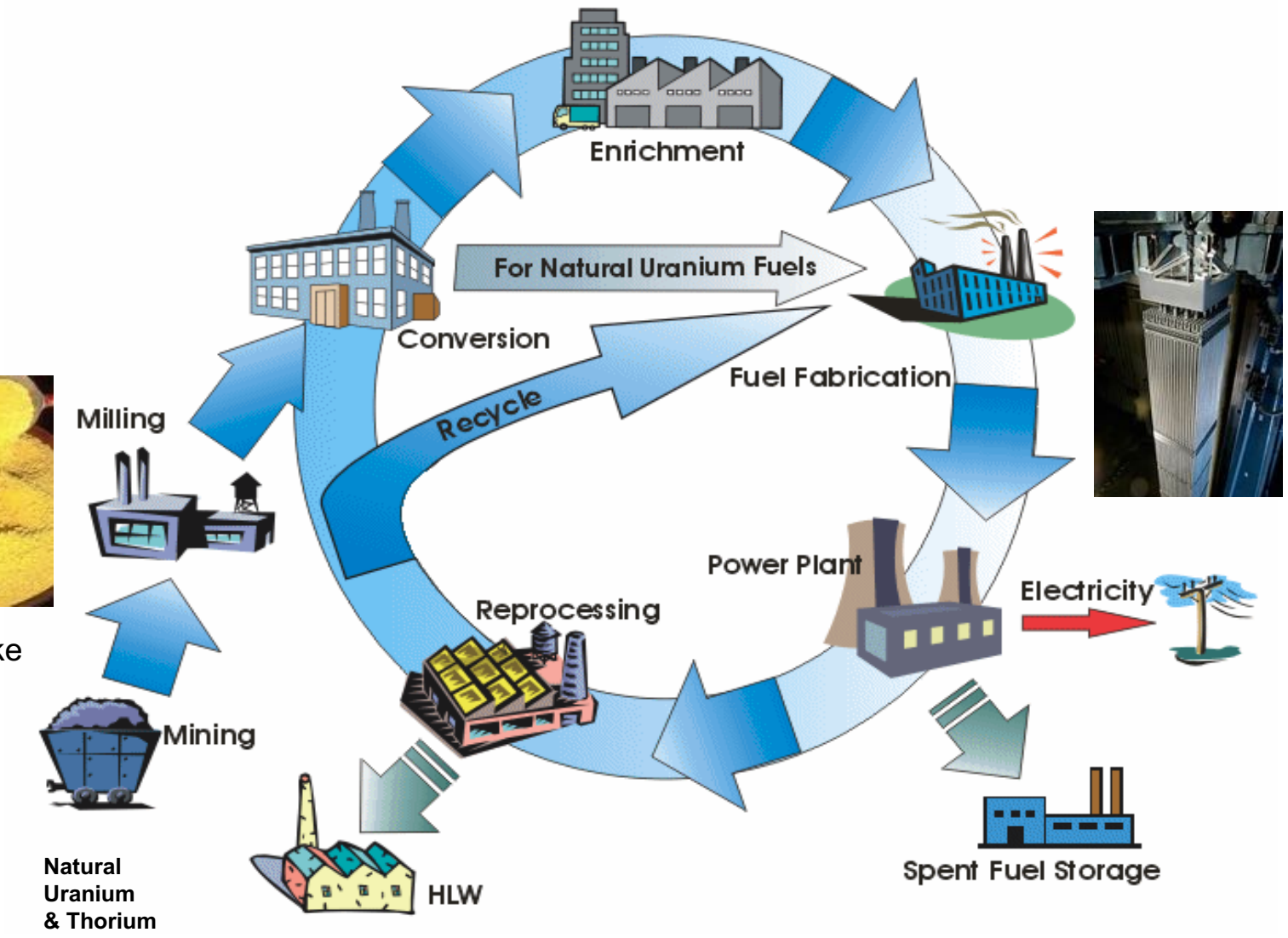
Dual-use dilemma of the nuclear fuel cycle

U_3O_8 or Yellowcake



Uranium isotope separation technologies

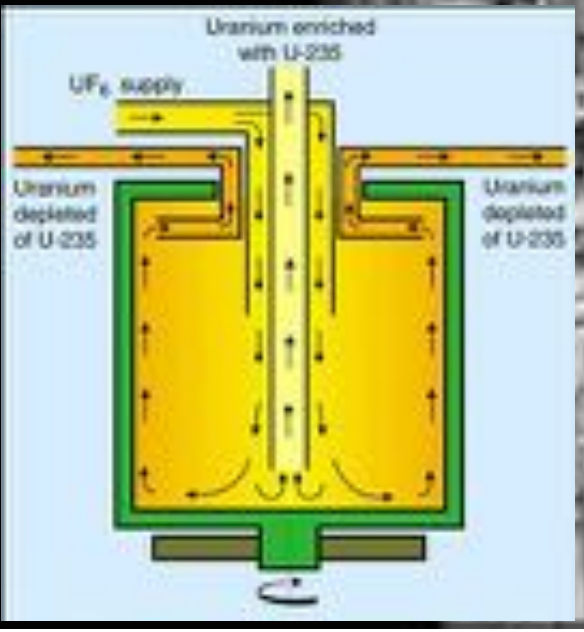
Natural uranium

U-238: 99.2752 - 99.2739
U-235: 0.7202 - 0.7198
U-234: 0.0059 - 0.0050

- Gas centrifuge
- Gaseous diffusion
- Thermal diffusion
- Electromagnetic separation
- Aerodynamic processes
- Plasma separation
- Chemical and ion exchange
- Laser isotope separation

The primary isotope separation processes are based on slight mass differences between U-238 and U-235

Centrifuge enrichment is technology of choice



A few thousand are sufficient for bomb fuel. Tens of thousands are required to fuel a commercial power reactor.

Plutonium production reactors

Pu production reactors typically use natural uranium fuel with graphite or heavy water moderators

North Korea 5 MWe reactor

Plutonium must be extracted from spent fuel in a reprocessing facility

North Korea reprocessing Facility at Yongbyon

Commercial power reactors typically produce plutonium that is less useful for bomb fuel, unless configured for plutonium production.

Plutonium production reactors

Pu production reactors typically use natural uranium fuel with graphite or heavy water moderators:

U-238 + n→ Pu-239

Rule of thumb:

100 MW_t = 100g Pu/day (36.5 kg/yr)

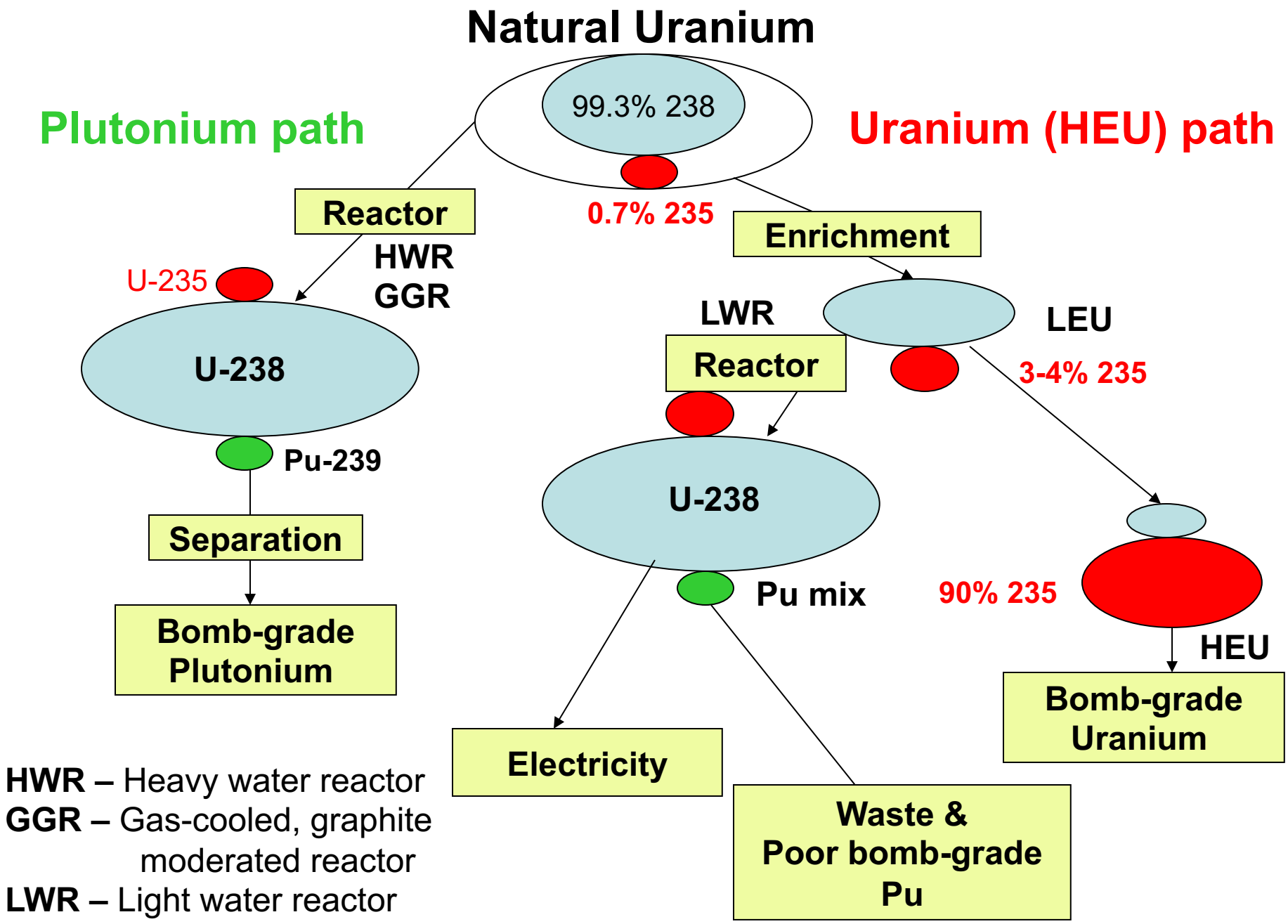
Short burn cycle keeps Pu-240 low.

North Korea 5 MWe reactor

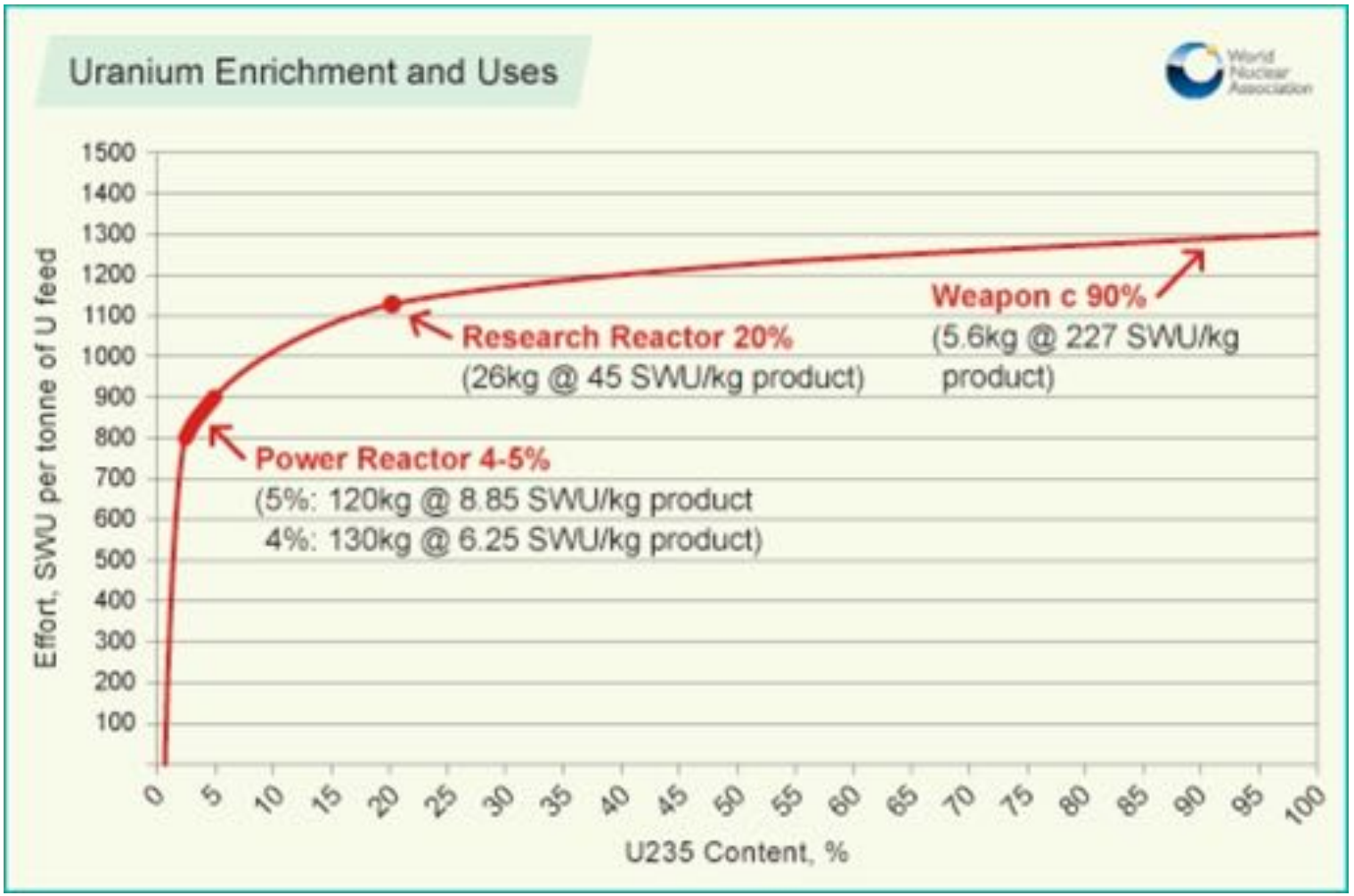
Plutonium must be extracted from spent fuel in a reprocessing facility – typically by PUREX process

- **Weapons grade Pu**
  - < 7% Pu-240
  - Typically > 93% Pu-239
- **Reactor grade**
  - > 19% Pu-240
  - Typically 55% Pu-239

North Korea reprocessing Facility at Yongbyon


Natural Uranium
99.3% 238
0.7% 235
Plutonium path
Uranium (HEU) path
Reactor
HWR
GGR
U-235
U-238
Pu-239
Separation
Bomb-grade Plutonium
Enrichment
LWR
Reactor
LEU
3-4% 235
U-238
Pu mix
90% 235
HEU
Bomb-grade Uranium
Electricity
Waste & Poor bomb-grade Pu
HWR – Heavy water reactor
GGR – Gas-cooled, graphite moderated reactor
LWR – Light water reactor

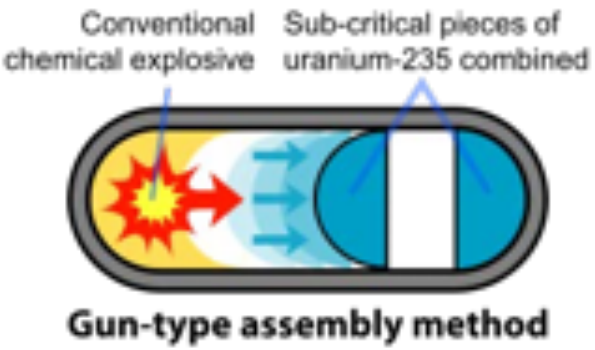
Uranium enrichment – from LEU to HEU



Product for 1 metric ton of uranium feed material

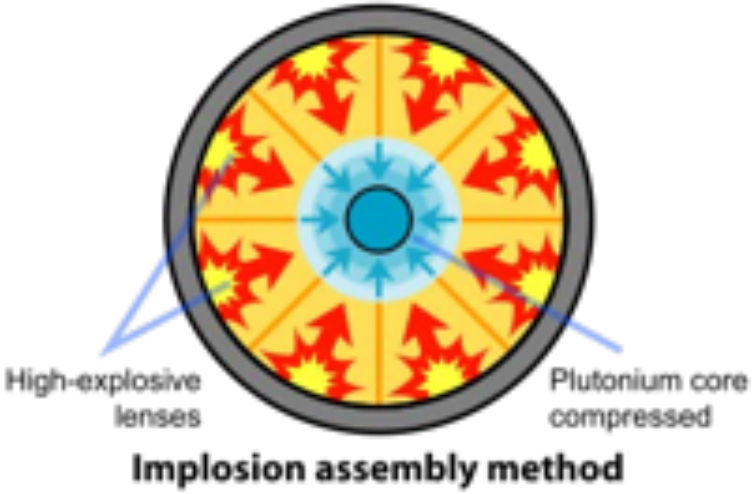
Two paths to the bomb

- **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

Little Boy and Fat Man

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How do we know anything about North Korea?

- **It is reputed to be the last Stalinist state – a black hole**
- **However, we have satellites – overhead imagery**
- **They invite people in**
  - **Tourists**
  - **News media – KCNA and Western** (Pyongyang AP)
    - Blogs and social media
  - **Track II visits**

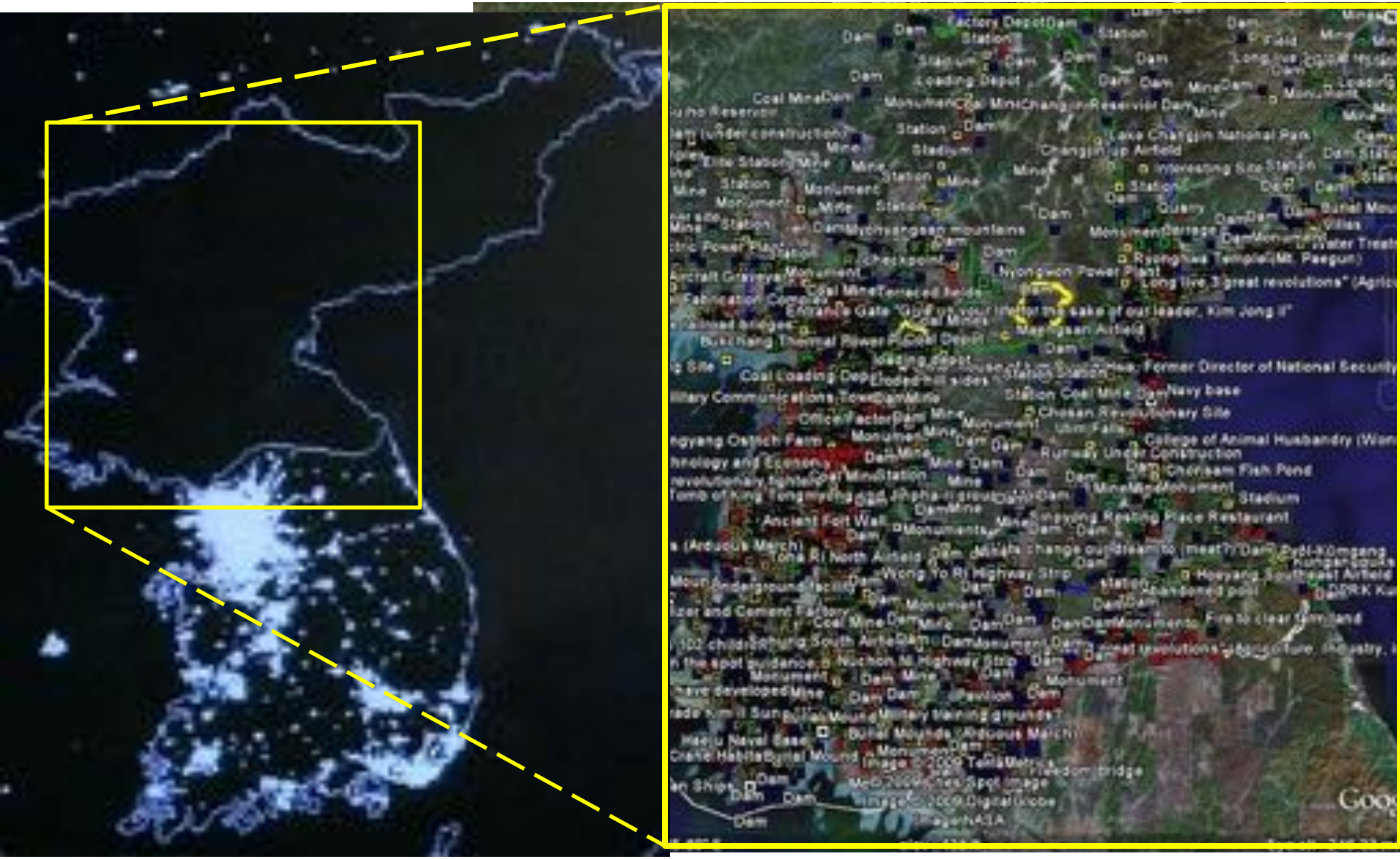
Much open source information available today

Looking from the outside

Source: GeoEye

June 2, 2012

North Korea Is No Longer a Black Hole!



http://gizmodo.com/5277184/north-korea-secrets-uncovered-in-google-earth-by-amateur-spies

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WEDNESDAY MAY 30TH 2012

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Informed analysis of events in and around the DPRK.

Satellite Imagery

New Launch Facilities Under Construction at Musudan-ri, Possible Iranian-

New satellite photos from April 29, 2012 indicate that a major upgrade of North Korea's Tonghae Satellite Launching Ground—more commonly referred to as Musudan-ri—underway since summer 2011, is making rapid progress. The new construction is intended to support future launches of rockets larger than the recently tested Unha – more capable liquid fueled space launch vehicles or missiles with intercontinental ranges – that will also swiftly [Read More]

WMD

Questions about the Unha-3 »
Three weeks have passed since the North Korean failed satellite launch and we're still waiting for more information to accurately assess what happened. The United States, as [Read More]

North Korea's New »
Introduction North Korea's unveiling of a new long-range missile in its April 15 parade, designated the KN-08 by Western experts, has caused a great deal of speculation. [Read More]

Blogs: Arms Control Wonk

ARMS CONTROL WONK

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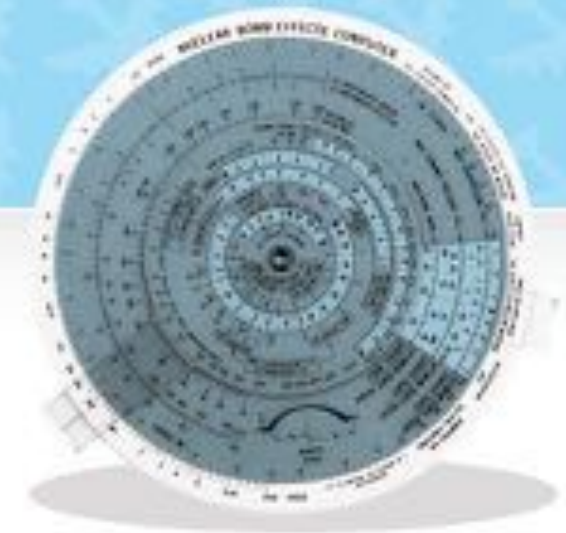

LEADING BLOGS ON
ARMS CONTROL, DISARMAMENT
AND NON-PROLIFERATION

US/ROK SOF in the DPRK?

BY JEFFREY | 29 MAY 2012 | NO COMMENTS

Last week, BG Neil H. Tolley, Commander of Special Operations Command, Korea, participated on a panel at the 2012 SOFIC (Special Operations Forces Industry Conference) with other theater special operations commanders. He was talking about the challenges in dealing with underground facilities in North Korea when he said something like this:

> "The entire tunnel infrastructure is hidden from our satellites," Tolley added. "So we send [Republic of Korea] soldiers and U.S. soldiers to the North to do special reconnaissance."

An unholy shitstorm has erupted. Let's go through this slowly.

Read Full Story →


Old-fashioned forensics:
Looking from the inside
Hecker

How did North Korea get the bomb?

- Soviet "Atoms for Peace" – 1950s & 1960s
- Going solo, but under civilian cover – 1970s to 1992
- Freeze: Agreed Framework 1994 – 2002
- Bomb production: Jan. 2003 – present
- Nuclear tests: October 2006; May 2009; February 2013
- Successful missile test Dec.2012

North Korean bomb – 50 years in the making.
Civilian nuclear cover followed by breakout.

A look back at situation 6 years ago
April 2009
Beginning of Obama Administration

Presentation at Texas A&M University
April 14, 2009

April 5, 2009 rocket lift-off

Musadan-ri, DPRK

Rocket launch was beginning of the end of dialogue by Obama Administration

UN Security Council condemns April 5, 2009 launch
Considered in contravention of UNSCR 1718

Calls for tightening 1718 sanctions
Demands DPRK conduct no further launches
Calls for early resumption of Six-Party talks
Expresses desire for peaceful and diplomatic solution

April 14, 2009 New York

KCNA Pyongyang, 9 hours later (April 14, 2009)

1. Denounce and reject UNSC statement – we will continue to use space
2. Six-Party Talks are no longer necessary
   - No longer participate and not bound by previous agreements
   - We will actively examine construction of LWR of our own
3. We will strengthen our self-defensive nuclear deterrent
   - Restore normal operation of nuclear plant
   - Reprocess spent fuel rods

The North Korean crisis in perspective

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- Breakout II – Jan. 2003 – Sept. 2005

2003 breakout and bomb production

- October 2002 altercation with Bush Administration
- U.S. accused DPRK of covert uranium program
- North Korea walked out
  - Expelled IAEA inspectors
  - Withdrew from NPT
  - Refueled and restarted 5 MWe reactor
  - Claimed it strengthened its deterrent
- U.S. did very little in return
- 2004 began Six-party negotiations

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- Return – Phased approach to denuclearization (2007)
- Breakout IV – April 2009

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- What's next?

Status of DPRK nuclear reactors (Aug. 2007)

5 MWe reactor
Shut down. Capable of 6 kg Pu per year.

50 MWe reactor
Construction site. Not salvageable

200 MWe reactor Taechon
Construction site. Not salvageable

Six-party diplomatic agreements

Agreement	DPRK	U.S. & Others
9/19/05 Joint Statement	- Verifiable denuclearization - Abandon all nuc. weapons & nuclear programs	- Normalization, peace regime, sovereignty - Economic cooperation
2/13/07 Initial actions	- Shut down & seal for eventual abandonment - Discuss declaration list	- Begin process of removing from terror list and TWEA - 50,000 tons HFO
10/13/07 Second phase	- Disable all existing nuc facilities - Complete and correct declaration - No transfer of nuc. materials, technology or know-how	- Removal from terror list and TWEA – actions depend on DPRK - 1 mil tons HFO equivalent - Ministerial meeting

A painfully slow process toward denuclearization

They had a specific message for each visit

Jan. 2004 Yongbyon

Aug. 2005 Pyongyang

Nov. 2006 Pyongyang

August 9, 2007, Yongbyon

Feb. 14, 2008, Yongbyon

Track II diplomacy

The Yongbyon plutonium labs – small and primitive

August 9, 2007

Uranium metal conversion furnaces removed

(Fuel fabrication facility)

Refractory bricks and mortar removed from furnaces

(Fuel fabrication facility)

Empty machine shop and stored lathes

(Fuel fabrication facility)

Symbolic destruction of 5 MWe cooling tower

June 27,2008 (one day after declaration delivered to six party talks)

DPRK nuclear program status (4/14/09)

- **Weapons-grade plutonium**
  - Estimated at 40 to 50 kilograms (6 or 8 bomb's worth)
  - DPRK declared 26 kg "weaponized"
- **Nuclear weapons**

Nuclear weapons

- Oct. 9, 2006 nuclear test – partial success
  - Aimed for 4 kilotons, got less than 1 kiloton
  - Significantly less than other nation's first test
- Likely to have small nuclear arsenal, but of limited utility
- Unlikely to have experience and confidence to mount on missile
- Additional test(s) could enhance weapon sophistication
- 50 MWe reactor operation would lead to dramatic increase in numbers

The nuclear test was a technical failure, but a political success. It changed the diplomatic dynamics.

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  - Still denies effort in spite of strong evidence

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- **Nuclear technology export**
  - Syria – yes
  - Iran and others – possible
- **Long-range missiles**
  - April 5 launch is third attempt in 12 years

Why does North Korea want nuclear weapons? A Russian perspective

- Use them as a diplomatic card to bring U.S. to bargaining table
  - Gain concessions – desire to negotiate a compromise based on mutual concessions, equality, and reciprocity
- Most powerful and cheapest deterrent against aggression
- Domestic consumption – increase tensions in area and distract people's attention from daily grievances. Make people more scared and more submissive
- International statement - Demonstrate that DPRK won't bend under pressure and defy all forms of control
- Raise international status – demonstrate technological achievement

Natalia Bazhanova in Moltz and Mansourov (2000)

April 14, 2009 status (6 years ago)

Possible next steps

- Restart
  - Make more plutonium (reprocess ~ 8 kg)
  - Restart reactor
    - Cooling tower, prepare fuel for 6 kg Pu/year
- Rebuild bigger reactors
- Build a modern LWR
- Reactivate uranium enrichment program
- More missile tests
- Test a second nuclear device
- Resume/accelerate nuclear exports

For now, DPRK appears in control in spite of a weak hand

Kim Jong Il still in power

Confidence is increasing

Slow-down was working

They walked out again

May 25, 2009

Nuclear test # 2

May 25, 2009

Nuclear test # 2

What happened next?

2010: Time of danger on Korean peninsula

March 26: Cheonan sinking

Oct. 10: Musudan road-mobile Intermediate-range rocket at Pyongyang parade

Nov. 23: Attack on Yeonpyeong Island

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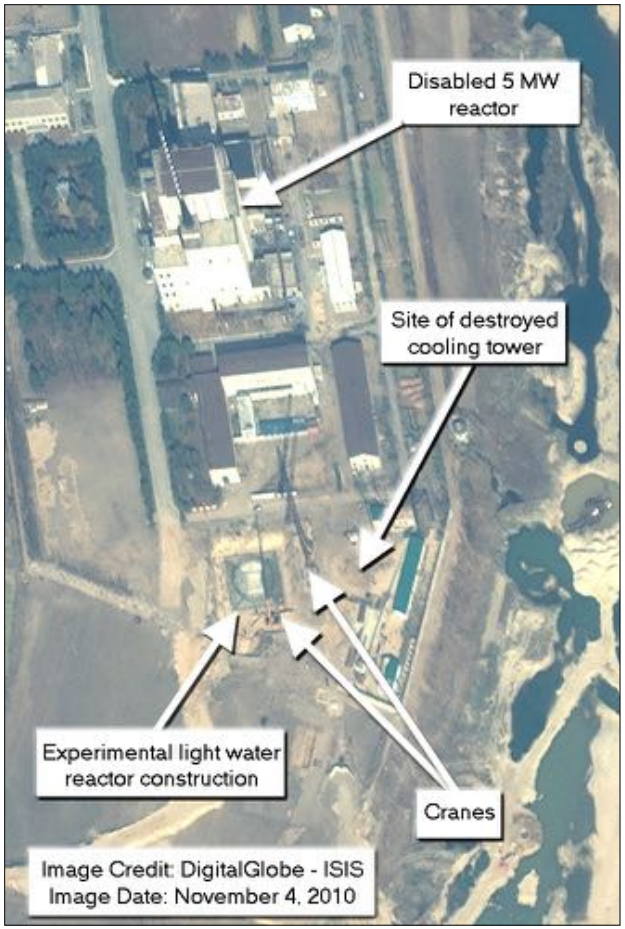
Lewis, Carlin and Hecker delegation in Pyongyang

Nov. 11, 2010

November 2010 visit to Yongbyon presented us with a new reality

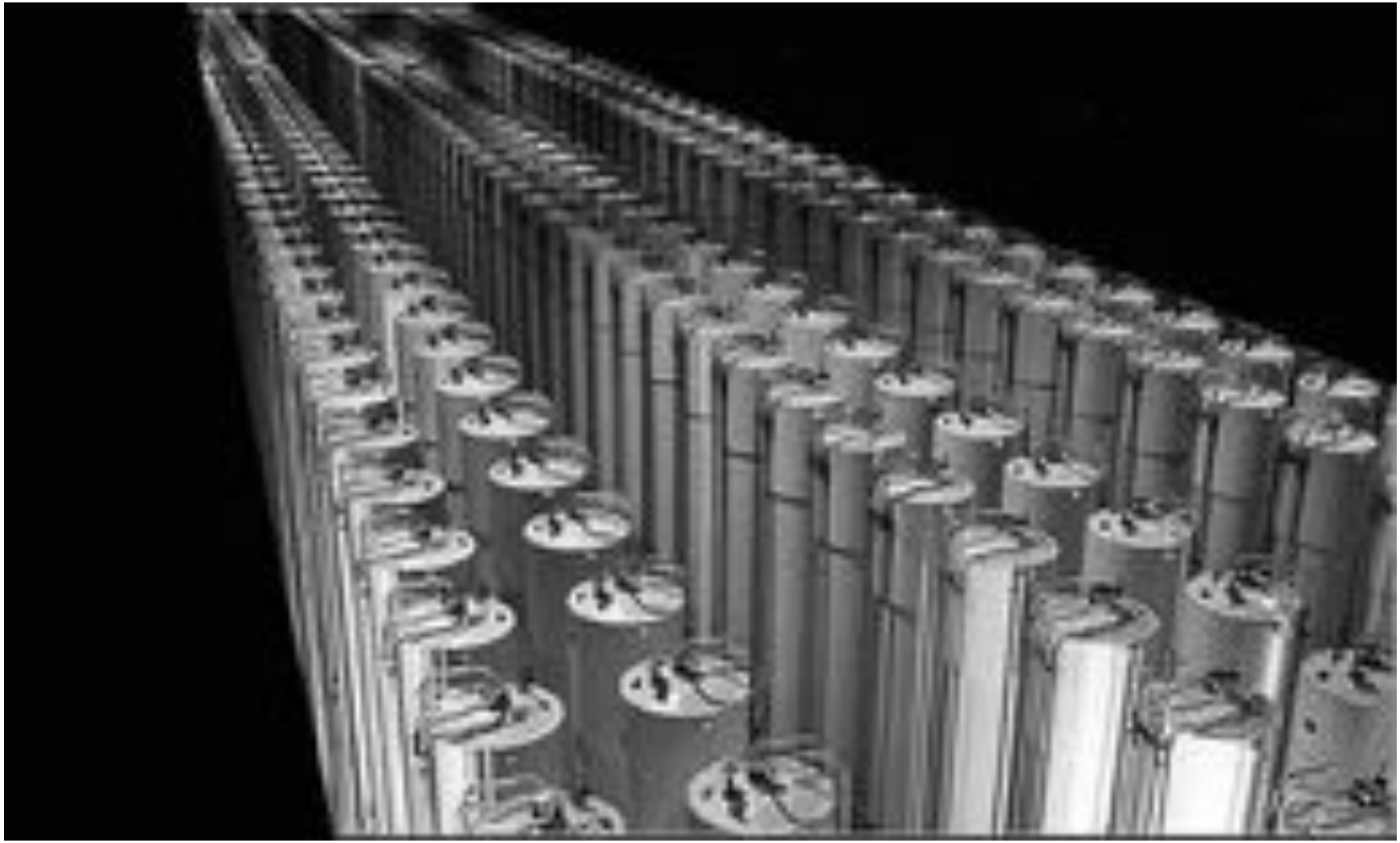
"We will convert our center to an LWR and pilot enrichment facility."

Vice Minister Ri Yong-ho, Nov. 2010



No foreigners have been at Yongbyon since Nov. 2010

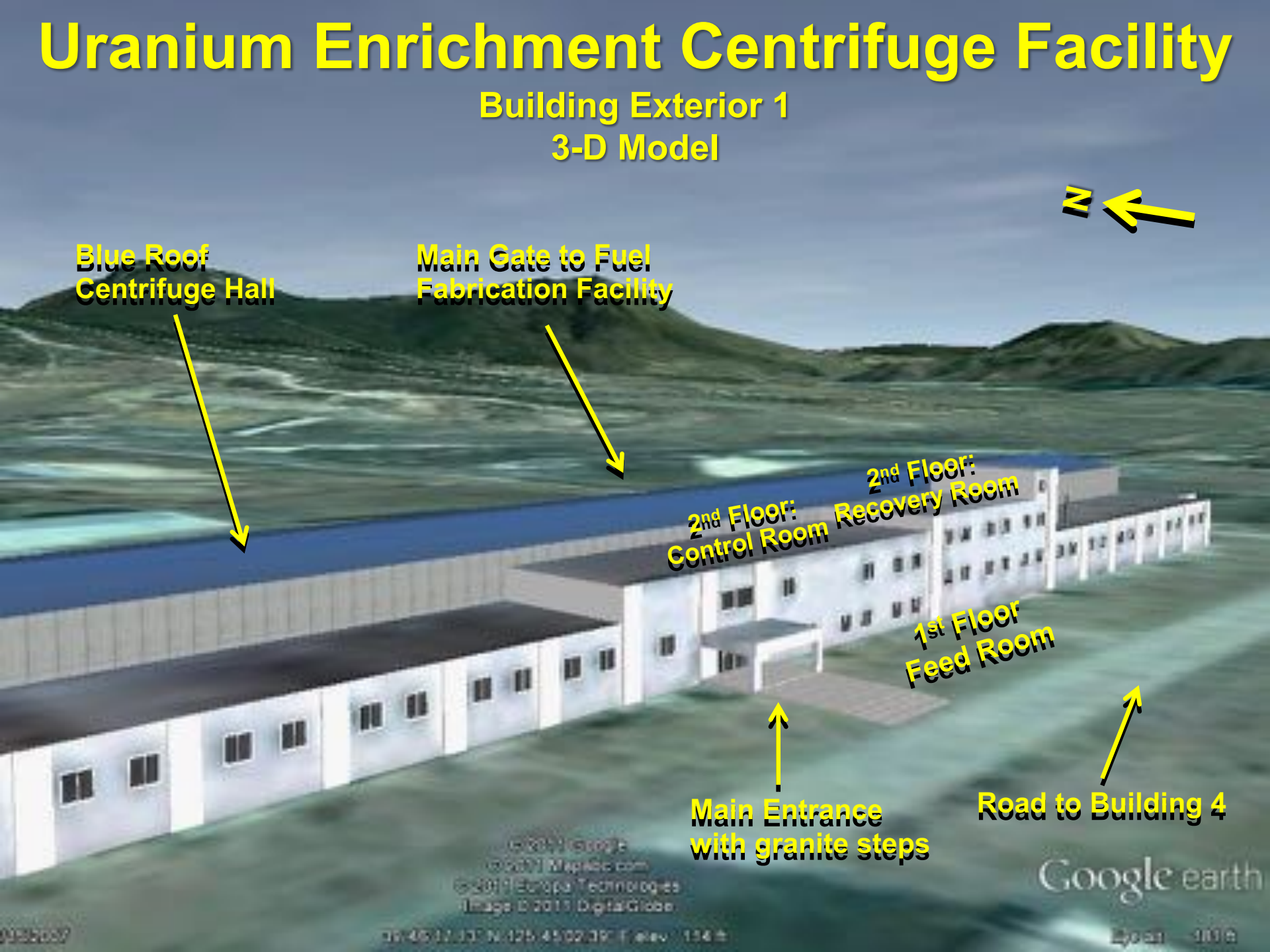
Purely illustrative - this is not Yongbyon, but close to what we saw (Nov. 12, 2010).



Piketon, Ohio Centrifuge plant, 1984 (Department of Energy)
Several additional centrifuge lines were removed graphically to try to get this as close as possible to the centrifuge cascades we saw in Bldg. 4 at Yongbyon

Uranium Enrichment Centrifuge Facility

Building Exterior 1
3-D Model



Uranium Enrichment Program

- **Yongbyon centrifuge facility**
  - No information since Nov. 2010 visit
  - Likely 2000 P-2 centrifuges – 8000 SWU/yr
  - Potential for 2 tonnes LEU fuel/yr or 40 kg HEU/yr
  - It likely was dedicated to LEU production for ELWR

- **Support facilities at Fuel Fabrication Plant**
  - Enormous amount of construction at FFP since 2010
  - Required to support ELWR and ceramic fuel fabrication

- **Concerns**
  - Must have covert facility because of size and timing of Yongbyon facilities
  - Very likely can produce HEU, but no estimate of size

Why uranium enrichment?

- **Fuel for LWR**

- **HEU for bombs or warheads**
  - HEU provides the most certain route to simple bomb
  - May be viewed as quicker route to miniaturized warhead
  - But, only with outside help (A.Q. Khan, Tinner family, Iran ?)
  - Uranium enrichment is easier to hide
  - May be able to scale up more easily

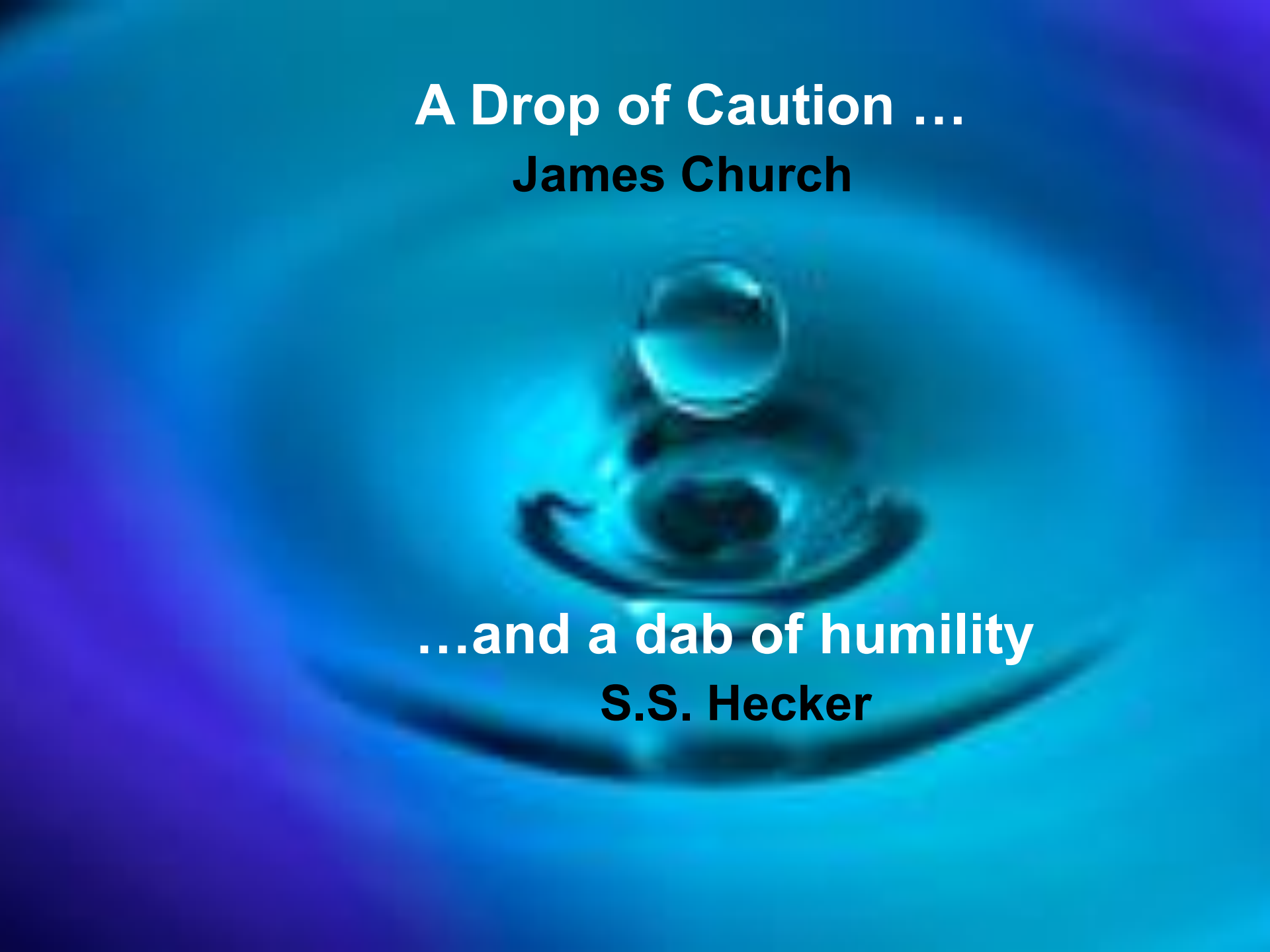
- **Uranium enrichment offers better export potential**

Uranium enrichment is dual use


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

A Drop of Caution …

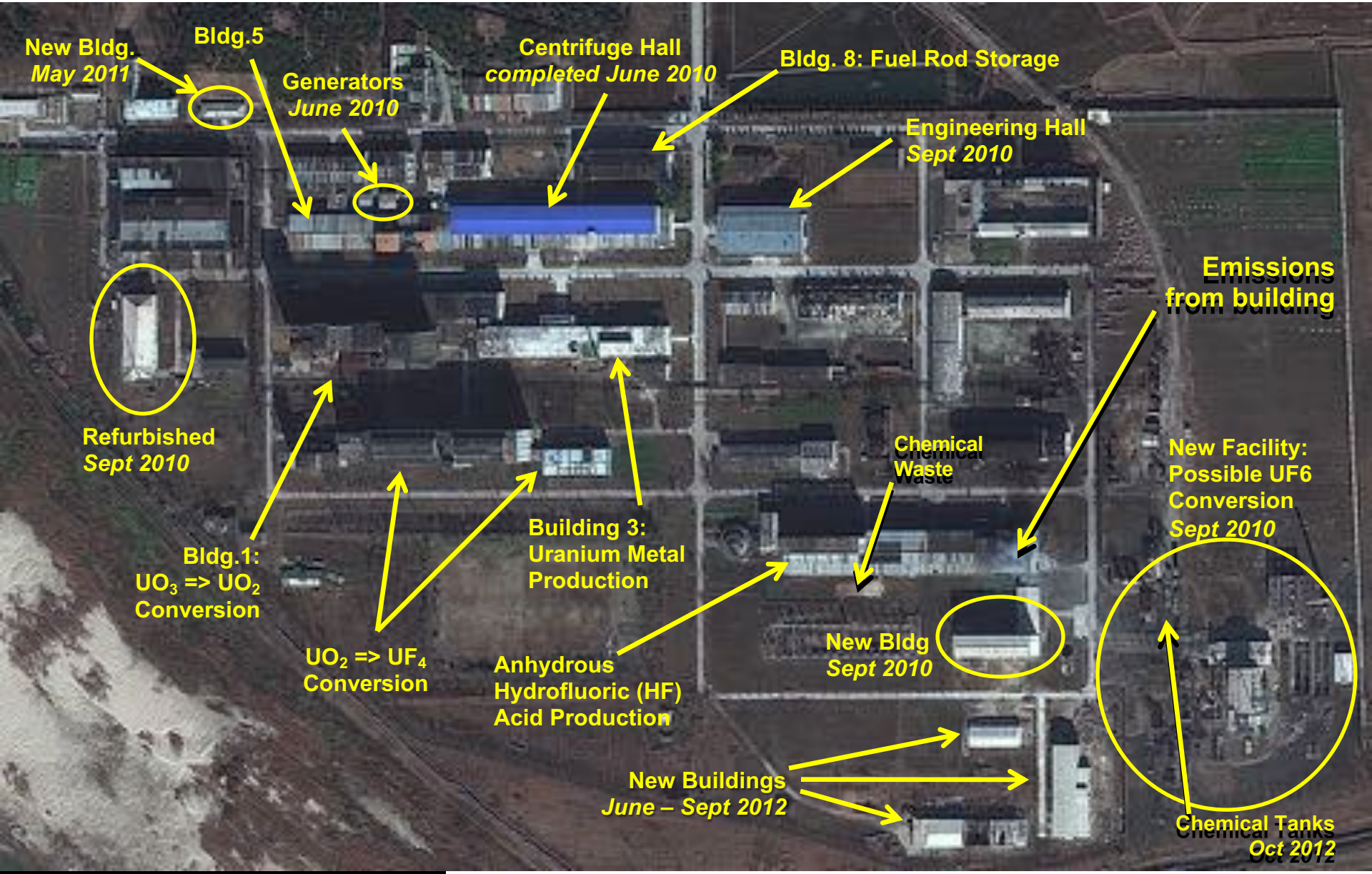
James Church



…and a dab of humility

S.S. Hecker

Yongbyon Fuel Fabrication Plant, North Korea



13 NOVEMBER 2012; Source: GeoEye

Lots of activity at Yongbyon since 2009


IHS Jane's Satellite Imagery Analysis
Yongbyon, North Korea
39.770027 N 125.750307 E
Image Date: 3 February 2014 / Pleiades Satellite
Fuel fabrication facility
Feb. 3, 2014ç
N
Settling ponds
New centrifuge buildings
Former fuel rod final assembly
Rail spur
Uranium trioxide to uranium dioxide conversion
New steam plant
Uranium dioxide to uranium tetrafluoride to uranium metal conversion
Uranium metallurgy
Hydrogen fluoride production
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.

Probability assessments for material and component acquisition by country of origin

Material	Percentile	Russia	China	Europe/ Japan	Iran	Pakistan
7075 Aluminum [metric tons]						
	10	50	3	25	1	3
	90	150	75	125	13	25
250-grade maraging steel [metric tons]						
	10	25	3	3	1	3
	90	125	50	75	3	13
350-grade maraging steel [metric tons]						
	10	25	1	3	1	1
	90	125	13	50	1	8
Pivot bearings [count]						
	10	1,000	2,000	5,000	100	100
	90	10,000	10,000	10,000	300	1,000
Controlling units [count]						
	10	2,000	2,000	5,000	100	100
	90	10,000	10,000	10,000	300	300

"A Bayesian Model to Assess the Size of North Korea's Uranium Enrichment Program"
John Bistline, David Blum, Chris Rinaldi, Gabriel Shields-Estrada, Siegfried Hecker, Elisabeth Paté-Cornell
Journal of Science and Global Security (to appear, 2015)

Probability of domestic production for centrifuge materials and components

Material	Probability
7075 aluminum	0.1
250-grade maraging steel	0.2
350-grade maraging steel	0.05
Special oils	0.95
Pivot bearings	0.2
Controlling units	0.2
Ring magnets	0.9

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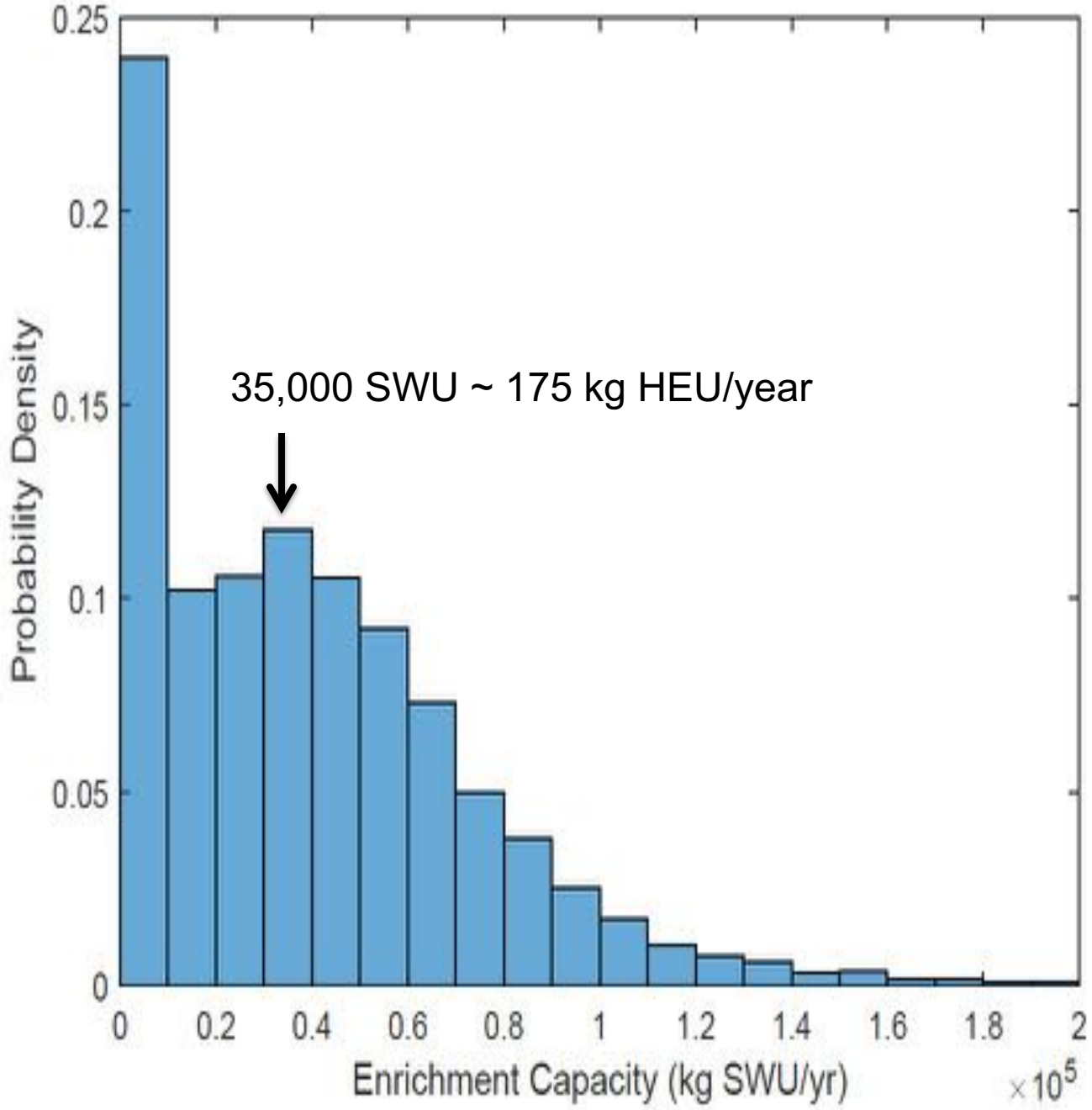
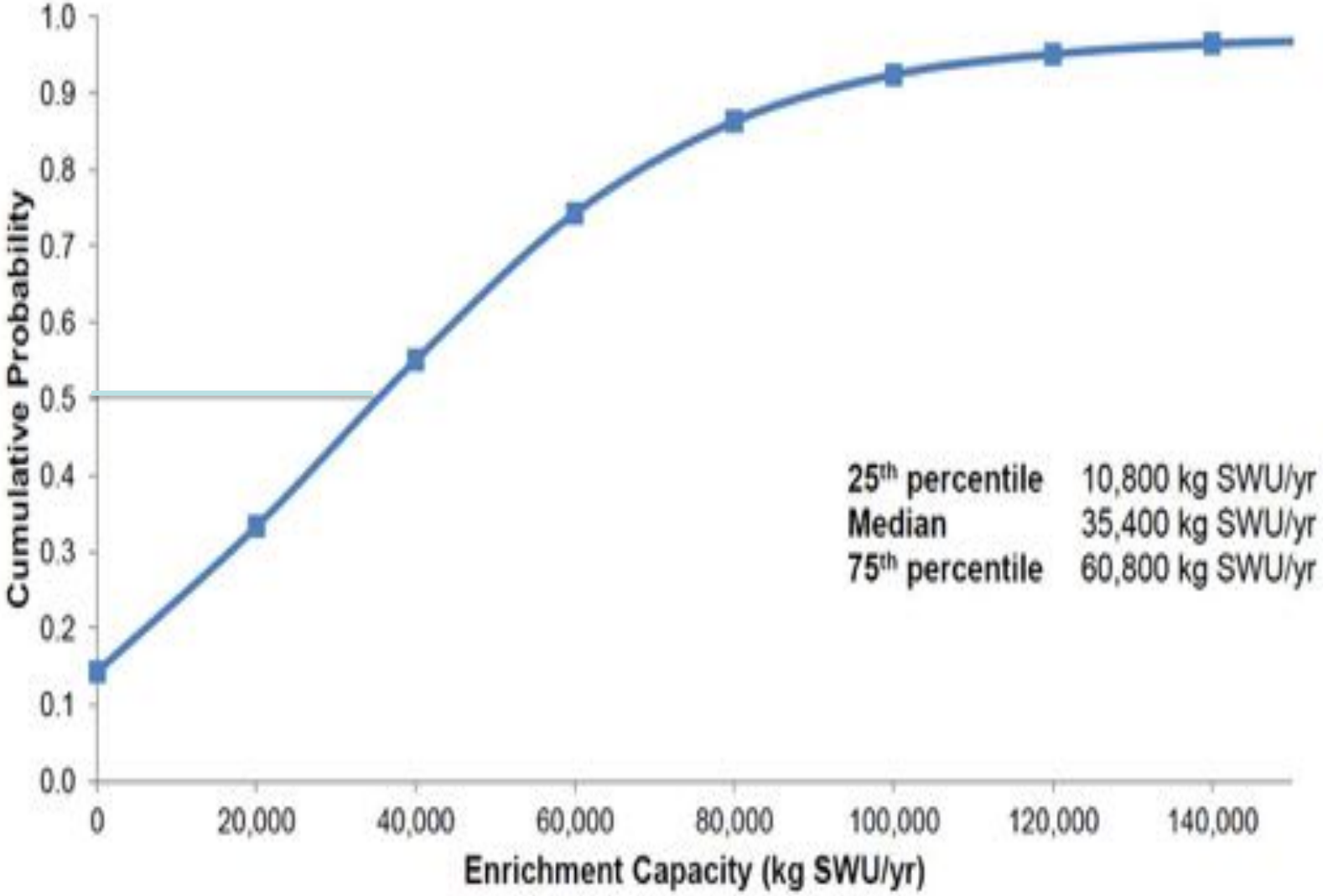
John Bistline, David Blum, Chris Rinaldi, Gabriel Shields-Estrada, Siegfried Hecker, Elisabeth Paté-Cornell
Journal of Science and Global Security (to appear, 2015)


35,000 SWU ~ 175 kg HEU/year
Probability Density
0.25
0.2
0.15
0.1
0.05
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Enrichment Capacity (kg SWU/yr)
×10^5


Cumulative Probability
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
20,000
40,000
60,000
80,000
100,000
120,000
140,000
Enrichment Capacity (kg SWU/yr)
25th percentile 10,800 kg SWU/yr
Median 35,400 kg SWU/yr
75th percentile 60,800 kg SWU/yr

Experimental LWR Program

- **Steady progress on EWLR (25 to 30 MWe)**
  - KEDO abandoned in 2006
  - No apparent plans in 2008
  - Site preparation in September 2010
  - Stanford visit in November 2010
  - Steady progress – possible operation by 2014/2015
- **First step toward full power reactor (like KSNP)**
  - KEDO and KSNP – 1000 MWe
- **Concerns**
  - Regulatory system, safety and emergency response
  - Low proliferation concern – but …
  - Albright – if configured for Pu production ~ 20 kg/year


26 SEP 2010
Overhead imagery
Source: DigitalGlobe


4 NOV 2010
Source: DigitalGlobe


28 MAY 2011
Source: GeoEye


4 NOV 2011
Source: DigitalGlobe, 38 North


26 JAN 2012
Source: DigitalGlobe

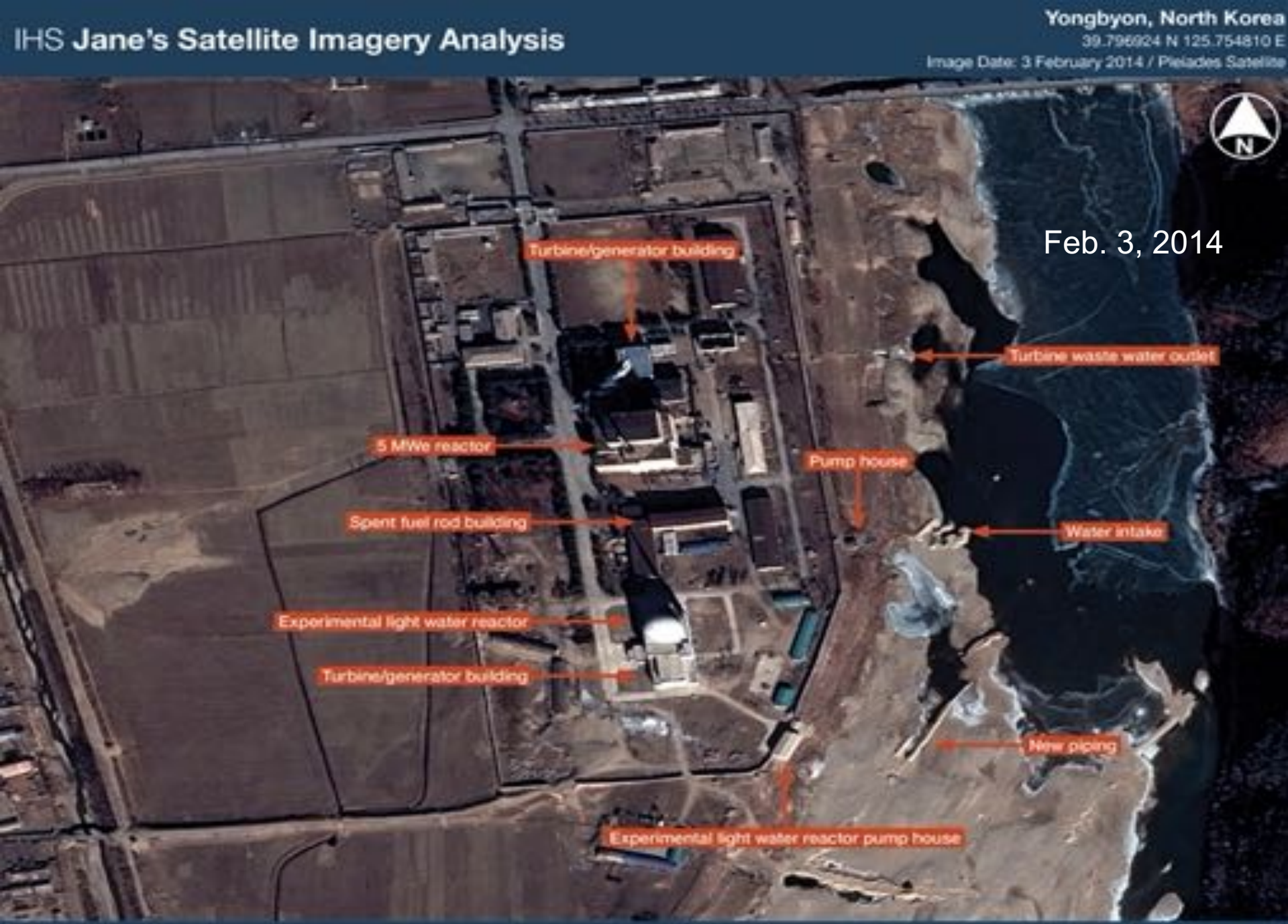

20 MAR 2012
Source: DigitalGlobe


24 JUN 2012
Source: GeoEye


6 AUG 2012
Source: GeoEye

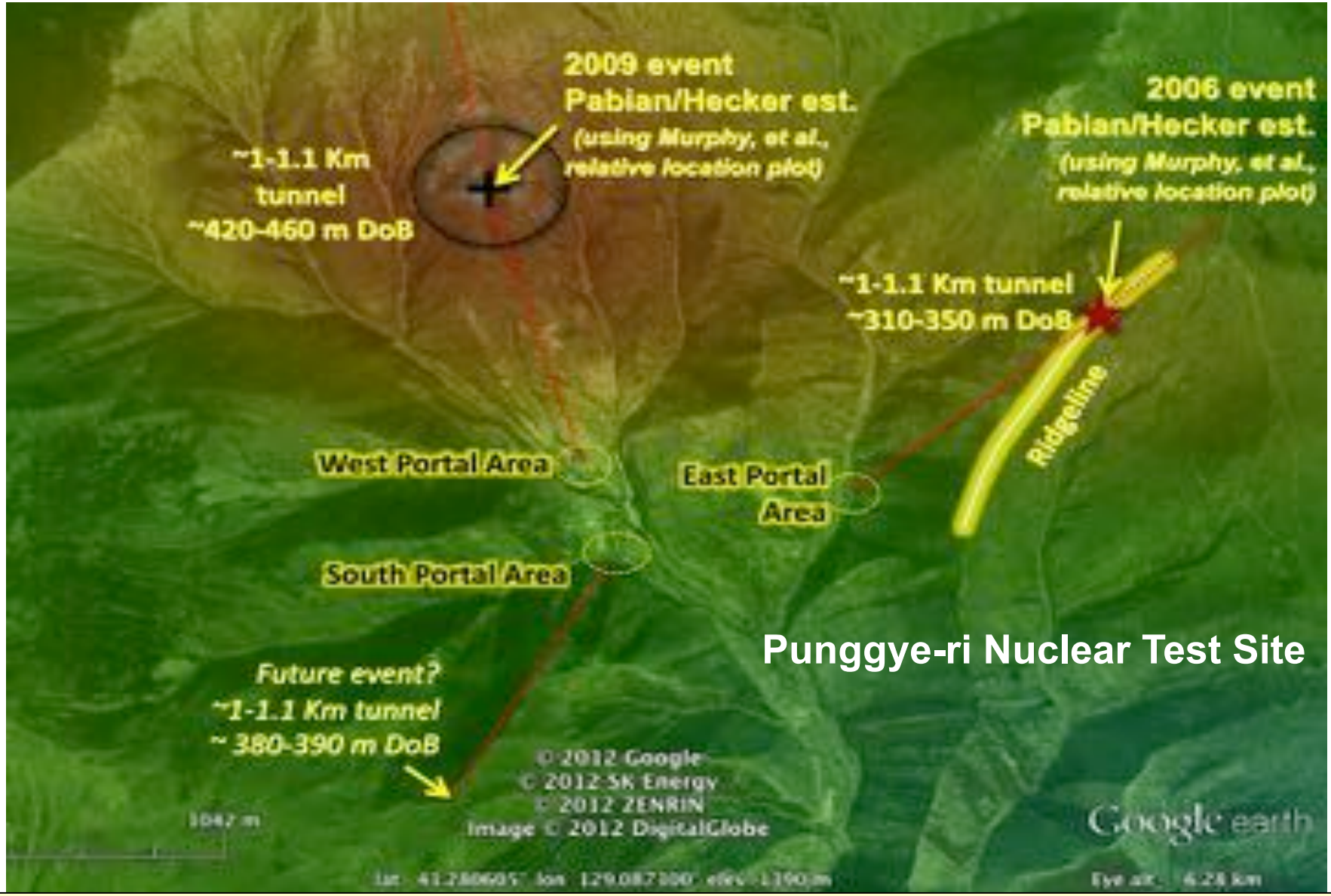

12 DEC 2013
Source: DigitalGlobe/ Google Earth


Newly constructed fence
New construction activity
New cement roads
Two new ring sections
Turbine Generator Hall
Excavated holes for tanks
Ventilation stack
5MWe Reactor
Heavy Manufacturing
Reactor Containment Structure
Cooling water Pumphouse
Trench sealing for cooling water pipes
5MWe spent fuel pool storage
New support building Oct 2010
New piping installed
New pipe trenches for cooling of reactor core/ Possible location for an electrical substation
Kuryong River (Reactor Cooling Source)
13 NOV 2012
©GeoEye



The new Experimental Light Water Reactor (ELWR) sits on the site of the original 5 MWe reactor's cooling tower. The ELWR's pump house will now serve a secondary cooling system for each reactor.

Better bombs? North Korea would require another test



Testing is only area of restraint at this time

Nuclear testing program

- **Previous nuclear tests**
  - Oct. 2006 – East tunnel, close to1kiloton
  - Oct. 2009 – West tunnel, between 2 and 7 kilotons
  - Feb. 2013 – Likely West tunnel, ~ 7 to 10 kilotons
- **South tunnel**
  - Excavation apparently started in 2009
  - Tunnel appeared ready for test by April 2012
  - Continued activity through floods and snow
- **Other activities**
  - West portal showed greatest activity in 2013
  - Cold tests or experiments at either tunnel possible
- **Nuclear testing issues**
  - Why test again? Needed to miniaturize;
  - Possibly test both Pu and HEU

North Korean nuclear test: #1 – Oct. 9, 2006

Results:

- Predicted 4 kt yield; actual seismic ~ 4; yield < 1 kt
- Likely Pu; likely rudimentary (Nagasaki like)

Motivation:

- Technical and military drivers
- Convince Kim Jong-il and military leaders
- Political - reinforce deterrence message to U.S.
- Response to sanctions

Consequences:

- China's displeasure, UNSCR sanctions
- No major impact of sanctions
- Bush administration came to negotiating table
- 2007 & 2008 – Restraint, hedge and regroup

North Korean nuclear test: #2 – May 25, 2009

Results:

- Seismic ~ 4.5; yield 2 to 7 kt
- Likely Pu; likely rudimentary (Nagasaki like)

Motivation:

- Strong technical drivers to improve on 2006 performance
- Convince Kim Jong-il, military leaders after 2006 attempt
- Convince U.S. and world
- Develop more credible deterrent (followed LR missile launch)

Consequences:

- China's displeasure, UNSCR sanctions
- No major impact of sanctions
- Killed six-party talks
- Stopped Obama administration from negotiating
- Facilitated expansion of nuclear weapons program

North Korean nuclear test: #3 – Feb. 12, 2013

Results:

- Seismic ~ 4.9; yield 7 to 16 kt; No info on Pu vs. HEU
- Likely achieved some miniaturization (so claimed by DPRK)

Motivation:

- Technical and military drivers for miniaturization
- Demonstrate more threatening nuclear weapon capability
- Preceded by successful LR missile launch
- Domestic - shore up Kim Jong-un's regime

Consequences:

- China's strong displeasure; sanctions may have more impact
- DPRK threatened pre-emptive nuclear strike followed by offer to talk
- Terminated Obama administration negotiation attempts
- Demonstrated expansion of nuclear weapons program

What next?

- **Why test again?**
  - Strong technical reasons
  - Strong military and political reasons
  - Domestic support
- **Why not test?**
  - China's displeasure and potential actions
  - Unlikely to be influenced by international constraints
  - Fissile materials constraints

Unha-3 rocket and Kwangmyonsong-3 satellite

- Unha-3 launched on Dec. 12, 2012 from Sohae Launch Site
  - First Stage fell in Yellow Sea
  - Second Stage near Philippines
- Kwangmyonsong-3 satellite in orbit
  - In elliptical path but no signals
  - Orbits globe at 7.6km/sec (every 95.4min)
- Unha-3 long-range rocket characteristics
  - Liquid fueled, three-stage rocket (not good for ICBM)
  - Estimate range of ~4,000 to 6,000km. Could be as much as 10,000km (capable of reaching the continental U.S.)

Unha-3 Rocket Launch Preparation

Construction at Sohae Satellite Launch Site

- Imagery reported by 38 North (Oct. 9, 2013) shows significant construction at Sohae

- Work ongoing to upgrade Unha launch pad and possibly build a second mobile missile launch pad

- Activities in line with North Korean desire to field mobile missile capability and launch larger rockets than the Unha-3 launched last December 2012

North Korea continues to prepare for future space launches, increasing the likelihood of rocket tests that improve its missile program

IHS Jane's Satellite Imagery Analysis

Sohae, North Korea
39.670496 N 124.706606 E
Image Dates: 3 April 2014 and 11 August 2014 / Pleiades Satellite

Airbus Defence and Space imagery shows infrastructure changes around the Sohae horizontal assembly building. During 2014 the rail spur, previously terminating at the rail siding, was extended to provide direct access to the launch pad.

Pyongyang's inventory of older liquid-fueled missiles is impressive, but its history shows a striking lack of progress compared to Pakistan and Iran.
John Schilling and Henry Kan, US-Korea Institute at SAIS, 2015

DPRK delivery systems

- SCUD (mobile, liquid fueled) 300 – 600 km
- KN-02 Toksa SRBM (solid fueled, like SS-21)
- Nodong IRBM (mobile, liquid fueled) 1200 – 1500 km
- 60 Il-28 light bombers
- **Future**: Long-range Taepodong ICBM (based on Unha SLV)
- Road mobile Musudan IRBM
- KN-08 ICBM (~ 9000 km)
- Short-range, sea-based land-attack missiles

Pyongyang's inventory of older liquid-fueled missiles is impressive, but its history shows a striking lack of progress compared to Pakistan and Iran.
John Schilling and Henry Kan, US-Korea Institute at SAIS, 2015

Images of DPRK's "Musudan" IRBM and KN-08 ICBM

Side View of the Musudan IRBM missile and MAZ-547A TEL as featured in the 10 Oct 2010 military parade in Pyongyang. Source: AP/Wide World

In this April 15, 2012 file photo, a Chinese TEL carries the North Korean KN-08 missile.
(AP Photo/Vincent Yu, File)

Neither has been flight tested
as far as we know

The great miniaturization debate

KN-08 ICBM Deployed?

"Our assessment is that they have the ability to put a nuclear weapon on a KN-08 and shoot it at the homeland," Admiral William Gortney, the head of the U.S. Northern Command (April 7, 2015)

"We have not seen them do that" and "we haven't seen them test the KN-08."

Outline

- What does North Korea have?
- A short nuclear primer
- How did it get there?
  - A close look at 6 years ago
- What now?

What are the prospects for North Korea?

- **Little hope of giving up nukes in the near term**
- **Must stop nuclear build up first**
- **Settle for 3 No's in return for 3 Yes's**
  - No more bombs
  - No better bombs (no nuclear or missile testing)
  - No export

  In return
  - Address the North's security concerns
  - Provide energy assistance
  - Provide economic assistance

Carlin, DeTrani and Mansourov will figure it out

Potential DPRK nuclear program by 2020

Nuclear Capability	December 2016 Estimates	2020
Plutonium	34 – 52 kg 30 – 35 kg	Possibly 70 kg 30 – 35 kg
HEU (Highly enriched U)	Possibly 450 kg China: Possibly 500 kg	~150 kg/yr China: HEU 200 kg/yr
Nuclear tests	3 or 4	Possibly 4
Nuclear weapons	Possibly 8 Pu + 18 HEU China: ~ 6 + 34	~10 Pu + 42 HEU China: Possibly 70
Long-range rockets	Unha-3 Possibly more tests	Musudan or KN-08 tests

Possible steps to 3 No's – halt and roll back

Nuclear activity	Informal agreement	Potential next steps	Intermediate steps
Plutonium	Stop 5 MWe	Unload fuel, reprocess, safeguard	Terminate all plutonium operations. Dismantle.
HEU	Open YB Centrifuge Facility - inspect	Open all other YB facilities. Declare all UE ops	Close covert facilities. Negotiate on YB.
Nuclear tests	Moratorium	Destroy test tunnels	Cease all testing
Missiles	Moratorium	Declaration. Offer satellite launch services.	No long-range tests. Provide launch services.
LWR	Declaration	Safety inspection.	Decide on future of LWR.