North Korea's nuclear program

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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 – July 2009**
- **Nuclear tests: October 2006; May 2009; February 2013**
- **Successful missile test Dec.2012**

North Korean bomb – 50 years in the making.
Nuclear tests had major impact.

Why countries build and keep nuclear weapons

- **National security**
- **International norms, statement, prestige**
- **Domestic statement and politics**

Scott D. Sagan, “Why Do States Build Nuclear Weapons? Three Models in Search of a Bomb,” *International Security* 21 (3) (Winter 1996/1997).

What about North Korea?

- **National security**
  - Primary reason, since 1950s
  - Remains primary reason today
- **International norms, statement, prestige**
  - Post 1994 with Agreed Framework
  - Increased importance post 2003
- **Domestic statement and politics**
  - Important only after 2006 test
  - Increasing importance today

The case of North Korea

< 2006 Only mention of a nuclear deterrent
But many attempts to send message to US

> Oct. 2006 DPRK claims test in response to hostile U.S. policy

> May 2009 "The test will contribute to defending the sovereignty of the country and the nation and socialism and ensuring peace and security on the Korean Peninsula…"

> Feb. 2013 Smaller and lighter warheads and a threat to launch pre-emptive nuclear strikes against the United States and Seoul

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National security drivers remain paramount, but once they tested the domestic and international drivers increased

Visits to North Korea provided valuable insight

Jan. 2004 Yongbyon

Aug. 2005 Pyongyang

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

“It worked and we are filled with pride”

Nov. 2006 Pyongyang

August 9, 2007, Yongbyon

Feb. 14, 2008, Yongbyon

Symbolic destruction of 5 MWe cooling tower

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

Creating the conditions for another test

Feb. 27, 2009, Pyongyang

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

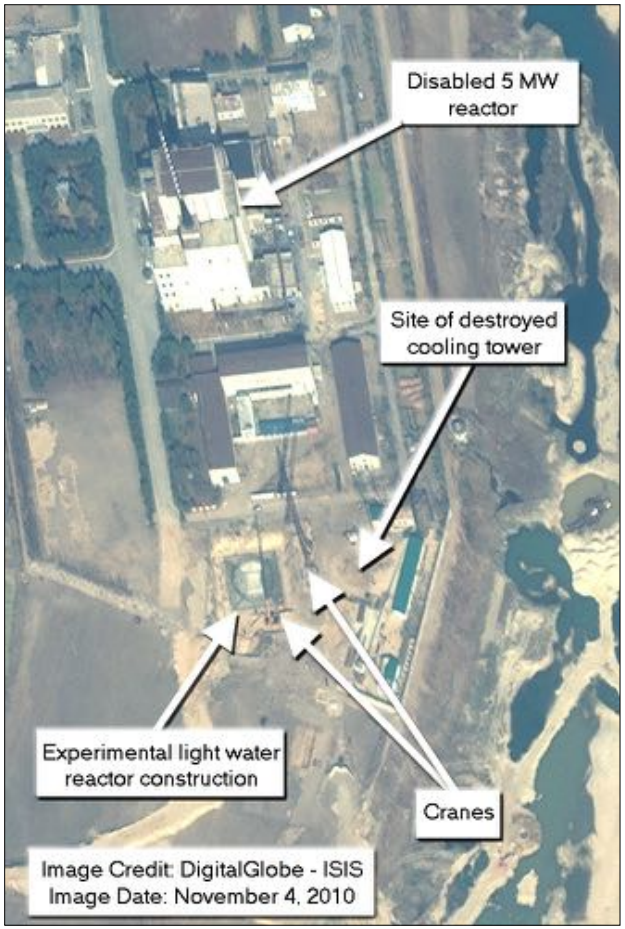
Security and Testing

- Potential strategies of nuclear coercion:
  - Deterrence (making threats to prevent another party from changing the status quo)
  - Compellence (making threats to try to change the status quo)
- Requires credible (implicit or explicit) nuclear threats.
- Testing often seen as necessary to make such threats
  - Announced first tests (China, UK, France, India, Pakistan, DPRK).
  - Counter-example: Israel
- Many pictures of tests declassified shortly afterwards.
- DPRK released a video with test tunnel simulations

November 2010 visit to Yongbyon presented us with a new reality

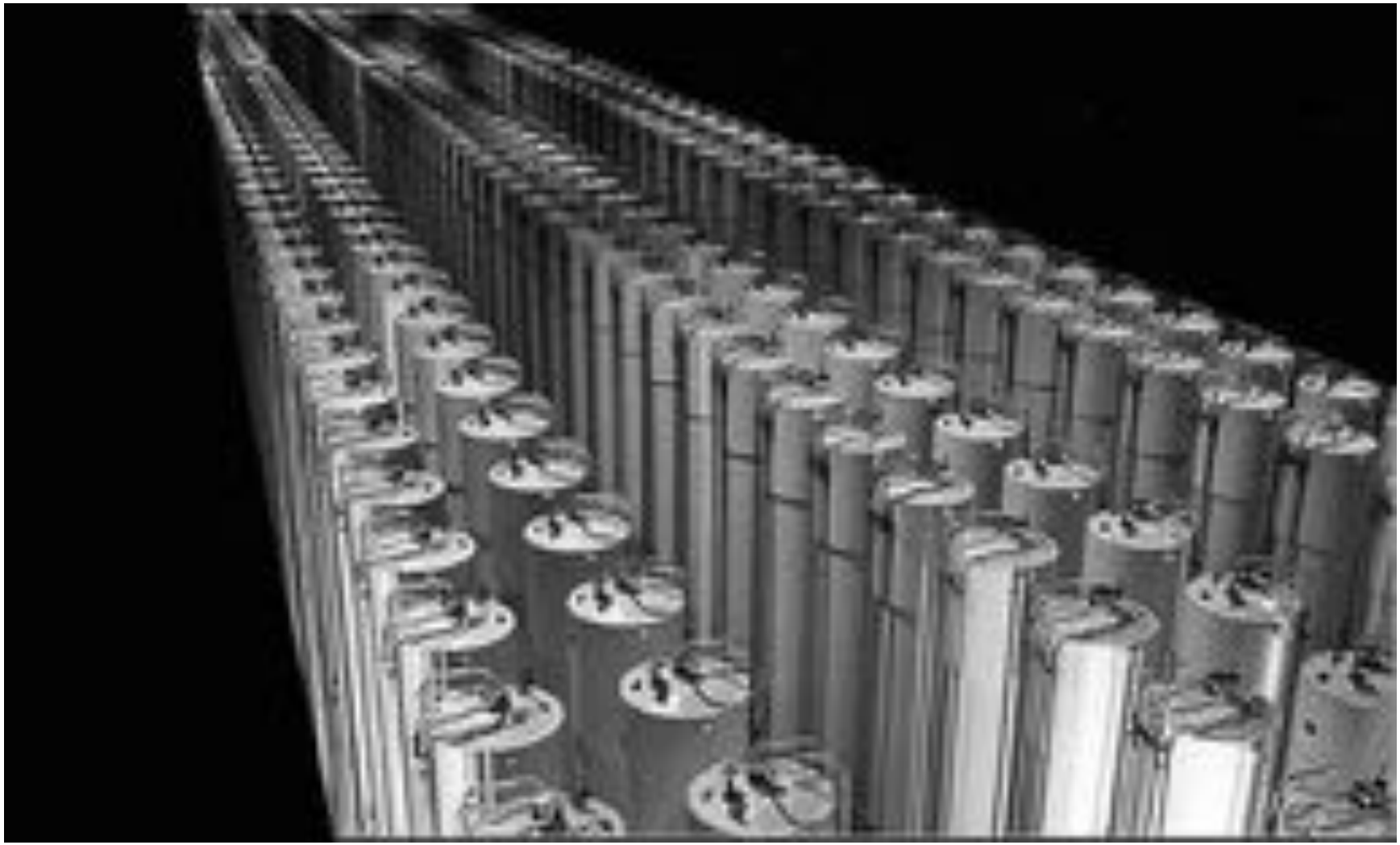
"We will convert our center to an LWR and pilot enrichment facility."

DPRK Official, Nov. 2010



No foreigners have been at Yongbyon since Nov. 2010

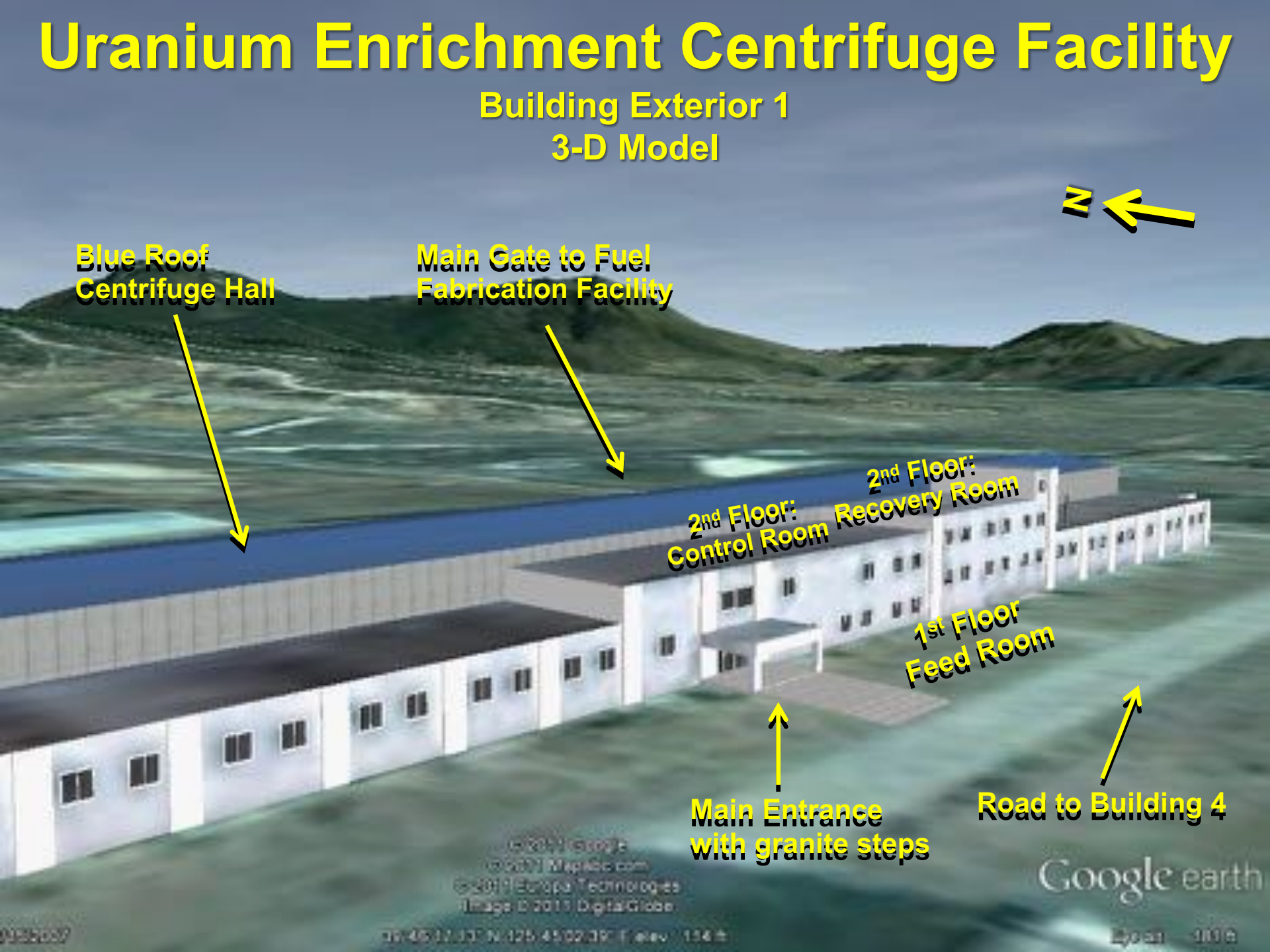
Purely illustrative - this is not Yongbyon, but close to what we saw (Nov. 12, 2010).



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




26 SEP 2010
Source: DigitalGlobe


4 NOV 2010
Source: DigitalGlobe


28 MAY 2011
Source: GeoEye


4 NOV 2011
Source: DigitalGlobe, 38 North


26 JAN 2012
Source: DigitalGlobe

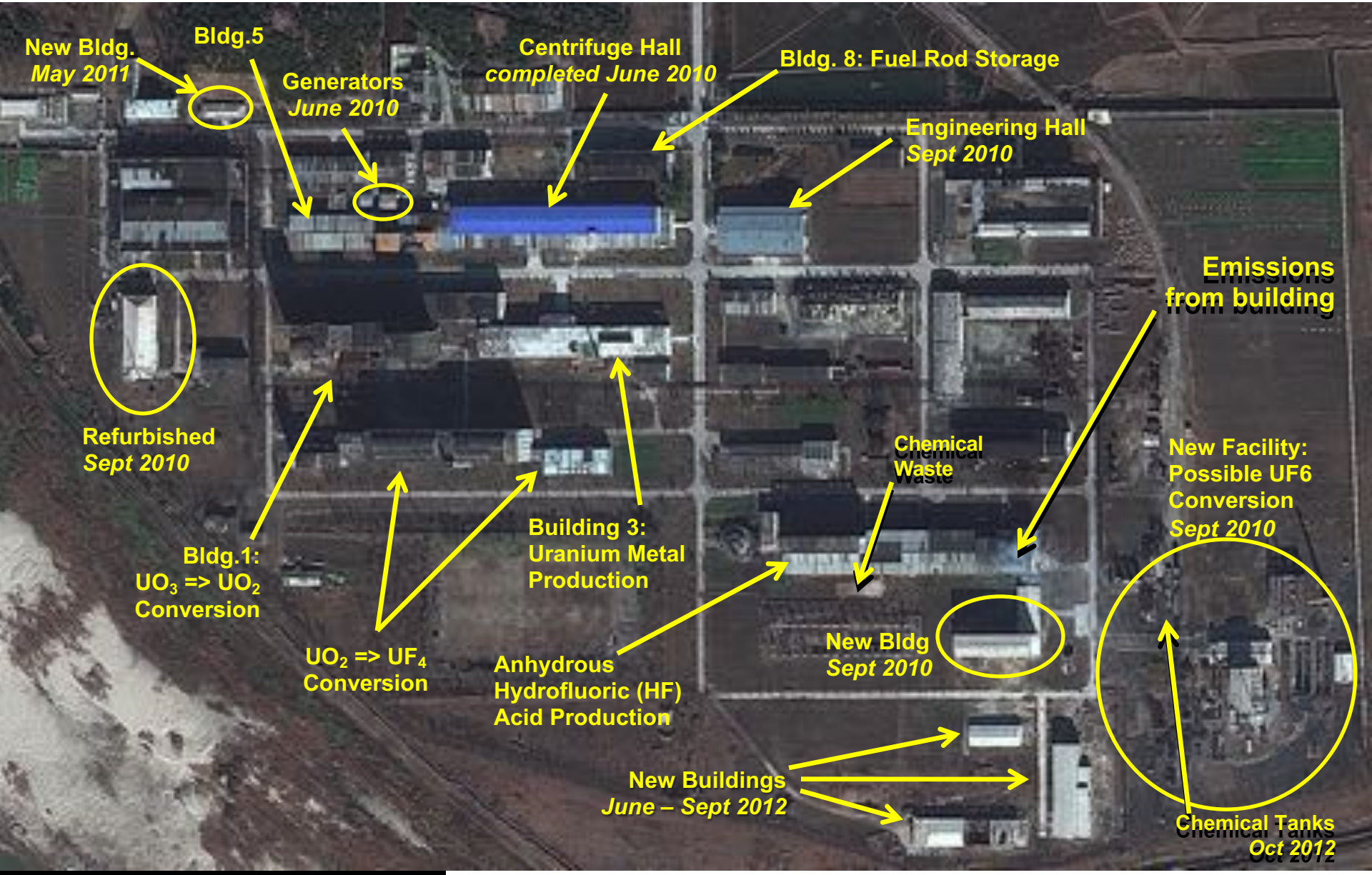

20 MAR 2012
Source: DigitalGlobe


24 JUN 2012
Source: GeoEye


6 AUG 2012
Source: GeoEye


2 JAN 2013
Source: DigitalGlobe

Yongbyon Fuel Fabrication Plant, North Korea



13 NOVEMBER 2012; Source: GeoEye

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

Dec. 12, 2012 Successful Unha-3 Rocket Launch

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

Results:

- Seismic ~ 4.9; yield 8 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

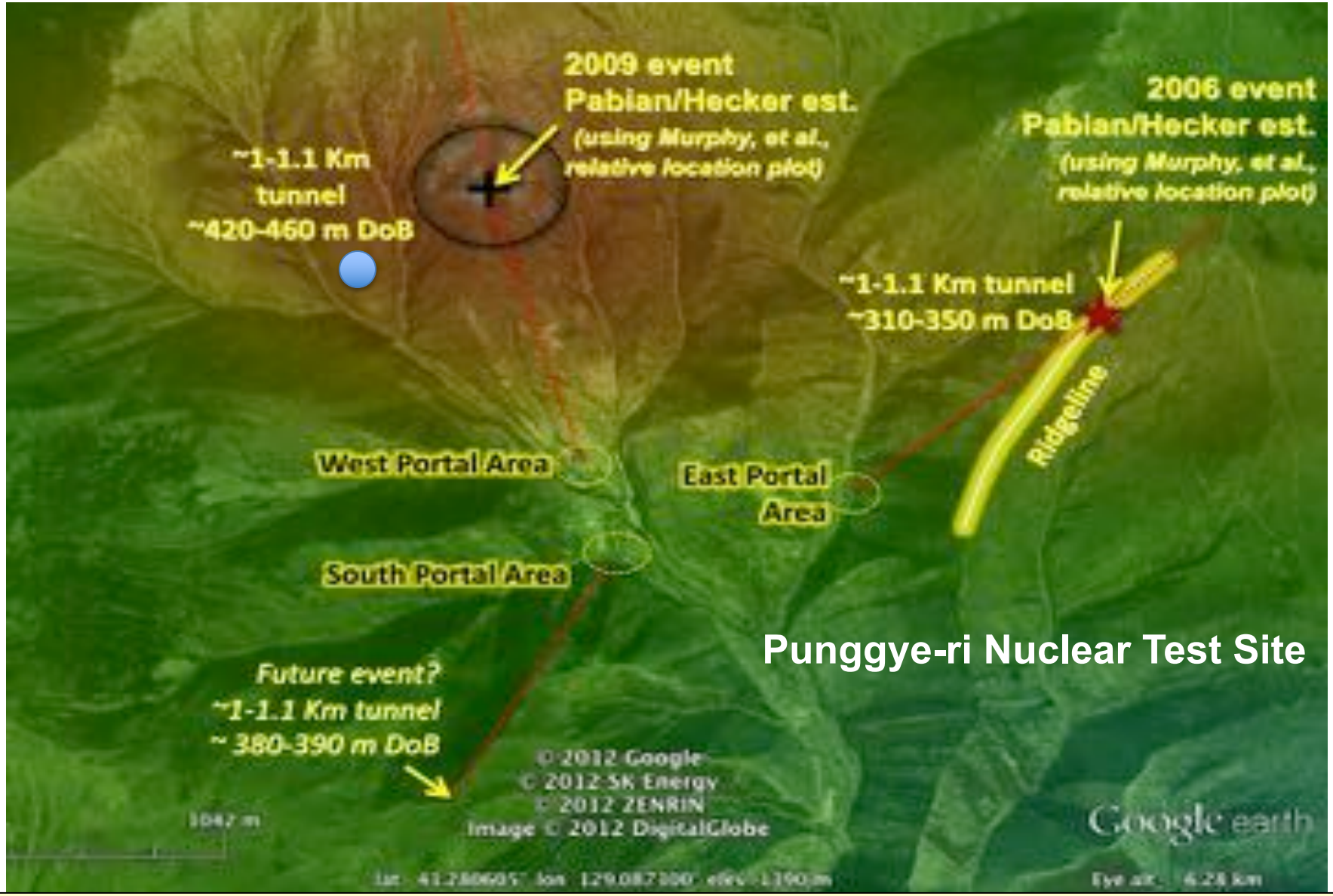
Current DPRK nuclear weapons assessment

- **Plutonium (Pu): 24 to 42 kg (~4 to 8 bomb's worth)**
- **Nuclear weapons (~4 to 8 primitive bombs)**
  - **Limited by plutonium and sophistication (lack of testing)**
  - **Some progress to miniaturization – Pu or HEU**
- **No plutonium in the pipeline**
  - **Recent announcement that it will restart 5 MWe reactor**
- **Additional nuclear test – needed for miniaturization for missiles**
- **Uranium enrichment**
  - **Small industrial scale apparently operational – others likely**
  - **Some HEU likely but do not know how much or production capacity**
- **Concern about nuclear imports, exports and cooperation**

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

Will DPRK test again – and if so, what will it be?



South tunnel is prepared

So, what to do now?

- Deal with DPRK as it is, not the way we'd like it to be
  - Time is not on their side
- Stay the course on denuclearization, but limit threat
- For now - three no's and a yes
  - No more bombs (no Pu or HEU)
  - No better bombs (no missile tests)
  - No export
- Yes - address fundamentals of North Korea's insecurity to create conditions favorable to disarmament and provide energy and economic assistance

Winds of change are blowing in DPRK

Cell phones in Nov. 2010

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
- **Nuclear testing issues**
  - Why test again? Needed to miniaturize;
  - Possibly test both Pu and HEU

Developments in Spring 2013

- **Dec. 12, 2012 – DPRK conducts "successful" space launch**
- **Feb. 12 – DPRK conducts third nuclear test**

U.N. Approves China-Backed Sanctions on North Korea, March 7, 2013

Pyongyang responds:

"Now that the U.S. is set to light a fuse for a nuclear war, the revolutionary armed forces of the DPRK will exercise the right to a pre-emptive nuclear attack to destroy the strongholds of the aggressors and to defend the supreme interests of the country."

Korean Peninsula on the Brink?

The New York Times
March 11, 2013
North Korea Declares 1953 War Truce Nullified

The Daily Telegraph
March 11, 2013
North Korea cuts off hotline to South

The New York Times
March 5, 2013
North Korea Threatens to Attack U.S. With 'Lighter and Smaller Nukes'

THE WALL STREET JOURNAL.
March 8, 2013
Iran-North Korea Pact Draws Concern

March 26, 2013 **Yonhap, Seoul**
N. Korean Military Enters Highest Combat Ready Posture, Fueling Tension

The New York Times
March 8, 2013
After U.N. Vote on Sanctions, 2 Koreas Ratchet Up Threats

U.S. official: North Korea could test fire missiles at any time
CNN, April 10, 2013

Should we be concerned?

Then, things got worse

- March plenary of Central Committee: Push forward economic construction (includes nuclear electricity) and nuclear armed forces
- April 2: General Department of Atomic Energy announced “readjustment and restarting all nuclear facilities at Yongbyon”
- Early April : Pyongyang moved road-mobile missiles to East Coast, apparently for flight testing

Then, things got worse

- **March plenary of Central Committee: Push forward economic construction (includes nuclear electricity) and nuclear armed forces**
- **April 2: General Department of Atomic Energy announced "readjustment and restarting all nuclear facilities at Yongbyon"**
- **Week of April 8: Pyongyang moved road-mobile missiles to East Coast, apparently for flight testing**

What does this mean?
How does it change the security threat?

Six visits to North Korea helped us assess the program

Jan. 2004 Yongbyon

Aug. 2005 Pyongyang

Nov. 2006 Pyongyang

August 9, 2007, Yongbyon

Feb. 14, 2008, Yongbyon

Feb. 27, 2009, Pyongyang

North Korea mastered the full plutonium fuel cycle

Front end of fuel cycle (reactor fuel)

- Mining to fabrication of natural uranium fuel
- No enrichment required

Fuel fabrication

Reactors (produce Pu, electricity & heat)

- 5 MWe gas-graphite reactor (currently shut down)
  - Produces ~ 6 kg Pu/year (one bomb's worth)
- 50 MWe construction halted in 1994
- 200 MWe construction halted in 1994

5 MWe reactor

Back end of fuel cycle (extract Pu, manage waste)

- Reprocessing facility using Purex process

Reprocessing Facility

Yongbyon nuclear complex

BY 1991 DPRK had a big plutonium program

5 MWe reactor
In stand-by mode
(6 kg Pu per year)

50 MWe reactor
~ 10 bombs/yr
Expected compl. 1995

200 MWe reactor Taechon
~40 bombs/yr, Exp. ~2000

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In 2007, DPRK decided to put plutonium production on hold

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The seventh brought the centrifuge facility surprise

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

So, what do recent developments mean?

- DPRK warned to strengthen its deterrent both in quantity and sophistication
- Now pursuing both plutonium and highly enriched uranium – alleviate shortage of fissile materials
- Road-mobile missile tests would boost its deterrent
- Demonstrates that it is pursuing a nuclear missile threat capability

DPRK nuclear facilities

Yongbyon nuclear complex

- **Fuel fabrication facility – uranium metal fuel**
- **5 MWe reactor – Magnox (gas – graphite)**
- **Reprocessing facility – plutonium separation**
- **50 MWe and 200 MWe reactors – not salvageable**
- **IRT-2000 research reactor – very little fuel remains**
  - Good for medical isotope production
- **Uranium centrifuge facility**

Other facilities outside Yongbyon

- Covert uranium facilities and weaponization facilities

DPRK nuclear facilities

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  - Fuel for reactor and feed for uranium centrifuges
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  - Large scale capability, small plutonium laboratory
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What Yongbyon facilities would be restarted?

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- **Uranium centrifuge facility "readjusted" to HEU?**

Other facilities outside Yongbyon

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Current DPRK nuclear weapons assessment

- **Plutonium (Pu): 24 to 42 kg (~4 to 8 bomb's worth)**
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- **Concern about nuclear imports, exports and cooperation**

How will assessment change?

- Plutonium (Pu): 24 to 42 kg (~4 to 8 bomb's worth)

- Nuclear weapons (~4 to 8 primitive bombs)
  - Limited by plutonium and sophistication (lack of testing)
  - Some progress to miniaturization – Pu or HEU

- **In roughly 3 years, produce 12 kg of Pu (2 bomb's worth)**
  - **Maximum capacity will be 6 kg/year (one bomb's worth)**

- **Additional nuclear tests – needed for miniaturization for missiles**

- **Uranium enrichment**
  - **Could produce ~ 40 kg/year of HEU – roughly two bomb's worth**
  - **Capacity of covert facility for HEU is unknown**

- **Greater concern about imports, exports and cooperation**

Nuclear testing program

- **Previous nuclear tests**
  - Oct. 2006 – East tunnel, close to1kiloton
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- **Nuclear testing issues**
  - Why test again? Needed to miniaturize;
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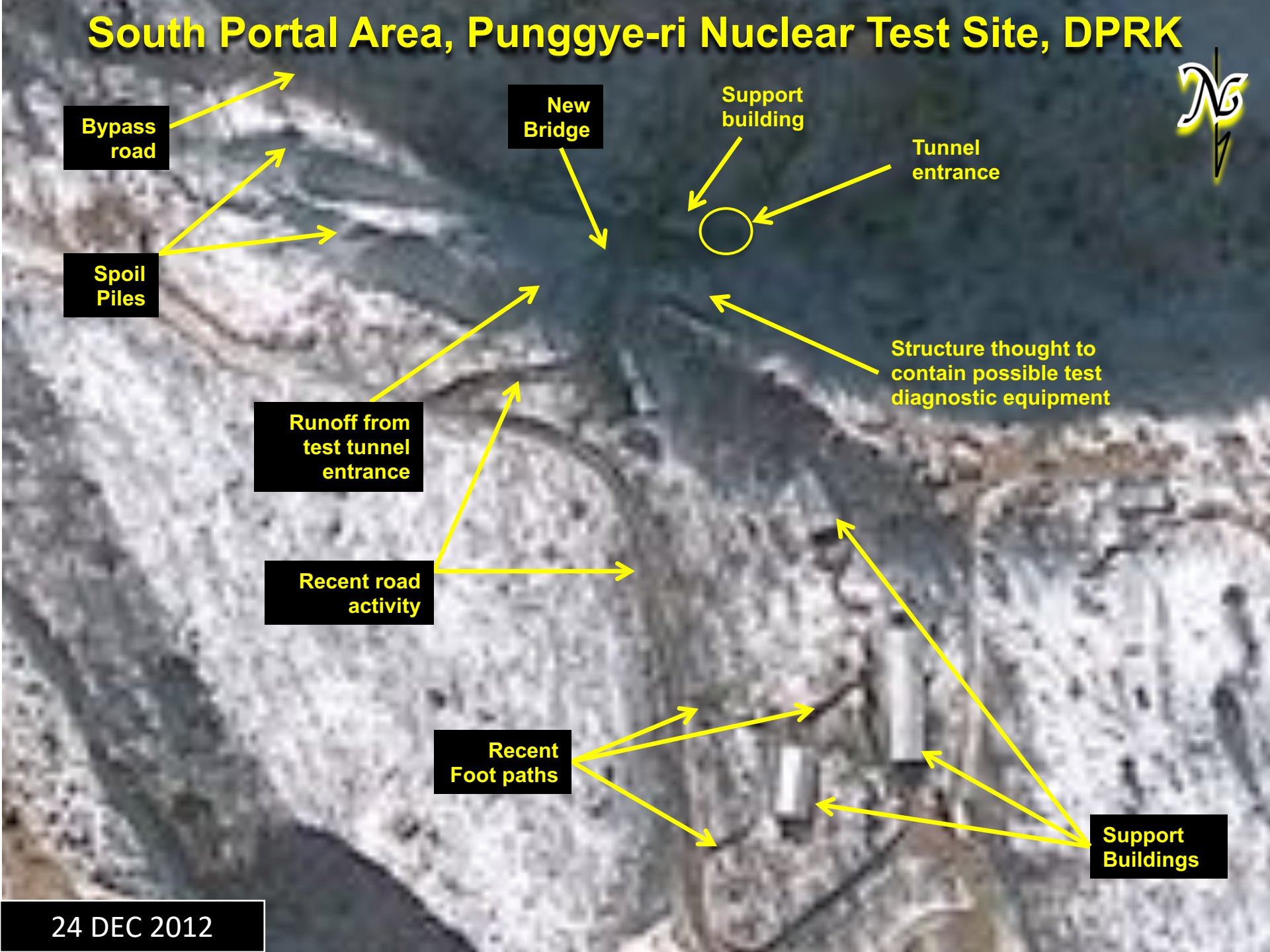
West Portal Area, Punggye-ri Nuclear Test Site, DPRK
Recent road activity from support area
Heavily eroded tailings spoil pile (nuclear test tunnel host rock)
Tunnel entrance area
Support buildings
Tunnel portal entrance
12 JAN 2013
© DigitalGlobe


South Portal Area, Punggye-ri Nuclear Test Site, DPRK
Bypass road
New Bridge
Support building
Tunnel entrance
Spoil Piles
Structure thought to contain possible test diagnostic equipment
Runoff from test tunnel entrance
Recent road activity
Recent Foot paths
Support Buildings
24 DEC 2012

DPRK Missile Program

April 13, 2012 Space launch

Combination of nuclear weapons and missiles increases the threat

Unha-3 Rocket Launch Preparation

Unha-3 recovered debris

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.)

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

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 North Korean vehicle carries a missile. (AP Photo/Vincent Yu, File)

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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

Can nuclear-tipped missiles reach US, Japan or South Korea?

- ICBM to reach U.S. is many years away
- Intermediate-range, road-mobile missiles are years away
- Short range up to 1000 km – not so clear, but likely still needs nuclear and missile tests

Can nuclear-tipped missiles reach US, Japan or South Korea?

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Besides, why would Pyongyang want to invite total destruction and end of the Kim regime?

Is DPRK interested in nuclear electricity?

- 1980s – push for gas-graphite reactors
- Mid-1980s – deal with Soviet Union for LWRs
- 1994 – Agreed Framework
- 2009 – Decision to build indigenous LWR
  - Showed me experimental LWR construction
  - Showed me Yonbyon centrifuge facility
- 2013 – Steady progress – but still 10 years from significant nuclear electricity production

Yes – DPRK nuclear programs have always pursued both bombs and electricity

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

Significant electricity production is at least 10 years off


26 SEP 2010
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

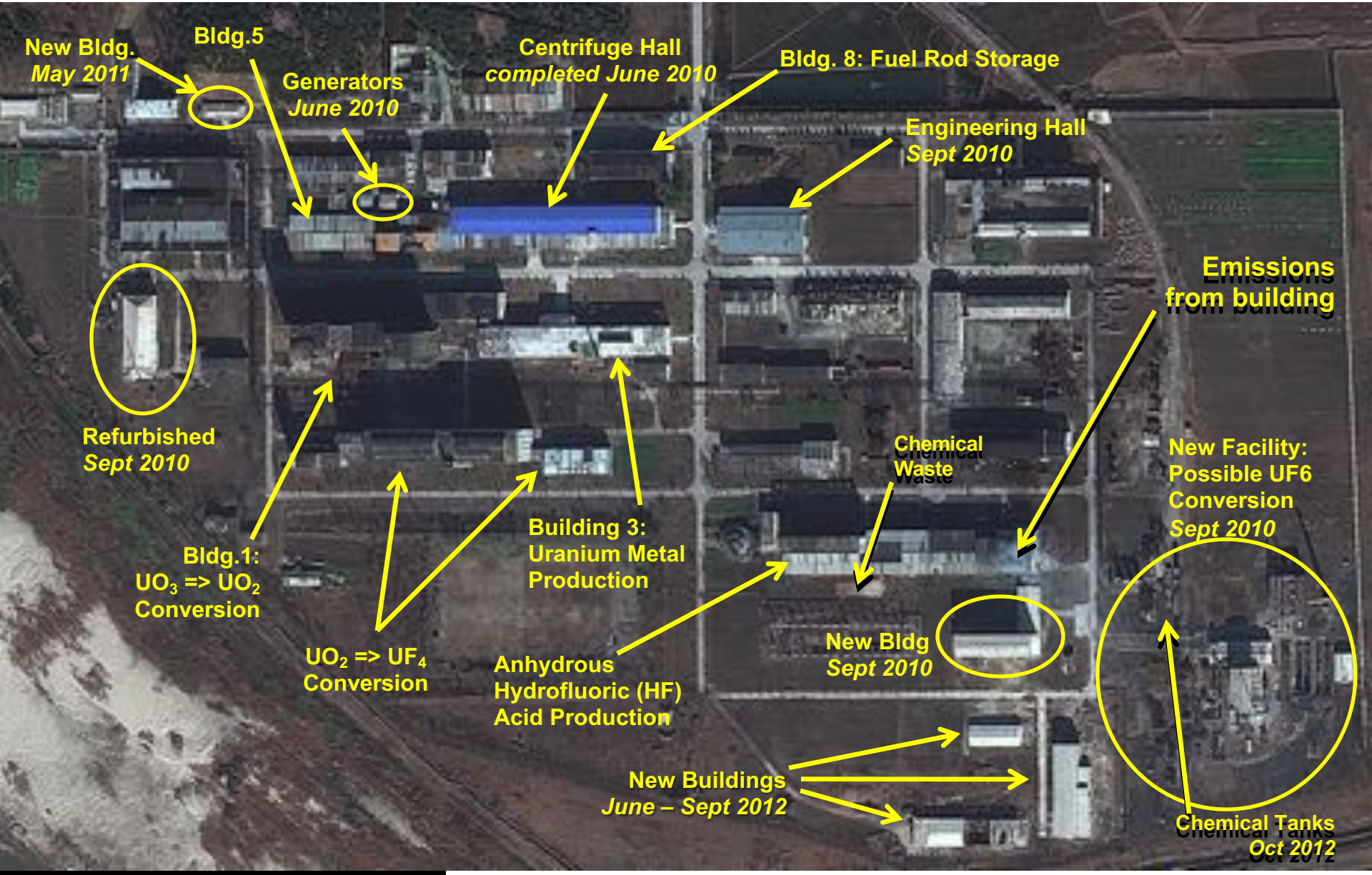

24 JUN 2012
Source: GeoEye


6 AUG 2012
Source: GeoEye


2 JAN 2013
Source: DigitalGlobe


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

Yongbyon Fuel Fabrication Plant, North Korea



13 NOVEMBER 2012; Source: GeoEye

We should be concerned about nuclear exports

- **Missile exports - definitely**
- **Libya – Uranium hexafluoride (UF_6) - yes**
- **Syria – plutonium-producing reactor - yes**
- **Iran and Burma ???**

These are big money makers for the DPRK and pose a serious threat – very difficult to stop

Syrian reactor site at Dayr az Zawr region bombed by Israel on Sept. 6, 2007

Before bombing

After bombing

Satellite Photos Show Cleansing of Syrian Site

By WILLIAM J. BROAD and MARK MAZZETTI

Published: October 26, 2007, New York Times

Suspected reactor site in Dayr az Zawr region bombed by Israel on September 6, 2007

Same site in Dayr az Zawr region in October after Syrian cleanup

Will DPRK give up the bomb?

- **Not in the near future - not voluntarily**
- **Must make it more attractive to give them up and more costly to keep them**
- **China holds the key to the price – U.S. and ROK hold the key to benefits**
- **We must understand why DPRK wants weapons – security, domestic and international reasons**

http://cisac.stanford.edu/publications/can_north_korea_nuclear_crisis_be_resolved

Why did North Korea get the bomb?

- **Security - Most powerful deterrent against aggression**
  - Best assurance to keep the regime in power

- **Domestic reasons**
  - Increase tensions and distract people's attention from daily grievances.
  - External threat justifies the bomb; bomb justifies sacrifices people continue to make

- **International statement – International prestige, bring U.S. to bargaining table, use as a bargaining chip**

Security was and remains the main driver.
Domestic and international reasons followed.

What are the nuclear security threats?

- **Nuclear attack – currently, a low threat**
  - Concerns in event of miscalculation or instability
  - Greater threat if many more bombs and better missiles
- **Miscalculations, instability or accidents – possible**
- **Uranium enrichment (HEU) – low** unless lots of HEU
- **Export – materials or technologies – very serious**
  - Centrifuge technologies may be attractive
  - HEU export bigger threat than plutonium

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Threat reduction – stop the nuclear program from becoming worse

So, what to do now?

- Deal with DPRK as it is, not the way we'd like it to be
  - Time is not on their side
- Stay the course on denuclearization, but limit threat
- For now - three no's in return for one yes
  - No more bombs (no Pu or HEU)
  - No better bombs (no missile tests)
  - No export
- Yes - address fundamentals of North Korea's insecurity to create conditions favorable to disarmament