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Strengthened IAEA Safeguards – Imagery Analysis

Frank Pabian
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Abstract

This slide presentation focuses on the growing role and importance of imagery analysis for IAEA safeguards applications and how commercial satellite imagery, together with the newly available geospatial tools, can be used to promote “all-source synergy.” As additional sources of openly available information, satellite imagery in conjunction with the geospatial tools can be used to significantly augment and enhance existing information gathering techniques, procedures, and analyses in the remote detection and assessment of nonproliferation relevant activities, facilities, and programs. Foremost of the geospatial tools are the “Digital Virtual Globes” (i.e., GoogleEarth, Virtual Earth, etc.) that are far better than previously used simple 2-D plan-view line drawings for **visualization of known and suspected facilities of interest** which can be critical to:

- 1) **Site familiarization and true geospatial context awareness**
- 2) **Pre-inspection planning**
- 3) **Onsite orientation and navigation**
- 4) **Post-inspection reporting**
- 5) **Site monitoring over time for changes**
- 6) **Verification of states’ site declarations and for input to State Evaluation reports**
- 7) **A common basis for discussions among all interested parties (Member States)**

Additionally, as an “open-source”, such virtual globes can also provide a new, essentially free, means to conduct **broad area search for undeclared nuclear sites and activities**...either alleged through open source leads; identified on internet BLOGS and WIKI Layers, with input from a “free” cadre of global browsers and/or by knowledgeable local citizens (a.k.a.: “crowdsourcing”), that can include ground photos and maps; or by other initiatives based on existing information and in-house country knowledge. They also provide a means to acquire ground photography taken by locals, hobbyists, and tourists of the surrounding locales that can be useful in identifying and discriminating between relevant and non-relevant facilities and their associated infrastructure. The digital globes also provide highly accurate terrain mapping for better geospatial context and allow detailed 3-D perspectives of all sites or areas of interest. 3-D modeling software (i.e., Google’s SketchUp6 newly available in 2007) when used in conjunction with these digital globes can significantly enhance individual building characterization and visualization (including interiors), allowing for better assessments including walk-arounds or fly-arounds...and perhaps better decision making on multiple levels (e.g., the best placement for International Atomic Energy Agency (IAEA) video monitoring cameras).

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19 June 2009

Strengthened IAEA Safeguards – Imagery Analysis

Geospatial Tools for Nonproliferation Analysis

Frank V. Pabian





NISA
National Nuclear Security Administration



Satellite Imagery Analysis

A Growing Role in State Infrastructure Analysis in the IAEA Safeguards Division

Satellite Imagery Analysis and GIS Support to International Safeguards

- Monitor NFC sites and activities
- Verify States' declarations
- Support inspection activities
- Investigate possible undeclared activities
- Conduct GIS analysis and generate geospatial products
- Employ emerging methods of geospatial technology

Geospatial Products



Verification Report



Baseline/Update Report



Notification



Brief Report

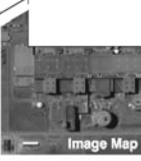


Image Map



3D Modeling

Create and Update Site Plans

- Compile multi-temporal imagery
- Assess changes feature by feature
- Attribute features
- Generate GIS-based map/illustration
- Internal standardized geodatabase schema
- ArcServer (SDE) vector technology
- Expose data through web services






12th Annual UNDOWG Plenary March 28-30 2012
<http://ungwg.cabot.org/interim-report/>

What is Imagery Analysis?

How Can It Help to Strengthen IAEA Safeguards?

- **Imagery Analysis:** Image analysis is the extraction of meaningful information from images, which, for this review, is primarily commercial satellite imagery. Imagery analysis is another means of assessing raw data that can be combined with other safeguards pertinent data, in a manner sometimes referred to as “Data Fusion,” that can often have significant synergistic results.
- For IAEA Safeguards purposes, this means deriving: New, “**value-added**,” information from the raw un-annotated imagery, and then adding that information to the overall existing body of knowledge with respect to a particular nuclear activity, facility, or program.
- **Imagery analysis provides answers not only to the questions of What? and Where?, but even more importantly... Why?, How ?, and What is the significance?**
- This briefing will show how the IAEA now routinely relies on imagery analysis for safeguards monitoring purposes with both Iran and Syria as examples, particularly as it applies to identifying “**Undeclared facilities and activities**”.
- Finally, new “**Geospatial Tools**” have become available that can further facilitate the process of imagery analysis for Safeguards purposes.

Imagery Analysis: *It's a Process*

- Imagery doesn't come with labels...it is just “a pile of pixels” that requires human interpretation to add meaning
- Among the features of an image that lead to identification and aid in interpretation include:
 - **Size:** the true and relative scale of the objects in the image
 - **Shape:** the physical appearance (“manmade” is often angular, vice “natural” amorphous)
 - **Shadows:** silhouettes provide insights
 - **Shade :** brightness and contrast variations of one object compared to another
 - **Surroundings:** the textual and cultural context ...What is the Setting?
 - **Signatures:** the *generally* consistent common functional characteristics (particularly when associated with the nuclear fuel cycle)
 - **Time:** Temporal changes including construction history, activity levels, operations, etc.
- “**Convergence of Evidence**”: If it looks like a duck....
- Beware of “**Signature Suppression**”: Deception is a constant threat
- Learn to think in **3-D** even when only working with **2-D** imagery
- Enlist collateral information: All other available sources should be tapped, including “**the new Geospatial Tools**” and always seek “Peer Review”
- Know the nuclear fuel cycle inside and out (materials, processes, equipment, infrastructure)
- Know your limitations: Use caveats to convey your confidence level
- Try a Quiz? Go to: http://www.defence.gov.au/DIGO/Imagery_Analysis/imageryQuizT3.htm



Geospatial Tools: What do we mean?



Earth Viewer 3D
2002
GoogleEarth
Mid-2005



NASA's Worldwind
Mid-2004



Microsoft's Bing Maps (Virtual Earth)
late-2005
3-D feature halted late-2010



Skyline Globe
2006
(Includes India Bhuvan and IGN Géoportail (France))



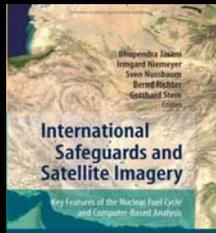
Nokia Maps 3D
2011
maps.yahoo.com

"Basir"?
2011
(Iran)

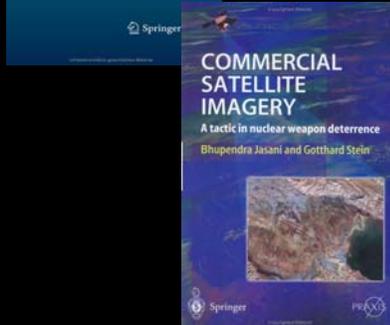
- **"Virtual Globes"** See: http://en.wikipedia.org/wiki/Virtual_globe
Provide the means to virtual fly to any place on earth and gather information in a 3-D geospatial context and provide a platform for additional overlays
- **BLOGs and WIKIs** can provide critical tip-off, background, & locational info
- **Social Networks** (Panoramio, Flickr, & Twitter for "geotagged" ground imagery)
- **Geospatial Meta-search Engines/Viewers**
 - "GeoHack" (<http://toolserver.org/~geohack/>)
 - "GAIAGI" (<http://www.gaiagi.com/>)
- **Commercial Satellite Imagery**
- **Media, Academia, & NGOs** (locational information, ground photos, graphics, etc.)

You can access much of it on a Smart Phone!

Additional Thoughts on Imagery Analysis for Safeguards



➤ Imagery Analysis, employing the new geospatial tools, should be viewed as just another form of “Open Source Analysis” to help strengthen IAEA Safeguards



➤ “Data Fusion” is the name of the game. Imagery analysis is a tool to augment other information in a synergistic way

➤ Knowing the key features (“Signatures”) of the nuclear fuel cycle is a necessary baseline for analysis (Shown are two examples of available reference material)

Satellite Imagery: From Corona (KH-4) to Commercial Comparison



Corona Photo, 25 September 1967

Source: <http://www.nro.gov/corona/cor-ab.html>
http://en.wikipedia.org/wiki/File:Corona_pentagon.jpg



**Google Earth 25 October 2007
(Digital Globe)**

Satellite Imagery for All: A New Era of Global Transparency!

"Perhaps this is also a good moment to step back in awe at what modern technology has wrought the ability for any sufficiently concerned citizen or organization to scrutinize any desired spot on Earth within hours of making the request, and then being able to publish the result to a context-rich virtual globe that is universally available. That's a profound shift in favor of accountability, transparency and democracy. *Monitoring the planet has been crowdsourced.*"

Stefan Geens of Ogle Earth

"Clearly it has an effect on the way diplomacy will be carried out in the future",
Einar Bjorgo (UNOSAT).

Applications Include:

- Emergency Response
- Disaster Management /Humanitarian Assistance
- Risk Prevention
- Peace-keeping
- Environmental Monitoring & Rehabilitation
- Post Conflict Reconstruction
- Social and Economic/Resource Development
- **Treaty Verification and Monitoring**

Sources: http://www.ogleearth.com/2009/09/qum_nuclear_sit.html#comments
http://www.unspecial.org/UNS621/UNS_621_T32.html



IAEA
Atoms for Peace

Board of Governors

GOV/2009/35
Date: 5 June 2009

8. Iran's refusal to grant the Agency access to IR-40 could adversely impact the Agency's ability to carry out effective safeguards at that facility, and has made it difficult for the Agency to report further on the construction of the reactor, as requested by the Security Council. The completion of the containment structure over the site,



Defense Update
Online Defense Magazine

Progress of the construction of the IR-40 Heavy Water Reactor, Arak, Iran 2007-2009



EROS-1B satellite imagery

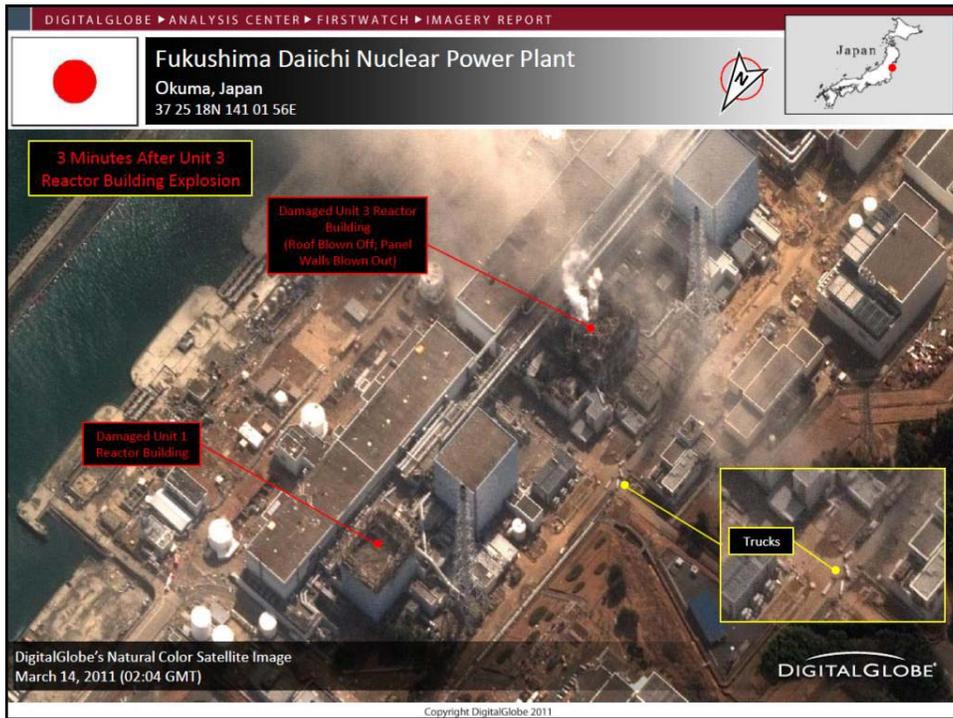
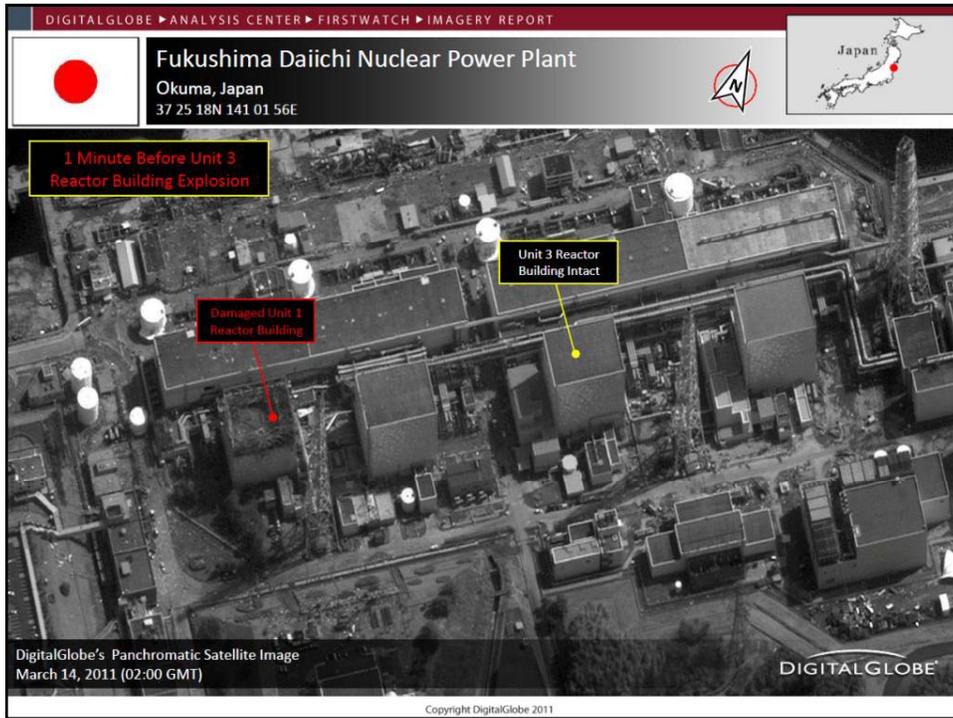
Dec 2007



EROS-1B satellite imagery

Feb 2009

Photos: Courtesy of  **Imagesat International**



Satellite Imagery: A Radar Example

SAR Provides Complementary & Additional Info

- Cloud Penetration
- All-Weather
- Day/Night
- Sensitivity to Metal Objects

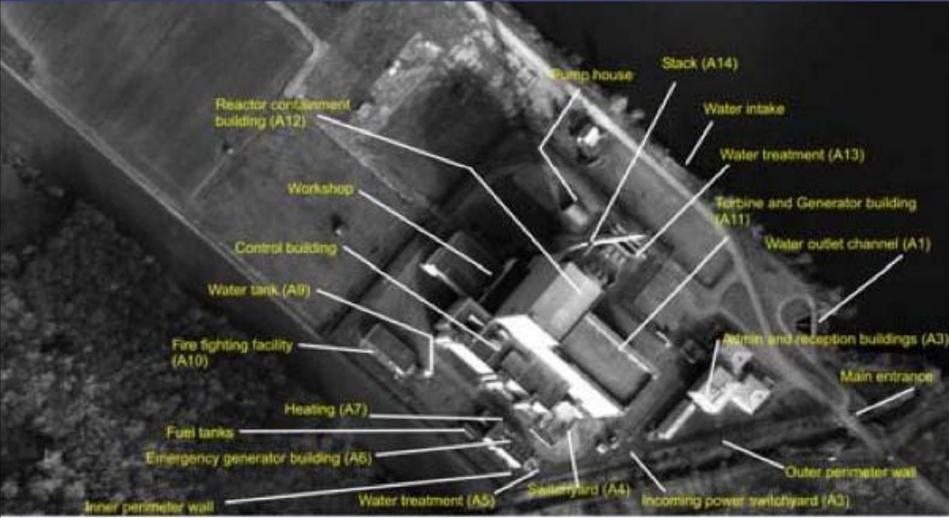




IAEA

Contains Infoterra copyrighted materials

Satellite Imagery: The Optical Counterpart

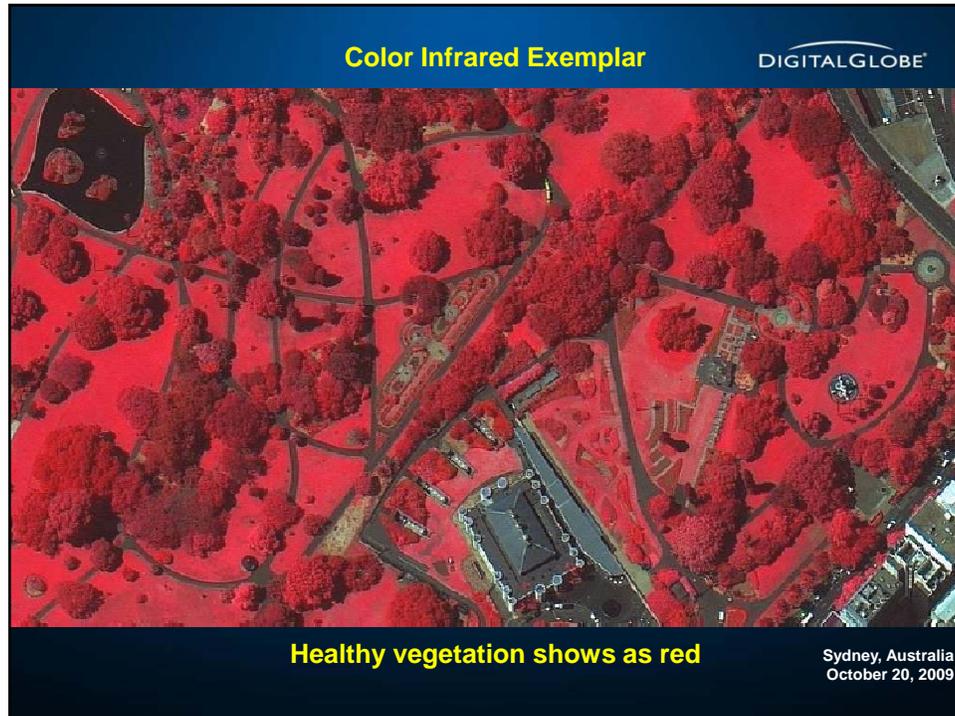




IAEA

Source: DIGITALGLOBE. Copyright Materials

Natural Color, High Interpretability, Clear/Direct Representation



Comparison of the Various Types of Commercial Imaging Systems and Their Relative Utility

Imagery Type	Advantages	Disadvantages
Optical/Electro-Optical:	Very high resolution possible. Near-infrared is optimal because it can penetrate haze and can be merged with true color for more natural appearance as an aid to interpretation.	Acquisition restricted by cloud cover and limited to daylight hours.
Multi-spectral: (Incl. Hyper-spectral)* Includes both visual bands and non-visual bands	Provide the means to view sites in a more natural, true color setting. May also provide a means for determining material/chemical composition and material transfer, and for detecting camouflage and concealment activities	Slightly lower resolution (i.e., currently 2.5-meters).
Thermal infrared	Provides a quantifiable measure of heat transfer as a basis for determining site status such as reactor power operations. When correlated with optical could determine heat flow, both qualitatively and quantitatively, from waste ponds, steam lines, vents, stacks, cooling towers, etc.	Generally of too low resolution for anything other than facility activity monitoring (currently no better than about 20 to 90 meters)#.
Radar:	Provides 24-hour monitoring capability, can penetrate clouds, and is a useful complement to optical imagery.** Resolution improved greatly in 2007 with successful launch of the 1-meter capable German built <i>TerraSAR-X</i> .	Processing and interpretation of imagery is much more difficult.

* Ingrid Niermeyer, Satellite Imagery Analysis for Safeguards and Non-Proliferation, *Strengthening detection capability for safeguards*, Institute of Nuclear Materials Management (INMM), Changing The Safeguards Culture: Broader Perspectives And Challenges, Santa Fe, New Mexico, USA, October 30 – November 2, 2005 <http://www.inmm.org/topics/content/wa0901.html#2>; Christopher L. Stork, Heidi A. Smart, Diana S. Blair, and Jody L. Smith, "Systematic Evaluation of Satellite Remote Sensing for Identifying Uranium Mines and Mills," Sandia National Laboratories, January 2006 <http://www.nndc.sandia.gov/cgi-bin/techlib/access.cgi?id=2015-057791.pdf>; and Q. S. Bob Truong, "Road Map B&W and Colour Imagery," *Strengthening detection capability for safeguards*, Institute of Nuclear Materials Management (INMM), Changing The Safeguards Culture: Broader Perspectives And Challenges, Santa Fe, New Mexico, USA, October 30 – November 2, 2005, <http://www.inmm.org/topics/content/wa0901.html#2>. See also <http://www.anso.dfoi.gov.au/publications/OASatimg.pdf>.

See Multispectral Thermal Imager (MTI) <http://www.fas.org/military/program/mssim/mti.htm> and <http://directory.scopint.org/pages/MTIMultispectralThermalImager.html> and ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer), <http://aster.eo.sci.nasa.gov/> and <http://edshare.spa.gov.au/aster/aster-overview.asp>.

**From Q. S. Bob Truong and Ron H. Saper, "Integration Of Satellite Imagery And Other Tools In Safeguards Information Analysis," *Strengthening detection capability for safeguards*, Institute of Nuclear Materials Management (INMM), Changing The Safeguards Culture: Broader Perspectives And Challenges, Santa Fe, New Mexico, USA, October 30 – November 2, 2005 <http://www.inmm.org/topics/content/wa0901.html#2>. See also <http://www.anso.dfoi.gov.au/publications/OASatimg.pdf>.

Minimum Overhead Imagery Resolution (in meters) Necessary for Analysis of Nuclear Fuel Cycle Related Facilities

Facility of Interest	Detection	General Facility Identification & Site Layout	General Functional Building Description	Precise Building Identification	Technical Analysis & OMV
Uranium mining, processing & feed materials	5 to 10	1 to 5	1	0.2 to 0.5	.5 for mines and processing, limited other
EMIS Enrichment Facilities	2 to 5	1 to 3	1	0.2 to 0.5	Limited to none at any resolution
Gas Centrifuge Facilities	N/A	1 to 3	0.5	0.2	Limited to none at any resolution
Heavy Water Plants	5	1-3	0.5	0.2	0.2
Research Reactors	2 to 5	1 to 3	1	0.5	Limited to none at any resolution
Plutonium Production Reactors	2 to 10	1 to 5	1	0.5 to 1	0.5 to 1
Nuclear Weapons R&D (i.e., High Explosives Testing)	1 to 2	0.5 to 1	0.5	0.5	0.1 to 0.5
Nuclear Weapons Mfg.	1 to 2	1	0.5	.1 to .5	Limited to none at any resolution
Test Site	10	1 to 3	1 to 2	.5 to 1	0.5 to 1

Table: Adapted from: Anne Florini, "The Opening Skies: Third-Party Imaging Satellites and US Security," *International Security*, Vol. 13, No. 2 (Fall 1988), p. 98; and G.T. Richardson and Robert N. Mertz, "High Resolution Commercial Imagery and Open Source Information: Implications for Arms Control," *Intelligence Note*, ACDA (May 1996), p.4.

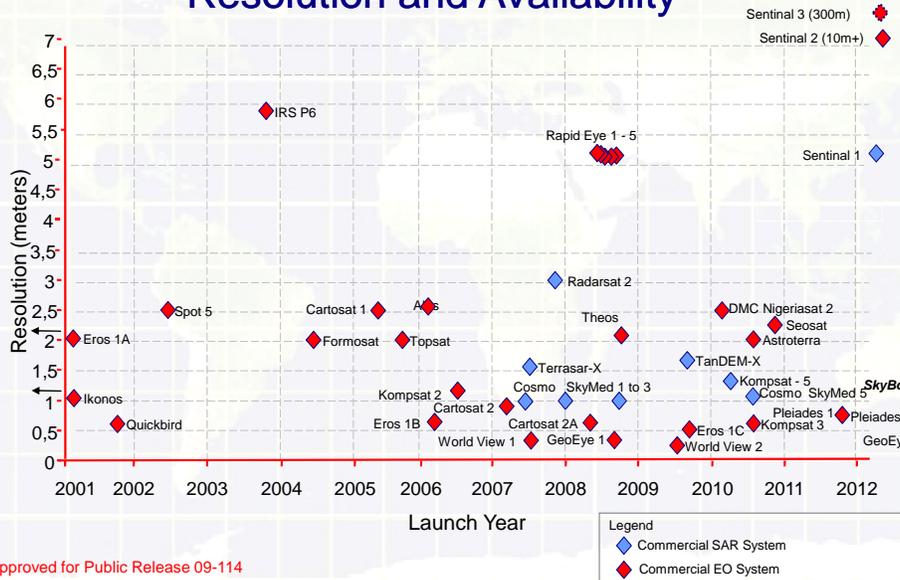
Detection: Identify the location of a facility of activity of FMCT/NPT interest (locate and define outline of nuclear related facility in light of other descriptive or geographically specific information) (Note: It can often be possible to detect and identify characteristic features, such as security fencing or power lines, despite the fact that any given section of such fencing may be of sub-pixel size, or below the given resolution of the image, because they are generally linear and span many pixels.)

General ID: Determination of general facility or activity type (Discriminate between research lab, mfg. facility, explosives prod, storage site)

General Functional Building Description: Size/dimension, configuration/layout of buildings (i.e., laboratory, production, utilities, support)

Precise Building ID: Precise determination of building function (i.e., reactor type/size, propellant mixing/casting, machine shop, administration)

Satellite Sensors: Resolution and Availability



Diversification of Sources

Available high-resolution commercial sensors

- Spot 5, 2.5m (France)
- Formosat-2, 2m (Taiwan, China)
- KVR-1000, 2m (Russia)
- TerraSAR-X, 1m SAR (Germany)
- Cosmo-Skymed, 1m SAR (Italy)
- Kompsat-2, 1m (Korea)
- DK-1, 1m (Russia)
- Ikonos-2, 1m (USA)
- Eros B, 0.7m (Israel)
- QuickBird, 0.6m (USA)
- WorldView-1, 0.5m (USA)



Commercial Satellite Imagery is Becoming Ubiquitous

*Constellations of
up to 12
satellites
imaging the
globe every hour*



*“Skybox
images will be
updated every
eight hours.”*

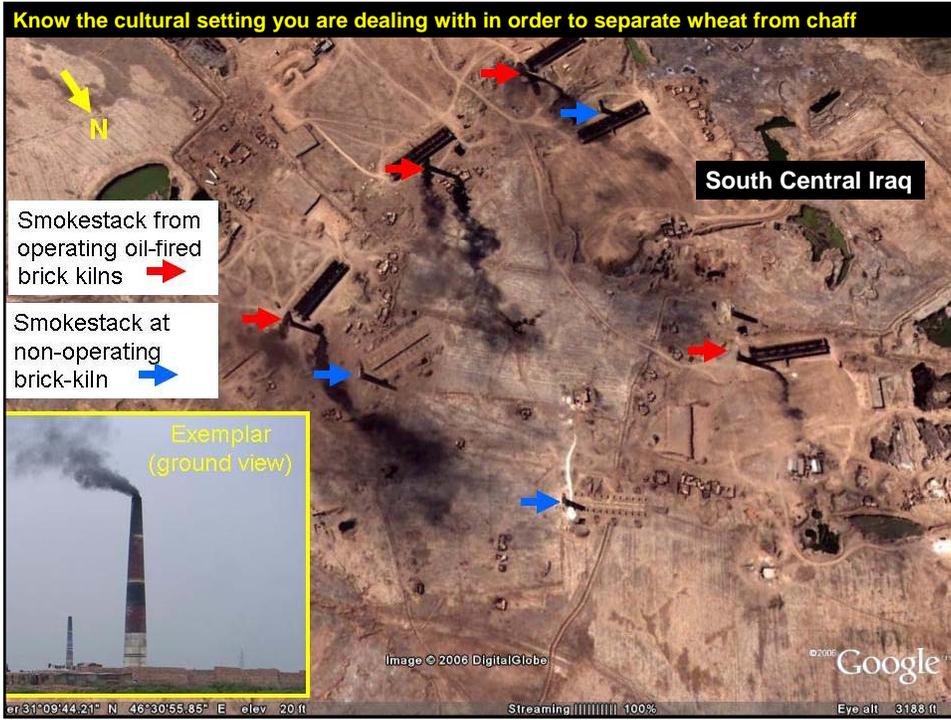

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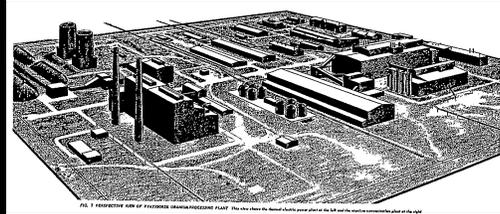
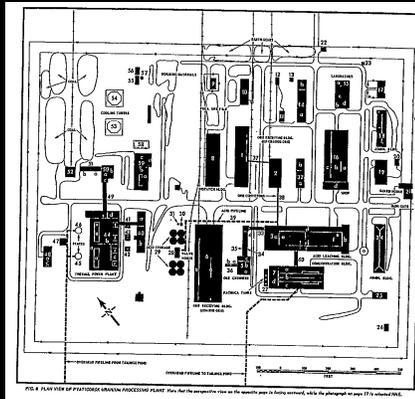


Mistakes Do Happen

Alleged Iraqi nuclear test site was claimed to have been located, but the site is nothing but a dry wadi that was cross-diked for water retention in plowed farm plots using water from adjacent springs

<http://www.globalsecurity.org/wmd/library/news/iraq/2001/stirevnws01015.htm>

US Intelligence Imagery Analysis of Nuclear Facilities Cold War Style



Line Drawing and Artist's 3-D Perspective View of Pyatigorsk Uranium Processing Plant in the Former Soviet Union (Pre-CORONA, circa 1959)

Source: <http://www.gwu.edu/~nsarchiv/NSAEBB/NSAEBB186/doc01.pdf>

**“Exceptionally”
high resolution
Gambit photos
acquired in stereo
made it possible to
build 3-D scale
models to aid in the
analysis of key sites**

“STEREO PAIRS AVAILABLE
IN ALL ROLL POSITIONS UP TO
MAXIMUM ROLL CAPACITY OF 44.45°”



Photoanalyst using Stereo-microscope

Sources: <http://www.nro.gov/foia/declass/GAMHEX/Videos/1.mov>
And <http://www.nro.gov/foia/declass/GAMHEX/GAMBIT/17.PDF>

Submarine Construction Yard and Launch Basin

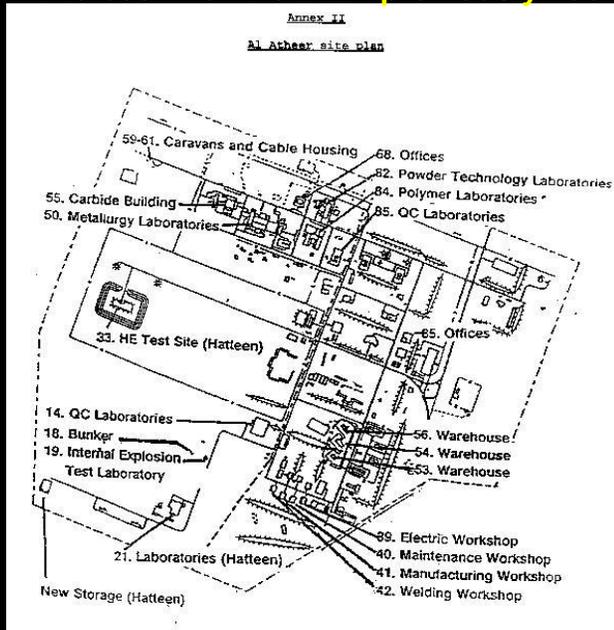


From Photo to 3-D Model



forth in the making of three dimensional terrain or in this

The best that the IAEA previously had for site visualization (circa mid-1990s)



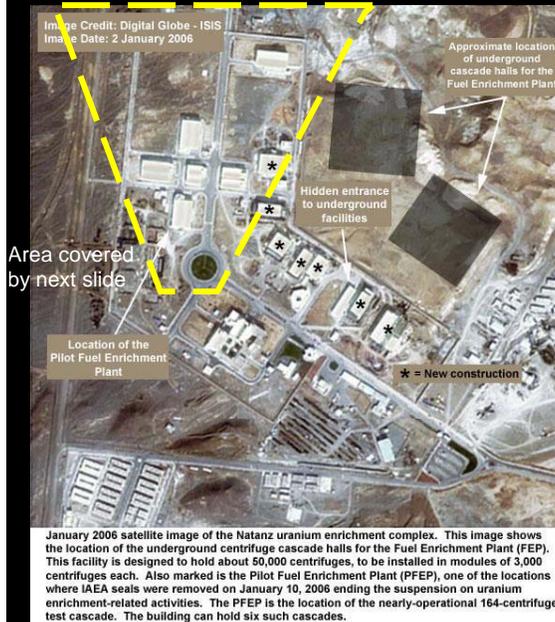
Typical plan-view line drawing used during IAEA site inspections in Iraq

NOTE: U-2 and helicopter imagery were also used in Iraq, but that was an exception not currently applicable to IAEA Safeguards

Source: <http://www.iraqwatch.org/un/IAEA/s-1995-1003-a.jpg>

What has been available to the IAEA since late 1999

Typical annotated near-nadir view "2-D" commercial satellite images



January 2006 satellite image of the Natanz uranium enrichment complex. This image shows the location of the underground centrifuge cascade halls for the Fuel Enrichment Plant (FEP). This facility is designed to hold about 50,000 centrifuges, to be installed in modules of 3,000 centrifuges each. Also marked is the Pilot Fuel Enrichment Plant (PFEP), one of the locations where IAEA seals were removed on January 10, 2006 ending the suspension on uranium enrichment-related activities. The PFEP is the location of the nearly-operational 164-centrifuge test cascade. The building can hold six such cascades.

Source: http://www.isis-online.org/images/iran/dg_jan2_2006_ann.jpg

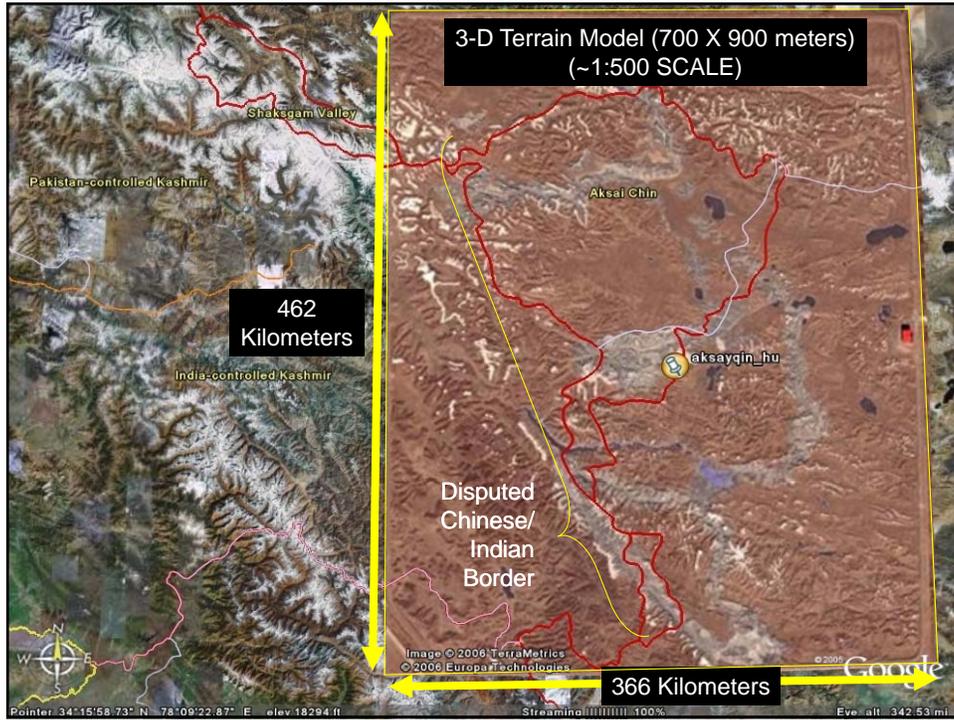
3-D Visualizations Can Support the IAEA Inspection and Assessment Process



GoogleEarth as a Broad Area Search Tool:

Detection of Probable Mountain Warfare Terrain Model of Disputed China/India Border Area in Huangyangtan, China





GoogleEarth Uncovers Concealment and Deception in Sweden Sweden's Spy HQ's uncovered



Swedish Government Mapping Service Image

From: http://www.ogleearth.com/2006/04/sweden_plays_hi.html

Another BLOG Revelation!

Sweden plays hide and seek with maps

Friday, April 07, 2006 (10:18 UTC)

Sweden's Lantmäterverket, the state GIS agency, has been caught camouflaging its censorship of the country's spy headquarters on aerial images it makes public, and Google Maps is directly responsible for the find.

It started when Eniro, a mainstream search and mapping site for Sweden, decided to use Lantmäterverket's images to add aerial shots and hybrid maps to its mapping service, much like Google Maps does. A publication eventually noticed that the aerial data provided by Eniro and Google don't match in a special spot on the outskirts of Stockholm. Here is Eniro's image:



GoogleEarth Image

It turns out that Lantmäterverket employs a person whose job it is to camouflage its censorship by painting over buildings with trees and fields. The story made it to Sweden's largest tabloid on Thursday in mangled form (of course), as blogged by Patrick Strang (in Swedish). Strang also rightly points out that the only effect of such camouflage, where you are lied to about the true information content of a map, is to distrust all maps by the same source, in this case Lantmäterverket. It makes these maps less than useless, especially when Google Maps and Earth is around. And it is behaviour unbecoming an open society. If you need to censor something, fine, but don't hide the decision. That way lies 1984.

Another interesting tidbit: The agency said it does not have a problem with Google's images, as they are satellite-based, and hence outside the jurisdiction of Sweden, whereas the images it can censor are taken from planes that fly within its jurisdiction. Countries do indeed have a monopoly on sovereignty in the air, and not in space.



Swedish Government Censored "Bird's Eye"



Microsoft Virtual Earth

OGLE EARTH

BLOG Revelations Keep Coming Concealment and Deception in Sweden: Sweden's Spy HQ's uncovered Microsoft Gets into the Act!

← Pixilated Aircraft coverage

← Censorship limited to aircraft coverage...
not satellite

← Uncensored satellite imagery

**More Assessment Tools:
"WIKIMAPIA" Layer
Exemplar**

Another optional Google Earth layer (most input is by locals, most in native language, but only spotty vetting)
(See also "Placeopedia")

This Layer is constantly being updated so it pays to revisit often

Moscow Engineering Physics Institute (MEPhI)
View or update this place information at Wikimapia.

Инженерно-Физический Институт (Государственный Университет) (МИФИ)

Image © 2008 DigitalGlobe
© 2008 Geoentle Consulting
Elev: 469 m

Google

"Panoramio" and "Flickr" Layer Exemplars
Moscow Engineering Physics Institute

More optional Google Earth layers (Ground photos and maps)

WEB LINKS FOR LAYERS:
KML photos (Flickr)
http://kmlphotos.metaltoad.com/kml_link.php?kmlphotos=85550f1bb7476ac3b0341b81b7e9d3d5f1ddee2

Panoramio
<http://www.panoramio.com/panoramio.kml>
And
<http://www.panoramio.com/panoramio.kml?2a>

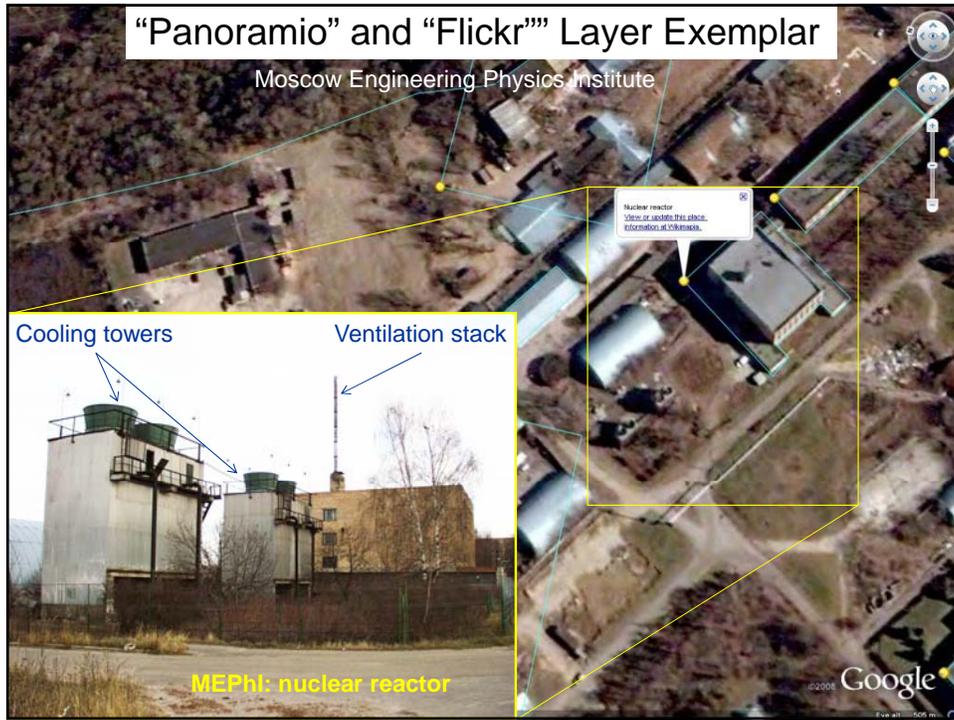
Panoramio

МИФИ
Photograph by ig-stillat

Инженерно-Физический Институт (Государственный Университет) (МИФИ)

Image © 2008 DigitalGlobe
© 2008 Geoentle Consulting
Elev: 469 m

Google



More “Crowd-Sourcing” or using “People as Ubiquitous Sensors”

Strategic Security Blog

A project of the Federation of American Scientists

« More from NNSA: and more is less, or less is more. | Main | United States
Removes Nuclear Weapons From German Base, Documents Indicate »

New Chinese Ballistic Missile Submarine Spotted

By Hans M. Kristensen



A new satellite image appears to have captured China's new ballistic missile submarine. Coordinates: 38°49'4.40"N, 121°29'39.82"E

A commercial satellite image appears to have captured China's new nuclear ballistic missile submarine. The new class, known as the Jin-class or Type 094, is expected to replace the unsuccessful Xia-class (Type 092) of a single boat built in the early 1980s. The new submarine was photographed by the commercial Quickbird satellite in late 2006 and the image is freely available on the [Google Earth web site](#).

BLOGS & WIKIs with Google Earth provide synergistic results

庆祝中国人民解放军建军 70 周年



Other Links to check:

- <http://bbs.keyhole.com/>
- <http://www.gearthblog.com/>
- <http://www.ogleearth.com/>
- <http://googleearthuser.blogspot.com/>
- <http://viavirtualearth.com/>
- <http://virtualearth.spaces.live.com/>
- <http://earthissquare.com/>
- <http://wikimapiablog.blogspot.com/>
- <http://www.virtualglobes.org/blog/>
- <http://googlesightseeing.com/>
- <http://www.armscontrolwonk.com/>
- <http://www.historypin.com/>
- <http://www.digitalgeography.co.uk/>
- <http://geimint.blogspot.com/>

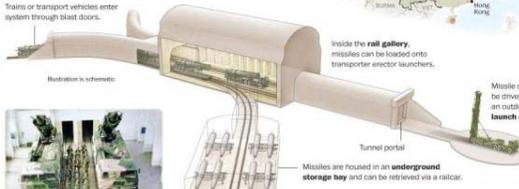
Georgetown University Makes Headlines

Students locate and describe nuclear-tipped ballistic missile forces and their concealment underground in China

The military branch in charge of China's nuclear arsenal has acknowledged building a network of tunnels more than 3,000 miles long. For the past three years, a team of Georgetown University students has studied those tunnels, led by their professor, a former senior Pentagon strategist. Using translated documents, satellite imagery and online video reports, the students and their professor concluded that China could have many more nuclear weapons than previously assumed hidden in those tunnels.

MORLIZING A MISSILE IN THE CHINESE TUNNEL SYSTEM

Each network of tunnels leads out to multiple, redundant portal openings in case of attack, in which an enemy may try to block missiles from getting out to launch. Trains or transport vehicles enter system through blast doors.

Inside the rail gallery, missiles can be loaded onto transporter erector launchers. Missiles can be driven to an outdoor launch pad. Missiles are housed in an underground storage bay and can be retrieved via a railcar.

UNCONVENTIONAL RESEARCH

The students based their findings on not only traditional sources, such as major books, journals and strategy manuals, but also on nontraditional sources, including the mapping software Google Earth, Chinese television coverage (right) and military Web sites and blogs (left).




THE WORLD'S NUCLEAR STOCKPILES, 2011

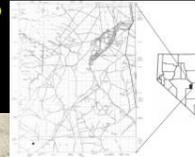
While some countries share numbers about their nuclear arsenals, China has maintained strict secrecy. In past years, government and independent studies have estimated the number of China's nuclear warheads at anywhere from 80 to 400. The Georgetown study argues that a much greater number may be hidden in China's tunnels.

North Korea	India	Pakistan	Israel	United Kingdom	China	France	United States	Russia
<10	80-100	90-110	80	225	400*	300	5,000	8,000

*The Natural Resources Defense Council estimated in 2010 that China had 400 warheads. The Federation of American Scientists, one of the most widely respected agencies for nuclear warhead counts, estimated in 2011 that China had 240 nuclear warheads.

And You Never Know What You May Find?

Detected Next to the **US Nevada Test Site & Area 51** ?...
It Could Be Just Art!



Gigantic Sculpture
Created over 36 years!



"As long as you're going to make a sculpture, why not make one that competes with a 747, or the Empire State Building, or the Golden Gate Bridge."

- Michael Heizer

Source: <http://doublenegative.tarasen.net/city.html>

1.52 Kilometers



© 2008 Terra Atlas | Google | 38°01'56.865"N 115°26'32.118"W | elev: 1576m | May 25, 2008 | EyeAlt: 1341km

A Double-Edged Sword!

Such Tools Can Be Used by Anyone:

Adversaries Can Use for Nefarious Purposes!

Google Earth Accused of Aiding Mumbai Terror Attacks

Wednesday, December 10, 2008

THE **TIMES**

Business Standard

Thursday, Dec 11, 2008

BS Online | Markets & Investing | Companies & Industry | Banking & Finance | Economy & Policy

Home > ICE World | [Live Markets](#) | [Smart Portfolios](#)

Terrorists used Google Earth

Makarand Gadgil / Mumbai November 30, 2008, 0:04 IST

Mumbai lawyer demands Google Earth ban claiming satellite images are a terrorist 'security hazard' **MailOnline**

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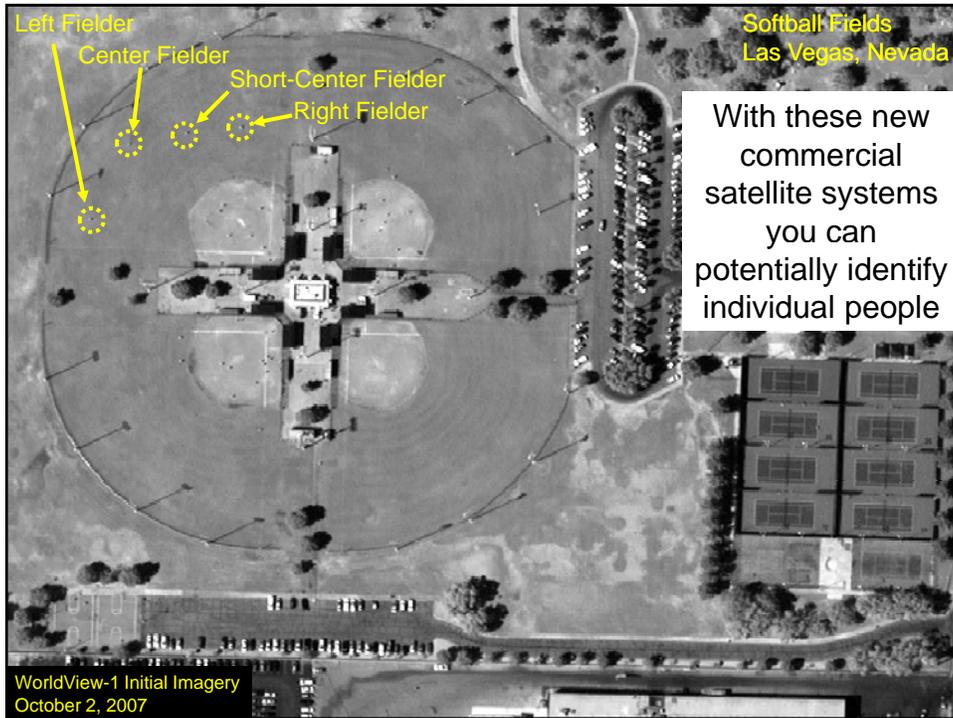
Where am I? > Home > News > Tech & Web > The Web

From Times Online

December 9, 2008

Google Earth accused of aiding terrorists





Using New Geospatial Tools to Follow-Up on Public Allegations
Foreign Affairs Committee of the
National Council of Resistance of Iran
HOME | ABOUT US | CONTACT US

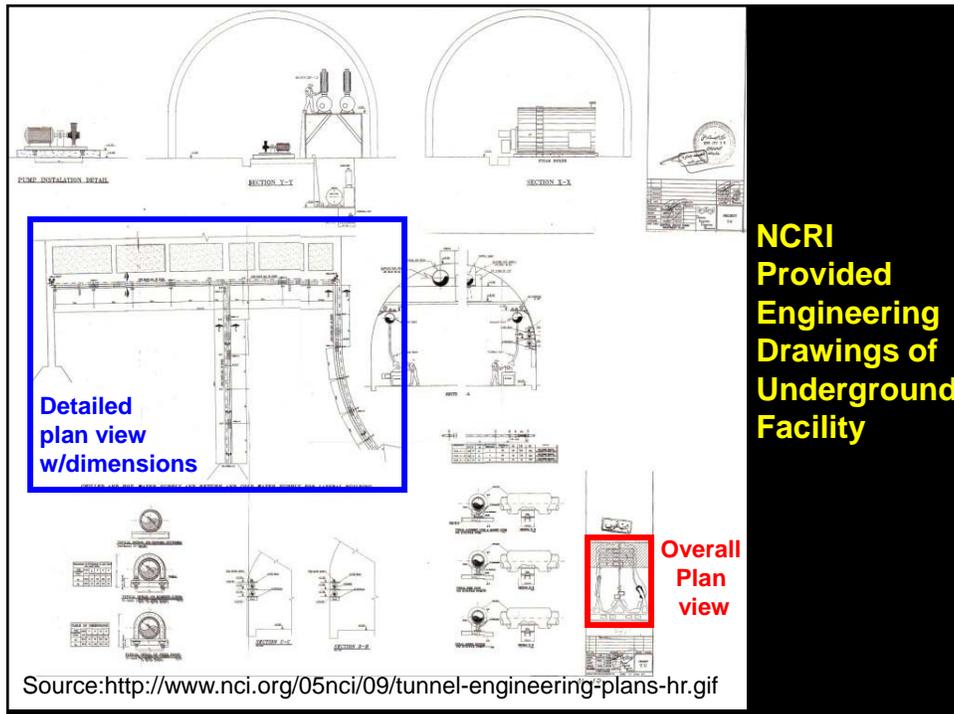
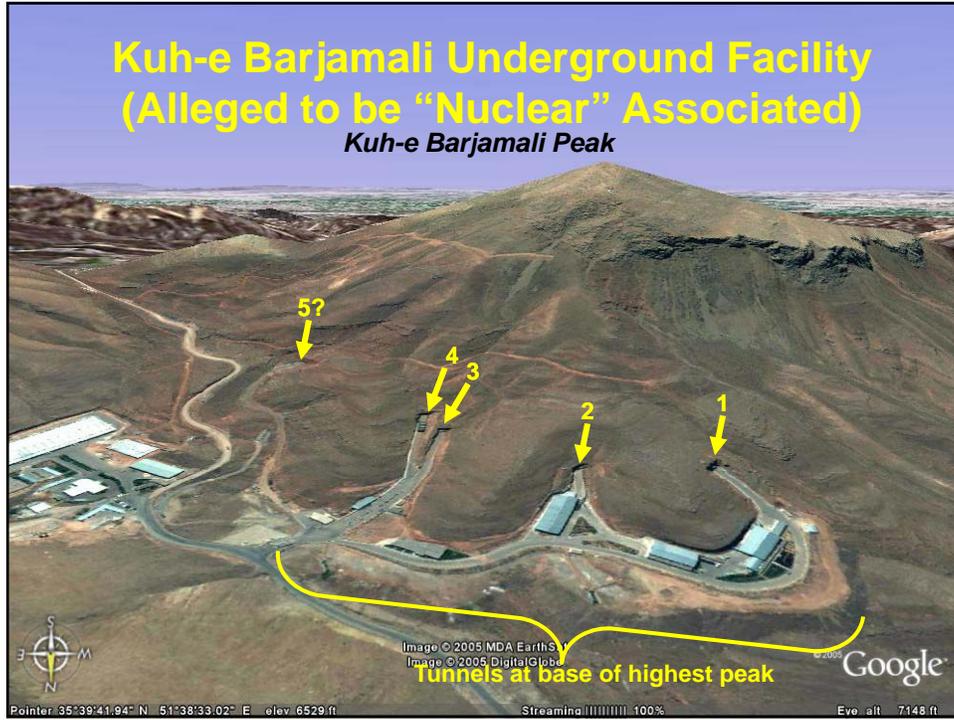
CASE #1: The NCRI Alleges Underground Nuclear-Capable Missile Related Facility Near Tehran

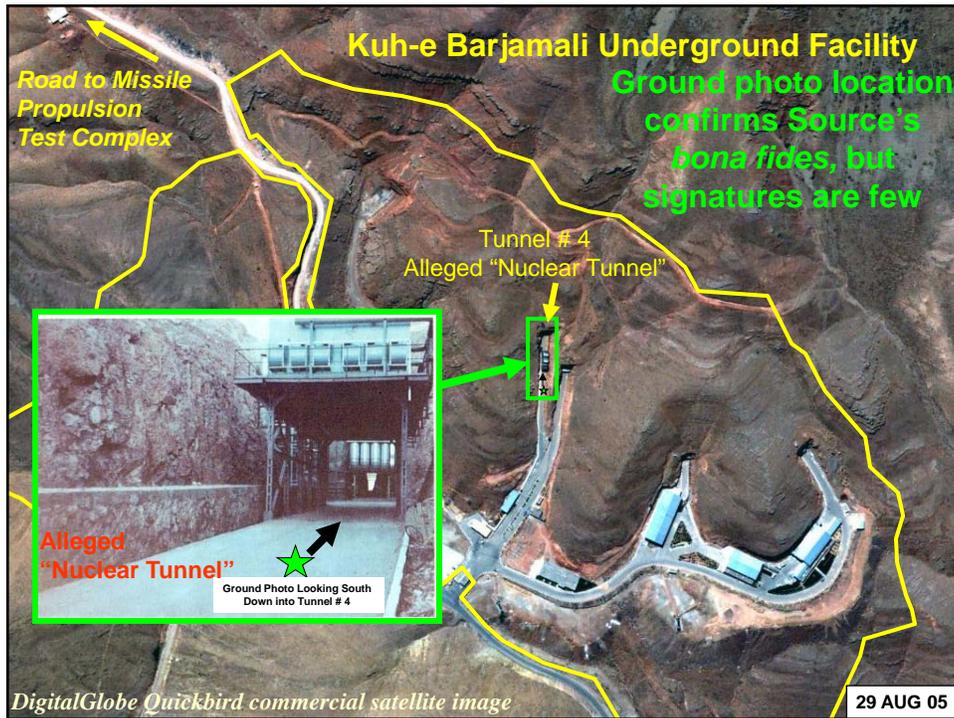
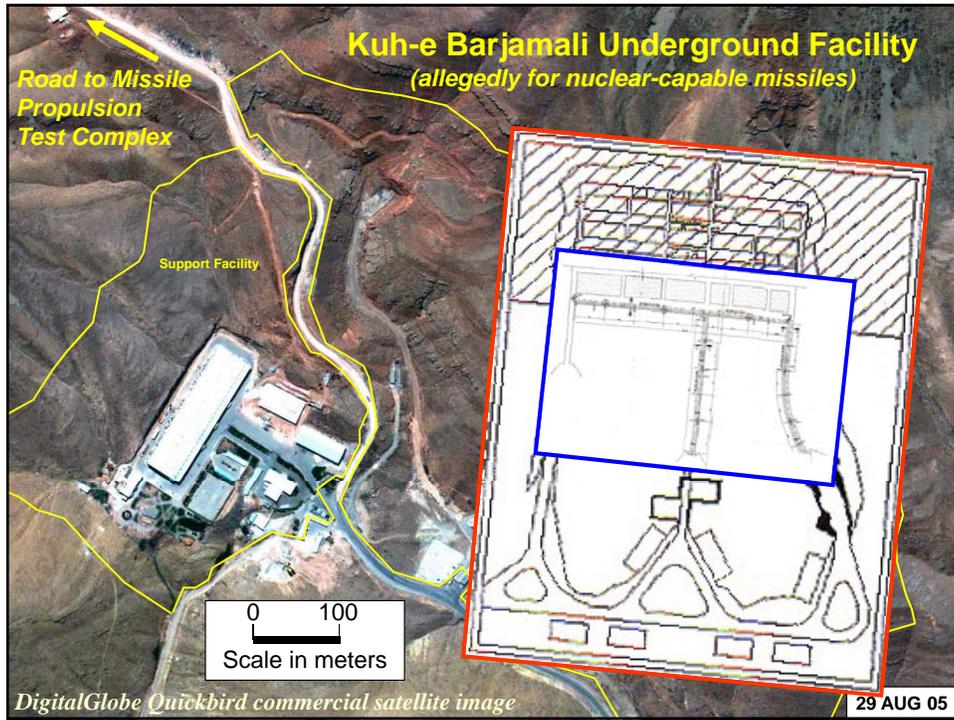
16 September 2005

21 November 2005

Four posters: A ground photo, two engineering drawings, and a location map were presented on 16 September 2005 and 21 November 2005

Source: http://spc.washington.com/index.php?option=com_content&task=view&id=124&Itemid=33







Bloggers Discuss Magnox Reactors

External view of Calder Hall Magnox Reactor (# 2) at Sellafield, UK (265MWth / 50 Mwe, Optimized for Plutonium Production)

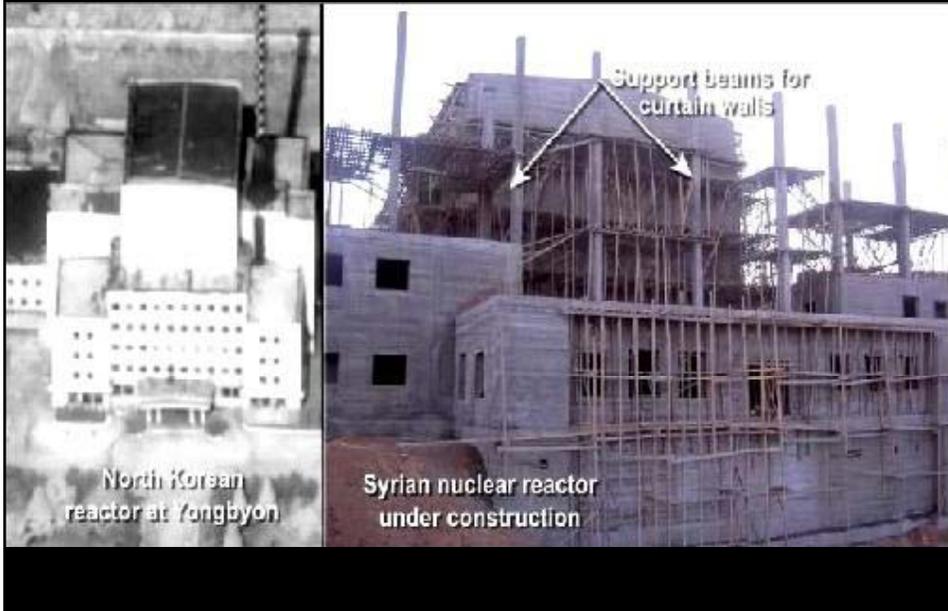
External view of Yongbyon Magnox Reactor, DPRK (25 MWth / 5 Mwe, Optimized for Plutonium Production)

-Section of one of the piles at Calder Hall "A" power station, showing the reactor core, pressure vessel, thermal and biological shields and one of the four heat exchangers

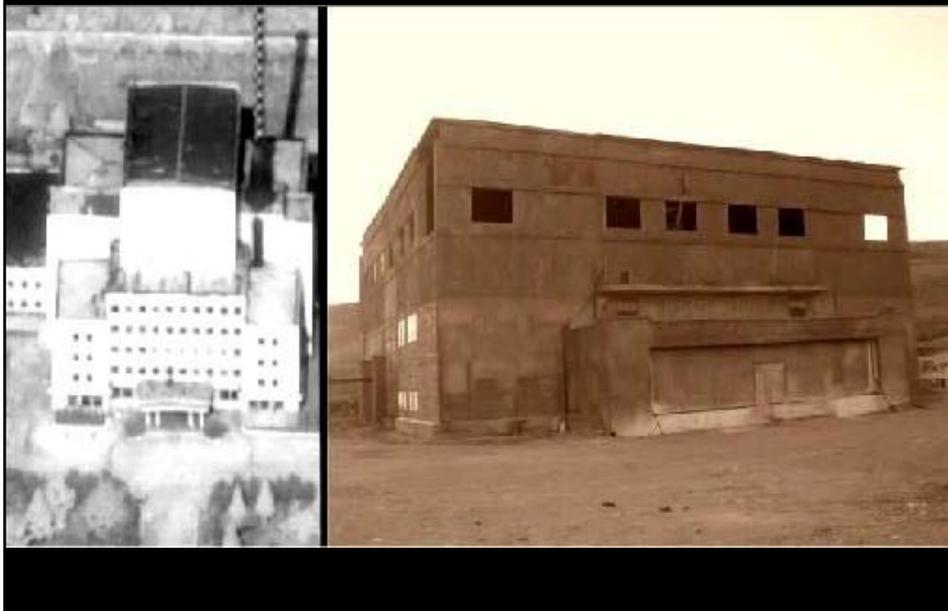
SOURCE: <http://www.armscontrolwonk.com/2142/more-pabian-on-iran-syria#comment>

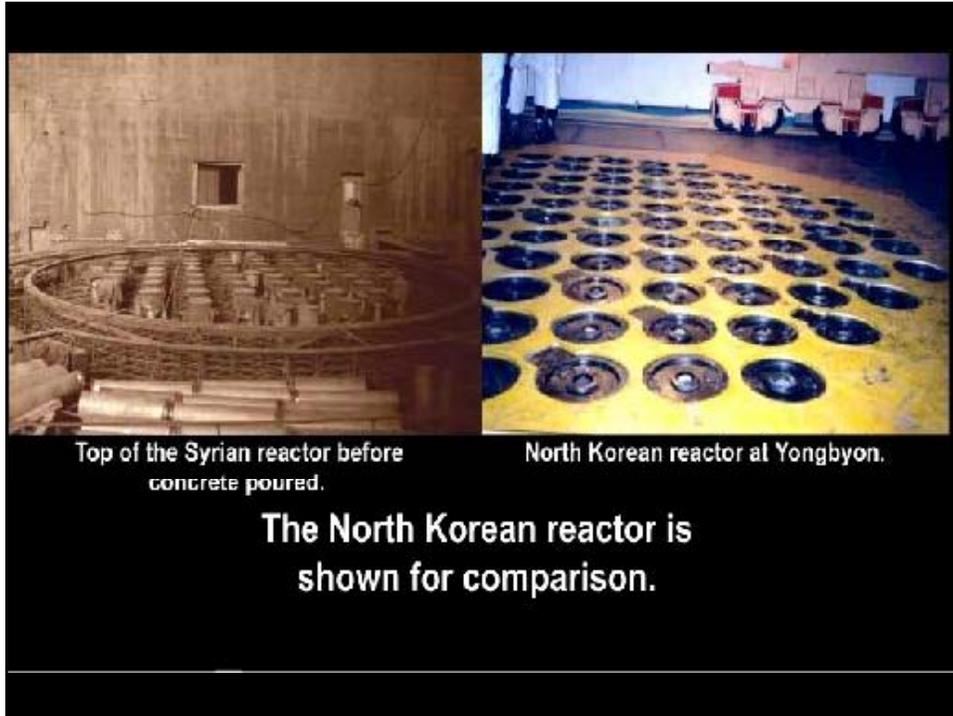
Calder Hall Magnox Reactor at Sellafield, UK Design

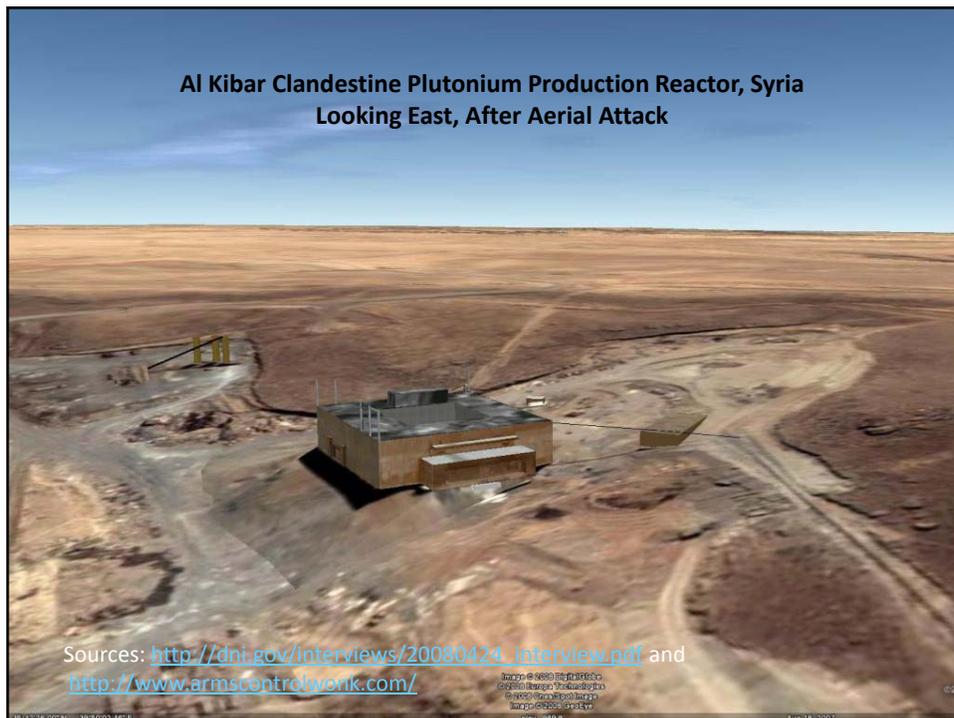
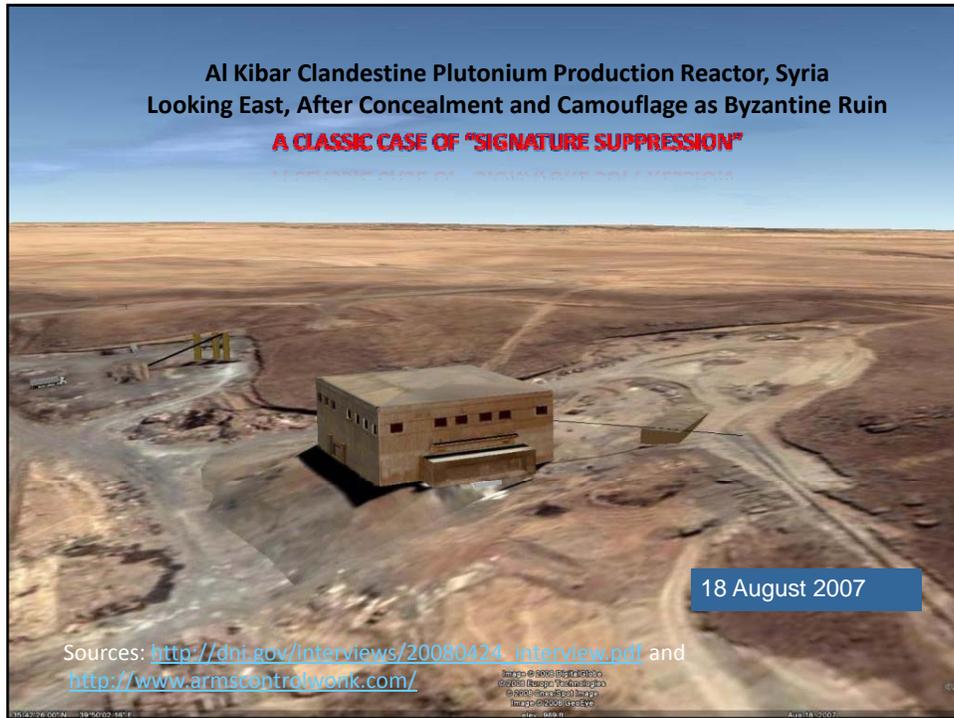
April 2008 ODNI Briefing Reveals Construction Image and Compares to Yongbyon Magnox Reactor

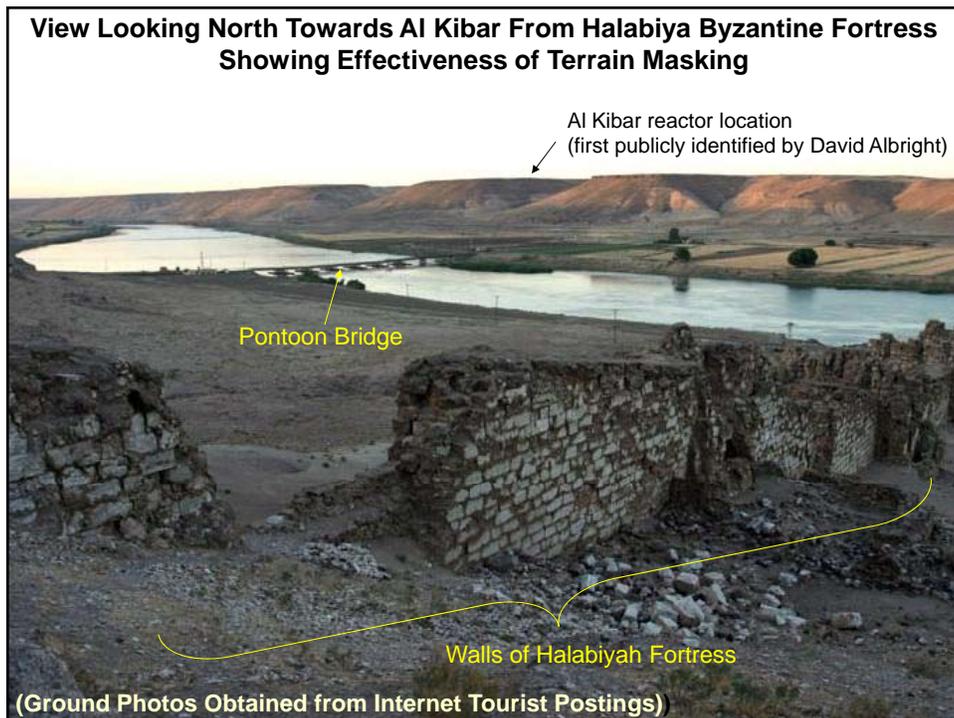


April 2008 ODNI Briefing Reveals Subsequent Image Showing Concealment Effectiveness

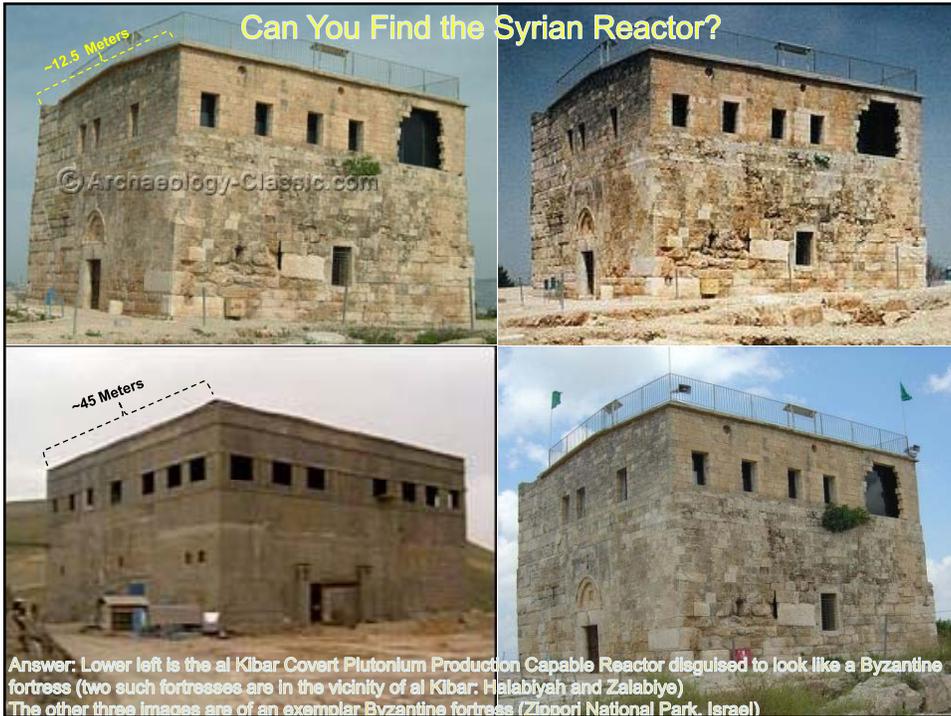
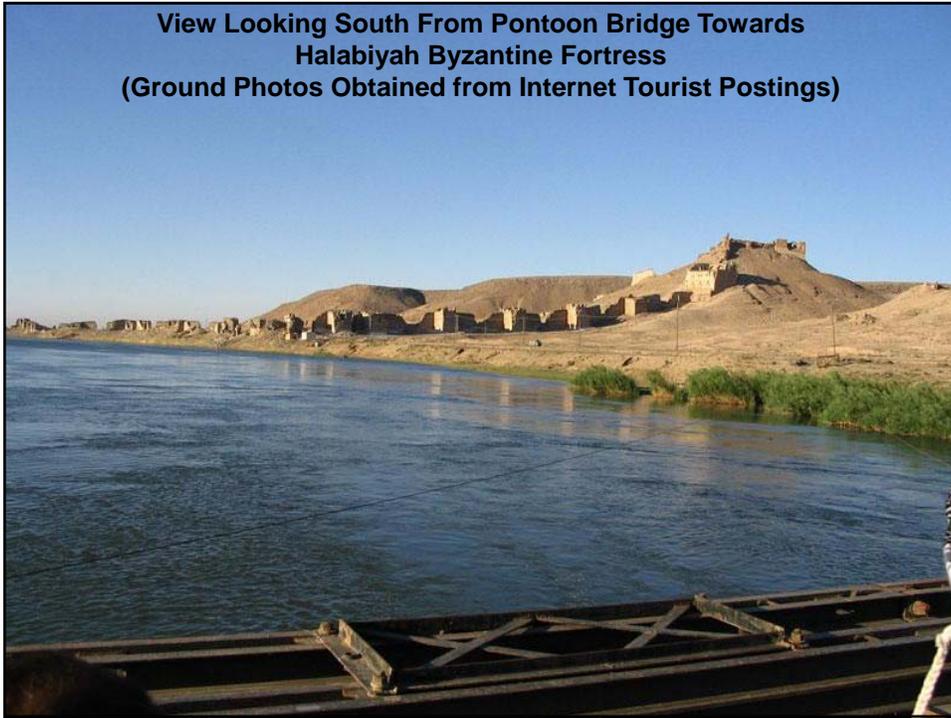








View Looking South From Pontoon Bridge Towards
Halabiyah Byzantine Fortress
(Ground Photos Obtained from Internet Tourist Postings)



Board of Governors



Implementation of the NPT Safeguards Agreement in the Syrian Arab Republic
Report by the Director General

GOV/2009/36

Date: 5 June 2009

Paragraph 18. **SUMMARY**

- 1) The presence of the uranium particles at the Dair Alzour (aka Al Kibar) site, the imagery of the site available to the Agency and certain procurement activities remain to be clarified.
- 2) The information provided by Syria to date does not adequately support its assertions about the nature of the site.
- 3) In order for the Agency to complete its assessment, Syria needs to be more cooperative and transparent.

Beware of Imagery Data Manipulation
(aka: "Fauxtography") as It Can
Lead to Erroneous Conclusions!

Comparison slide as taken directly from IAEA Inspector Dr. Abushady's briefing on Egyptian National Television that claimed to be "To Scale," and therefore "Proved" that the Al Kibar facility was not comparable to the reactor at Yongbyon



Reactor Image Comparison that is "TO SCALE"

(Left image re-scaled to match right image vertically and horizontally)

(Compare with Dr. Abushady's slide)

The reactor hall building at Yongbyon is a little more than twice as tall as the Al Kibar Building (~45 meters versus ~20 meters high as measured from ground level), BUT at Al Kibar the reactor was entirely below grade (vice above ground at Yongbyon) and likely had a basement depth of at least 16 meters*, providing a total height of at least 36 meters or no more than 9 meters less than the Yongbyon reactor hall. This comparison shows that all the dimensions of Al Kibar are slightly less than, but nonetheless still proportional to, those of the Yongbyon reactor hall.

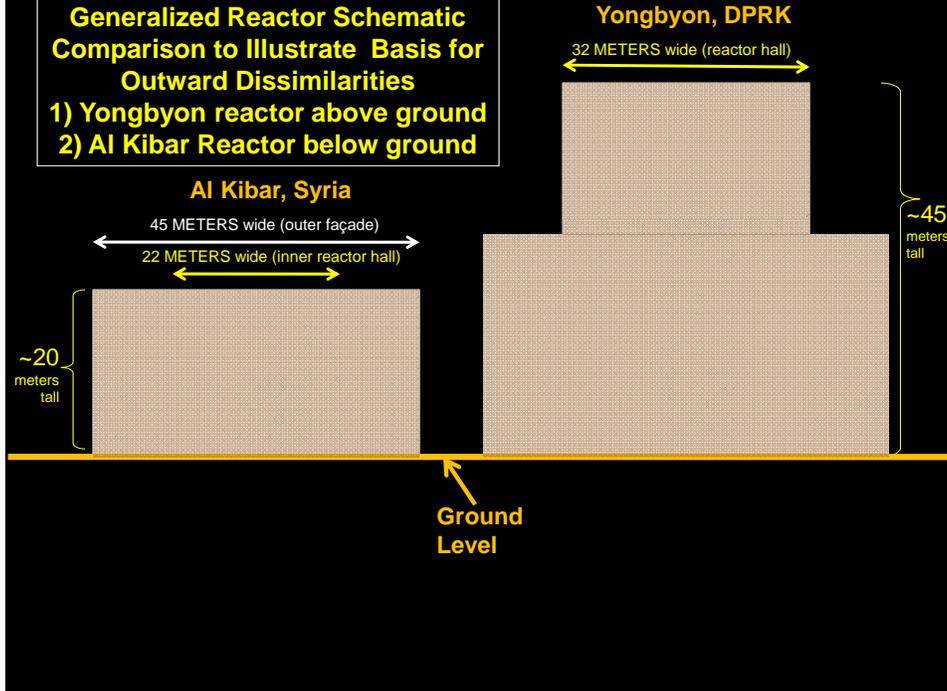


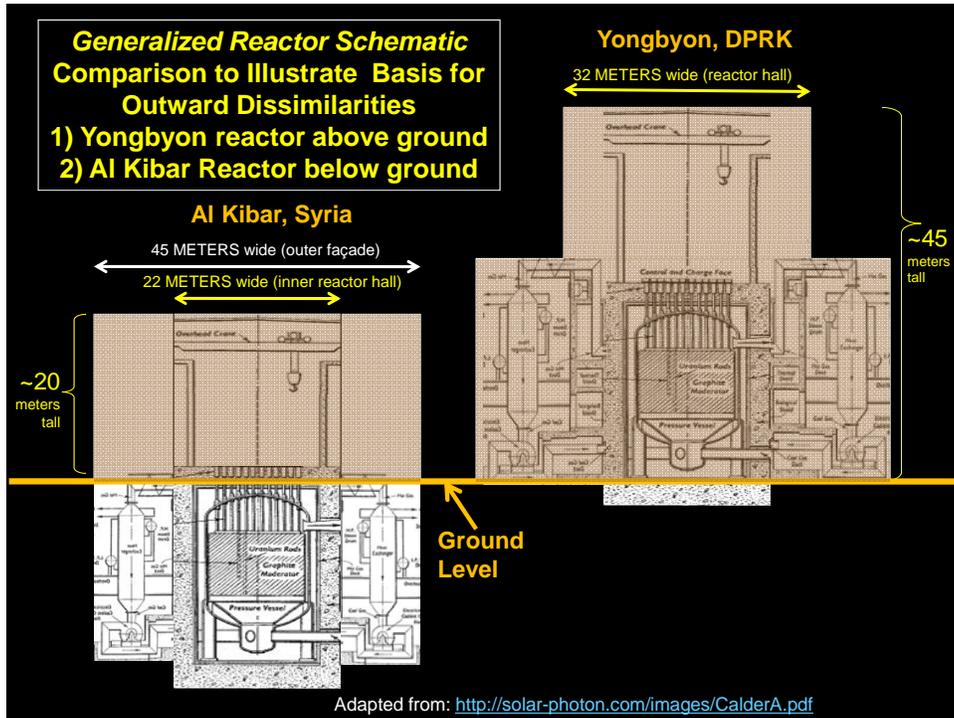
•Source: ODNI images and <http://www.armscontrolwonk.com/2149/iaea-official-on-the-box>

Source: http://is-db.stanford.edu/events/5220/gallery/images/IMG_2009.jpg

Generalized Reactor Schematic Comparison to Illustrate Basis for Outward Dissimilarities

- 1) Yongbyon reactor above ground
- 2) Al Kibar Reactor below ground





UNCLASSIFIED LA-UR 10-04532
21 July 2010

Using the New Google Earth to Locate a Newly Revealed Underground Plutonium Production Complex in China

Los Alamos National Laboratory
U.S. National Nuclear Security Administration

UNCLASSIFIED

Los Alamos NATIONAL LABORATORY
OPERATED BY LOS ALAMOS NATIONAL SECURITY, LLC FOR DOE/NSA



PAGE ONE | MAY 22, 2009 **Commercial Satellite Imagery and Global Transparency**
Gulags, Nukes and a Water Slide: Citizen Spies Lift North Korea's Veil

With Sleuthing and Satellite Images, Mr. Melvin Fills the Blanks on a Secretive Nation's Map

By EVAN RAMSTAD

SEOUL -- In the propaganda blitz that followed North Korea's missile launch last month, the country's state media released photos of leader Kim Jong Il visiting a hydroelectric dam and power station.

Images from the report showed two large pipes descending a hillside. That was enough to allow Curtis Melvin, a doctoral candidate at George Mason University in suburban Virginia, to pinpoint the installation on his online map of North Korea.



A Glimpse at North Korea

See some of the sites "North Korea Uncovered" users have identified.

Mr. Melvin is at the center of a dozen or so citizen snoops who have spent the past two years filling in the blanks on the map of one of the world's most secretive countries. Seeking clues in photos, news reports and eyewitness accounts, they affix labels to North Korean structures and landscapes captured by Google Earth, an online service that stitches satellite pictures into a virtual globe. The result is an annotated North Korea of rocket-launch sites, prison camps and elite palaces on white-sand beaches.

"It's democratized intelligence," says Mr. Melvin.

<http://online.wsj.com/article/SB124295017403345489.html#project%3DNKGOOGLE0509%26articleTab%3DInteractive>



North Korea Uncovered - (Google Earth)

The most authoritative map of North Korea on Google Earth
 Version 17: May 14, 2009
 Click [here to download](#)
 (Recently featured in the *Wall Street Journal*)



Click on the screen shots above for larger images

This Google Earth project offers an extensive mapping of North Korea's economic, cultural, political, and military infrastructures. Through the topic menu, users of this program have easy access to geographical information on North Korea's agriculture projects, aviation facilities, communications, hospitals, hotels, energy infrastructure, financial services, leisure destinations, manufacturing facilities, markets, mines, religious locations, restaurants, schools, and transportation infrastructure. In addition to locations of economic interest this map also displays anti-aircraft locations, the Demilitarized Zone (DMZ) and Northern Line Limit Line (NLL), incarceration facilities, political monuments, political residences, military bases, and nuclear facilities.

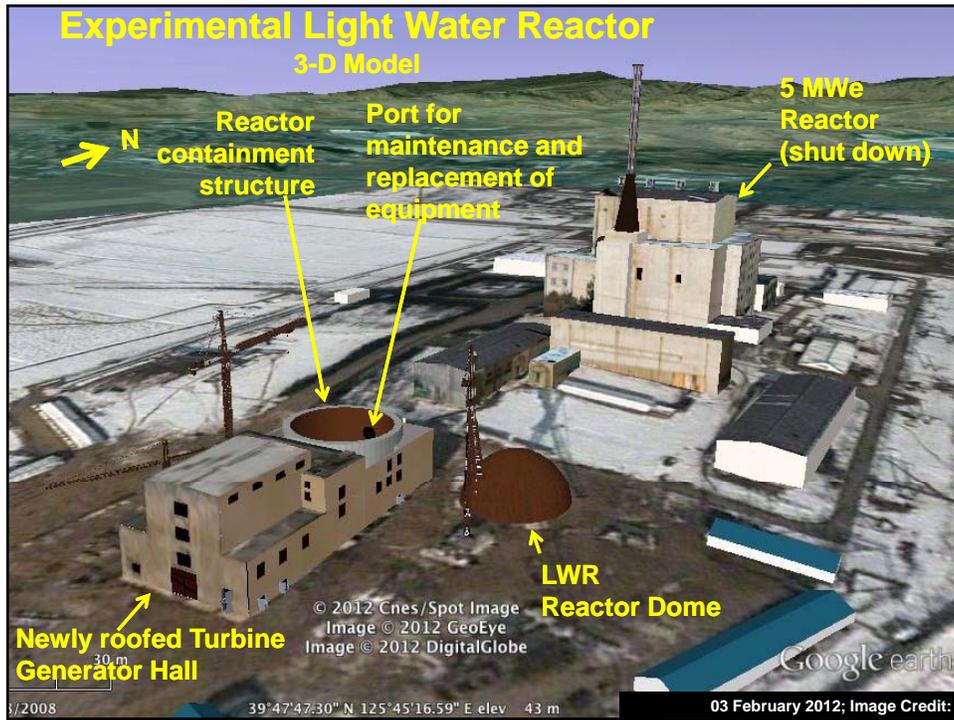


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 Arlington, VA
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Kim Jong Il's pool (Filled with water), courtesy North Korean Economy Watch



<http://www.nkeconwatch.com/north-korea-uncovered-google-earth/>

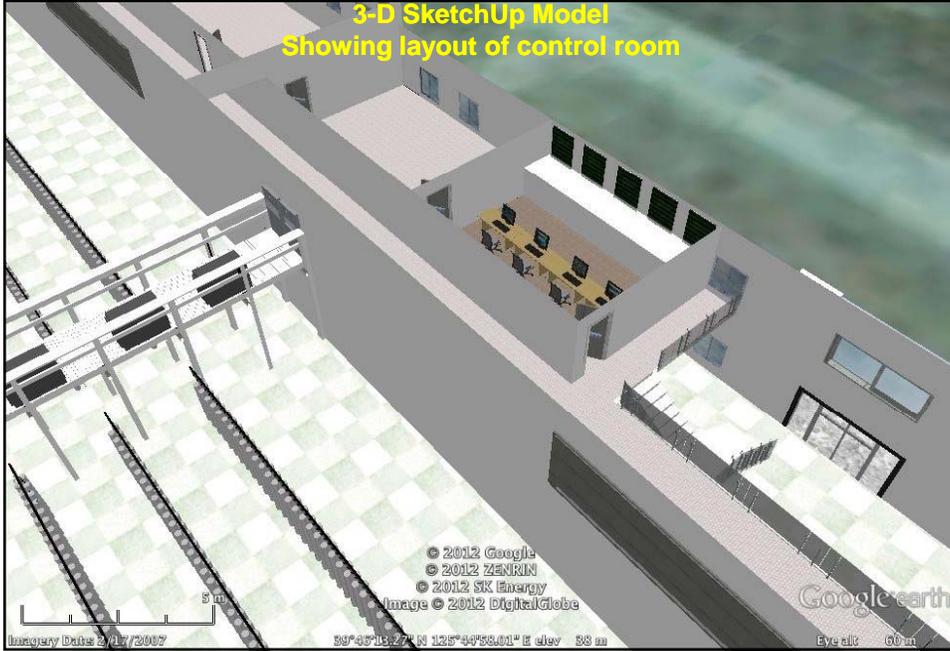






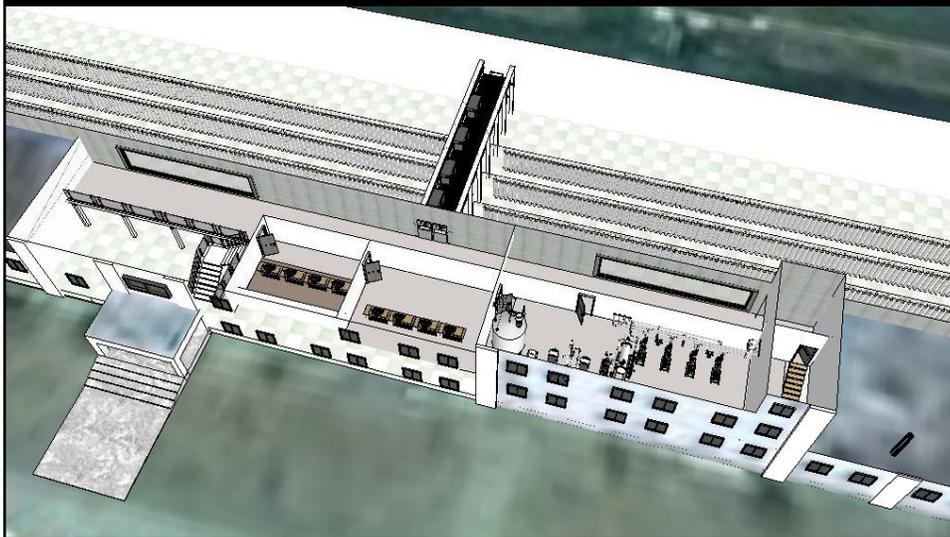
Cascade Hall, Yongbyon NRC, DPRK

3-D SketchUp Model
Showing layout of control room

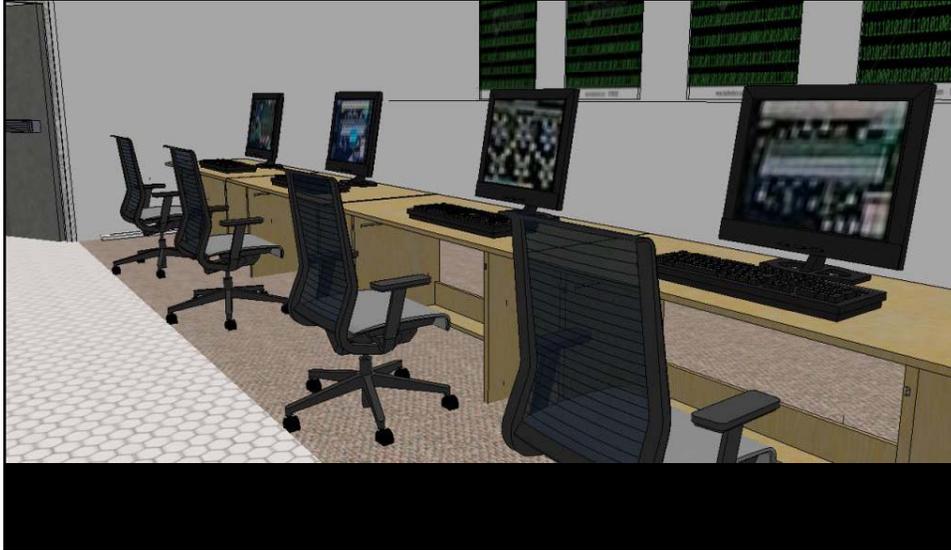


Cascade Hall, Yongbyon NRC, DPRK

3-D SketchUp Model
(Just a place holder...items placed in Recovery Room are not meant to be realistic)



**Control Room, Yongbyon NRC,
DPRK
3-D SketchUp Model**

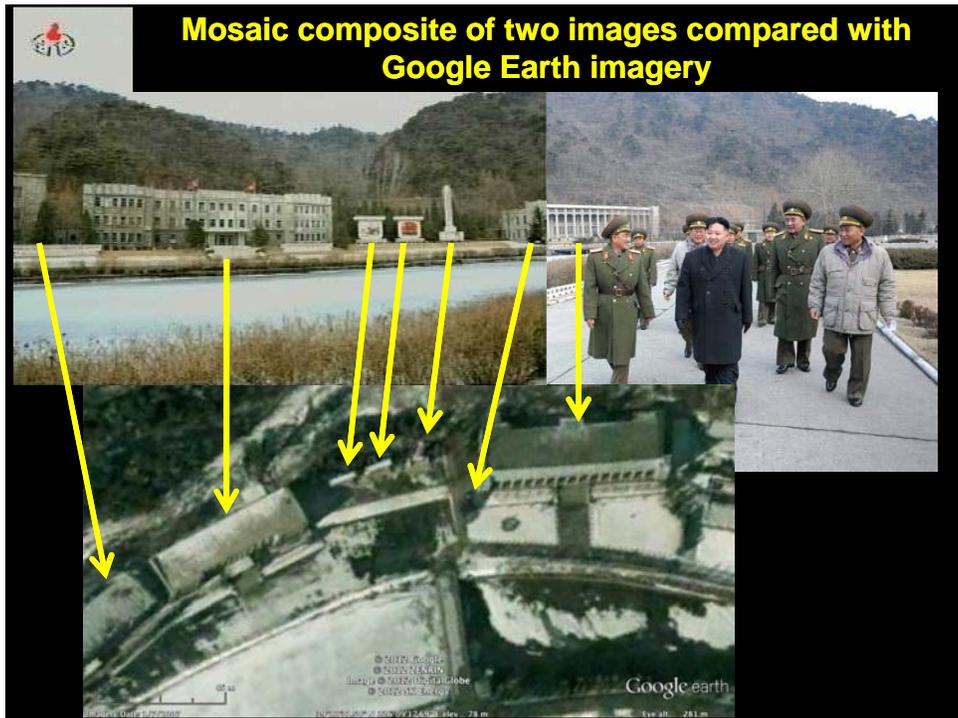


Cascade Hall, Yongbyon NRC, DPRK

**3-D SketchUp Model
West Observation Window**





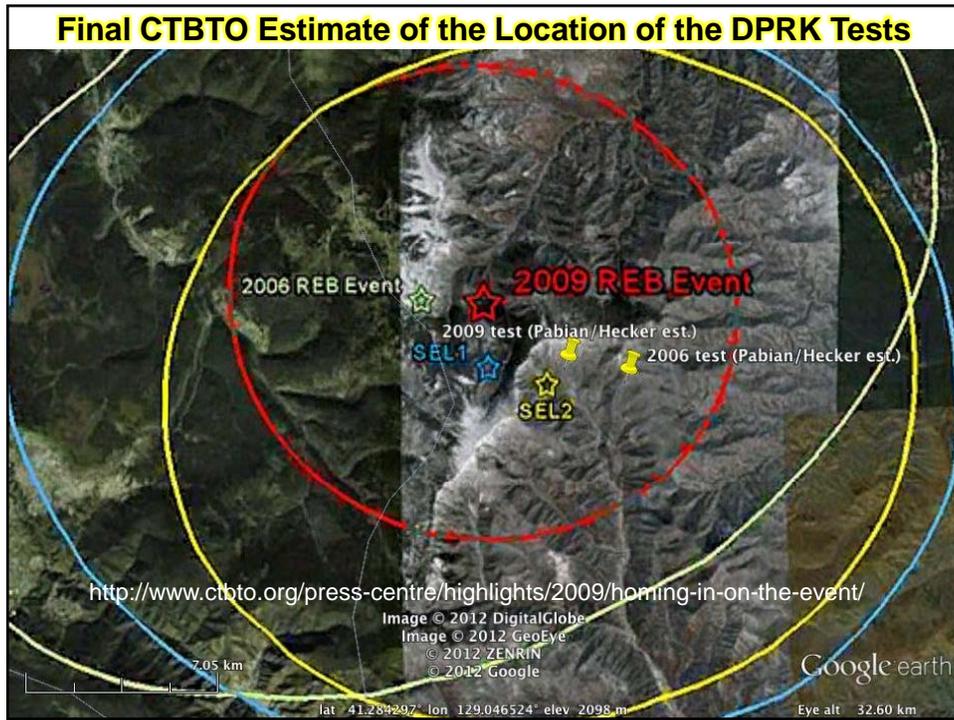


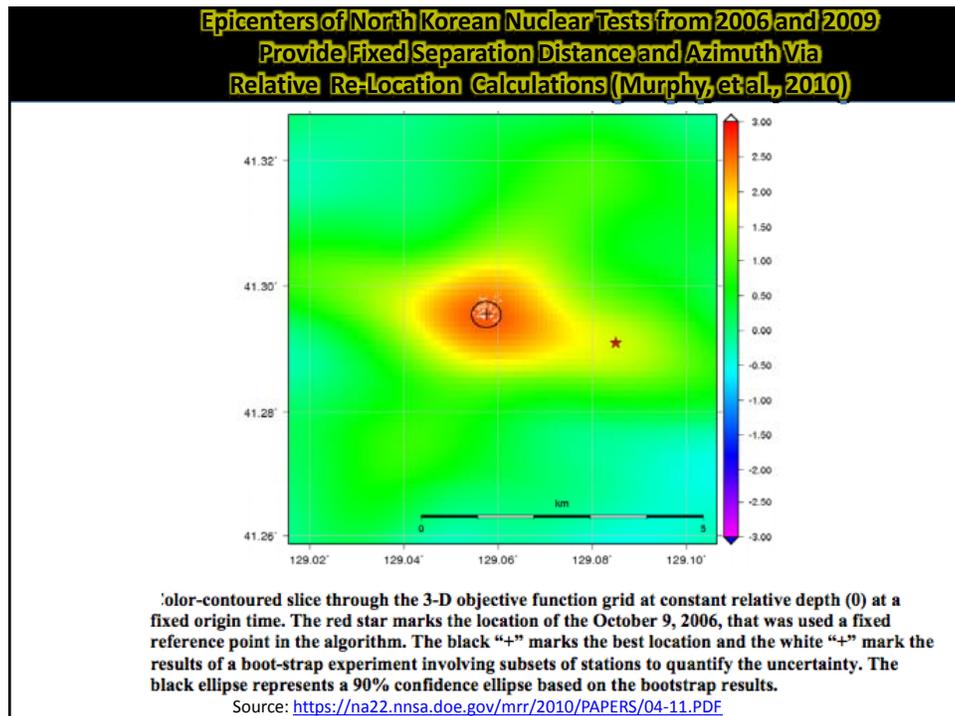


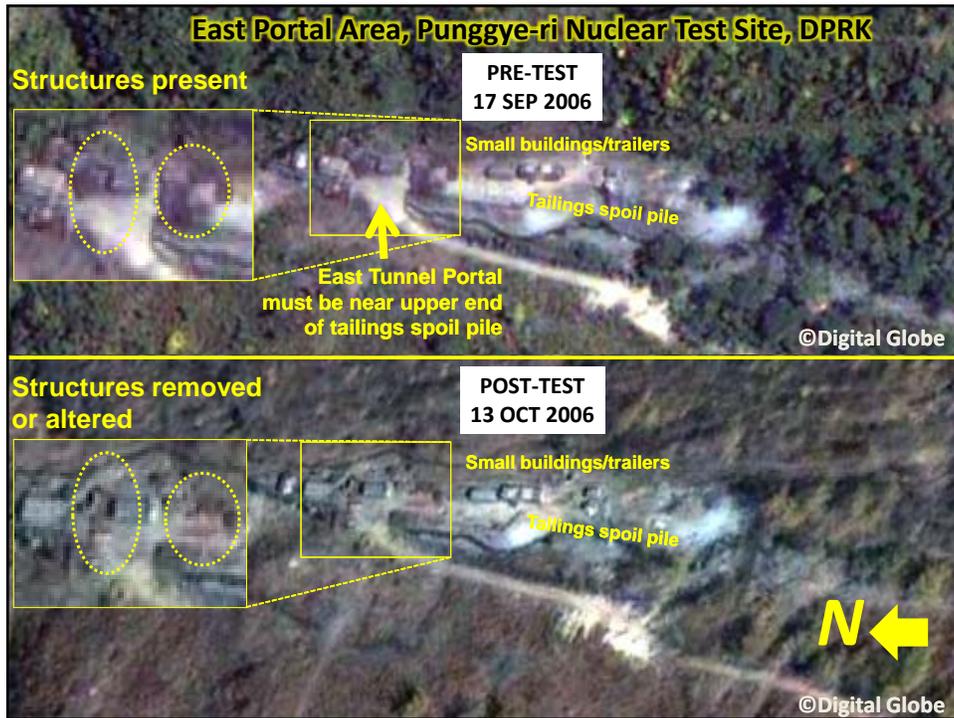
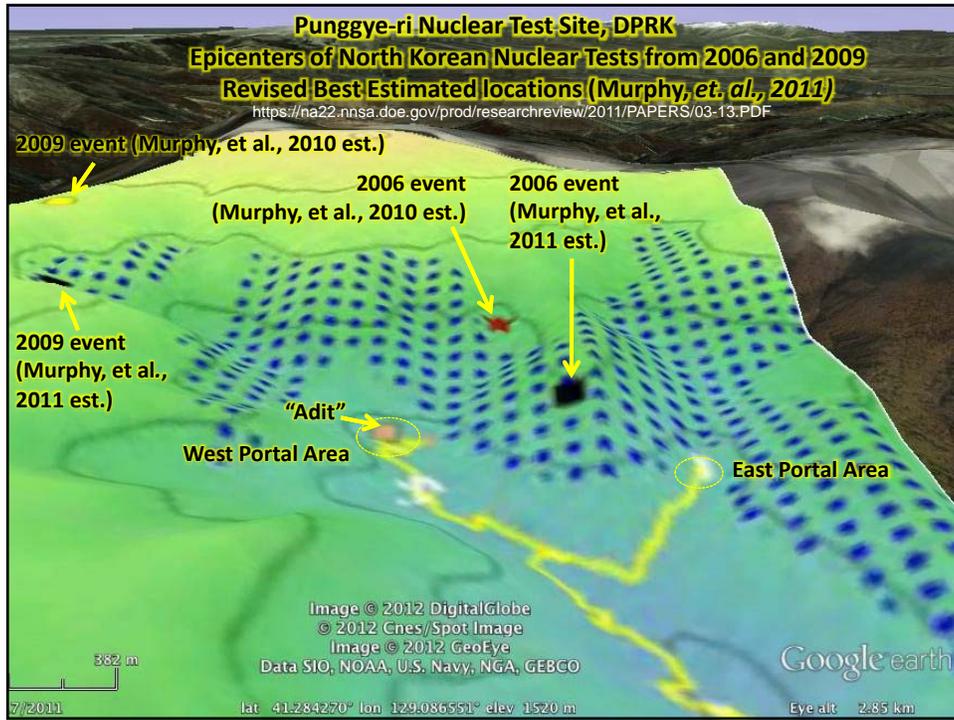


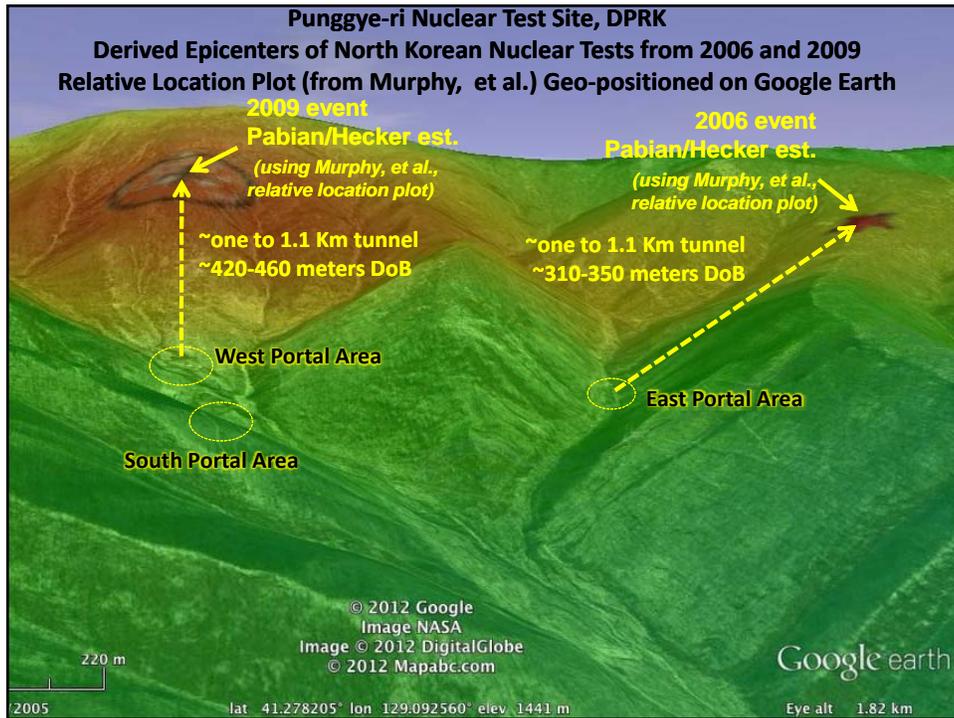
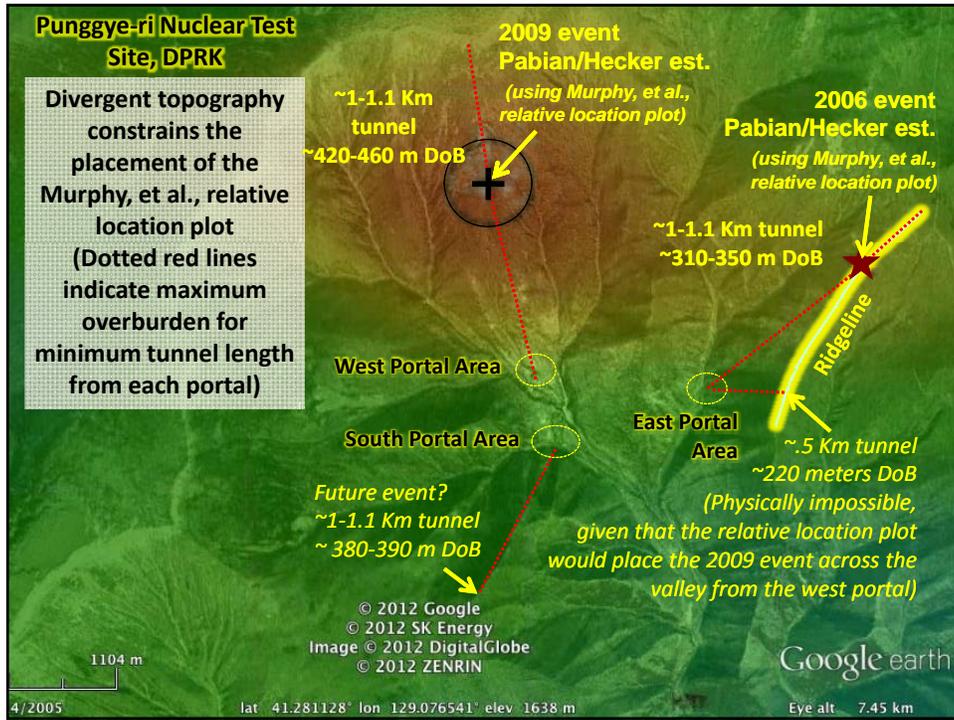
Kim Jong Un (3rd R) looks at training equipments during his visit to the KPA Strategic Rocket Force Command in the suburbs of Pyongyang. Also in attendance is Gen. Pak Jae Gyong (R) (Photo: KCNA/Yonhap)

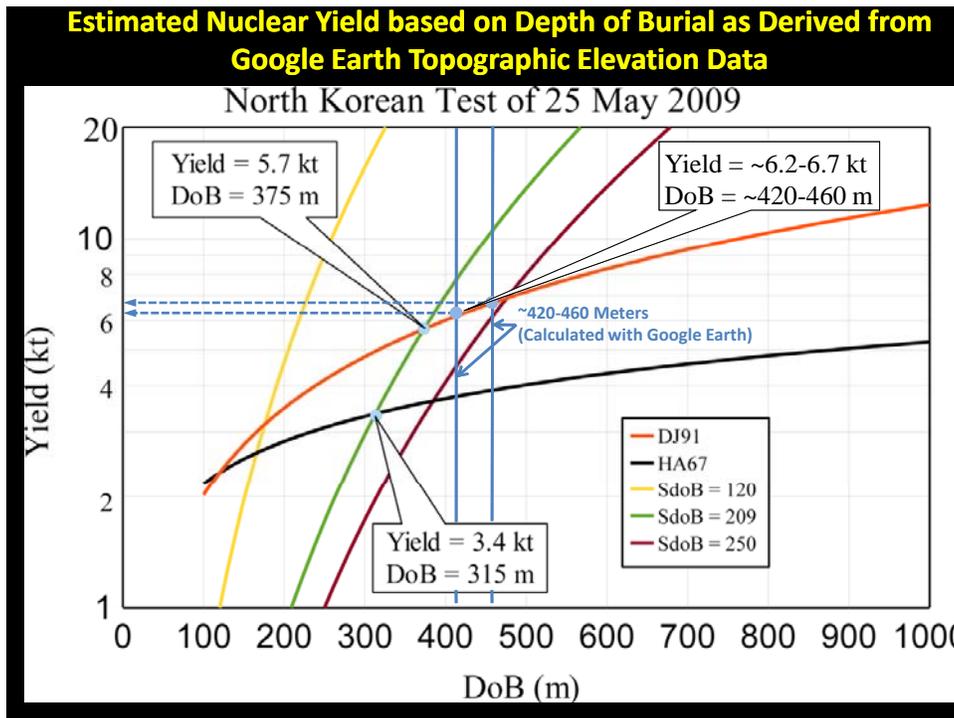
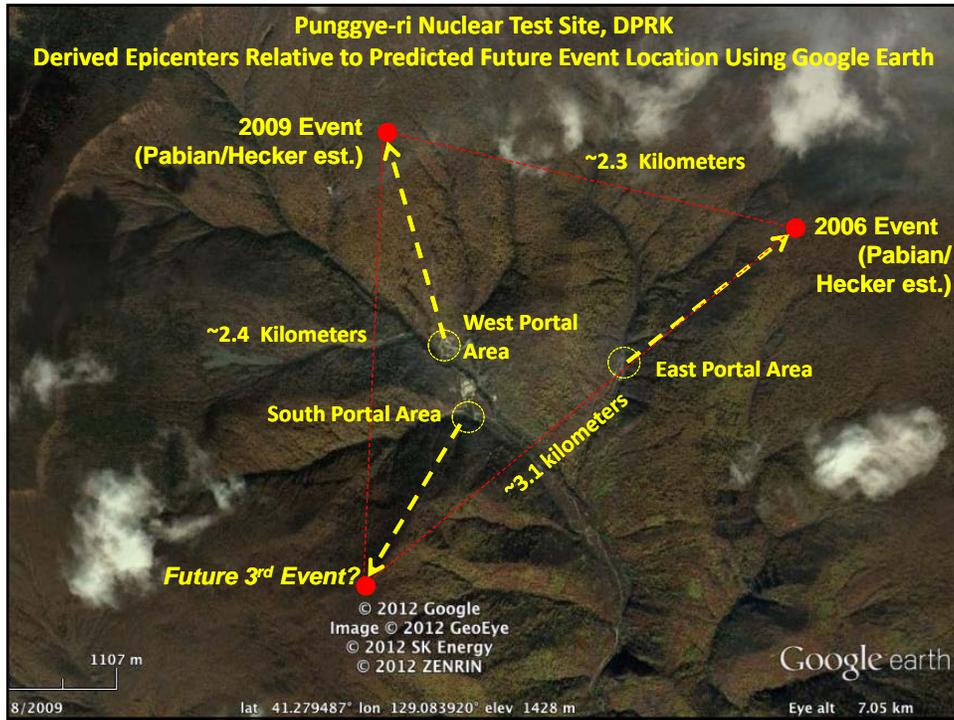


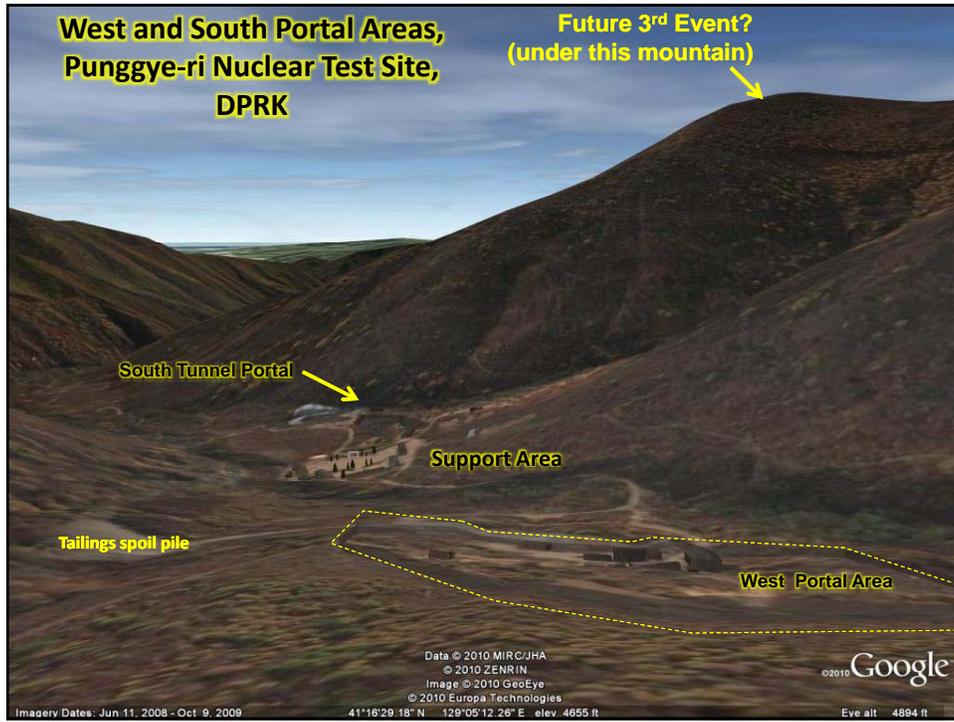


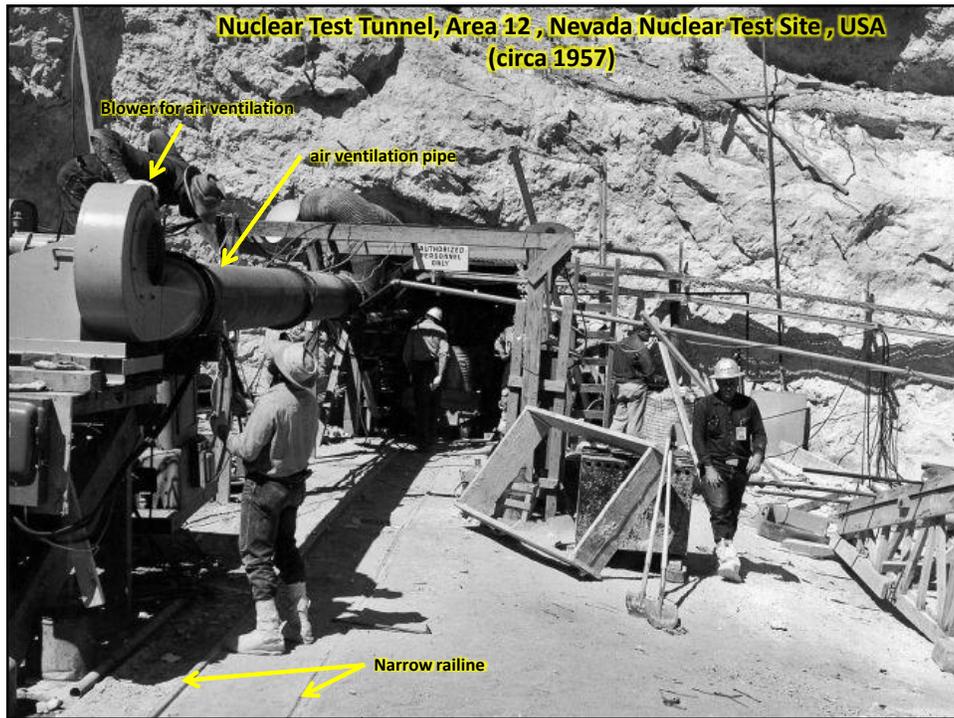
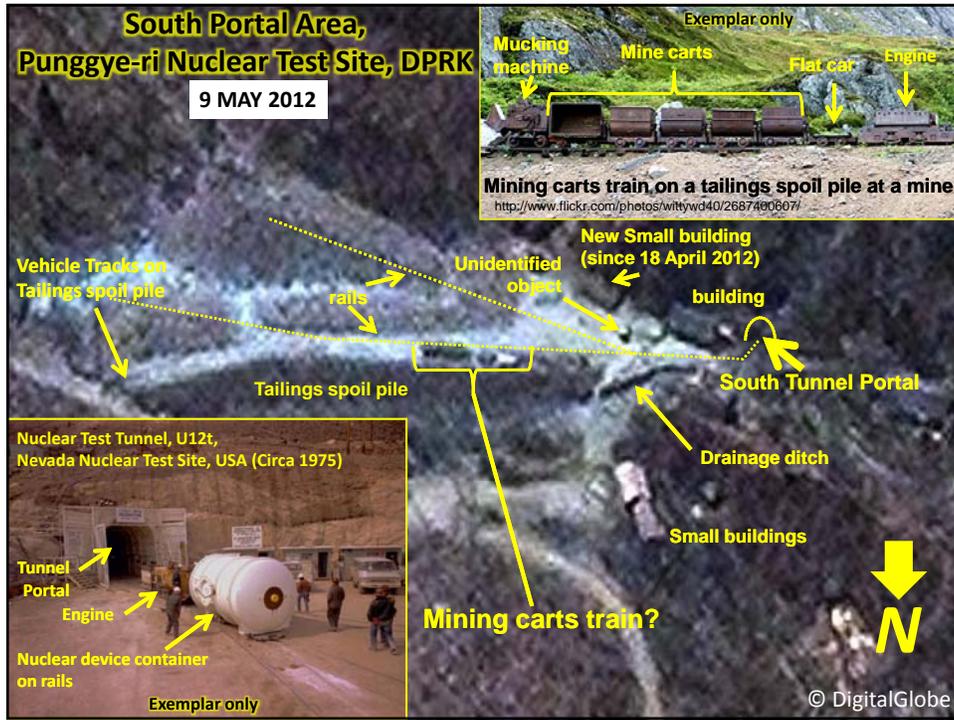


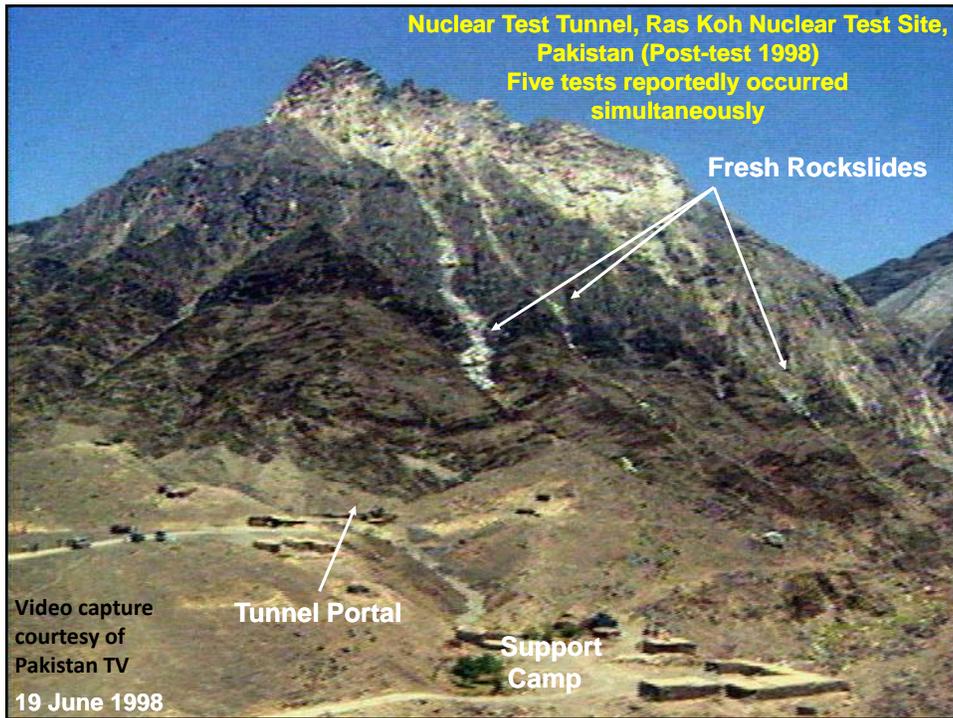
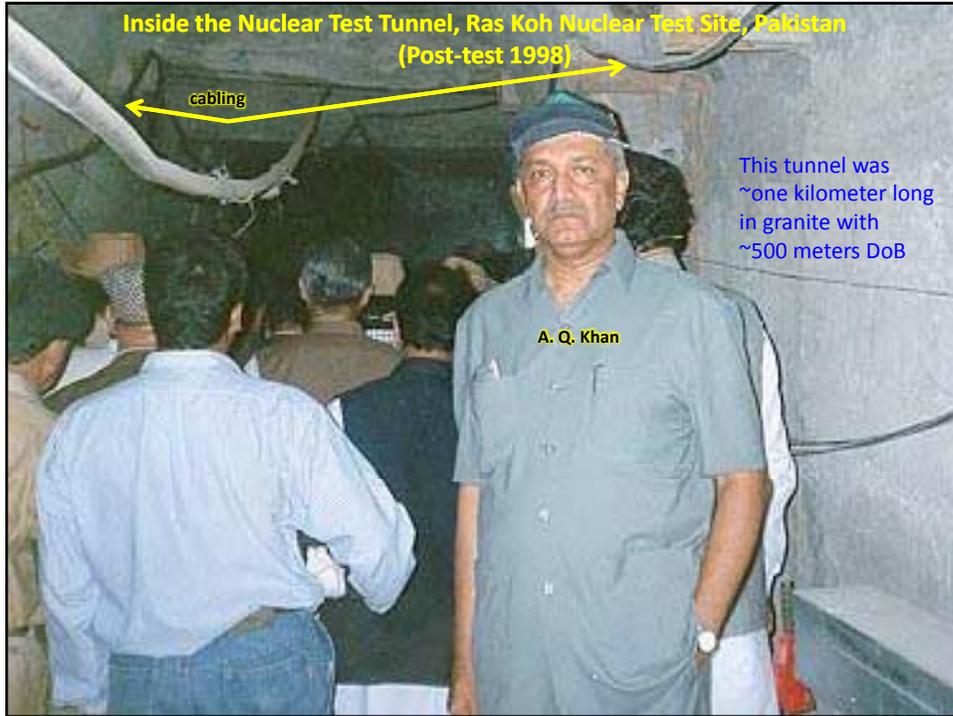




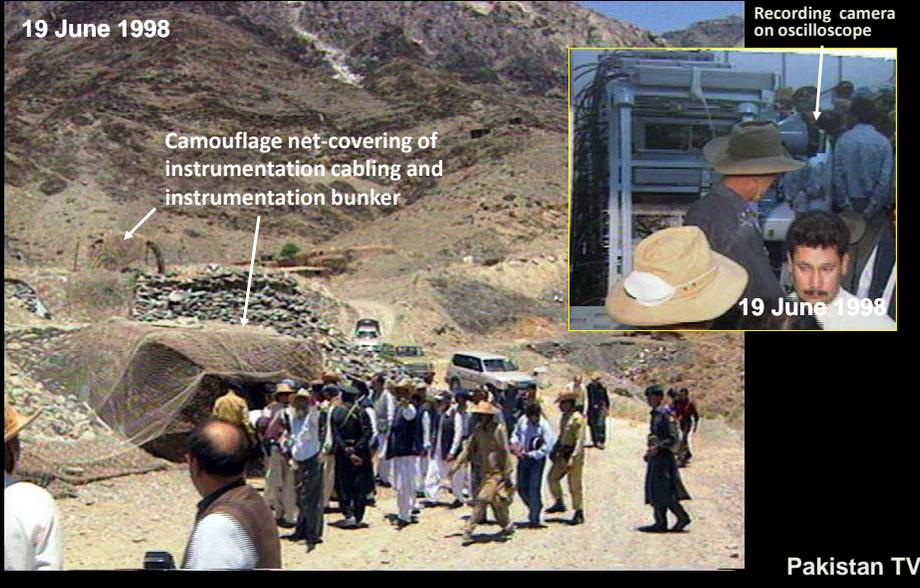




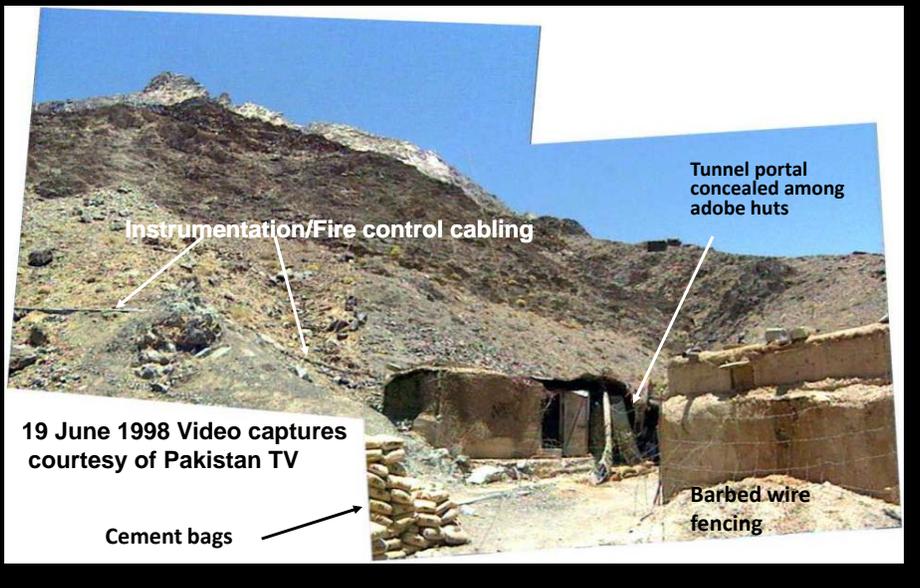




**Nuclear Test Tunnel, Ras Koh Nuclear Test Site, Pakistan
(Post-test 1998)
Exemplar of what might be found outside of portal**

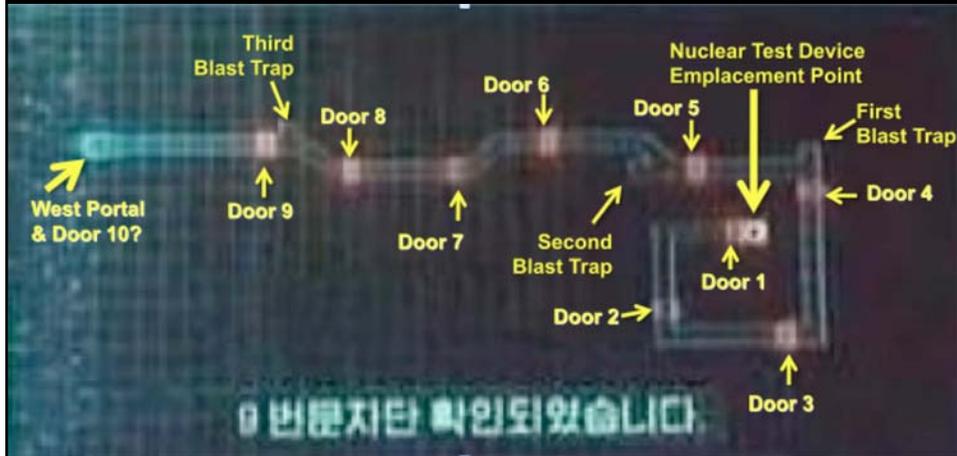


**Nuclear Test Tunnel, Ras Koh Nuclear Test Site, Pakistan
(Post-test 1998)
Exemplar of what might be found outside of portal**





KCTV Animation Video Frame Grab Showing Tunnel Layout and Nine Interior Doors for Containment of the 2009 Nuclear Test in North Korea



Large Flat Panel Monitor Screen Showing Simulated Door Closing Sequence

Google+ **Google Earth is a Growing Part of Global Pop-Culture**

<https://plus.google.com/100156589101321820776/posts/NfaRHQgsmVP>

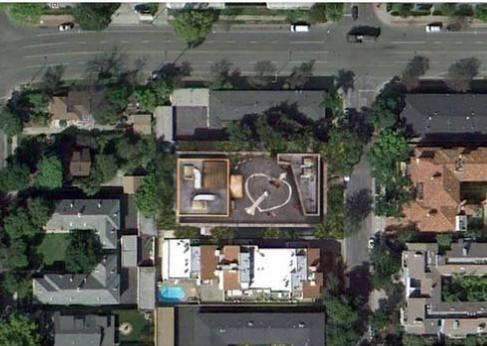
[Join Google+](#) Share the right things with just the right people.

 **David Vávra** May 11, 2012 (edited) · Public

The Big Bang Theory apartment from season finale on Google Earth!

Last episode of the TV series showed Howard and Bernadette getting married on the rooftop of Leonard's and Sheldon's apartment while being captured by Google Earth satellite. I have compared the satellite images from the show with the real ones and found *exact location of their (fictional) apartment!*. Download this to view it in Google Earth:
http://www.destil.cz/TBBT_apartment.kmz

You can browse it in Google Maps as well, but turn off the 45° view:
<http://g.co/maps/k&avn>





Worked at Google

Attends Czech Technical University in Prague

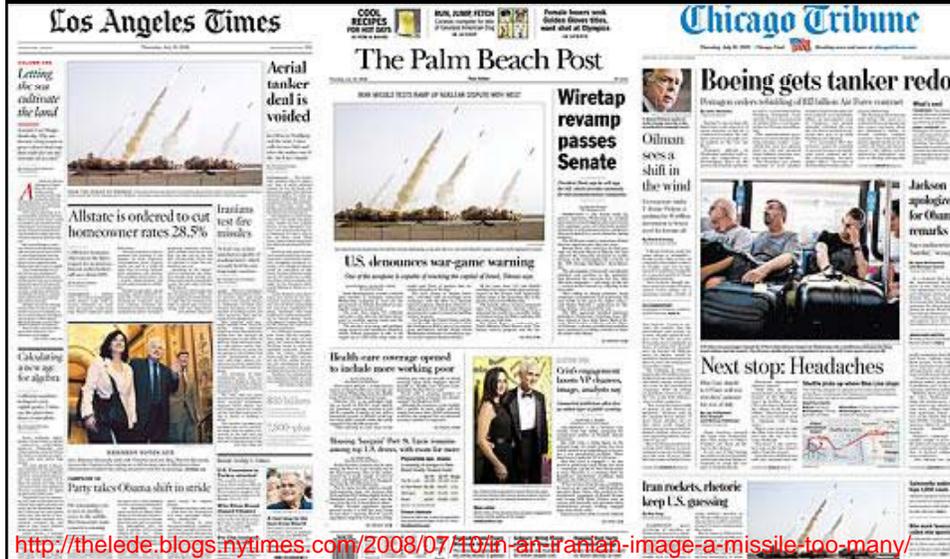
Lives in Řevnice, Czech Republic

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“Fauxtography” is a potential problem:

But MUCH less so for satellite imagery than with ground imagery as there are: multiple satellites- from multiple vendors- and from multiple nations



Original Ground Image: Un-“Photoshopped”



July 2008 Iranian missile launch was "Photoshopped"



Why Stop at Just Four?



Students Making a Difference With GE

Monterey Institute Student's Innovative Geospatial Analysis Work Cited by Assistant Secretary of State Rose Gottemoeller

Second-Year Student Developed Analysis Technique to Aid Arms Control Verification

Monterey, CA—In a speech delivered yesterday at Stanford University, Assistant Secretary of State for Arms Control, Verification and Compliance Rose Gottemoeller cited the geospatial analysis research of **Monterey Institute of International Studies** student Tamara Patton (NPTS '12) as an example of innovative work being done in the area of arms control verification.

Secretary Gottemoeller explained in her remarks how Patton, a second-year honors student in the Institute's **Nonproliferation and Terrorism Studies** program, had taken open-source satellite images of Pakistan's Khushab Plutonium Production Complex and used a freely available program called **Google Sketch-up**, as well as **Google Earth** tools and basic trigonometry, to construct a three-dimensional model of the facility. The model can then be overlaid onto a map.

Patton, whose geospatial analysis research is the subject of her honors thesis, is expected to graduate next year from the Institute's unique Nonproliferation and Terrorism Studies program. The program draws heavily for its curriculum on the expertise and resources resident in the Institute's **James Martin Center for Nonproliferation Studies (CNS)**. CNS is the world's largest research center devoted to combating the spread of weapons of mass destruction.

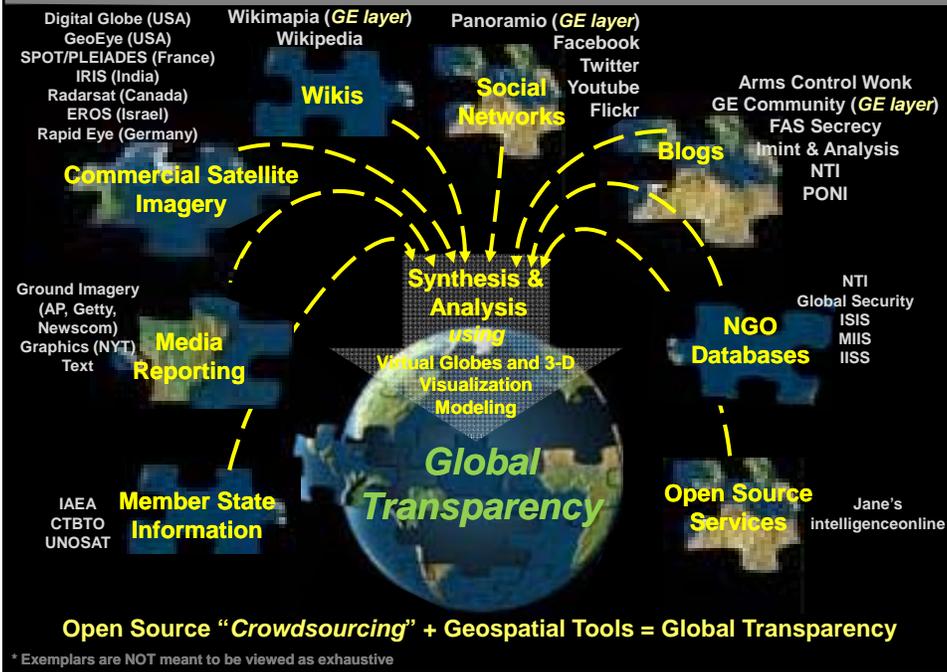
Delivering the Sidney Drell Lecture at Stanford, Secretary Gottemoeller explored a range of innovations in arms control verification techniques, including open source information technologies and social networking.

"It's important to recognize the vast potential of freely available software tools like Google Earth and Google SketchUp to identify and analyze nuclear proliferation challenges. Such tools not only allow us to create an immense 'neighborhood watch' effect, but they also allow students and professionals in nonproliferation to perform their own analysis rather than relying on a few confined sources."

—Tamara Patton



Using the New Geospatial Tools: Putting All the Pieces Together



CONCLUSIONS:

Google Earth is a Critical Tool for Monitoring & Verification

- You No Longer Have To Be a Super-Power!
- Google Earth is a Great Starting Point for Any Assessments
- Ideal Global Visualization Tool
- Broad Area Search Tool
- Historical Imagery Archive
- Virtual Global Transparency:
Free "Open Source" "Crowdsourcing" cadre
(>1.1 Billion downloads!)
- Ground-Based Imagery Layers: Panoramio, Street View

