

# Imaging

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# NOTES

# Windows into North Korea

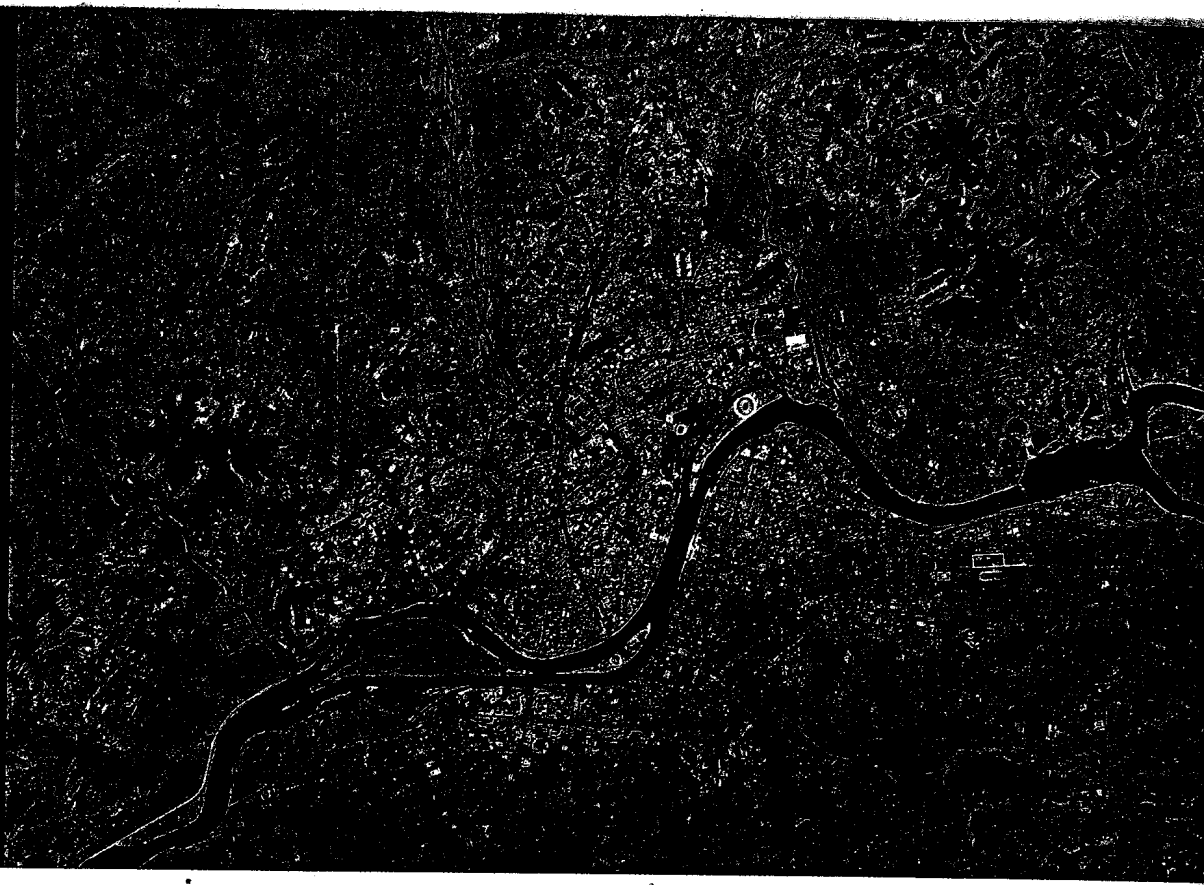
**Subsidence  
in Arizona**

**Solar Power  
Potential**

**Fire Mitigation  
Solutions**

FIGURE 1 >>

Image of P'yongyang from NaturalVue 2000, a simulated natural color, global, mosaiced image dataset derived from Landsat7 photographs acquired between 1998 and 2002 (© Earth Satellite Corporation). The cover image of this issue shows a closer view of P'yongyang. See page 4 for details.



## Satellite Views of the Hermit Kingdom

# Windows into North Korea

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THE OPENING EVENT OF Condoleezza Rice's first trip to South Korea as U.S. Secretary of State this March was a speech to soldiers at the U.S. military's underground command bunker south of Seoul rather than a diplomatic ceremony — signaling that the security problems posed by the Democratic People's Republic of Korea (DPRK or North Korea) are a central focus for U.S. foreign policy in the region.<sup>1</sup> In February of 2005, this secretive militaristic society claimed to possess nuclear weapons and is now believed to be slowly augmenting its small arsenal.

In provocative moves this May, North Korea fired a short-range missile into the Sea of Japan and claimed that fissile material for nuclear weapons had been harvested from a reactor in Yongbyon. On May 15th, the United States warned the DPRK not to test a nuclear weapon, citing (albeit controversial) evidence from classified satellite imagery.

The United States currently seeks to bring the DPRK back to the "six-party talks" on nuclear disarmament,<sup>2</sup> but the road ahead appears difficult and may lead to a United Nations resolution this summer involving economic sanctions, further international isolation of the regime, or

more drastic actions. Inter-Korean talks ended in late May without agreement on resumption of negotiations over North Korea's nuclear program.

Meanwhile the exodus of refugees continues as North Koreans flee famine, economic hardship and political repression. Commercial remote sensing data are among the few available research tools permitting Non-Governmental Organizations (NGOs) to understand better both the security and the human rights situations in the DPRK.

Today even basic geographic information related to North Korea's society and military is considered sensitive, much as the geography of the Soviet Union was viewed during the Cold War. In order to shed light on the North Korean military capabilities and potential targets should there be a future conflict, the Natural Resources Defense Council (NRDC), an environmental group based in Washington, D.C., undertook a project to create a geospatial database of North Korea.

The effort initially drew on information from U.S. and South Korean military maps and features visible in 10-meter resolution SPOT and 15-meter resolution Landsat imagery covering the entire Korean peninsula.

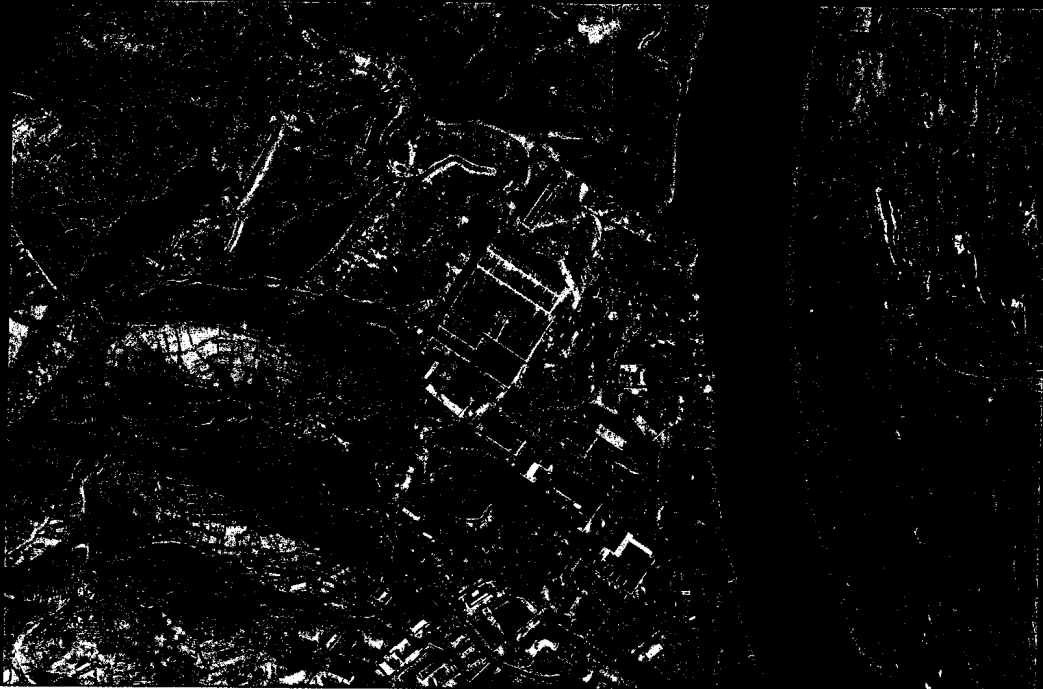


FIGURE 2 ◀ QuickBird photograph of Pakch'on Uranium Concentration Plant, acquired December 13, 2003.

Using this data as a guide, NRDC then systematically obtained remotely sensed data imaged by the IKONOS and QuickBird satellites for discrete areas of interest, including cities, industrial facilities, airfields, navy bases, nuclear sites, a missile test site and the demilitarized zone (DMZ). Currently the NRDC database contains over 3,500 records. As an application of this project, NRDC worked in collaboration with the U.S. Committee on Human Rights in North Korea, a Washington D.C.-based NGO, to interview DPRK defectors using high-resolution satellite imagery to identify and map out North Korea's extensive political prison camp system and to delineate the structures of specific prisons.

#### NORTH KOREA'S NUCLEAR INFRASTRUCTURE

For almost half a century, the DPRK has pursued a nuclear weapons capability at great cost to its society and economy. NRDC has obtained high-resolution satellite images of half a dozen key nuclear sites. The full extent of the DPRK's nuclear program is not known to NRDC, or for that matter even to the U.S. intelligence community.

IKONOS and QuickBird satellite images of the extensive Yongbyon nuclear complex have often been featured on television and in the print media, yet less has been revealed about North Korea's uranium mining, milling and enrichment programs — key uncertainties in estimating how rapidly additional nuclear weapons could be constructed. In October of 2002 North Korea claimed to have a uranium enrichment program in addition to its known plutonium path to the bomb. More recently it has been revealed that the DPRK sold uranium hexafluoride gas to Pakistan, which in turn sold it to Libya.<sup>3</sup>

North Korea's first uranium mill was set up at a site near Pakch'on, 80 kilometers north of the capitol city, P'yongyang (see Figure 1). This industrial facility initially processed graphite, phosphate and other substances, but in 1982 it was modified to produce uranium concentrate from the uranium ore extracted out of several DPRK mines.<sup>4</sup> A second uranium production plant was established in the early 1990s at P'yongsan, 170 kilometers southeast of Pakch'on. Figure 2 displays a QuickBird image of the one hundred thousand square-meter uranium concentrate facility at Pakch'on, situated along the west bank of the Taeryong River. Pakch'on is also rumored to be the location of additional underground facilities associated with North Korea's nuclear program.

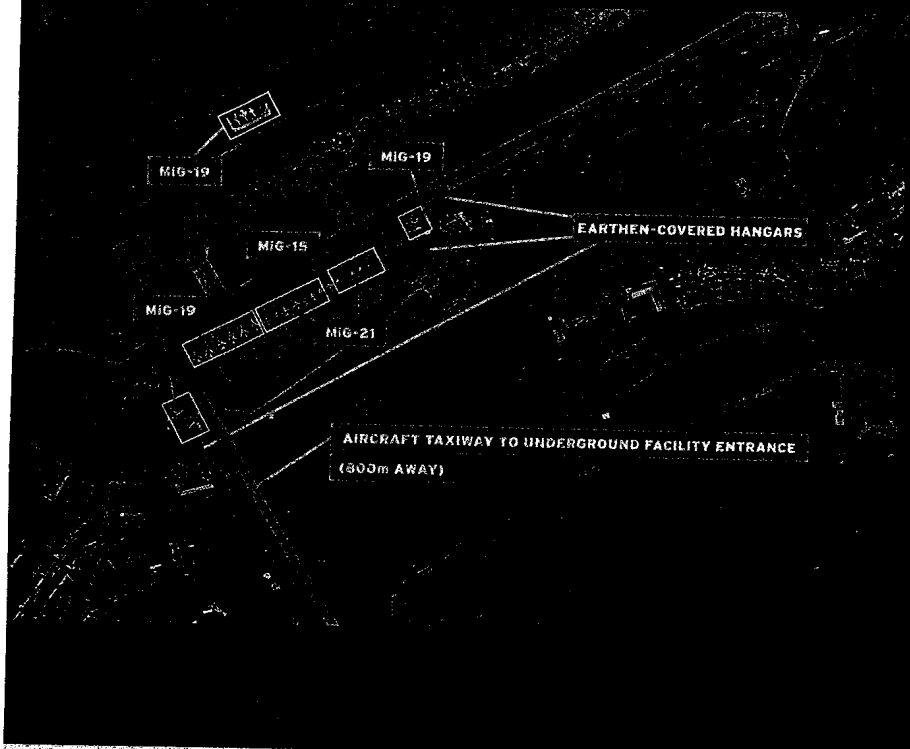


FIGURE 3 IKONOS image of Koksan Airbase, acquired October 15, 2000.

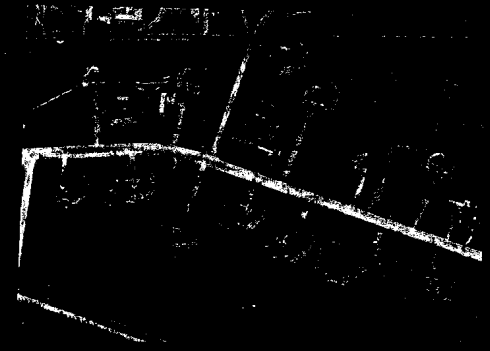


FIGURE 4 QuickBird image of An-2 (Colt/Y-5) Biplanes at T'aech'on Airfield, photographed December 8, 2003.

“The pairing of commercial high-resolution satellite imagery with the testimony of North Korean defectors who were exposed to the Gulag creates a revealing window into this closed society.”

At a concentrate plant, uranium is extracted from ore, purified and concentrated in the form of yellowcake, which is a yellow-colored salt. The yellowcake produced at both Pakch'on and P'yongsan is shipped to the nearby Yongbyon nuclear complex for reactor fuel fabrication. The location where North Korea produces uranium hexafluoride from yellowcake is not known.

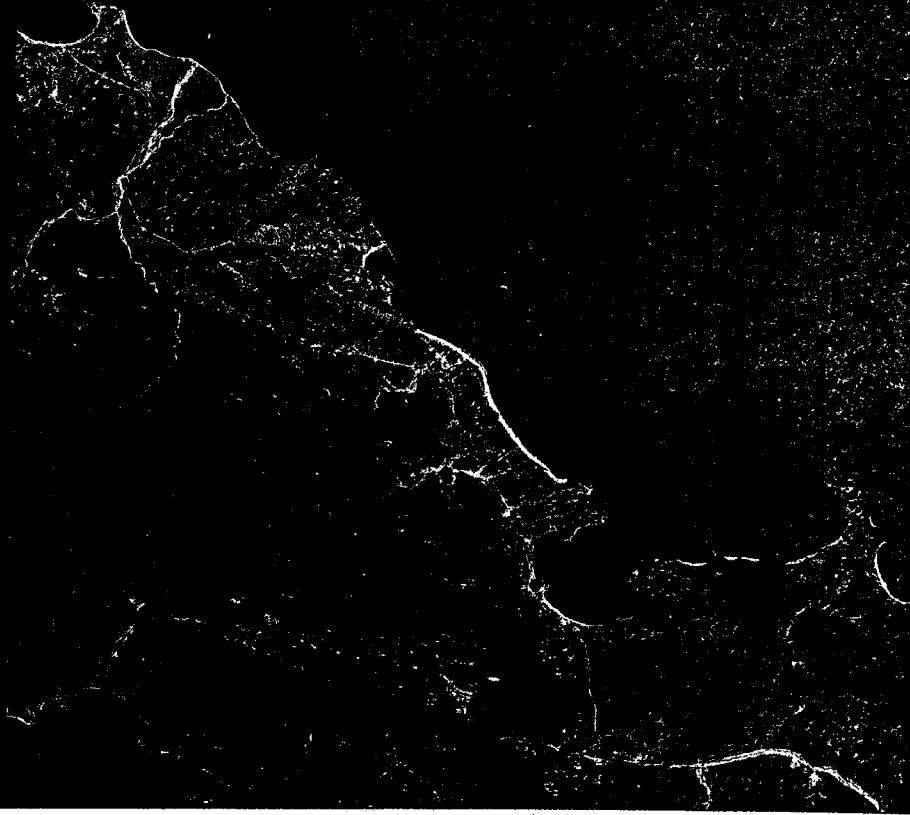
#### AN UNDERGROUND AIR FORCE

The missions of the Korean People's Air Force (KPAF) are to guard North Korea during peacetime and to perform limited offensive operations in the event of war. Perhaps overshadowing these roles for the KPAF in the eyes of South Korean and U.S. military planners is the possibility that a North Korean aircraft could be used to deliver nuclear weapons against Seoul or other targets.

NRDC analyzed high-resolution commercial satellite imagery of 21 North Korean air bases to extract data on the numbers of military aircraft of different types, on base activity, and on airfield infrastructure, including underground facilities. These photographs were acquired by QuickBird and IKONOS between October 2000 and May 2004. It is known that the KPAF conducts an annual winter training exercise from November through April, and about half of the satellite images were photographed during those months.

Using these remotely sensed data, about 40 percent of all DPRK airfields and 80 percent of DPRK airfields with hard surface runways were surveyed. The QuickBird and IKONOS sensors permitted differentiation of DPRK aircraft by type, and — assuming the same aircraft were not photographed at different air bases at different times — this limited set of images captured approximately two-thirds of the estimated numbers of North Korea's fixed-wing military aircraft. NRDC found that most of the aircraft appear to be deployed north of P'yongyang, greater than 100 kilometers from the DMZ.

FIGURE 5 ⇨ CNES/SPOT  
Image of North Korean Navy  
Bases on the east coast:  
Namae-ri and Kosong,  
acquired January 24, 1995 (©  
CNES/SPOT Image 1992-1994).



NRDC determined that 20 North Korean airbases contained underground facilities accessible to aircraft. Tunnel entrances can be seen in satellite images in the sides of hills typically about one hundred meters in height and several hundred meters from the main runway. Most of these underground facilities were observed to have two to four entrances.

Figure 3 shows an IKONOS image of Koksan airbase which is located in south-central DPRK, approximately 85 km from P'yongyang and 130 km from Seoul. Koksan is a primary operating airfield for North Korea's 3rd Air Division, the combat air division with responsibility for defense of the southern section of the country (along the DMZ).<sup>5</sup> A total of 50 MiG-19 and MiG-21 fighters (vintage 1950s Soviet-designed aircraft) are seen parked at the southwest end of the runway near several earthen-covered hangars. Just south of the 2.5-km main runway is a hill in which entrances to underground facilities can be seen in the satellite photo connected to the main runway by a taxiway. On the south side of the hill is a second underground entrance and an auxiliary runway. The two underground entrances on opposite sides of the hill are separated by 650 meters.

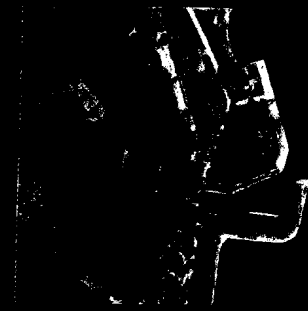
Of special concern would be the use of such a facility to shelter strike aircraft loaded with nuclear weapons. Seoul is no more than ten to twenty minutes in flight time from key DPRK air bases that have such underground shelters.

Significantly, most North Korean military aircraft are older models, technologically inferior to U.S. and South Korean planes. Almost 90 percent of KPAF aircraft were developed half a century ago or more. For example, a large number of North Korea's transport aircraft are biplanes. Figure 4 shows An-2 (Colt/Y-5) biplanes parked in or near revetments at T'aech'on airfield, located about 100 km north of P'yongyang. The Colt biplane, which is commonly used for crop dusting elsewhere in the world, holds patriotic symbolism for North Koreans, as these aircraft were used for bombing runs in the Korean War (which is known in the DPRK as the "Fatherland Liberation War"). Despite the limitations of the biplanes, the U.S. military has expressed concern about the possibility that these transport aircraft could insert DPRK special operations forces into South Korea to attack airfields or other targets.

#### SUBMARINE CAVES AND HOVERCRAFT

The Korean People's Navy (KPN) is primarily a coastal defense force, with a limited ability even to guard the DPRK's territorial waters. Geographically North Korea's Navy is divided into separate West Sea and East Sea fleets with about 400-500 vessels in each fleet. The combat ships of North Korea are a mixture of former Soviet, Chinese and indigenous construction. A significant number of the vessels are more than 20 years in age and most are smaller than 100 tons.

NRDC systematically scanned the DPRK coastline along the Korea Bay, Yellow Sea (western coastline) and the Sea of Japan (eastern coastline) using SPOT and Landsat imagery to pinpoint ports and potential KPN bases. Figure 5 shows CNES/SPOT imagery, which was purchased by NRDC from the U.S. government in the form of a data package called "10 Meter Resolution Digital Orthorectified Imagery" (DOI-10M), produced by the National Geospatial-Intelligence Agency (NGA).



**FIGURE 6** << QuickBird  
image of Submarine Cave at  
Ch'aho-nodongjagu Navy Base,  
acquired on June 29, 2002.



**FIGURE 7** >> IKONOS image  
of Hovercraft at a North Korean  
Navy Base at P'ungmu-ri,  
photographed April 24, 2000.

IKONOS and QuickBird imagery were then obtained for these areas of interest. Nearly all of the limited number of larger KPN vessels were identified, including diesel-powered submarines, 74-meter and 102-meter length frigates, 62-meter long T-class patrol craft and 42-meter long Soju-class missile ships. NRDC located a total of 48 North Korean submarines using QuickBird images at three KPN bases.

Like the KPAF bases, many of North Korea's Navy bases have underground structures. Ten entrances to such underground sites at six Navy bases are visible in the high-resolution satellite imagery. One example is the Ch'aho-nodongjagu Navy Base, located mid-way on the DPRK's eastern coast. *Figure 6* shows three Romeo-class diesel-powered submarines — two berthed along a concrete pier and one berthed near the entrance to the protective cave. A partially-open double door is visible at the cave entrance.

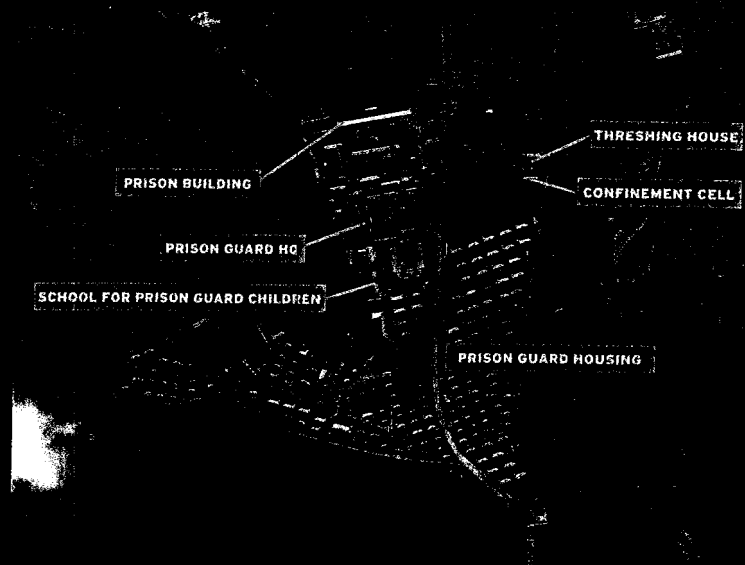
Hovercraft is another interesting class of KPN vessel that NRDC located in the high-resolution satellite imagery. In the 1980s the DPRK began constructing "Kongbang" class hovercraft, which measure about 20 meters in length. Their military role is to insert troops or special operations forces into South Korea in time of war, particularly via navigation of the tidal flats and mud pools along the western shoreline of the Korean peninsula. *Figure 7* shows 16 hovercraft located at a North Korean Navy Base at P'ungmu-ri on the eastern coast. Each hovercraft reportedly can carry 40-50 troops and travel up to 50 miles per hour.

#### **NORTH KOREA'S GULAG AND HUMAN RIGHTS ISSUES**

Beginning in the mid-1990s, several thousand North Koreans have made the difficult journey to South Korea to escape famine and political repression. A small fraction of these refugees has had experience with the extensive political prison camp system in the DPRK. In collaboration with the NRDC, the U.S. Committee for Human Rights in North Korea published an unprecedented systemic study of the North Korean political prison camp system, supplementing defector interviews with satellite imagery.<sup>6</sup>

Because objects such as buildings, forests, orchards, fields, fences, rivers, railways, trails, and roads are easily recognizable in IKONOS and QuickBird images, satellite photographs were shown to former North Koreans once imprisoned at these places who were then able to identify specific features in the photographs and describe their purposes. Interviews with former prisoners were conducted in Seoul, Washington, D.C., and Los Angeles.

FIGURE 8 >> IKONOS image of a section of Yodok Political Prison Camp, photographed on November 25, 2001.



The pairing of commercial high-resolution satellite imagery with the testimony of North Korean defectors who were exposed to the Gulag creates a revealing window into this closed society. Annotated satellite images of five sites in the North Korean Gulag offer a glimpse into the different sorts of work that prisoners are forced to perform: food production and mining camps, for example, at very large sites consisting of several villages spread over more than a hundred square kilometers. Smaller prison sites have factories or workshops where prison laborers are forced to produce bricks, clothing, shoes, or other goods.

An IKONOS image of a small section of the Yodok political penal-labor colony is shown in *Figure 8* (Yodok is a very large site — approximately 80 square km in size). Yodok is one of the most thoroughly described prison camps (documented from 1977 through 1999) because a small number of prisoners held there were released back into North Korean society. Yodok's capacity is reportedly 40,000 to 50,000 prisoners, most detained for their lifetimes. Forced labor activities at Yodok include mining and agriculture. It is notable that officials at P'yongyang have declared North Korea's Yodok district off limits to the United Nation's World Food Program.<sup>7</sup>

High-resolution satellite imagery has proven to be a highly effective tool to understand better the North Korean military and to verify and refine public estimates of DPRK air force and navy weapons systems. Unusual features of the North Korean military were captured in the photographs — entrances to submarine caves and underground runways — which have significance for the nuclear situation on the Korean peninsula. Furthermore, satellite imagery provides added documentation and the only photographic component to an understanding of the North Korean Gulag. NRDC's efforts have revealed remarkable and unique features of the "Hermit Kingdom." <<

*This report has not been previously published. It was presented in January 2005 to the Carnegie Endowment for International Peace in Washington, D.C., and was thereafter featured on CNN.*

#### FOOTNOTES

1. Joel Binkley, "Visiting Korea Base, Rice Sends Forceful Reminder to the North," *New York Times*, March 20, 2005.

2. The "six-party talks" involve the United States, China, Russia, Japan and South Korea in diplomatic negotiations with North Korea concerning its nuclear program. Three rounds of six-party talks have taken place in Beijing, in August of 2003, in February and in June of 2004.

3. Dafna Linzer, "U.S. Misled Allies About Nuclear Export; North Korea Sent Material To Pakistan, Not to Libya," *Washington Post*, March 20, 2005.

4. See the Nuclear Threat Initiative's North Korea country profile at [www.nti.org](http://www.nti.org).

5. Joseph S. Bermudez, Jr., *The Armed Forces of North Korea*, I.B. Tauris: London, 2001, pp. 128-130.

6. David Hawk, *The Hidden Gulag: Exposing North Korea's Prison Camps: Prisoners' Testimonies and Satellite Photographs (2003)*, available at [www.hrnk.org/hiddengulag-press.pdf](http://www.hrnk.org/hiddengulag-press.pdf).

7. As of October 30, 2003, the World Food Program had access to 163 of DPRK's 203 counties/districts; see [www.reliefweb.int](http://www.reliefweb.int).