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North Korean Nuclear Forces and the Threat of Weapons of Mass Destruction in Northeast Asia

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Introduction

The two Koreas differ sharply in their political and military need for missiles and weapons of mass destruction. South Korea is now a global economic power that is fully integrated into the international system. North Korea's economy is close to that of a failed state, and it needs nuclear weapons and missiles for both political prestige and leverage in negotiating with the United States and its neighbors.

The ROK has examined nuclear options. It has the capability to create nuclear weapons and possesses a sound base of nuclear technology to build upon. It also can almost certainly design and build cruise and ballistic missiles that can accurately reach any target in the DPRK, and can do so in a relatively short period of time. It has all of the technology and industrial base to design and build advanced chemical and biological weapons. This gives the ROK a near breakout capability to compete with North Korea if it chooses to do so. So far, however, it has chosen to rely on the United States for extended deterrence and has focused more on deploying advanced air and missile defense systems than offensive capabilities.

The DPRK, in contrast, lacks anything like the ROK's resource and technical base. Nevertheless, it is a long-standing chemical weapons power and has tested four nuclear devices – albeit with mixed success. It is actively developing long-range missiles and almost certainly has researched biological weapons and has the capacity to build them. So far, however, it has focused on offensive systems and it has not seriously modernized its air defenses or shown that it plans, or is able, to buy and deploy missile defenses.

Nuclear weapons and long-range missiles offer North Korea the ability to pressure or intimidate its neighbors. They give the DPRK added international status, they deter ROK and US counterattacks and escalation, and they provide a cheaper alternative than trying to compete with the ROK and the United States in modernizing conventional forces.

They also give Pyongyang a strong incentive to retain and expand its asymmetric capabilities. As the 2012 Japanese Defense White Paper notes, "North Korea seems to maintain and reinforce its

so-called asymmetric military capabilities by developing weapons of mass destruction (WMD) and ballistic missiles and by maintaining large-scale special operation forces."[1]

An ROK government report adds, "The development of asymmetric capabilities seems to serve three objectives: to secure military superiority over others, to have an effective bargaining chip, and to promote internal unity."[2]

US Director of National Intelligence James Clapper testified to the Senate in January 2014 that:[3]

> North Korea's nuclear weapons and missile programs pose a serious threat to the United States and to the security environment in East Asia, a region with some of the world's largest populations, militaries, and economies. North Korea's export of ballistic missiles and associated materials to several countries, including Iran and Syria, and its assistance to Syria's construction of a nuclear reactor, destroyed in 2007, illustrate the reach of its proliferation activities. Despite the reaffirmation of its commitment in the Second-Phase Actions for the Implementation of the September 2005 Joint Statement not to transfer nuclear materials, technology, or know-how, North Korea might again export nuclear technology.
>
> In addition to conducting its third nuclear test on 12 February 2013, North Korea announced its intention to "adjust and alter" the uses of existing nuclear facilities, to include the uranium enrichment facility at Yongbyon, and restart its graphite moderated reactor that was shut down in 2007. We assess that North Korea has followed through on its announcement by expanding the size of its Yongbyon enrichment facility and restarting the reactor that was previously used for plutonium production. North Korea has publicly displayed its KN08 road-mobile ICBM twice. We assess that North Korea has already taken initial steps towards fielding this system, although it remains untested. North Korea is committed to developing long-range missile technology that is capable of posing a direct threat to the United States. Its efforts to produce and market ballistic missiles raise broader regional and global security concerns.
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> Because of deficiencies in their conventional military forces, North Korean leaders are focused on deterrence and defense. We have long assessed that, in Pyongyang's view, its nuclear capabilities are intended for deterrence, international prestige, and coercive diplomacy. We do not know Pyongyang's nuclear doctrine or employment concepts

In his 2016 testimony, Clapper reemphasized these warnings. He noted that while the January 2016 nuclear test was unlikely to have been a hydrogen bomb, the DPRK remained a potent threat to the United States, stating:[4]

> North Korea has also expanded the size and sophistication of its ballistic missile forces—from close range ballistic missiles to intercontinental ballistic missiles (ICBMs)—and continues to conduct test launches. In May 2015, North Korea claimed that it successfully tested a ballistic missile from a submarine. Pyongyang is also committed to developing a long-range, nuclear-armed missile that is capable of posing a direct threat to the United States; it has publicly displayed its KN08 road-mobile ICBM on multiple occasions. We assess that North Korea has already taken initial steps toward fielding this system, although the system has not been flight-tested.

This mix of political and military factors has made the DPRK's nuclear programs – and efforts to acquire nuclear weapons and long-range ballistic missiles – a source of growing concern, and has led to ongoing negotiation and arms control efforts for the better part of two decades. Despite these efforts, the DPRK became the world's eighth atomic power when it conducted an underground nuclear weapons test in October 2006, and currently continues both its nuclear weapons and long-range missile programs.

DPRK Chemical and Biological Developments

The DPRK's nuclear programs are only part of this aspect of the military balance. Weapons of mass destruction include chemical, biological, radiological, and nuclear (CBRN) weapons. The DPRK reportedly possesses a sizable stockpile of chemical and, possibly, biological weapons as

well as the ability to mount them on conventional and unconventional delivery systems. It is also important to note that the balance also includes the CBRN weapons of outside actors like the United States and China, which may be a reason why the ROK has chosen (or been coerced) to maintain little, if any, CBRN stockpiles relative to the DPRK.

While Pyongyang openly declares itself to be a nuclear and missile power, it denies possessing chemical or biological weapons or agents. The DPRK acceded to the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction (BWC) in March 1987, but not to the Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on Their Destruction (CWC).[5]

A wide range of sources raise serious doubts about such DPRK denials. A 2000 Department of Defense (DOD) report to Congress stated,[6]

> We assess North Korea is self-sufficient in the production of chemical components for first generation chemical agents. They have produced munitions stockpiles…of several types of chemical agents, including nerve, choking, blister, and blood. We assess that North Korea has the capability to develop, produce, and weaponize biological warfare agents, to include bacterial spores causing anthrax and smallpox and the bacteria causing the plague and cholera.

The Nuclear Threat Initiative reports that,[7]

> …the DPRK is thought to be among the world's largest possessors of chemical weapons, ranking third only after the United States and Russia, who are working to destroy their Cold War caches. In its most recent assessment (2010), the South Korean Ministry of National Defense (MND) estimated the DPRK possesses between 2,500 and 5,000 metric tons of chemical weapons, including phosgene (choking), hydrogen cyanide (blood), mustard (blister), and sarin (nerve agent).

As long as the balance of conventional forces continues to be unfavorable for the DPRK, chemical weapons are likely to remain part of DPRK military strategy, and it seems likely that it has developed at least some biological agents.

There has been considerable debate among government officials and scholars as to whether or not the DPRK has the ability to put nuclear, biological, and/or chemical weapons on their missiles, especially on any potential ICBMs. While the country almost certainly does possess all the components – all three weapons types, as well as missiles – it is uncertain that the DPRK can now equip its ballistic missiles with reliable and effective WMD warheads:[8]

> For warheads armed with biological, chemical, and nuclear weapons, verification of their functionality is a must. During flight, warheads suffer extreme mechanical loads, vibrations, accelerations, wide temperature ranges, and pressure differences from near vacuum to extreme dynamic pressures at reentry. Chemical and biological agents are highly sensitive to temperatures, as are nuclear weapons. A nuclear weapon is a complex mechanical device, and the ejection mechanisms of biological and chemical weapons are complex, as well.
>
> The same is true for the respective detonators and fuses. The functionalities of these devices can only be proven under real conditions, thus requiring flight tests. No test flights with nuclear, biological, or chemical warheads in North Korea are known. The functionality and reliability of these weapons is therefore unknown, even to the North Koreans. If these warheads exist, either they have been imported from Russia or China, which seems highly unlikely, or they are unlikely to perform well once launched.

It is always possible, however, that the DPRK would arms its missiles with CBRN weapons even if they had uncertain or limited effectiveness, knowing that the political, intimidation, and terror effects would be all too real even n peace time, they could have some deterrent value out of sheer uncertainty on the part of the ROK and U.S., and force major defensive preparations in the case

of war. Moreover, the problems in creating effective chemical and biological weapons are much less severe with "slow fliers" like cruise missiles.

DPRK Chemical Weapons

The DPRK is one of only six countries[9] that has neither signed nor acceded to the Chemical Weapons Convention and is not expected to do so in the near-term due in part to the intrusive inspection and verification requirements mandated by the agreement.[10]

A number of sources indicate that the DPRK produced its first experimental chemical weapons during the late 1950s and early 1960s in the wake of the Korean War.[11] Since then, its chemical weapons program has increased in scale and lethality, and the DPRK now ranks among the world's largest possessors of chemical weapons. Many of the fire support systems in the DPRK inventory could deliver chemical agents and be employed in offensive military operations.

Western Estimates of DPRK Stockpiles and Capacity

According to a 2006 unclassified CIA report, the DPRK is believed to possess a sizable stockpile of chemical weapons. Since 1989, it has had the ability to indigenously produce bulk quantities of nerve, blister, choking, and blood chemical agents as well as a variety of different filled-munitions systems.[12]

The Nuclear Threat Initiative (NTI) provides similar data, alleging the DPRK's chemical arsenal to include four of the five major classes of chemical warfare (CW) agents, including phosgene (choking), hydrogen cyanide (blood), mustard (blister), and sarin (nerve agent). North Korea does not appear to possess nervous system incapacitants such as BZ. Nerve agents (i.e., Sarin and VX) are believed to be the current focus of the DPRK's CW production.[13] Additionally, GlobalSecurity.org estimates that the DPRK may produce tabun and adamsite.[14] However, the DPRK may require imports of some specific precursors to produce nerve agents that are relatively more difficult to fabricate than the first generation blister, blood and choking agents.[15]

The International Crisis Group (ICG) and IISS also provide estimates of possible DPRK CW agents, and other reports indicate that the DPRK appears to have increased its CW agent production capacity in the last two decades and has been able to develop and deploy a variety of delivery systems.

The country's arsenal includes thousands of artillery of various calibers and hundreds of forward-deployed *Hwasong*-5/-6 missiles and *Frog*-5/-7 missiles capable of being fitted with chemical warheads.[16] According to defector accounts, the DPRK 's long-range missiles such as the *Nodong* and other ballistic rockets and artillery pieces with calibers larger than 80 mm are capable of delivering CW agents, and beginning in 2002 the DPRK began to substantially increase the number of long-range multiple rocket 280 mm and 320 mm launching systems near the DMZ.[17]

The possible range of DPRK chemical weapons is shown in **Figure V.1.**

Figure V.1: DPRK Possible CW Agents

AGENT	AGENT ID	MAJOR EFFECTS

Blister Agents		
Lewisite	HD	Cutaneous (skin): Pain and irritation of eyes and skin followed by blisters and lesions on the skin. Pulmonary (inhalation): runny nose, hoarseness, bloody nose, sinus pain, coughs. Intestinal: diarrhea, nausea, vomiting.
Mustard Agents	L, H	Cutaneous (skin): Pain and irritation of eyes and skin followed by blisters and lesions on the skin. Pulmonary (inhalation): runny nose, hoarseness, bloody nose, sinus pain, coughs. Intestinal: diarrhea, nausea, vomiting.
Choking Agents		
Phosgene	CG	Coughing, blurred vision, shortness of breath, nausea, pulmonary edema, heart failure, death.
Diphosgene	DP	Coughing, blurred vision, shortness of breath, nausea, pulmonary edema, heart failure, death.
Vomiting Agents		
Adamsite	DM	Coughing, severe headache, muscle spasms, chest pains, shortness of breath, nausea, vomiting.
Vomiting Agent	DA	Headache, nausea, vomiting, diarrhea, abdominal cramps.
Chloropicrin	PS	Coughing, severe skin irritation on contact, corneal edema and liquefaction of the cornea, pulmonary edema.
Tear Gas	CN	Tears, coughing, mucus, burning in the nose and throat, disorientation, dizziness restricted breathing, burning of the skin.
Tear Gas	CS	Tears, coughing, mucus, burning in the nose and throat, disorientation, dizziness, restricted breathing, burning of the skin.

Blood Agents		
Cyanide (Hydrogen Cyanide/Cyanogen Chloride)	ANCK	Rapid breathing, dizziness, weakness, headache, nausea, vomiting.
Nerve Agents		
Tabun	GA	Runny nose, watery eyes, rapid breathing, nausea, unconsciousness, paralysis, respiratory failure, death.
Sarin	GB	Runny nose, watery eyes, rapid breathing, nausea, unconsciousness, paralysis, respiratory failure, death.
Soman	GD	Runny nose, watery eyes, rapid breathing, nausea, unconsciousness, paralysis, respiratory failure, death.

VX	--	Salivation, runny nose, sweating, shortness of breath, muscle spasms, unconsciousness, death.
VE	--	Salivation, runny nose, sweating, shortness of breath, muscle spasms, unconsciousness, death.

For further information see:

• Organization for the Prohibition of Chemical Weapons (OPCW): http://www.opcw.org/resp/html/cwagents.html

• World Health Organization (WHO):www.who.int/csr/delibepidemics/biochem_threats.pdf

• Carnegie Endowment for International Peace:www.ceip.org/files/publications/RegimeAppendix7.asp?p=

• NATO Handbook on the Medical Aspects of NBC Defensive Operations AmedP-6(B): http://www.fas.org/nuke/guide/usa/doctrine/dod/fm8-9/toc.htm

• US Government, the Chemical & Biological Warfare Threat; US Army Medical Research Institute of Chemical

Defense, Chemical Casualty Care Division, http://ccc.apgea.army.mil.

Source: International Crisis Group, *North Korea's Chemical and Biological Weapons Programs*, Asia Report No. 167, June 18, 2009, 25, http://www.crisisgroup.org/~/media/Files/asia/north-east-asia/north-korea/167_north_koreas_chemical_and_biological_weapons_programs.pdf; John Chipman, "North Korea's Chemical and Biological Weapons (CBW) Programs," *North Korea's Weapons Programs*, IISS, 2004, 55.

Korean Estimates of DPRK Stockpiles and Capacity

Official reports and testimonies from North Korean defectors are uncertain, but most agree with the ROK Ministry of National Defense (MND), which in its most recent assessment in 2010 indicated that the DPRK could possess between 2,500 and 5,000 metric tons of chemical weapons. These estimates are summarized in **Figure V.2**.[18] The ROK also estimates that the DPRK is capable of producing 12,000 metric tons.[19]

Kwon Yang-Joo of The Korea Institute for Defense Analyses (KIDA) agreed with this analysis in an October 2010 report, stating that the DPRK was capable of producing "up to 12,000 tons of chemical weapons," which could "contaminate about 2,500 square kilometers (950 square miles), four times the area of Seoul."[20]

This stockpile is not believed to be increasing, however, because there is no indication of the necessary expansion of storage facilities to do so.[21]Despite this, South Korea continues to be vigilant, and distributed gas masks to civilians and civil defense corp members in the month following the Yeonpyeong Island shelling.[22]

Guesstimates of Key Locations

The DPRK maintains a number of facilities involved in producing or storing chemical precursors, agents, and weapons that are shown in **Figures V.3 and V.4**. GlobalSecurity.org estimates that North Korea has at least eight industrial facilities that can produce chemical agents; however, the production rate and types of munitions are uncertain.[23]

ICG also has reported that the DPRK's Second Natural Science Academy conducts weapons-related research and development and that the main CW research facility is co-located with a production plant in Kanggye City, Chagang Province.[24] In addition, a number of civilian chemical facilities have been implicated in chemical weapons production, such as the Manpo Chemical Factory and Aoji-ri Chemical Complex.[25]

Chemicals are part of heavy industry and a key component for the DPRK's economy, especially in an atmosphere in which military preparedness is strongly emphasized. All chemical production – and other heavy industry – is militarized in North Korea, though it is unclear exactly how much of the production is geared towards chemical warfare. According to the NTI, the DPRK has:[26]

4 military bases equipped with chemical weapons

11 facilities where chemical weapons are produced and stored

13 locations where research and development is carried out relating to chemical weapons

2 facilities near the cities of Kanggye and Sakchu are reportedly equipped for CW agent final preparation and filling of artillery shells, as well as testing, possibly in large underground facilities

The DPRK's leadership has traditionally had total control over procedure and policy regarding armaments production. The National Defense Commission (NDC) is the highest military industry-related decision-making body, and the Second Economic Committee (SEC) is directly subordinate to it. Set up in the 1970s, the SEC is key for the majority of DPRK planning, development, manufacturing, and distribution of ordnance and WMD. The SEC is located in Kangdong-kun, Pyongyang, and controls eight bureaus and 190 munitions factories. The Ministry of Chemical Industry is separate from this line of command, but likely coordinates production and transfer of CW agent intermediaries with the SEC and its subordinate bureaus. The eight bureaus are:[27]

- A general affairs office
- First Machine Industry Bureau: ammunition and small arms
- Second Machine Industry Bureau: armored personnel carriers (APCs) and tanks
- Third Machine Industry Bureau: multi-stage rockets
- Fourth Machine Industry Bureau: guided missiles
- Fifth Machine Industry Bureau: chemical, biological, and nuclear weapons
- Sixth Machine Industry Bureau: submarines and battleships
- Seventh Machine Industry Bureau: production and purchase of war aircraft

While the SEC establishes requirements, the Fifth Machine Industry Bureau is the most important for chemical and biological weapons in that it carries out the production of the agents. The Nuclear and Chemical Defense Bureau (NCDB) is directly subordinate to the General Staff Department, is responsible for offensive and defensive chemical operations, and is in charge of the filling, storage, and handling of munitions. The NCDB works in the research and development of chemical weapons as well as undertakes chemical and nuclear defense measures. It is composed of seven department units and two further research institutions:[28]

- Operations unit
- Training unit
- Materials unit
- Technology unit
- Reconnaissance unit
- Mining/underground facility operations unit

- Section 32 unit (reportedly working in developing specialized chemical-delivery warheads for the Nodong-1 missile)
- Section 55 [research institute]: simulating nuclear and chemical contamination for decontamination operations and training (approximate research staff of 70)
- Section 398 [research institute]: decontamination operations in both nuclear and chemical environments and is reportedly developing antidotes, masks, and suits (approximately 250 researchers)

Munitions plants located at Ganggye and Sakju are nominally civilian, but are under the control of the SEC's General Machine Industry Bureau and the NCDB's Equipment Department. At these locations, chemical weapons agents from the Fifth Machine Industry Bureau are inserted into artillery shells (including mortar shells) previously received from the Third Machine Industry Bureau. Also at these two plants, aerial munitions and chemical spray tanks are prepared and can be used in wartime when filled with chemical agents from bulk storage facilities located at various airfields. Factory 279 produces defensive equipment, such as protective suits, detection systems, and decontamination chemicals.[29]

After the munitions are assembled and filled, they are taken to the Maram Materials Corporation (Maram neighborhood, Yongsong district station, Pyongyang) and the Jiha-ri Chemical Corporation (in Pangyu-gun, Gangwon province) for storage. It has been reported that DPRK chemical weapons storage facilities are in underground tunnels, with the agents stored in 12-foot-high tanks along with Factory 279's defensive materials.[30]

According to an ROK source in 2002, the DPRK has several different chemical troops under different organizations. The NCDB has eight battalions in its department of operations – the 17th and 18th battalions are considered active, while the 13th, 14th, 15th, 16th, 27th, and 36th are reserve.

The 18th Nuclear Chemical Defense Battalion is composed of six companies; according to a DPRK defector, the 18th Battalion has a nuclear/chemical reconnaissance company (the 1st Company), while the 2nd, 3rd, 4th, and 5th companies are "decontamination" units. The 6th company is flame-throwers and likely obscurant smokes (also referred to as "Smoke Screen Company"), which had once been located in Sadong district station, Pyongyang, and had been transferred to the 18th Battalion in 1993. According to the defector, none of these companies have specific offensive duties, instead being primarily concerned with reconnaissance and decontamination.[31]

Defensive Preparations

In spite of the lack of any key threat in kind, the DPRK has devoted considerable resources to defensive measures aimed at protecting its civilian population and military forces from the effects of chemical weapons. Such measures include extensive training in the use of protective masks, suits, detectors, and decontamination systems.[32]

The DPRK has chemical defense units at all levels of its forces equipped with decontamination and detection equipment, and DPRK military units conduct regular NBC (nuclear-biological-chemical) defensive training exercises in preparation for operations in a chemical environment.[33] Though these measures seem to be focused on a perceived threat from US and ROK forces, they could also support the offensive use of chemical weapons.

Figure V.2: Defector Reports on the DPRK CW Program (as of 2004)

Name	Background	Defector Comment
Yi Chung Kuk	Sergeant in the 18th Nuclear and Chemical Defense Battalion in the early 1990s. Defected in March 1994.	Warned that the DPRK was capable of killing everyone in the ROK with chemical and bacterial weapons. Linked the Sunchon Vinalon Complex to the DPRK's CW program.
Choi Ju Hwal	Served in the Ministry of Defense from 1968 to 1995. (Acknowledged that he did not have direct knowledge of the CBW program, but he obtained second-hand information from other officials.)	As of 1997, the DPRK had stockpiled over 5,000 tons of toxic gases, including nerve gases (sarin, soman, tabun, and V agents), first-generation blister gases (lewisite and mustard gas), and blood agents (hydrogen cyanide and cyanogen chloride). Choi identified numerous facilities associated with CW research and production, including several civilian chemical factories involved in vinalon production.
Yi Sun Ok	Inmate at a DPRK prison. Defected in 1995.	Said that some 150 fellow inmates died due to a chemical weapons test.
Hwang Chang Yop	Secretary of the DPRK's Workers Party. Defected in August 1996.	Claimed that the DPRK had both nuclear and chemical armed missiles capable of hitting the ROK and Japan. He quoted the DPRK leadership as saying that the DPRK ranked third or fourth in the world in chemical weapons.
Yi Chun Sun	Commander of a missile station. Defected from the KPA in 1999.	Said that chemical agents are produced in Factory 102.
Yi Mi (pseudonym)	Worked at the Yongbyon nuclear complex. Defected in September 2000.	Said the 304 Lab mainly worked on nuclear weapons development but also conducted research and development in chemical weapons.

Source: Chipman, "North Korea's Chemical and Biological Weapons (CBW) Programs," *North Korea's Weapons Programs*, 54.

Figure V.3: Map of Possible DPRK Chemical Facilities

Note: Locations are approximate.

Sources: International Crisis Group, *North Korea's Chemical and Biological Weapons Programs*, Asia Report No. 167, 23; Chipman, "North Korea's Chemical and Biological Weapons (CBW) Programs," *North Korea's Weapons Programs*, 50–52.

Figure V.4: Major DPRK Civilian Chemical Production Facilities (as of 2004)

Aoiji-ri (Haksong-ri) Chemical Complex	Production of methanol, ammonia, ammonium bicarbonate, coal tar derivatives, and liquid fuel products. About 3,500 employees. Processes 600,000 tons of lignite coal processing per year; produces 100,000 tons of ammonium bicarbonate and 35,000 tons of methane per year.
April 25th Vinalon Factory (Hamhung)	Produces 540,000 tons per year of fertilizer, herbicides, and pesticides. Other products include ammonia, as well as other chlorine-based pesticides – probably DDT and chlordane, among others.
February 8th Vinalon Complex (Hamhung)	One of the largest chemical facilities in the DPRK. Around 10,000 employees. Comprises about 50 large buildings. Produces 50,000 tons of vinalon and 10,000 tons of movilon per year. Also produces carbide, methanol, sodium hydroxide, livestock feed, sodium carbonate, vinyl chloride, and agricultural insecticide.
Hamhung Chemical Factory	Produces sulfuric acid, nitric acid, ammonia, and fertilizer products.
Hungnam Chemical Fertilizer Complex (Hamhung)	Produces ammonium sulphate, ammonium nitrate, phosphate, and urea. Employs more than 10,000 people. Production capacity of 1.4 million tons (unclear whether annual capacity or other time period).
Institute of Chemistry, Hamhung	R&D, education, and training in applied chemistry. Established in 1960.
Chongjin Chemical Fiber Complex	Employs around 3,000 people. Produces 300 tons of pesticides, 10,000 tons of other chemical products, and 30,000 tons of synthetic fiber per year. Also produces carbonic acid, formalin, and phenol.
Chongsu Chemical Complex	Production of large quantities of calcium carbide and smaller amounts of phosphate fertilizer and calcium cyanamide.
Hwasong Chemical Factory	Produces agricultural chemicals and 2,500 tons of phenol per year. Unknown iodine capacity.
Hyesan Chemical Factory	Produces chemicals such as benzol, phenol, and hydrochloric acid.
Manpo Chemical Factory	Produces ammonia, sodium hydroxide, and sulfuric acid.
Namhung Youth Chemical Complex	Produces ammonia, ethylene, fertilizers, fibers, and paper. Annual production capacity of approximately 500,000 tons.
Sariwon Potash Fertilizer Complex	Produces Fertilizers – planned production target of 510,000 tons per year of potash fertilizer (unclear whether annual capacity or other time period).

Shinhung Chemical Complex	Produces calcium hypochlorite, caustic soda, dyes, hydrochloric acid, paints, vinyl chloride, polyvinyl chloride, potassium carbonate, sodium carbonate, sodium bicarbonate, barium chloride, ammonium sulfate fertilizer, magnetized fertilizer, slag fertilizer, and sulfuric acid fertilizer.
Sinuiju Chemical Fiber Complex	Produces calcium cyanide, chlorine, sodium hydroxide, sulfuric acid, synthetic fiber, and paper products. Annual production capacity of 107,000 tons.
Sunchon Vinalon Complex	The DPRK's largest chemical production facility with about 50 affiliated factories. First stage of construction completed in 1989; final construction reportedly still not completed as of 2000. Estimated annual production (if completed) of 100,000 tons of vinalon, one million tons of carbide, 750,000 tons of methanol, and 900,000 tons of vinyl chloride.
Sunchon Calcium Cyanide Fertilizer Factory	One of the DPRK's four major fertilizer plants. Produces calcium cyanide and calcium carbide. Annual chemical production capacity of 100,000–150,000 tons. Probably a part of the Sunchon Vinalon Complex.
Source: Based on information from the NTI's website: http://www.nti.org/e_research/profiles/NK. This draws on information from documents such as 'DPRK Factories Suspected of Producing Chemical Agents,' FBIS: KPP2001021600106; 'Alleged Locations of DPRK Nuclear, Biological, Chemical Warfare Facilities Mapped,' 6 June 2001, FBIS: KPP20010606000075; 'North Korean Chemical Industry,' FBIS: FTS19981230001322; and 'Chemical Engineering, Experts Described,' 23 December 1999, FBIS: FTS199991223001168. Chipman, "North Korea's Chemical and Biological Weapons (CBW) Programs," *North Korea's Weapons Programs*, 50.	

DPRK Biological Weapons

Much less is known about the North Korean biological warfare program than about its chemical warfare program. The DPRK acceded to the Biological and Toxin Weapons Convention (BTWC) in March 1987, but most official estimates conclude that the DPRK possesses the scientists and facilities for producing traditional infectious biological warfare (BW) agents and weapons, and has done so since the 1960s. Several DPRK defectors have claimed that the North tested biological and/or chemical weapons on mentally or physically deficient children and concentration camp prisoners.[34]

Capabilities

An April 2012 ROK official report stated that the DPRK was able to equip its rocket launchers, mortars, and field artilleries with biological weapons and assessed that botulinum toxins, smallpox, and anthrax were the most likely to be weaponized.[35] The South Korean government further estimated that half of the DPRK's long-range missiles and 30% of its artillery were able to deliver biological or chemical weapons, though it was unknown if the North was able to equip missiles/artillery in a way that would allow the biological payloads to survive and effectively disperse.[36]

As the DPRK appears to be focusing on improving its nuclear and missile capabilities, recent assessments have tended to downgrade the threat of biological weapons, compared with past assessments.[37] There is, however, no clear public source of evidence as to its actions and intentions.

North Korea has dual-use facilities that could be used to produce biological agents and a munitions industry that could be used to weaponize such agents – a recent Deputy DNI report, noted that "North Korea has a biotechnology infrastructure that could support the production of various BW agents."[38] However, there is not enough information to determine whether Pyongyang has progressed beyond the research and development stage and actually has stocks of biological weapons. But while the DPRK may not possess ready-to-use weapons, it certainly has the technical abilities to produce them.

According to GlobalSecurity.org, Pyongyang's resources presently include a rudimentary (by Western standards) biotechnology infrastructure that is sufficient to support the production of limited quantities of toxins as well as viral and bacterial biological warfare agents.[39]

BW agents are reportedly cultured in both civilian and military-related research institutes in the DPRK, and, according to NTI, pathogens that have possible utility for BW and that are allegedly being researched and developed by the DPRK include: Bacillus anthracis (anthrax), Clostridium botulinum (botulism), Mycobacterium tuberculosis (tuberculosis), Rickettsia prowazekii (typhus), Salmonella typhi (typhoid), Vibrio cholerae 01 (cholera), Yersinia pestis (plague), Korean hemorrhagic fever, Variola major (smallpox), Yellow fever virus (yellow fever), Dysentery, Brucellosis, Staphylococcus aureus, and Yellow Rain (T-2 Micro Toxins)

These possible agents are described in **Figure V.5**.[40]

Figure V.5: Possible DPRK Biological Agents

TYPE	SYMPTOMS/CHARACTERISTICS	STATUS
Bacteria		
Bacillus anthracis (Anthrax)	Pulmonary (inhalation): difficulty breathing, exhaustion, toxemia, terminal shock. Cutaneous (skin): itching, small lesions and possible blood poisoning. Intestinal: nausea, fever, diarrhea. Mortality (if untreated): Pulmonary 80–95%; Cutaneous 5–20%; Intestinal 25–60%. Incubation period: Symptoms usually occur with 7 days. Not contagious.	Possibly weaponized, with delivery system
Vibrio cholera (Cholera)	Diarrhea, vomiting, and leg cramps. Rapid loss of body fluids, dehydration and shock. Mortality (if untreated): 5–10%. Death in 1–3 hours. Not contagious.	Unknown
Yersinia pestis (Plague)	Fever, headache, exhaustion, swollen lymph nodes, blood infection, and pneumonia. Mortality (if untreated): 50–60%. Incubation period: 1–3 days, death in 2–6 days. Contagious.	Unknown
Salmonella Typhi (Typhoid Fever)	Fever, malaise, chills, stomach pains, headache, loss of appetite, and rash. Mortality (if untreated): 12–30%. Contagious.	Unknown
Typhus	Fever, headache, chills, whole body rash, and general pains. Mortality (if untreated): 30–50%. Incubation Period: 6–12 days. Not contagious.	Unknown
Mycobacterium tuberculosis (tuberculosis)	Coughing, chest pain, fatigue, loss of appetite, chills, fever, and coughing blood. Mortality (if untreated): 30–50%. Incubation period: 14 days–1 year. Contagious.	--
Virus		
Hemorrhagic fever (Korean Strain)	Fever, fatigue, dizziness, muscle aches, exhaustion, internal bleeding, coma, delirium, and seizures. Mortality (if untreated): 5–15%. Incubation period: 7–17 days. Contagious.	Unknown
Variola (smallpox)	Fever, malaise, aches, rash, and crusting scabs. Mortality (if untreated): 30–40%. Incubation: 7–17 days. Contagious.	Unknown
Yellow Fever	High fever, chills, headache, muscle aches, and vomiting; can lead to shock, kidney, and liver failure. Mortality (if untreated): 5–40%. Incubation: 3–6 days. Not contagious.	--
Toxin		
Clostridium Botulinum (Botulism)	Nausea, weakness, vomiting, and respiratory paralysis. Mortality (if untreated): 60–90%. Incubation: 12–36 hours after inhalation. Death in 24–72 hours. Not contagious.	Unknown

Note: World Health Organization, http://www.who.int/csr/delibepidemics/en/annex3May03.pdf; NATO, *Handbook on the Medical Aspects of NBC Defensive Operations AmedP-6(B)*, http://www.fas.org/nuke/guide/usa/doctrine/dod/fm8-9/2toc.htm; and US Army Medical Research Institute of Infectious Diseases, *Medical Management of Biological Casualties Handbook*, http://www.usamriid.army.mil/education/bluebook.html; and Centers for Disease Control, http://www.cdc.gov.
Source: Nuclear Threat Initiative, "North Korea: Biological," http://www.nti.org/country-profiles/north-korea/biological/; Chipman, "North Korea's Chemical and Biological Weapons (CBW) Programs," *North Korea's Weapons Programs*, 50.

Facilities

A number of DPRK facilities have been linked to ongoing work in biological weapons research, development, and manufacture that are shown in **Figures V.6 and V.7**. Although the indicators involved are often uncertain, the IISS provides a detailed list and map of possible facilities.

Additionally, the ROK MND estimated in 2001 that the DPRK maintains at least three possible BW production facilities and six BW or BW-related research centers, including the No. 25 Factory in Chongju, the Central Biological Weapons Research Institute in Pyongyang and a plant in the City of Munchon, Kangwon Province. One ROK newspaper reported the existence of more than 10 facilities, while NTI has also reported a number of facilities in addition to the No. 25 Factory linked to BW production. They include:[41]

- The Research Institute of the Armed Forces Ministry (synonymous with the Bacterium Research Institute, Second Academy of Natural Sciences), responsible for developing biological weapons.
- A Biological research facility located in Songch'on County, South P'yongan Province, adjacent to the Onjong-ni chemical weapons facility; growth media is allegedly supplied (approximately 200 tons per year) by a facility in Munchon, Kangwon Province.
- A germ-producing facility known as the 25 February Plant (also known as the 25 Plant), located in Chongju, North Pyongan Province.
- The National Defense Research Institute and Medical Academy (NDRIMA), which conducts studies on disease pathogens such as the bacteria and viruses that cause anthrax, cholera, bubonic plague, smallpox, yellow fever, and others.

In 2015, pictures depicting the Pyongyang Bio-technical Institute (which Kim Jung Un was visiting) were released by the North Korean media. Subsequent analysis determined that the site could potentially be used to produce mass quantities of anthrax.[42]

Few details are known about these facilities or which, if any, microorganisms have been or are being weaponized. Regardless, whatever the status of its biological weapons efforts, the DRPK possesses a number of dual-use biotechnology facilities that could be used to research biological weapons agents and produce militarily significant quantities of biological agents.[43]

Figure V.6: Civilian DPRK Biological Facilities

Aeguk Compound Microbe Center	R&D and production of microbial-based fertilizer supplements.
Aeguk Preventative Medicine Production Factory	Comprised ten laboratories and various workshops devoted to R&D and production of vaccines and medicines. The main product has been hepatitis B vaccine.
Branch Academy of Cell and Gene Engineering	One of nine research branches of the Academy of Sciences. Conducts research on cellular biology and genetic engineering.
National Sanitary and Anti-Epidemic Research Center	Administers quarantines and provides inoculations against various diseases.
Endocrinology Institute	Mainly diagnoses and treats diabetes.
Industrial Microbiology Institute	R&D and production of microbial cultures.
Munchon Agar Plant	Agar (growth media) production. As of 1992, the annual agar production capacity was 200 tons.
Pharmaceutical Institute of the Academy of Medical Sciences	R&D of medicaments. Reportedly located in Pyongyang.
Pyongyang Pharmaceutical Factory	As of August 2000, the factory produced seven drugs, including antibiotics and multivitamins. Has received raw materials and support from UNICEF and Diakonie Emergency Aid of Germany.
Synthetic Pharmaceutical Division, Hamhung Clinical Medicine Institute	R&D of medicaments and clinical diagnostics.
Taedonggang Reagent Company	R&D of vaccines. Previously known as the November 19 Institute.

Sources: NTI, "North Korea: Biological"; "DPRK's NAS Pursues Cultivation of Stock Bacteria for Microbial Fertilizers," Chungang Ilbo, January 17, 2000; "DPRK Korea Donor Update," UNICEF Emergency Programs, August 7, 2000, http://www.reliefweb.int; Chipman, "North Korea's Chemical and Biological Weapons (CBW) Programs," *North Korea's Weapons Programs*, 50.

Figure V.7: Map of Possible DPRK Civilian Biological Facilities

Source: Chipman, "North Korea's Chemical and Biological Weapons (CBW) Programs," *North Korea's Weapons Programs*, 57.

DPRK Nuclear Developments

US intelligence estimates of the DPRK's nuclear weapons program have long warned that the DPRK has an active program. It is clear that Pyongyang has effectively ignored or terminated its past agreements to limit the production of nuclear materials and missile tests, posing very real concerns not only in the region, but also in the International community.

According to a May 2010 UN Security Council report on the DPRK's nuclear program, "the Democratic People's Republic of Korea believes…that its nuclear programmer can provide the country a way to achieve its stated goal of becoming a 'strong and prosperous country' (*kangsongdaeguk*) by the year 2012 without succumbing to what they view as 'foreign influences.'"[44]

Motivations for Acquisition

The broad rationales for the DPRK's efforts have already been discussed. The DPRK noted in a state-run newspaper, "The DPRK was left with no option but to choose the way of accessing nuclear deterrent in order to put an end to the U.S. ever-more intensified nuclear threat and defend the sovereignty, dignity, and vital rights of the country" – making nuclear weapons a matter of defense and dignity, not offense.[45]

In June 2010, a DPRK Foreign Ministry spokesman stated that "recent developments" have underscored the need for the DPRK "to bolster its nuclear deterrent in a newly developed way."[46] Given the aggressiveness in the DPRK sinking of the ROK Corvette *Cheonan* in March 2010 and the shelling of Yeonpyeong Island in November, there may be little possibility that the DPRK will give up its nuclear weapons program any time soon.

US officials assess DPRK nuclear capabilities as "being more for deterrence, international prestige, and coercive diplomacy than for war fighting, and assess that Pyongyang most likely 'would consider using nuclear weapons only under narrow circumstances.'"[47]

One former DOD official called the DPRK's nuclear weapons acquisition a "survival game" in that nuclear weapons are the only reason anyone pays attention to the DPRK, which is necessary for the regime to gain aid and assistance. As the poorest country in the region, it would receive little without calling attention to itself so forcefully.[48] Furthermore,[49]

> It should also be considered that even speculative sources estimate that North Korea cannot have more than a few nuclear weapons available. If they exist, these devices are very precious to the regime, and it seems unlikely that they would be mounted on inaccurate and unreliable missile systems—the risk of "loosing" a weapon is simply too high. Of course, a singular shot can never be totally ruled out, but the chances of success are very low. And even if this unlikely event was to happen, with North Korea unable to repeat this feat on short notice, this scenario should be seen more like a terrorist attack than nuclear warfare.

DNI James R. Clapper noted in 2011,[50]

> Based on the scale of the facility and the progress the DPRK has made in construction, it is likely that North Korea has been pursuing enrichment for an extended period of time. If so, there is clear prospect that DPRK has built other uranium enrichment related facilities in its territory, including likely R&D and centrifuge fabrication facilities, and other enrichment facilities. Analysts differ on the likelihood that other production-scale facilities may exist elsewhere in North Korea.

Ironically, the Arab Spring may have acted as a further incentive to the DPRK. Some experts feel that North Korea sees Muammar Qaddafi's willingness to give up Libya's nuclear programs as one reason that the UN and NATO were willing to impose a no-fly zone and make a de facto

effort to remove him from power. It also sees India, Iran, Israel, and Pakistan as examples of states whose nuclear efforts also give them political and military leverage where they may not have had it. Looking at the examples of Libya and Iraq, countries that gave up their WMD programs, the DPRK state media outlet noted on April 4, 2013 that "the nuclear weapons of Songun Korea are not something for display and the DPRK is very different from Iraq, Libya and the Balkans."[51]

In any case, the DPRK's third nuclear test in February 2013 signaled that it was attempting to establish itself as a nuclear power or, at the very least, a de-facto nuclear state – like Israel, India, and Pakistan – a nation that is implicitly recognized as a nuclear state by the international community, though not formally recognized under the NPT framework. The Institute for Science and International Security ISIS) also reported in August 2013, that satellite data indicated that the DPRK might have doubled the area used to enrich uranium at its Yongbyon reactor complex – its key source of weapons grade material – over the previous months.[52]

It is also clear that the DPRK stepped up its nuclear research and production activity in 2014, as well as gave indications that it planned new nuclear tests in June and November.[53] Gen. Curtis M. Scaparrotti, the Commander of US forces in the ROK stated publically on October 24, 2014 that he believed that the DPRK had probably developed a nuclear weapon small enough to be used in a nuclear warhead on a ballistic missile.[54]

Scaparrotti's public statement at a Pentagon press conference was particularly significant because of the uncertainty as to the DPRK's ability to deploy nuclear missile warheads, and an intelligence incident in April 2013, when the Defense Intelligence Agency had issued a statement that it had concluded with "moderate confidence" that the DPRK now had the technology to make a nuclear weapon small enough to fit a ballistic missile warhead. A few days later, James R. Clapper Jr., the Director of National Intelligence, stated that the DIA's one-paragraph assessment had been declassified by mistake, and was inadvertent disclosure that revealed competing views on the country within the United States' spy agencies.[55]

Assessments of Capabilities: Plutonium

It is difficult to determine just how large the DPRK's nuclear program is and how much progress it is making. The DPRK is an extremely isolated and secretive state and provides few signals of the existence – let alone the extent – of its nuclear weapons program, which has resulted in substantial uncertainty about its size and capability. However, a general picture of the program has become relatively clear over the past two decades.

The US Intelligence Community estimates that Pyongyang see its nuclear capabilities as intended for "deterrence, international prestige, and coercive diplomacy," and would consider using nuclear weapons only "under certain narrow circumstances."[56] In addition, research centers like Institute for Science and International Security (ISIS) have indicated that the DPRK may be sharing at least some aspects of its nuclear weapons technology with Iran and the Syria.[57]

CSIS's Mike Green notes "the danger of horizontal escalation by the DPRK – namely, transferring weapons to third parties in the event of tensions or conflict. The DPRK directly threatened the United States with this in March 2003."[58]

The DPRK reported in May 2008 that it had extracted roughly 38.5 kg of weapons-grade plutonium from fuel rods.[59]

A February 2013 report by the Congressional Research Service (CRS) reported that North Korea had between 30 and 50 kilograms of separated plutonium, enough for at least half a dozen nuclear weapons.[60] In 2011, the NTI estimated that the DPRK had 6-10 kg of weapons-grade plutonium and another 29-34 kg of plutonium in spent fuel stockpiles that could be reprocessed and weaponized.[61]

ROK MND figures are similar, estimating that the DPRK has secured about 40 kg of plutonium as a result of three reprocessing procedures (as of 2010).[62] Additionally, the Strategic Studies Institute (SSI) believes that the DPRK has discharged anywhere from 43 to 61 kg from its 5MWe reactor since 1989. Furthermore, it has been reported that approximately 3,000 people work on the DPRKs nuclear program, including about 200 key researchers and scientists.[63]

In contrast, an assessment by David Albright of the Institute for Science and International Security (ISIS) that is shown in **Figure 8,** found that the DPRK was more likely to process some 30-34 kilograms of separated plutonium for a full range of 5-18 nuclear weapons (with a more likely distribution of some 9-10 weapons) at the end of 2014. This assessment took account of various production stoppages and the material used in the three preceding nuclear test. However, Albright cautioned that this would only be the case if *all* plutonium was being converted into nuclear weapons, which seems unlikely.[64]

Some sources indicate that DPRK nuclear technologies and materials appear to be poorly guarded and could be exploited or stolen by personnel in the security services or military and transferred to criminal groups, terrorist organizations, and/or other states. After his visits to the DPRK, Dr. Siegfried Hecker stated that he had seen "little recognition of the safety hazards posed by primitive nuclear bombs," likely meaning that security is also minimal.[65]

The DPRK has sometimes halted its plutonium production from its 5MWe reactor in Yongbyon, but it can easily restart plutonium production and weaponization, and the DPRK announced in March 2013 that it was going to do so. According to a CRS report:[66]

> In order to produce additional plutonium, the North Koreans would need to restore their 5-MWe reactor or build a new reactor. Timelines for restoring the 5-MWe reactor are uncertain, although experts estimate between six months and one year. Rebuilding the cooling tower, which was destroyed in June 2008, could take approximately six months, but other venting solutions for the reactor could be possible. Additionally, this aging reactor may be in need of additional parts or repair… After the facilities were operating, they could produce approximately 6 kg of plutonium per year.

In 2013, evidence emerged that the DPRK was restarting the Yongbyon reactor. While information on the facility's operational capacity is hard to discern, by 2014 there was some evidence that the plant had begun producing fuel.[67] Despite these signs, it is still not 100 percent certain whether the reactor has returned to an operational standing.[68]

On November 18, 2014, the U.S.-Korea Institute at SAIS at Johns Hopkins University, issued a report that recent commercial satellite imagery of the Yongbyon nuclear facility indicated the DPRK might be preparing to reprocess spent nuclear fuel to extract weapons-grade plutonium.

Assessments of Capabilities: Uranium

While North Korea's weapons program was plutonium-based at the start, intelligence has emerged showing that it is pursuing a second route to obtaining weapons grade fissile material using highly enriched uranium (HEU). The DPRK confirmed this in June 2009 when it announced it would commence uranium enrichment, stating "enough success has been made in

developing uranium enrichment technology to provide nuclear fuel to allow the experimental procedure."[69]

Three months later, DPRK officials announced that experimental uranium enrichment had entered into the "completion phase."[70] According to the US Intelligence Community, the exact intent of these announcements is unclear, and they do not speak definitively to the technical status of the uranium enrichment program.[71]

In November 2010, a visit by Dr. Hecker to Yongbyon shed additional light on the DPRK's HEU program. On his visit he saw "a small, recently completed, industrial-scale uranium-enrichment facility" that *appeared* fully operational, though Dr. Hecker and his colleagues were unable to confirm whether it was in fact operating at full capacity.[72]

ISIS released a report in mid-2012 warning that, in the best case scenario, the DPRK would use its uranium centrifuges at Yongbyon to make enough low enriched uranium to have a maximum of 25 nuclear weapons by 2015 – an increase of two from the ISIS's current estimate. In the worst case scenario – the absence of effective sanctions – the DPRK could build as many as 48 nuclear weapons by 2015 (an increase of 25).[73]

An additional assessment by ISIS concluded that the DPRK is now "poised for significant expansion over the next five years" and – at a worst case scenario – on track to develop up to 100 nuclear weapons by 2020.[74]These reports were followed by press reports that the International Atomic Energy Agency (IAEA) suspected that the DPRK had at least one additional covert centrifuge site and might have significant additional sites.[75]

Given the speed with which the DPRK outfitted the Yongbyon location, it seems unlikely that there wasn't a previously built facility where the process of constructing such a centrifuge plant was perfected.[76] In July 2016, a report by ISIS indicated that such an early site might be located at the Panghyon Aircraft Plant, some 45 kilometers west of Yongbyon in an underground facility.[77] These reports mean that the DPRK may have substantial stocks of enriched uranium as well as plutonium.

At a minimum, this means the DPRK's future production of weapons-grade material is impossible to predict and that both targeting and arms control are far more difficult because of the inability to predict how many dispersed centrifuge facilities the DPRK may have. However, the DPRK is probably far from having a self-sufficient program. According to ISIS: [78]

> Whatever North Korea has accomplished in building centrifuges, it faces an ongoing, fundamental problem. It is not self-sufficient in making and operating centrifuges. It acquired key equipment and materials abroad and appears to be continuing its overseas procurements. North Korea will undoubtedly need additional equipment and materials to build and operate large numbers of centrifuges successfully.

Figure V.8: Estimates of DPRK Nuclear Fuel Production and Weapon Equivalents (as of 2014)

North Korea's Military Fissile Material Stocks and Weapon Equivalent, end of 2014			
Fuel Type	Amount	Nuclear Weapons	Estimated Nuclear

		Equivalent	Weapons Built
Separated Plutonium	30-34 kg	-	-
Irradiated Plutonium	2-4 kg	-	-
Weapons Grade Uranium – Scenario 1 (2 Centrifuge Plants)	240 kg (median only)	22	15-16
Weapons Grade Uranium – Scenario 2 (1 Centrifuge plant)	100 kg (median only)	15	10-11
Source: David Albright, "North Korean Plutonium and Weapon-Grade Uranium Inventories", ISIS, January 8, 2015 (Revised October 7, 2015).			

Nuclear Weapons and Warhead Developments

Despite the progress of the DPRK's nuclear program, it is unclear whether the DPRK has mastered the ability to efficiently and reliably weaponize a nuclear device it can deploy on a missile. The detonation of a nuclear explosive device is a significant scientific achievement, but creating a device that can be included in a small bomb or a missile warhead presents a number of difficult engineering problems.[79] Theoretically, the DPRK could use an aircraft, a ship, or even a vehicle to deliver a nuclear weapon, but these platforms are either vulnerable or unreliable.

ROK intelligence believes, however, DPRK engineers were able to make significant progress in warhead miniaturization between 1999 and 2001, and the national defense ministry – along with ROK experts – now believes the DPRK has warheads that can be mounted on ballistic missiles.[80] Furthermore, ROK intelligence sources told the ICG in 2009 they believe the DPRK has deployed nuclear warheads for *Nodong* missiles in the northern part of the country.[81] As noted earlier, US intelligence experts and senior officers also indicate in 2013 and 2014, however, that the DPRK may have reached the point where it has the technical capability to deploy a nuclear missile warhead.

It is also unclear how reliable or safe such a warhead would be, what the risks would be if it might malfunction, how well it could survive an accident, and whether the DPRK could predict its operational yield in kilotons.[82]

The Early Program

North Korea's strengths and weaknesses in weaponizing and deploying nuclear weapons become clearer if one examines the full history of its efforts. The origins of the DPRK nuclear program seem to stem from the gross insecurity felt by then-leader Kim-Il-sung following the near defeat of his forces in the Korean War. Although nuclear weapons were never used, US political leaders and military commanders threatened their use during the war. In February 1956, Pyongyang signed the founding charter of the Soviet Union's Joint Institute for Nuclear Research and began to send scientists and technicians to the USSR for training shortly thereafter.[83]

When the US deployed nuclear weapons to South Korea for the first time in 1958, the DPRK began a rudimentary nuclear program primarily focused on basic training and research, relying on assistance from the Soviet Union. The program trained North Korean scientists and engineers and helped to construct basic research facilities, including a small research reactor (the IRT-2000) in Yongbyon.[84]

In the late 1960s, the DPRK expanded its educational and research institutions to support a nuclear program for both civilian and military applications. By the early 1970s, DPRK engineers had begun using indigenous technology to expand the IRT-2000 reactor, and Pyongyang began acquiring plutonium reprocessing technology from the Soviet Union.[85] In July 1977, the DPRK signed a trilateral safeguards agreement with the IAEA and the USSR that brought the IRT-2000 research reactor and a critical assembly plant in Yongbyon under IAEA safeguards.[86]

In 1980, Pyongyang's nuclear program began a period of expansion to the point that it could produce substantial amounts of nuclear energy and weapons-grade plutonium.[87] This expansion included uranium milling facilities, a fuel rod fabrication complex, and a 5 MW(e) nuclear reactor, as well as research and development institutions.[88] By the mid-1980s, Pyongyang began construction on a 50 MW(e) nuclear power reactor in Yongbyon and expanded its uranium processing facilities.[89]

Pyongyang was also exploring the acquisition of light water power reactors (LWRs), and agreed to sign the Non-Proliferation Treaty (NPT) in December 1985 in exchange for Soviet assistance in the construction of four LWRs.[90] However, the DPRK refused to sign a safeguards agreement with the IAEA, an obligation under the NPT.[91]

Denuclearization of the Korean Peninsula and the 1993–1994 Crisis

In September 1991, US President George H.W. Bush announced that the US would withdraw its nuclear weapons from the ROK, and on December 18, 1991, South Korean President Roh Tae Woo declared that South Korea was free of nuclear weapons.[92] As a result, the DPRK and ROK signed the Joint Declaration on the Denuclearization of the Korean Peninsula. In the document, both sides promised to "not test, manufacture, produce, receive, possess, store, deploy or use nuclear weapons," "use nuclear energy solely for peaceful purposes," and to forgo the possession of "nuclear reprocessing and uranium enrichment facilities."[93]

Following the signing of the Joint Declaration, the DPRK signed an IAEA safeguards agreement on January 30, 1992. Under the terms of the agreement, North Korea provided an "initial declaration" of its nuclear facilities and materials and allowed IAEA inspectors to verify the completeness and correctness of the initial declaration.[94] Inspections began in May 1992 and concluded in February 1993. However, when the IAEA requested access to two suspect nuclear waste sites, North Korea declared them to be military sites and therefore off-limits.[95] In response,

the UN Security Council passed Resolution 825 on May 11, 1993, urging the DPRK to cooperate with the IAEA and to implement the 1991 North-South denuclearization accord.[96]

Having reached a deadlock with the IAEA and facing sanctions from the UN, North Korea announced on March 12, 1993 that it intended to withdraw from the NPT. The US responded by holding political-level talks with the DPRK in early June 1993 that led to a joint statement outlining the basic principles for continued US-DPRK dialogue and North Korea's "suspending" its withdrawal from the NPT before it became legally effective.[97]

The agreement was short-lived. Immediately following the return of IAEA inspectors to North Korea in March 1994, the DPRK refused to allow the inspection teams to inspect a plutonium reprocessing plant at Yongbyon, and in May 1993 the IAEA confirmed that North Korea had begun removing spent fuel – which can be reprocessed for use in nuclear weapons – from its 5 MW(e) nuclear research reactor even though international monitors were not present.[98]

Faced with renewed UN sanctions, the DPRK withdrew from the IAEA on June 13, 1994. Although still a member of the NPT, the DPRK no longer participated in IAEA functions as a member state and thus refused to allow inspectors to carry out their work under the Safeguards Agreement.[99]

The crisis was defused by then-former President Jimmy Carter's visit to the DPRK in June 1994. Four months of negotiations concluded in an Agreed Framework between the US and the DPRK on October 21, 1994. Under the agreement the US committed to arranging for the provision of a LWR with a generating capacity of approximately 2,000 MW(e) in exchange for a DPRK "freeze" and ultimate dismantlement of its reactors and related facilities.[100] Although the accord froze North Korea's plutonium production facilities and placed them under IAEA monitoring, the US estimated that the DPRK could have recovered enough plutonium for one or two nuclear weapons before the agreement came into force.[101]

The Collapse of the Agreed Framework (1994–2002)

The DPRK's indigenous plutonium production facilities remained frozen following the agreement, and its known plutonium stocks were subject to IAEA monitoring. The facilities subject to the freeze were the 5 MW(e) reactor, the Radiochemical Laboratory (reprocessing), the fuel fabrication plant, and the partially built 50 and 200 MW(e) nuclear power plants.[102] It was during this time that the international community discovered the extent of the DPRK's plutonium production in the late 1980s and early 1990s. According to the American Federation of Scientists:[103]

> A close examination by the IAEA of the radioactive isotope content in the nuclear waste revealed that North Korea had extracted about 24 kilograms of Plutonium. North Korea was supposed to have produced 0.9 gram of Plutonium per megawatt every day over a 4-year period from 1987 to 1991. The 0.9 gram per day multiplied by 365 days by 4 years and by 30 megawatts equals to 39 kilograms. When the yearly operation ratio is presumed to be 60 percent, the actual amount was estimated at 60% of 39 kilograms, or some 23.4 kilograms. Since 20-kiloton standard nuclear warhead has 8 kilograms of critical mass, this amounts to mass of material of nuclear fission out of which about 3 nuclear warheads could be extracted.
>
> Estimates vary of both the amount of plutonium in North Korea's possession and number of nuclear weapons that could be manufactured from the material. South Korean, Japanese, and Russian intelligence estimates of the amount of plutonium separated, for example, are reported to be higher—7 to 22 kilograms, 16 to 24 kilograms, and 20 kilograms, respectively—than the reported US estimate of about 12 kilograms. At least two of the estimates are said to be based on the assumption that North Korea removed fuel rods from the 5-MW(e) reactor and subsequently reprocessed the fuel during slowdowns in the reactor's

operations in 1990 and 1991. The variations in the estimates about the number of weapons that could be produced from the material depend on a variety of factors, including assumptions about North Korea's reprocessing capabilities—advanced technology yields more material—and the amount of plutonium it takes to make a nuclear weapon. Until January 1994, the Department of Energy (DOE) estimated that 8 kilograms would be needed to make a small nuclear weapon. Thus, the United States' estimate of 12 kilograms could result in one to two bombs. In January 1994, however, DOE reduced the estimate of the amount of plutonium needed to 4 kilograms—enough to make up to three bombs if the US estimate is used and up to six bombs if the other estimates are used.

Despite the freeze, neither party was completely satisfied with either the compromise reached or its implementation. The United States was dissatisfied with the postponement of safeguards inspections to verify Pyongyang's past activities, and North Korea was dissatisfied with the delayed construction of the LWRs.

Uranium Enrichment, Six Party Talks, and the Banco Delta Asia (2002-2005)

The fact the plutonium route was partly blocked by the Agreed Framework may help explain why Pyongyang seems to have instigated a secret program in the late 1990s to develop the means to produce weapons-grade enriched uranium utilizing gas centrifuge technology.[104] These efforts were brought to light in October 2002 with the announcement by the US that the DPRK had acknowledged, in talks with Assistant Secretary of State for East Asian and Pacific Affairs James Kelly, a "program to enrich uranium for nuclear weapons."[105]

This led to the conclusion that the DPRK's program was a violation of the Agreed Framework, the NPT, the DPRK-IAEA Safeguards Agreement, and the North-South Joint Declaration on the Denuclearization of the Korean Peninsula.[106] In November 2002 the IAEA adopted a resolution calling upon North Korea to "clarify" its "reported uranium-enrichment program."[107] The DPRK rejected the resolution, saying the IAEA's position was biased and in favor of the United States.[108]

The United States responded in December 2002 by suspending heavy oil shipments, and North Korea subsequently retaliated on January 10, 2003 by lifting the freeze on its nuclear facilities, expelling IAEA inspectors, and announcing its withdrawal from the NPT.[109] On December 26, 2002, an IAEA press release stated that North Korea had cut all IAEA seals, disrupted IAEA surveillance equipment on its nuclear facilities and materials, and started moving fresh fuel rods into the reactor.[110]

It was reported in mid-2002 that US intelligence had found evidence of HEU materials and/or technology transfers from Pakistan to the DPRK, in return for ballistic missile technology. Furthermore, it was reported in 2004 that the DPRK had been part of the AQ Kahn network, purchasing gas-centrifuge technology.[111]

The US government also established the Illicit Activities Initiative, an attempt to create a parallel track to diplomacy by increasing efforts to stop the DPRK's international criminal activities (i.e., illicit weapons sales, counterfeiting, drug smuggling, etc. – discussed in Chapter III). Japan cut economic ties with the DPRK, curtailed remittances to the DPRK from the pro-DPRK ethnic Korean population in Japan, and increased oversight and restrictions on DPRK ships ferrying between the DPRK and Japan. However, the ROK and China did not introduce any new sanctions, although there were reports that the PRC briefly stopped energy shipments in March 2003.[112]

Little progress was made in arms control following the DPRK's withdrawal from the NPT. In early 2003, US intelligence detected activities around Yongbyon, which indicated that North Korea was probably reprocessing the 8,000 spent fuel rods that had been in a temporary storage pond.[113] The assessment was reaffirmed in September, when a DPRK Foreign Ministry spokesman said that reprocessing of this spent fuel had been completed, providing enough plutonium for approximately four to six nuclear devices.[114] This was confirmed in January 2004 when a delegation of invited US experts, headed by Dr. Hecker, confirmed that the canisters in the temporary storage pond were empty.[115]

In April 2003, a multilateral dialogue involving six nations – the US, ROK, DPRK, China, Russia, and Japan – began with the aim of ending the DPRK's nuclear weapons program; however, little was accomplished. Throughout the Six Party Talks, DPRK officials often expressed their preference for bilateral engagement with the US rather than the multilateral forum.

After multiple meetings spanning two years, the parties could only agree to a Statement of Principles.[116] However, due to disagreements over light water reactors and the Banco Delta Asia sanctions, progress on both the Statement and on further Six Party Talks stalled.[117] **Figure V.9** highlights the progress made during the Talks, while **Figure V.10** summarizes the primary agreements reached.

Throughout the talks, the DPRK had continued its plutonium reprocessing, and when the Six-Party process stagnated April 2005, the North shut down its 5MW(e) reactor and removed the spent fuel.[118] The reactor had been operating since February 2003, meaning that it could have produced enough plutonium for between one and three nuclear devices in its spent fuel.[119]

In 2005, the US government used the Patriot Act to designate Banco Delta Asia (BDA) -- a small Macanese bank holding DPRK accounts -- as an institution of money laundering concern. It did so by applying based on Section 311 of the USA PATRIOT Act, 31 U.S.C. 5318A. In the wake of this designation, the government of Macau froze the DPRK's accounts at the BDA, totaling approximately $25 million, an action that was quickly followed by other major international financial institutions refusing to undertake transactions with the DPRK, apparently fearing that they could be cut off from the US financial system.

This was effective in reducing the DPRK's access to its international financial accounts, but at the same time became a major source of tension in the Six Party Talks – though positively, also contributing to DPRK concessions several years later. The funds were returned in February 2007.[120]

As for the impact of the measures, the CRS reports,[121]

> In addition to the issue of returning the frozen funds, some analysts claim that the BDA issue brought to the surface lingering questions about the way the international banking community treats DPRK accounts. Specifically, the financial effects of the BDA action were larger than expected. It caused a run on accounts at the bank that compelled the government of Macau to take over BDA's operations and place a temporary halt on withdrawals. It also appears to have obstructed some legitimate North Korean financial interests, as the BDA action caused other banks around the region, including Chinese, Japanese, Vietnamese, Thai, and Singaporean banks, to impose voluntarily more stringent regulations against North Korean account holders. As North Korean traders and others move forward, some question whether the situation will return to "business as usual," "business with caution," or remain as "no business at all." In the case of China, a media report indicates that the country is allowing North Koreans to open bank accounts in China to settle business transactions in Chinese yuan. This enables them to conduct transactions in the Chinese currency.

The October 2006 Test and 2007 Accords and the Chinese Reaction

The situation continued to deteriorate throughout 2006, reaching a low point in October when North Korea conducted its first nuclear test. Following the underground test, the US Director of National Intelligence (DNI) issued a press release stating, "Analysis of air samples collected on October 11, 2006, detected radioactive debris which confirms that North Korea conducted an underground nuclear explosion in the vicinity of P'unggye on October 9, 2006. The explosion yield was less than a kiloton."[122] North Korea was reportedly expecting at least a 4 kiloton yield, perhaps indicating that the North Korean plutonium program still had a number of technical hurdles to overcome before it had a usable warhead.[123]

In response, China "used unprecedentedly harsh language to rebuke Pyongyang for 'flagrantly' conducting a nuclear test in disregard of the universal opposition of the international community;" until this point, China had only used the term "flagrantly" to condemn acts of its adversaries. Furthermore, China voted in favor of UN Security Council Resolution 1718, which prohibited states from transferring or providing luxury goods, heavy military equipment, or dual-use items to the DPRK.[124]

After intense diplomatic activity by the Chinese government and others involved in the Six-Party process, the parties met again, and in February 2007 they agreed on the "Initial Actions for the Implementation of the Joint Statement." The DPRK agreed to abandon all its nuclear weapons and existing nuclear programs and return to the NPT and IAEA safeguards in exchange for energy assistance and a release of the DPRK's frozen Banco Delta Asia assets.[125] After the February 2007 agreement, Pyongyang began shutting down and sealing its main nuclear facilities at Yongbyon under IAEA supervision.[126]

Further progress was made in the Six Party Talks when the parties adopted the second "action plan" that called on the DPRK to disable its main nuclear facilities and submit a complete and correct declaration of all its nuclear programs by December 31, 2007.[127] While disablement activities on the three key plutonium production facilities at Yongbyon progressed as shown in **Figure V.11**. Pyongyang failed to meet the December 31 deadline to submit its declaration. Almost six months past the deadline, on June 26, 2008, North Korea submitted its declaration, which indicated that North Korea had separated a total of about 30 kilograms of plutonium and used approximately 2 kilograms for its 2006 nuclear test.[128]

According to NTI, various media reports claimed that the declaration failed to address the DPRK's alleged uranium enrichment program or suspicions of its nuclear proliferation to other countries, such as Syria.[129] Despite these issues, in return for North Korea's declaration, President George W. Bush rescinded the application of the Trading with the Enemy Act toward Pyongyang and notified Congress of his intention to remove the DPRK from the list of state sponsors of terrorism after 45 days, in accordance with US law.[130]

Following the US government's action, Pyongyang demolished the cooling tower at the Yongbyon reactor.[131] Yet, when the 45-day period expired, the US did not carry out the de-listing. The State Department claimed that the 45-day period was a "minimum" rather than a deadline.[132] In response, the KCNA released a statement by the Foreign Ministry stating that because the US had not carried out its commitment to remove the DPRK from the State Department's terrorism list, Pyongyang would suspend the disablement of its key nuclear facilities at Yongbyon and consider taking steps to restore them "to their original state."[133]

The next month, the DPRK asked the IAEA to remove seals and surveillance from the reprocessing plant in Yongbyon.[134] Then in April 2009, North Korea's Foreign Ministry indicated that Pyongyang would withdrawal from the Six Party Talks and "would no longer be bound" by any of its agreements, saying instead that it would "fully reprocess" the 8,000 spent fuel rods from its Yongbyon reactor in order to extract plutonium for nuclear weapons.[135] Two days later, IAEA inspectors at the Yongbyon nuclear facilities removed safeguards equipment and left the country.[136] Although there were moves in mid-2011 to restart the process, the Six Party Talks have been suspended since late 2008.

While some see the Six Party Talks as useless, one ROK Deputy Foreign Minister has argued that they are still helpful in dealing with the DPRK. There are actually many bilateral relationships and working groups formed under the umbrella of the Talks that continue to this day. Through these meetings, there is still a signaling dialogue going on with the DPRK. Furthermore, should North Korea decide to return to the negotiating table, the Deputy Foreign Minister believes that the Six Party Talks have a lot of merit – the intransigence of the DPRK has been the problem, not the format of the forum. Every major regional player is involved in the discussions, so any decision reached would have a lot of weight. Furthermore, if the Talks are able to resolve the DPRK nuclear issue, the forum could continue as an inter-governmental or multilevel forum for a Northeast Asian security dialogue, a framework that is currently lacking in the region.[137]

Figure V.9: Uncertain Progress in the Six Party Talks

Round		Date	Major Progress
First		August 27-29, 2003	Formation of a consensus on denuclearization of the Korean Peninsula and the principle of peaceful resolution through dialogue
Second		February 25-28, 2004	Reaffirmation of a consensuses on Korean Peninsula denuclearization and the principle of peaceful resolution
Third		June 23-26, 2005	Formation of a consensus on the need for initial actions for denuclearization of the Korean Peninsula and phased process based on the principle of "commitment for commitment, action for action"
Fourth	**Session 1**	July 26 – August 7, 2005	Adoption of the September 19 Joint Statement
	Session 2	September 13-19, 2005	
Fifth	**Session 1**	November 9-11, 2005	Affirmation of willingness to fully implement the September 19 Joint Statement
	Session 2	December 18-22, 2006	Reaffirmation of willingness to fully implement the September 19 Joint Statement and agreement on taking coordinated steps in implementation
	Session 3	February 8-13, 2007	Agreement on first-phase actions for the implementation of the September 19 Joint Statement (the February 13 Agreement)
Sixth	**Session 1**	March 19-22, 2007	Agreement on the second-phase actions for the implementation of the September 19 Joint Statement (the October 3 Agreement)
	Session 2	September 27-30, 2007	

Source: Ministry for Unification and Institute for Unification Education, *Understanding North Korea*, ROK Government, 2012, 86.

Figure V.10: Key Agreements in the Six Party Talks

Agreement Name	Key Points
Joint Statement (September 19, 2005)	• **Dismantlement of North Korea's Nuclear Programs and Removal of North Korea's Security Concerns** o North Korea committed to abandoning all nuclear weapons and existing nuclear programs. o The United States affirmed that it has no nuclear weapons on the Korean peninsula and has no intention to attack or invade North Korea. o North Korea stated that it has the right to peaceful uses of nuclear energy. The other parties expressed their respect and agreed to discuss, at an appropriate time, the subject

	of the provision of light water reactor to North Korea. • **Normalization of Relations** o North Korea and the United States undertook to respect each other's sovereignty, exist peacefully together, and take steps to normalize their relations. o North Korea and Japan undertook to take steps to normalize their relations. • **International Assistance to North Korea** o The six parties undertook to promote economic cooperation in the fields of energy, trade and investment. o China, Japan, ROK, Russia and the US stated their willingness to provide energy assistance to North Korea. o The ROK reaffirmed its proposal of July 12, 2005 concerning the provision of 2 million kilowatts of electric power to North Korea. • **Vision for Peace and Stability on the Korean Peninsula and Northeast Asia** o The directly related parties will negotiate a permanent peace regime on the Korean peninsula at an appropriate separate forum. o The six parties agreed to explore ways and means for promoting security cooperation in Northeast Asia. • **Principles for Implementation** o The six parties agreed to take coordinated steps to implement the aforementioned consensus in a phased manner in line with the principle of "commitment for commitment, action for action."
Agreement on February 13, 2007	• **Action Plans for Initial Phase: Within first 60 days** o North Korea will shut down and seal existing nuclear facilities, including the reprocessing facility, and invite back IAEA inspectors. o North Korea will discuss with other parties a list of all its nuclear programs. o North Korea and the US will start bilateral talks aimed at moving toward full diplomatic relations. The US will begin the process of removing the designation of North Korea as a state-sponsor of terrorism and terminating the application of the Trading with the Enemy Act with respect to North Korea. o North Korea and Japan will start bilateral talks aimed at taking steps to normalize their relations. o The parties agreed to the provision of emergency energy assistance equivalent to 50,000 tons of heavy fuel oil to North Korea. • **Establishment of Five Working Groups: First WG meetings within next 30 days** o Denuclearization of the Korean Peninsula, Normalization of North Korea-US Relations, Normalization of North Korea-Japan Relations, Economy and Energy Cooperation, Northeast Asia Peace and Security Mechanism. • **Action Plans for Next Phase: After the completion of the initial phase** o North Korea would make a complete declaration of all nuclear programs and disable all existing nuclear facilities. o The other parties would provide economic, energy, and humanitarian assistance equivalent of 950,000 tons of heavy fuel oil to North Korea. • **Ministerial Meeting: After the completion of the initial phase** • **Peace Regime on the Korean Peninsula: The directly related parties will negotiate a permanent peace regime on the Korean peninsula at an appropriate separate forum.**

Agreement on October 3, 2007	• **North Korea agreed to disable all existing nuclear facilities by the end of year.** • **North Korea agreed to declare all its nuclear programs by the end of year.** • **North Korea reaffirmed its commitment not to transfer nuclear materials, technology, or know-how.** • **The United States would begin the process of removing the designation of North Korea as a state sponsor of terrorism.** • **The United States would advance the process of terminating the application of the Trading with the Enemy Act with respect to North Korea.** • **The United States and Japan would make sincere efforts to normalize their relations with North Korea.** • **The five parties would provide economic, energy and humanitarian assistance equivalent of one million tons of heavy fuel oil.**

Source: Ministry for Unification and Institute for Unification Education, *Understanding North Korea*, ROK Government, 2012, 82.

Figure V.11: Known Disablement Steps at Yongbyon (as of January 2013)

Step	Facility	Status
Discharge of 8000 spent fuel rods to the spent fuel pool	5-megawatt reactor	6400 completed as of April 2009
Removal of control rod drive mechanisms	5-megawatt reactor	To be done after spent fuel removal completed
Removal of reactor cooling loop and wooden cooling tower interior structure	5-megawatt reactor	Tower demolished June 26, 2008
Disablement of fresh fuel rods	Fuel fabrication facility	Not agreed to by DPRK; consultations held Jan. 2009 with ROK on possibility of purchase
Removal and storage of 3 uranium ore concentrate dissolver tanks	Fuel fabrication facility	Completed
Removal and storage of 7 uranium conversion furnaces, including storage of refractory bricks and mortar sand	Fuel fabrication facility	Completed
Removal and storage of both metal casting furnaces and vacuum system, and removal and storage of 8 machining lathes	Fuel fabrication facility	Completed
Cut cable and remove drive mechanism associated with the receiving hot cell door	Reprocessing facility	Completed
Cut two of four steam lines into reprocessing facility	Reprocessing facility	Completed
Removal of the drive mechanisms for the fuel cladding shearing and slitting machines	Reprocessing facility	Completed
Removal of crane and door actuators that permit spent fuel rods to enter the reprocessing facility	Reprocessing facility	Completed

Source: Mary Beth Nikitin, *North Korea's Nuclear Weapons: Technical Issues*, Congressional Research Service, February 12, 2013, 18-19.

Note: As of now, it appears that DPRK has halted its demolition of the Yongbyon facility and intends to use it once again for nuclear fuel production

The May 2009 Test

On May 25, 2009, the DPRK issued the following statement: "The Democratic People's Republic of Korea successfully conducted one more underground nuclear test on May 25 as part of the measures to bolster up its nuclear deterrent for self-defense in every way as requested by its scientists and technicians."[138] The DPRK also expelled nuclear inspectors and declared it would "never" return to the Six Party Talks.[139] The US Intelligence Community assessed that the DPRK probably conducted an underground nuclear explosion in the vicinity of Punggye with an explosion yield of approximately a few kilotons.[140]

Most yield estimates were in range of 4 to 5 kilotons, but an initial Russian statement gave a much higher estimate of 20 kilotons.[141] The test produced seismic signals characteristic of an explosion, indicating that they were generated by human activity, but no radioactive materials were reportedly detected, in contrast to the first test.[142]

Verification experts such as Professor Paul Richards considered the scenario of a bluff – the creation of a nuclear explosion-like seismic signal using conventional explosives – but while technically possible, he stated that it was highly implausible, seeing as "several thousand tons of conventional explosives to be fired instantaneously would have been virtually impossible under the prevailing circumstances and would not have escaped detection."[143] It is generally agreed that the test suggested the DPRK had the capability to produce nuclear weapons with a yield of roughly a couple kilotons TNT equivalent.[144]

In response, China condemned the test using critical language, while a spokesperson for the Foreign Ministry described DPRK-Chinese relations as "normal state-to-state relations" that were similar "with any country around the world" – in contrast to its past official references to the DPRK as a traditional ally and friend. Also, China voted in favor of UN Security Council Resolution 1874, which tightened financial sanctions and trade restrictions on the DPRK while also calling on all countries to inspect vessels believed to be carrying prohibited cargo, in ports and on the high seas, and to seize and dispose of such cargo if it was identified.[145]

Furthermore, in March 2010, the DPRK announced plans to construct a 25-30 MW(e) light-water reactor, which US nuclear expert Siegfried Hecker confirmed during his November visit. The reactor could be operational by 2014. Hecker also reported DPRK construction of a uranium enrichment facility at Yongbyon with 2,000 P-2 centrifuges in six cascades, claimed by the DPRK to be used for producing low-enriched uranium to fuel the light water reactor under construction. This enrichment facility would be able to make up to 40 kg – enough for one or two nuclear warheads – of HEU each year.[146]

The Leap Day Agreement

After a series of bilateral meetings with the US beginning in the summer of 2011, the US and the DPRK prepared for resumption of the Six Party Talks by announcing a Leap Day Agreement on February 29, 2012. The DPRK promised to halt uranium enrichment and missile testing as well as resume international monitoring of its nuclear sites, while the US committed to 240,000 tons of food aid, at an estimated cost of $200-250 million. The two countries released separate statements regarding the agreement:[147]

> The United States announced that the two countries would hold further talks to finalize details on a "targeted U.S. program consisting of an initial 240,000 metric tons of nutritional assistance with the prospect of additional assistance based on continued need." The U.S. statement also emphasized several

> wider security issues, such as its continued commitment to the 1953 armistice agreement and desire to increase people-to-people contacts with the DPRK.
>
> The DPRK statement included a reference to a "discussion of issues concerning the lifting of sanctions on the DPRK and provision of light water reactors" as priorities once the Six-Party Talks have resumed. The United States did not include those issues in its statement, and they are likely areas of continued disagreement between the parties. In the past, U.S. officials have not supported the lifting of sanctions until after full denuclearization and a determination by the U.N. Security Council, and have supported only "discussion" of light-water reactors in the 2005 Six Party statement.

During the meetings, "U.S. negotiators verbally warned their North Korean counterparts that any missile testing, including under the guise of a peaceful satellite launch, would violate the terms of the agreement, but this message was not received or was ignored by Pyongyang."[148]

Two and a half weeks later, on March 16, the DPRK announced it would be conducting another satellite launch, undertaking the test the following April, while also proclaiming itself a "nuclear armed state" and revised its constitution accordingly. The US suspended the promised food aid and cancelled another outreach program that had planned to resume US-DPRK missions to search for missing US soldiers' remains from the Korean War,[149] and the UN Security Council passed Resolution 2087 condemning the rocket launch. A further satellite test launch was conducted in December 2012, which has been discussed previously in this report.

The February 2013 Test and Reactions

After widespread speculation, the DPRK followed its December launch with a third nuclear test on February 12, 2013. Since mid-2012, activity at the Punggye nuclear test site had given analysts advance indication that the DPRK was likely planning another nuclear test. After the test, the DPRK official news organ announced a "successful" underground detonation, while seismic monitoring equipment in the vicinity registered a 5.1 magnitude earthquake with waves similar to the nuclear tests in 2006 and 2009.

According to the CRS,[150]

> The South Korean Ministry of Defense estimated that the test yield was between 6 and 7 kilotons. North Korea claimed that the February 12, 2013, nuclear test was to develop a "smaller and light" warhead. At a minimum, the test would likely contribute to North Korea's ability to develop a warhead that could be mounted on a long-range missile. It is unclear what impact a third nuclear test would have on future negotiations, but it would make their success far less likely, and the UN Security Council was discussing additional sanctions measures.
>
> Observers are also waiting for evidence from test emissions that might show whether the North Koreans tested a uranium or plutonium device. This information could help determine the type and sophistication of the North Korean nuclear warhead design about which little is known. Two U.S. experts, Hecker and Pabian, have assessed that North Korea used plutonium in both the 2006 and 2009 tests, and that without at least one additional successful plutonium test, the North would not have confidence in its miniaturized plutonium design. Other experts believe North Korea may choose to test highly enriched uranium-based devices. Testing of a uranium device might indicate a clandestine supply of highly enriched uranium, potentially from an enrichment facility in North Korea. If venting of the nuclear test site has occurred, air samples could indicate what kind of material was used.

The earthquake magnitude of the 2006 test was 3.9, the 2009 test was 4.4, and the February 2013 test was 5.0-5.1, according to the US Geological Survey.[151] At a yield of approximately 6 kilotons, the test was larger than the first test (less than a kiloton of power) and the second test (approximately two kilotons). However, this is small compared to other countries – for example, China's first three nuclear tests were measured at 22 kilotons, 35 kilotons, and 250 kilotons.[152]

One Western diplomat said that Iranian scientists may have witnessed the nuclear test – indeed, Iran may have paid the DPRK tens of millions of dollars (in Chinese currency) to gain access to the test.[153]

Following the 2013 test, all UN Security Council members approved a press statement condemning the test and pledging further action – setting the stage for negotiations over a fourth round of sanctions. While Russia announced it was ready to support additional sanctions on the DPRK's nuclear program, the Russian Deputy Foreign Minister said it would "oppose any sanctions damaging normal trade and economic relations with North Korea."[154]

Furthermore, in a 15-0 vote on March 7, the UN Security Council passed sanctions that further constrained DPRK trade, travel, and banking, while imploring countries to search any suspect DPRK cargo. The vote came just hours after the DPRK, angry with the proposed resolution and annual US-ROK joint military exercises, threatened for the first time to carry out "a pre-emptive nuclear strike" on the ROK and the US.[155]

According to UN Security Council diplomats, the latest resolution is intended to make the DPRK sanctions regime similar to the tough sanctions against Iran's nuclear program – which they argue have been more effective than previous DPRK sanctions – using the Iranian sanctions used as a model.[156] However, similar US sanctions on Iran have been judged to be ineffective, at least in stopping Iran from nuclear development, according to US Central Command head General James Mattis.[157]

One of the most important aspects of the sanctions, however, is that China participated in the three-week drafting process – suggesting that China was losing patience with its ally. China's Foreign Ministry has repeatedly condemned the DPRK's recent actions:[158]

> Beijing's reaction was strong and swift. Immediately after the test, Chinese Foreign Minister Yang Jiechi summoned the North Korean Ambassador and 'lodged a solemn representation' over the test. He said that China 'was strongly dissatisfied with and firmly opposed to' the test. Chinese media carried editorials and essays expressing frustration and opposition to the North Korean action — even the Global Times, known for its critical stance against the west, issued an editorial arguing that China should reduce aid to North Korea and that if Pyongyang is not happy, so be it. Pyongyang's ill-conceived criticism of China's agreement to an UN resolution condemning the test further fueled Chinese frustration with Pyongyang. It is against this background that the debate in China has changed from one about whether China should work with other countries to impose sanctions against North Korea to one about the kind of sanctions China should endorse.

Conversely, Russian officials and the general public did not react sharply to the DPRK's third nuclear test. The US, ROK, and Japan all believed that Russia should be more proactive regarding the DPRK nuclear issue, but Russia did not agree for several possible reasons:

- One was that Russian policy-makers did not actually think that the DPRK would ever attack Russia or use nuclear arms against it. Russia maintained a stable relationship with the DPRK and has never called for regime change.
- Second, although missile and nuclear tests are carried out near the DPRK-Russian border, Russia does not see these as dangerous. Radiation has stayed at normal levels, and while a missile could theoretically crash into Russia in a failed launch, the low population density in Eastern Russia means that not much damage would be done.[159]
- Third, the US would not likely reduce its missile defense buildup even if the DPRK did give up its nuclear weapons and missiles, and Russia was more worried about European-area US missile defense. Also, Russia has not accused the DPRK of missile and nuclear trafficking, unlike other Western countries.

- Finally, Russia perceived a rising "geopolitical pressure on Russia on behalf of the United States and its allies," according to Russian Federal Security Service chief Alexander Bortnikov, meaning that it was more concerned about a potential confrontation with the US.[160]

In March 2013, the US Treasury imposed its own financial sanctions on the Foreign Trade Bank of North Korea, the DPRK's primary foreign exchange institution. The Treasury Undersecretary also visited the ROK, Japan, and China to persuade the countries to adopt similar measures, in an attempt to apply further pressure on the DPRK to disrupt their nuclear development.[161]

In addition, the US Army Pacific (USARPAC) elevated the USARPAC Commander position from a three-star to a four-star general, because the DOD saw a war on the Korean Peninsula as increasingly likely – in which case a four-star general would be better-equipped to lead USARPAC forces.[162]

Two weeks after the DPRK's third nuclear test, one Chinese academic, Deng Yuwen, the deputy editor of a respected journal published by a Party school, published an article in a British newspaper entitled, "China should abandon North Korea." Several other leading Chinese academics have made similar calls. Deng wrote that the DPRK's third nuclear test was a good time for the PRC to re-evaluate the DPRK-PRC alliance, and there were several good reasons for China to withdraw its support of North Korea and instead support reunification of the Peninsula:[163]

- Basing a state-to-state relationship on ideology is dangerous.
- The DPRK no longer holds much value as a geopolitical ally – especially if the US launched a preemptive strike, with the Chinese then being obligated to respond and in turn engage the US military.
- The DPRK will not and likely cannot reform and it cannot continue indefinitely in its current state, so why should China keep a relationship with a country and leadership that will ultimately fail?
- The DPRK is repudiating its relationship with China. During the Korean War, hundreds of thousands of Chinese soldiers were killed while supporting the DPRK, so China views the bilateral relationship as cemented by this shared sacrifice. However, starting in the 1960s, the DPRK rewrote the history of the war – and left the Chinese out. Kim Il-sung took all the credit, and many cemeteries with Chinese soldiers' remains were leveled.
- The DPRK could use its nuclear weapons as a means of blackmail against China. According to one Chinese scholar, during President Clinton's 2009 visit to the DPRK, the North Koreans blamed China's "selfish" strategy and American sanctions for their economic poverty. During the same visit, Kim Jong-il also hinted that the DPRK had withdrawn from the Six Party talks in order to gain more independence from China, and that if the US agreed to help the DPRK, North Korea could become a strong fortress against China.

Overall, Deng concluded that the PRC should think about abandoning the DPRK, or at least trying to force the country to start acting more accommodating to the PRC and/or give up nuclear weapons: [164]

> North Korea's development of nuclear weapons is, in part, based on the illusion that it can achieve an equal negotiating position with the US, and thereby force Washington to compromise. But it is entirely possible that a nuclear-armed North Korea could try to twist China's arm if Beijing were to fail to meet its demands or if the US were to signal goodwill towards it.
>
> Considering these arguments, China should consider abandoning North Korea. The best way of giving up on Pyongyang is to take the initiative to facilitate North Korea's unification with South Korea. Bringing about the peninsula's unification would help undermine the strategic alliance between Washington, Tokyo

> and Seoul; ease the geopolitical pressure on China from northeast Asia; and be helpful to the resolution of the Taiwan question.
>
> The next best thing would be to use China's influence to cultivate a pro-Beijing government in North Korea, to give it security assurances, push it to give up nuclear weapons and start moving towards the development path of a normal country.

In response, Deng was given a month-long suspension from his job. Other Chinese commentators, especially those linked to the security and military establishment, argue that China should strengthen relations with the DPRK – and Russia – to counterbalance the US pivot to Asia. One recent commentary in the main military newspaper, the People's Liberation Army Daily, argued: "The main reason why North Korea is bent on developing nuclear weapons is basically the threat that the U.S. poses to its security."[165]

At the same time, China announced that it would not abandon the DPRK and that support of tougher sanctions should not be interpreted to mean that China's basic attitude was changing or that it did not still believe that dialogue was the best way to persuade the DPRK to abandon its nuclear weapons program.[166] In late March 2013, one state-run Chinese newspaper ran an editorial supporting the DPRK and blaming the US for the nuclear situation on the Korean Peninsula:[167]

> It is time for both sides to take a step back and let cooler minds prevail to avoid any escalation of the situation. The US has long adopted a punishment heavy approach in dealing with ties to the DPRK. It has imposed rounds after rounds of severe sanctions against Pyongyang… the approach has only heightened Pyongyang's seeds of insecurity and forced it to resort to more extreme actions to defend itself… Both the DPRK and the US should tone down their rhetoric and work with Beijing for an early return to the long stalled six-party talks.

There are indications that China was increasing DPRK-bound cargo inspections in the wake of the March 2013 UN sanctions while it was setting up back-channel negotiations with the DPRK.[168] Other reports note that prices of rice and other produce rose sharply as Chinese customs and border control impose more stringent inspections on exports to the DPRK. A Japanese newspaper reported that the price of rice had increased 50%, from 6,000 to 9,000 won per kilogram.[169] It also appears that Chinese exports of rice to the DPRK dropped to zero in January, then rebounded in February, while exports of crude oil also dropped to zero in February. It is not clear if these are cyclical declines or signs of a changing policy in China.[170]

Traders in Jilin Province, a northeastern Chinese province next to the DPRK, reported there was no noticeable slowdown of goods passing across the border, and no crackdown on smugglers.[171] It does appear, however, that increased border controls by both the DPRK and China have resulted in a significantly decreased number of DPRK defectors to China – compared with the first several months of 2012, there have been approximately 57% fewer in 2013.[172] It was also reported in early May 2013 that the state-controlled Bank of China had ended all dealings with a key DPRK bank. Experts evaluated this move as the strongest public PRC response to the DPRK's continued development of its nuclear and missile programs to date.[173]

Though China and Russia both supported the March 2013 UN Security Council sanctions, Russia had very little trade with or control over the DPRK, meaning it has little influence. China has voted for sanctions against the DPRK in the past, followed them for several months, and then quietly returned to assisting the regime.[174] Indeed, according to the Korea Trade-Investment Promotion Agency (KOTRA) overall bilateral trade between the PRC and DPRK actually

increased by 8.9 percent in 2013, despite a first quarter drop in Chinese exports and a hold on oil shipments in February.[175]

Further Escalation in 2013

In late January 2013, the DPRK proclaimed the 1992 Joint Declaration on Denuclearization of the Korean Peninsula to be null and invalid.[176] In late February, the chief delegate of the DPRK military mission to the DMZ (Panmunjom mission), Pak Rim-su, in a rare direct message to USFK Commander General James Thurman, warned that, "If your side ignites a war of aggression by staging the reckless joint military exercises… at this dangerous time, from that moment your fate will be hung by a thread with every hour" and that US forces would "meet a miserable destruction."[177]

In early March 2013, the DPRK said the 1953 Korean War armistice was null and void and that it would also cut off the DPRK-USFK hotline, with the DPRK Foreign Ministry announcing that a "second Korean War is unavoidable."[178] The two sides normally speak twice a day during the week on the hotline, which was established in 1971.[179] The DPRK has also shut down the Red Cross hot lines with the ROK, and it decided in late March to further cut off military hot lines with the ROK – although it was reported that one dialogue channel, a hotline between civil aviation authorities, still remained.[180]

Citizens in the DPRK were seen covering up buses and trains with camouflage in an attempt to be ready for war, while some citizens were evacuated into tunnels with emergency provisions.[181] Kim Jong-un continued his visits to DPRK military installations and commented, "Once an order is issued, you should break the waists of the crazy enemies, totally cut their windpipes and thus clearly show them what a real war is like."[182] On March 30, the DPRK proclaimed it had entered "a state of war" with the ROK.[183]

At the same time, the DPRK announced that it would "exercise the right to a preemptive attack" if US-ROK military exercises went ahead.[184] The three-star general and Vice Defense Minister of the DPRK, Kang Pyo-yong, also claimed, "With their targets set, our intercontinental ballistic missiles and other missiles are on a standby, loaded with lighter, smaller, and diversified nuclear warheads… If we push the button, they will blast off and their barrage will turn Washington, the stronghold of American imperialists and the nest of evil, and its followers, into a sea of fire."[185] The DPRK also declared a no-fly, no-sail zone off of its costs – suggesting possible short-range rocket testing[186] – and the DPRK army "ratified" a potential "diversified nuclear strike" against the US.[187]

The DPRK argued that the armistice was a military document, not a peace treaty. DPRK state media further argued that the country had made repeated demands for peace talks since the 1970s, only to be rebuffed by the US – further justifying a unilateral nullification of the armistice. However, the armistice states that any change must be agreed to by all signers, and that unilateral declarations are unacceptable.[188]

This was the seventh time the DPRK had said it would nullify the armistice.[189] The DPRK has also cut off, and later restored, the military hotline at least six times in the past when it wanted to raise tensions. The DPRK last cut off all military hotlines during US-ROK military drills in 2009.[190] In fact, the ROK and DPRK have together formally accused each other of more than 1.2 million armistice violations:[191]

> Since the end of the war, South Korea has accused North Korea repeatedly of violating the armistice by sending armed spies across the border, infiltrating submarines in South Korean waters, kidnapping hundreds of South Korean fishermen and still holding them there and launching an artillery attack on a South Korea island in 2010 that killed four people. Thousands of men from both sides, including many American soldiers, are believed to have died or remain missing,
>
> As of the mid-1990s, North Korea had violated the truce 420,000 times, according to American and South Korean military data. North Korea alleged more violations by its enemies; until recently it has routinely accused them of sending spy planes into its airspace and bringing heavier weapons into the Demilitarized Zone along the border than allowed.

At the same time, the DPRK announced, "If they think we have acquired our nuclear weapons to trade them for some economic benefits, it will be nothing but an utterly absurd miscalculation… as long as the United States does not abandon its hostile policy, we have no intention of talking with it, and we will stick fast to our course under 'songun.'" This is in contrast to its until-recently stated ultimate goal of ridding the Korean Peninsula of all nuclear weapons.[192] In response, the US has announced on multiple occasions that the US would not accept the DPRK as a nuclear state.[193]

While initial reports did not indicate any sign of imminent DPRK military action accompanying the February 2013 nuclear test, extra troop and vehicle movements at the DPRK's mid- and long-range missile sites were reported in the South Korean news by March 29. The timing is ambiguous.

On March 28, the US had flown two radar-evading B-2 spirit bombers over South Korea, flying from the US and back, dropping inert munitions as a practice run in the South for the first time. The following day, the DPRK put its missile units on standby to attack US military bases, with Kim Jong-un reportedly signing a plan to technically prepare the country's strategic rockets to be on standby. In previous periods of US-ROK joint military exercises, the DPRK has similarly put its military on highest readiness to fight, and Kim Jong-un has also previously given "final orders" for the DPRK military to wage revolutionary war with the ROK.[194]

At the end of March, the DPRK also announced a "new strategic line" to build both its nuclear arsenal and its economy simultaneously – because a growing nuclear deterrent would allow the DPRK to reduce military spending and invest more resources into light industries and the agricultural sector. In order to promote the new guidelines, the Central Committee of the ruling Workers' Party met for the first time since 1993, with Kim Jong-un presiding; the next day the Supreme People's Assembly – the DPRK's rubber-stamp Parliament – was expected to follow up and pass the guidelines.[195]

In early April 2013, the DPRK passed a decree at the 7th session of the 12th Supreme People's Assembly on "further consolidation of the self-defense nuclear power status."[196] The North also announced that, as part of a plan to put all of its nuclear facilities to use in expanding its nuclear arsenal, it would restart its plutonium reactor at Yongbyon, the cooling tower of which had been destroyed pursuant to the Six Party Talks in 2007 – and continue construction on other reactors. The DPRK also cited the need to generate more electricity as a motivation for its actions.

This was significant because, as Siegfried Hecker has noted, it would take six months to a year for the DPRK to restart the aging plutonium reactor, and another three years to reprocess and extract enough fissile material for more weapons. Hecker has a,lso stated that the DPRK could do so without needing foreign materials or equipment, and, once operational, could produce 6 kg of plutonium per year.[197]

That same month, the US reported that an Aegis-class warship had been moved to the ROK's southwest coast, and an SBX-1 sea-based radar platform was being moved to the western Pacific to monitor the DPRK as well.[198]

In addition, the DPRK moved what appeared to be two Musudan missiles (unveiled in 2010 but not yet tested) and seven mobile launchers to its east coast in early April, and a ROK military source noted on April 21, 2013 that satellite images showed that the DPRK had moved an additional two short-range Scud mobile missile launchers to South Hamgyeong Province (also on the east coast). These missiles appeared to have been removed by early May 2013.[199]

In response to the movement of the Musudan missiles on the east coast, Japan deployed ballistic missile interceptors near Tokyo.[200] The US repositioned two Aegis missile destroyers – the John McCain and the Decatur – in waters near the Korean Peninsula, and announced it would deploy a second TPY-2 missile-defense tracking radar in Japan,[201] along with the Terminal High-Altitude Area Defense (THAAD) system – a land-based missile defense system that includes a truck-mounted launcher, a component of interceptor missiles, an AN/TPY-2 tracking radar, and an integrated fire control system – to Guam within the next several weeks. [202]

The US deployed B-2 and B-52 planes, both with nuclear capabilities, over the ROK, and used F-22s in drills with the ROK.[203] On April 10, ROK-US combined forces raised their alert level to Watchcon 2 to increase surveillance monitoring, while the ROK had raised its alert level to "vital threat," as it appeared that at least one of the Musudan missiles was fueled and ready for launch.[204]

The US also announced that it would deploy additional ballistic missile interceptors in California and Alaska, increasing the number of ground-based interceptors from 30 to 44 at a cost of just under $1 billion. While the system has only been successful in 50% of tests, the weapons send a signal of credible deterrence, showed the ROK and Japan that the US remained committed, and also warned Beijing to restrain the DPRK or face an expanding US military focus in the Asian-Pacific region; according to one senior government official, "We want to make it clear that there's a price to be paid for letting the North Koreans stay on the current path." The missiles could also be used to deter Iran.[205] At the same time, in an attempt to avoid misperception by the DPRK, a long-scheduled test of Minuteman-3 ICBMs was delayed.[206]

Several foreign companies operating in the ROK announced they were considering contingency plans for their employees' safety,[207] while the ROK stock market was negatively affected by the growing tension on the Peninsula. One expert noted that the DPRK was attempting to use extreme propaganda to damage foreign direct investments in South Korea, a type of asymmetrical psychological warfare attack on the ROK's economic strength.[208] While on a visit to China, Secretary of State John Kerry attempted to garner increased Chinese support of the US position towards the DPRK – meaning, a reduction in Chinese support of the North – and reportedly offered to reduce US missile defense in the Asia-Pacific if the DPRK abandoned its nuclear program.[209]

In early 2015, however, the US made it increasingly clear to the ROK that it should install the THAAD system as a deterrent to the DPRK's missile threats. This issue brought increased tension between Seoul and Beijing because China worries that the THAAD system would compromise its own strategic deterrent capabilities by having US radar sensors extend deeper into Chinese territories.[210]

Halting Operations at the ROK-DPRK Joint Industrial Complex at Kaesong

On April 3, 2013, the DPRK shut down the ROK-DPRK joint industrial complex at Kaesong, followed shortly thereafter by a pull-out of 53,000 workers. It blocked border traffic three times before – in 2009 – the longest of which was for three days;[211] the April 2013 closing has been the longest period since the facility was first installed. The factories in Kaesong produced approximately $470 million annually in textiles and other labor-intensive products.[212] A basic map of Kaesong's location can be seen in **Figure V.12**.

However, there reportedly was friction within the DPRK's ruling elite over the decision, with the military demanding an immediate shut-down of the complex and some Workers' Party officials arguing instead that a shutdown would affect 50,000 DPRK workers' livelihoods, as well as their 200,000 family members. If the complex closes permanently, the total loss to ROK business owners, the ROK government, and investors would be approximately $5.3 billion.[213] North Korea, which makes approximately $2 billion annually in trade due to the complex ($90 million in wages alone),[214] remarked in its state-run press,[215]

> But the puppet group of south Korea, its dutiful media and hack writers are saying that "the north does not take up the issue of the zone because it is a source for its foreign currency income" and talking about "two faces of the north". They are even insulting the dignity of the supreme leadership of the DPRK.
>
> It is an extremely unusual thing that the Kaesong Industrial Zone is still inexistence under the rave situation in which the north-south relations have plunged into a deadlock and the Korean Peninsula is on the verge of a war due to the U.S. and the south Korean warmongers' vicious moves for igniting a nuclear war against the DPRK
>
> Under the situation, the South Korean puppet forces are left with no face to make complaint even though we ban the south sides' personnel's entry into the zone and close it.
>
> But we have exercised self-restraint, taking into consideration that the closure of the zone on which the livelihood of small and medium businesses of south Korea hinge can leave those businesses bankrupt and lots of people jobless. In fact, it is the puppet group and small and medium businesses of south Korea, not the DPRK, which benefit from the zone.

By the middle of April 2013, the 123 ROK companies that had operations at Kaesong were beginning to feel the effects. Several companies reported that their foreign business partners had cancelled contracts and asked for their investments to be returned, while others indicated they might move their factories to China.[216] On April 24, ROK President Park Geun-hye announced a financial aid package of $8 billion in special loans and $14.3 million in bank loans with government-assisted postponed repayments. Two weeks later, this was enlarged to a $270 million emergency loan fund. The companies would also receive tax relief and unemployment allowances if they had to lay off workers because of the Kaesong troubles.[217]

Two days later, the ROK announced it would pull out the remaining 175 factory managers from Kaesong, hours after the DPRK rejected the ROK's proposal for talks about the future of the Kaesong Complex despite the ROK's threat of a "grave measure" if its proposal was rejected. President Park reportedly told her cabinet that she had no intention of "waiting forever" for the DPRK to change its mind about the industrial complex. One DPRK analyst stated that the DPRK was likely to confiscate the assets of the ROK companies in Kaesong – which had happened after operations at the joint tourism resort on Diamond Mountain were suspended in 2008 following the fatal shooting of a 53-year-old ROK tourist. The ROK's Unification Minister warned the DPRK not to seize ROK assets at Kaesong, which had cost the ROK almost $1 billion to build after an agreement was reached in 2000 to begin the project.[218]

The ROK's decision to evacuate Kaesong was fully supported by the US, but criticized by Chinese media. The PRC's official Xinhua News Agency ran an article asserting that a total shutdown would cost the ROK $1 trillion annually, while the DPRK would lose $87 million per year – and the livelihoods of the 300,000 people living there would be directly affected.[219] While the DPRK attempted to tell the residents of the city that the shutdown was temporary, it was reported that workers – who had been earning $134 monthly – and residents were increasingly discontent and voicing their complaints.[220]

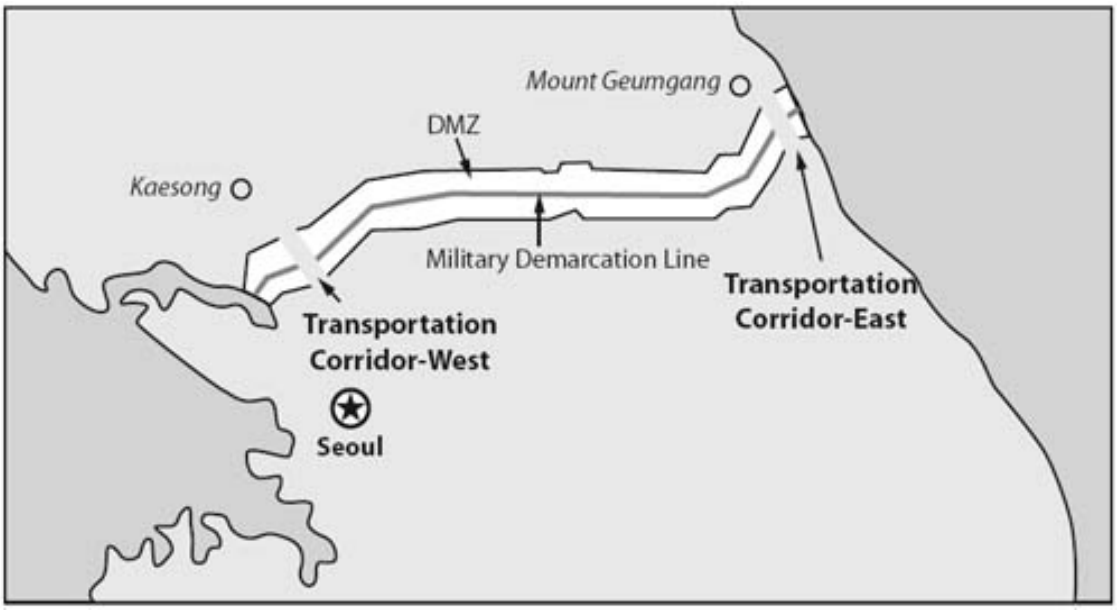
Experts in the ROK believe that the DPRK was trying to pressure the ROK over Kaesong as a way to avoid dialogue, but that the move backfired due to President Park's strong response. The DPRK was judged to be likely to "await a pretext to revive the Kaesong complex depending on the situation, such as a special envoy from China or improvement in relations with Washington," according to one ROK-based expert.[221]

On April 23, several days after hundreds of leaflets supporting the DPRK and threatening ROK Defense Minister Kim Kwan-jin were distributed near the Defense Ministry, Kim received a letter containing a suspicious white powder – which was concluded to be wheat flour – and a leaflet in the mail. The leaflet threatened to "punish" Kim if he dared to challenge the DPRK's "highest dignity" and instigate war on the Korean Peninsula. The Minister is known for his tough stance on the DPRK and has often promised to respond harshly to any provocation; in turn, the DPRK's state media has called him a "war maniac," a "traitor," and published pictures of DPRK soldiers shooting paper targets with his likeness. Although it is unclear who sent the letter, the Defense Ministry called it "an attempted act of terrorism."[222]

Kaesong was eventually reopened in September 16 2013 in an attempt to defuse tensions; the total loss for South Korean business during the shutdown was estimated at $944 million.[223]

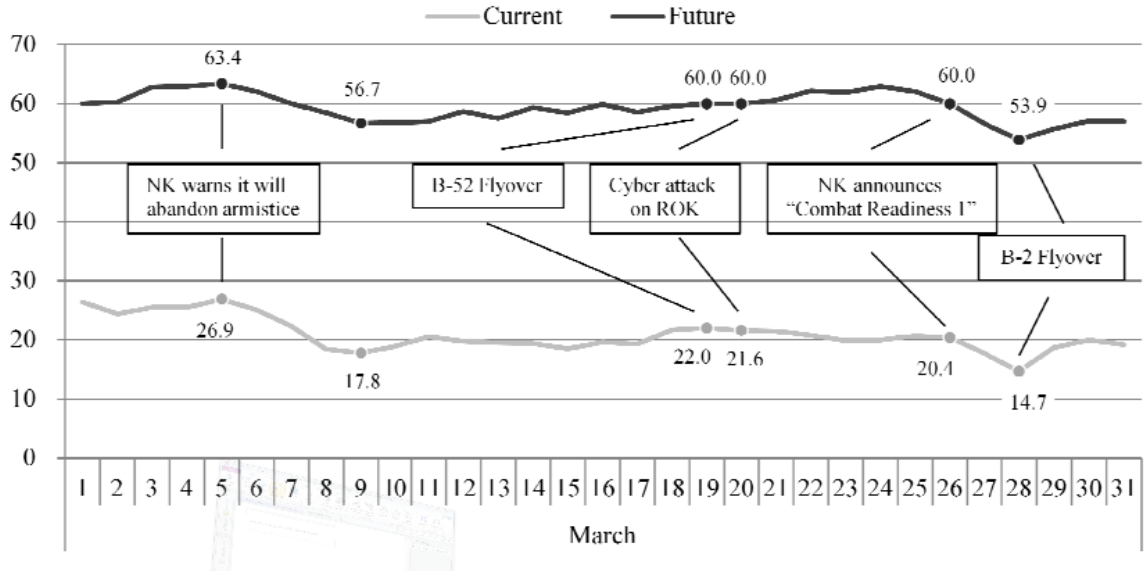
The results of the 3 DPRK provocations in early 201 on South Korean public opinion can be seen in **Figure V.13**. It is interesting to note that while most ROK citizens viewed their current security situation as not particularly positive, many had a much higher perception of future security – and thus, it appears that South Koreans do not believe that the DPRK's provocations would be particularly lasting or have a significant effect on the future.[224]

Figure V.12: Inter-Korean Transportation Corridors



Source: Statement of General Leon J. LaPorte, Commander United Nations Command, Commander, Republic of Korea–United States Combined Forces Command and United States Forces Korea before the 108th Congress House Armed Services Committee, March 12, 2003, 108th Congress, 1st sess., http://armedservices.house.gov/openingstatementsandpressreleases/108thcongress/03-03-12laporte.pdf.; in Dr. Bruce E. Bechtol Jr., "The Future of US Airpower on the Korean Peninsula," *Air & Space Power Journal,* September 2005. http://www.airpower.maxwell.af.mil/airchronicles/apj/apj05/fal05/bechtol.html.

Figure V.13: South Korean Positive Perceptions of National Security (Present and Future), March 2013



Source: Kim Jiyoon and Karl Friedhoff, *The Asan Public Opinion Report*, Asan Institute, March 2013.

Attempted De-escalation

The US responded by working with the ROK on a Counterprovocation plan, calling for an immediate but proportional "response in kind" to any potential DPRK attack, and as discussed earlier, delayed a planned missile defense test.[225]

China consistently called for both sides to engage in dialogue, arguing that this was the only want to ease tensions on the Peninsula. In mid-April 2013, the ROK made a conditional offer of talks to the North, but these were rejected as a "crafty trick." The US said it was willing to talk to the North – but only if the DPRK upholds its previous disarmament agreements, meaning providing a promise to give up nuclear weapons,[226] something at which the North scoffs.

The DPRK reacted by releasing its own conditions for negotiations through its state-run newspaper on April 18, 2013, along with its own analysis of ROK and US offers for talks:[227]

> The preconditions for dialogue raised by them include a stop to "provocative" remarks which the DPRK has so far been engaged in and demonstration of its intention to realize denuclearization and suspend missile launch. These are absurd ones…. It is another provocation against the DPRK that the U.S. urged the former to show the "will for denuclearization" as a precondition for dialogue.
>
> The U.S. and the south Korean puppet regime should make a bold decision to take the following practical measures if they want to shirk off the historical responsibility for the prevailing grave situation on the Korean Peninsula, escape sledge-hammer retaliatory blows of the army and people of the DPRK and if they truly stand for dialogue and negotiations:
>
> First, they should immediately stop all their provocative acts against the DPRK and apologize for all of them. As the first phase, they should take the measure of retracting the UNSC's "resolutions on sanctions" cooked up under absurd pretexts. They should bear in mind that doing so would be a token of good will towards the DPRK. The south Korean puppet forces should promptly halt all their anti-DPRK rackets, not linking their own mishaps such as Cheonan warship sinking incident and the "March 20 hacking case" to the north.
>
> Second, they should give formal assurances before the world that they would not stage again such nuclear war drills to threaten or blackmail the DPRK. Dialogue can never go with war actions. Frequent nuclear war maneuvers will only strain the situation and totally block the way of dialogue.
>
> Third, they should make a decision to withdraw all nuclear war means from south Korea and its vicinity and give up their attempt to reintroduce them as their immediate duty. They should bear in mind that the denuclearization of the Korean Peninsula… may lead to the global denuclearization.
>
> The chief of Chongwadae should not forget that the prospect of south Korea may be rosy when the north's nukes are considered as a property common to the nation but south Korea is bound to go to ruin when it remains under the U.S. nuclear umbrella.

A ROK Foreign Ministry spokesman rejected these, responding, "North Korea's demands are totally incomprehensible. It's absurd."[228]

The North issued several threats in late April 2013, claiming that the DPRK was "one click away from pushing the launch button" (Strategic Rocket Force Commander Kim Rak-gyom) and "Stalwart pilots, once given a sortie order, will load nuclear bombs, instead of fuel for return, and storm enemy strongholds to blow them up" (Air and Anti-Air Force Commander Ri Pyong-Chol).[229] Chinese Chief of the General Staff General Fang Fenghui also stated on April 22 that a fourth DPRK nuclear test was a possibility.[230]

As has been described earlier, no progress was made in 2014. North Korea was reported to be making preparations for a fourth test, and threatened to carry out such a test in November 2014. Time was, however, imposing other changes. In July 2014, General Jon Pyong Ho, a key figure

in North Korea's ballistic missile, nuclear weapons, and space programs, passed away. As Michael Madden notes, His death was part of a generational shift that is taking place within the community developing North Korea's nuclear capabilities. "North Korea's plans to develop new nuclear weapons designs, produce more fissile materials for a larger stockpile, and launch bigger and better rockets will depend largely on the capabilities of its next generation of WMD scientists and technicians." [231] The subsequent 2016 testing demonstrated the continued willingness of the DPRK to pursue a full nuclear weapons program, and put to bed most hopes of immediate de-escalation.

The January 2016 Test and Reactions

On January 6, 2016, the DPRK conducted it fourth nuclear test, after which it announced that it had successfully developed and tested a hydrogen bomb, following a similar claim made by Kim Jung Un in December 2015. A non-earthquake seismic event was recorded by the U.S. Geological Society with a magnitude of 5.1, about the same as the 2013 test[232]. While the US government did admit that a nuclear test had occurred, White House spokesman Josh Earnest claimed that "The initial analysis is not consistent with the claim the regime has made of a successful hydrogen bomb test."[233]

In a subsequent analysis, David Albright of ISIS claimed,[234]

> First, it is likely that this was not a test of what in the popular literature is interpreted as an H-Bomb, namely a two-stage fission-fusion weapon developed by the major nuclear-weapon states capable of obtaining explosive yields of hundreds or thousands of kilotons. First, the explosive yield of the test did not match the expected yield of the H-Bomb. If North Korea had indeed tested this type of H-bomb, the device's yield would be expected to be many tens of kilotons, at least. However, the need to contain the underground explosion and prevent radioactive releases from its test site may have led North Korea to limit the yield of this test device. Thus, if it tested an H-bomb, it is possible that it did not test the device at its full potential yield. Nonetheless, the explosive yield of a two-stage H-Bomb test would have been expected to be far higher than reported so far. Second, the development of a two-stage thermonuclear weapon is very challenging. It is assessed as beyond North Korea's capabilities at this stage.

Another possibility put forth by a variety of experts was that the DPRK had detonated a "boosted" fission bomb, which consists of a "fission device plus a small amount of hydrogen isotopes (tritium and deuterium gas) which undergo fusion"; the "resulting energy release sustains the fission reaction for longer, causing a larger blast". In addition, a boosted weapon is smaller and lighter than conventional fission bombs, and is potentially a step toward the DPRK's goal of fitting a nuclear device to one of their missile systems[235].

There were additional confrontational moves on the part of the DPRK, ROK and US following the 2016 test, there. As it did after the 2013 test, the US military responded by flying a B-52 over South Korea as a show of force.[236] Despite the potentially heavy loses to South Korean businesses, the ROK government shut down the complex again in 2016 in response to the DPRK's nuclear test, the first time that the South Koreans had initiated a shutdown; workers were repatriated and both water and power were shut off.[237]

In February, North Korea shot off a long-range missile under the auspices of sending a satellite into orbit. Countries condemned the launch as a further testing of long-range missile technology; the test was an extra impetuous for the UNSC negotiations.[238] A month later, South Korea and the United States launched one of their biggest annual joint military exercises, provoking another reaction from the DPRK. Its state run media stated that, "as the joint military exercises to be staged by the enemies are regarded as the most undisguised nuclear war drills aimed to infringe

upon the sovereignty of the Democratic People's Republic of Korea, its military counteraction will be more preemptive and offensive nuclear strike to cope with them" and responded with further short-range missile launches into the ocean.[239]

The 2016 test also precipitated a new round of international condemnations and sanctions. On March 2 2016, the UNSC unanimously decided to toughen its existing sanctions in reaction to the nuclear test and February missile test, following the negotiations of Chinese and American officials. [240]. On paper, Resolution 2270 added "numerous, qualitatively different restrictions" to the sanctions regime; it compelled countries to inspect all North Korean exports and imports, cease the purchase of certain North Korean rare-earth minerals and limit the purchase of the DPRK's coal and iron exports, end the export of jet fuel to the DPRK, expel certain institutions and individuals from their countries, seize and refuse port access for certain DPRK ships, and end any relationships with DPRK banks.[241]

Where previous resolutions had been primarily aimed at restricting the DPRK nuclear project and military capabilities, the new sanctions seemed at least in part designed to actively hit the North Korean economy, as punishment for its continued defiance of UN resolutions and as a harsher incentive to bring North Korean leaders back to the negotiating table.[242]

China once again played a key part in drafting the new resolution, and following its passage "unequivocally pledged to uphold the letter and spirit of the council's decision."[243] The key factor in the success of the new sanctions is still China's willingness to fully implement them; in particular, if China were to fully enforce the inspection provision on all trade between it and North Korea, this could seriously disrupt illicit DPRK activities and slow cross-border exchanges in general.

Any serious reduction in the Chinese purchase of North Korean iron and coal would also be significant.[244] China's participation in drafting the new sanctions reflected its aggravated response in the immediate aftermath of the test, which stated that the PRC was strongly opposed to the test and that pressed "North Korea to fulfill its promise of denuclearization and stop any actions that would worsen the situation."[245]Several Chinese leaders, such as Xi Jinping and Wang Yi, have reiterated their support for the imposing of UN sanctions and the dissolution of North Korea's nuclear program.[246]

There has been other evidence of a growing Chinese frustration with the DPRK leadership in the aftermath of the 2016 test. An editorial in the Global Times, known for its strong nationalistic leanings, criticized the DPRK's nuclear and missile testing as "reckless risk taking" and warned that China's international influence might not be enough to protect it if such provocations continued. In another article, the Global Times declared that the new UNSC resolution displayed the unity of the great powers and demonstrated that "there is no future for North Korea's possession of nuclear weapons"[247].

These were accompanied by the statements of skeptical Chinese academics like Pang Zhongying, who pointed out that China was unlikely to aid the DPRK in the event of an actual war. More materially, following the adoption of Resolution 2270 there were initial reports of proactive PRC moves on the border, such as an increase in Custom cargo inspectors and the release of blacklists for DPRK individuals and vessels.[248]

However, the extent or existence of any changes in China's DPRK policy remains to be seen. During the initially meetings between Secretary of State John Kerry and his Chinese counterpart

Foreign Minister Wang Yi over possible UN responses to the testing, there appeared to be continued Chinese adherence to longstanding positions on the Korean nuclear issue. Wang insisted that Chinese policy would "not be swayed by specific events or the temporary mood of the moment" and that the PRC valued "the commitment to uphold peace and stability (and) the commitment to resolve the issue through dialogue and consultation" as much as Korean denuclearization.[249]

Chinese officials also watered down certain aspects of the sanctions package (such as a provision allowing the purchase of DPRK coal for "livelihood" purposes), suggesting a continued reluctance to exercise harsh economic measures that could potentially destabilize the North Korean regime. Without China's strict enforcement of the UN resolution, the DPRK can rely on numerous workarounds to maintain ongoing illicit trade and financial ties with the outside world.[250]As of now, it is unclear how stringently the PRC intends to enforce sanctions. While KOTRA findings show an increase in trade in March, observers believe the jump to be a one-off event before sanctions are fully put in place.[251]

Russia also released a pointed statement in the aftermath of the January 6 testing, labeling it a "flagrant violation of international law".[252] During a meeting with his Chinese counterpart in March, Russian Foreign Minister Sergei Lavrov insisted that North Korean's actions were "irresponsible" and insisted that the international community was united in its condemnation and that the DPRK should not expect any forthcoming assistance.[253]

Despite several planned economic projects between Russia and the DPRK, Russia voted for Resolution 2700 along with its Security Council fellows, directly putting those projects in jeopardy. However, Russian officials (and PRC officials as well) remain suspicious of US and ROK responses to DPRK provocation, particularly the deployment of the anti-missile THAAD system in South Korea.[254]

In addition to UN imposed sanctions, the United States has moved forward with additional unilateral restrictions on North Korean financial flows. On June 1, the Treasury department labeled North Korea a "primary money-laundering concern," requiring further due diligence on the part of US financial institutions to prevent indirect DPRK access to the US financial system[255]. In effect, this cut off third country banks with DPRK connections from US banks and business.

The move impacted primarily on regional Chinese banks doing business with North Korea. While larger national banks had largely cut off relations with the DPRK over the previous few years, local banks near the North Korean border maintained business connections with DPRK nationals and state entities. While few banks heavily depend on North Korean business, China objected to the decision, stating that instead of imposing unilateral sanctions, countries should simply fully implement and enforce Resolution 227. [256]

The escalating tension on the peninsula resulted in increased ROK and US interest in placing the THAAD anti-missile system in South Korea New talks between the two countries were underway by mid-2016. Chinese leaders, including Foreign Minister Wang and Xi Jinping, reacted by expressing uneasiness about the system's deployment in its strategic backyard, claiming that its operational coverage reached into PRC territory and constituted a security concern. Russian policymakers have made similar statements.[257]

In early July, the talks reached an agreement to deploy THAAD in the ROK, with the intent of having it operational by 2017. [258] Both China and Russia registered opposition to the move, while Japan has hinted that, "it is considering another layer of ballistic missile defense, such as THAAD".[259]

North Korea reacted to the new deployment, as well as the concurrent sanction targeting of Kim Jung Un by the US, stating that ""there will be physical response measures from us as soon as the location and time that the invasionary tool for U.S. world supremacy, THAAD, will be brought into South Korea are confirmed" and "it is the unwavering will of our army to deal a ruthless retaliatory strike and turn (the South) into a sea of fire and a pile of ashes the moment we have an order to carry it out."[260]

According to polling from South Korea, the events of 2016 saw a precipitous decline in approval for both North Korea and Kim Jun Un among ROK citizens. In addition, a majority of respondents favored the closing of the Joint Industrial Complex at Kaesong as a way to punish and bring pressure on the DPRK leadership.[261]

Key Issues and Weapons Design

Decades of talks and arms control negotiations have sometimes delayed the DPRK's nuclear programs, but scarcely stopped them. The DPRK has unfrozen its plutonium program and instigated a highly enriched uranium program in violation of the 1991 North-South denuclearization agreement, the 1994 Agreed Framework, and the basic tenants agreed upon in the Six Party Talks. As a result, the value of further arms control negotiations us uncertain. According to Dr. Christopher Ford, "there seems to be increasing agreement across the breadth of the US policy community that there is little to be gained from further engagement."[262]

This makes an assessment of the DPRK's progress in weapons design even more important. As has been noted earlier, there is no way to be certain of the DPRK's progress in weaponizing its nuclear capabilities. Moreover, experts debate the number of nuclear weapons it could now make and can acquire in the near term, and there are critical areas of uncertainty like its access to Chinese designs and the level of technology sharing with Iran and Syria.

According to an ROK government report discussing DPRK nuclear and strategic weapons,[263]

> As early as in the 1960s, North Korea had sent its nuclear scientists to the largest nuclear research institute in the Soviet Union, the Joint Institute for Nuclear Research in Dubna. The number of professionals currently working in the North Korean nuclear industry is known to be about 3,000, including over 200 top-class experts. North Korea is also known to have about 4 million tons of uranium in recoverable deposits…. Over 300 scientists and engineers are known to have been stricken with atomic-related diseases during the course of their work.

It is important to note that the DPRK has so far only conducted four low-yield nuclear tests – on October 9, 2006 with a yield of less than one kiloton, one on May 25, 2009 with a yield of a few kilotons, a third on February 12, 2013 with a yield of approximately six kilotons (a 5.1 magnitude seismic shock in the area was reported by the US Geological Service), and a fourth on January 6th, 2015 with a similar yield to the 2013 test. This compares with a yield that would have been at least three to five times higher (20 kilotons) in an efficient fission weapons system.

This helps explain why US officials cannot be certain whether the DPRK can weaponize its arsenal to the point it can put low yield fission weapons on ballistic missile.[264] It also helps explain the assumption is that Pyongyang's current nuclear weapon designs are, or will be, based

on a first-generation implosion device, the logical choice for states in the initial stage of nuclear weapon development.[265] Data collected from the DPRK's May 2009 and February 2013 nuclear tests suggest the DPRK has the capability to produce nuclear weapons with a yield of roughly five or six kilotons TNT equivalent.[266]

It also indicates that it may be years before the DPRK can develop high-yield boosted weapons or the megaton and thermally dominated yields of fusion weapons. This is a major issue in assessing the DPRK program where few unclassified data are available. While low-yield fission weapon are still extremely lethal, they are very different in war-fighting lethality and deterrent impact from a high-yield weapon and presents further substantial problems if the DPRK deploys long-range missiles with operational accuracy that can be more in tens of kilometers than several hundred meters.

Miniaturization

Most experts estimate that a primary objective of the DPRK's nuclear program is to develop a nuclear warhead capable of being mounted on intermediate- and long-range missiles. This would require miniaturization – making the nuclear warhead small enough to be mounted on a missile – and would likely require further missile and nuclear tests.

Most experts believe that the DPRK has not yet achieved miniaturization of its nuclear arsenal. However, it has been reported that the DPRK received materials/assistance from the AQ Khan network, potentially providing the DPRK with a Chinese HEU-based nuclear weapon design that could help the DPRK create a reliable ballistic missile warhead – robust, small, and light.

The assessment by the US Defense Intelligence Agency in 2013, made "with moderate confidence, that the DPRK had nuclear weapons capable of delivery by ballistic missile" – was qualified by the statement that the weapon would have "low reliability." It is important to note, however, that it later became clear that the DIA had been making somewhat similar assessments since 2005.

As noted earlier, DNI James R. Clapper issued a statement that the DIA assessment did not reflect consensus of the US intelligence community, commenting, "North Korea has not yet demonstrated the full range of capabilities necessary for a nuclear armed missile." Secretary of State John Kerry responded similarly, and the Obama Administration downplayed the report.

Accordingly, as noted earlier, the statement by General Curtis Scaparrottii, commander of US Forces Korea, in October 2014 that North Korea "has had the right connections and technology" to develop a miniaturized nuclear weapon that could be launched by a missile is significant. The general stated:[267]

> I think given their technological capabilities, the time that they been working on this, that they probably have the capabilities to put this together. I don't believe that they have. I don't know that they have at this point.

In 2016, there were additional reports from members of the United States and ROK intelligence community that new analysis indicated that the DPRK was capable of fitting nuclear devices on short to mid-range rockets capable of hitting much of "Japan and South Korea". According to a New York Times report:[268]

> The assessment of the North's new capabilities is not based on direct evidence from inside its nuclear program, senior officials said, but draws on intelligence gleaned from high-level defectors, analysis of propaganda images and data collected from North Korean missile and nuclear tests, which have accelerated

> over the past six months. While some intelligence agencies suggested as early as 2013 that the North had learned enough about rocket engineering and the miniaturization of nuclear warheads to mount one on a shorter-range missile, there is a new consensus and greater confidence in that view in both Washington and Seoul, the officials said.

These new viewpoints were at least partially motivated by new DPRK propaganda photos released showing Kim Jung Un examining what appeared to be a miniature nuclear device. However, the opinions expressed by the quoted officials are still not the formal position of the US government; a Pentagon spokesperson noted that while it was wise to prepare for such contingencies, it "does not mean that they (DPRK) have that capability. They've not demonstrated that."[269]

These are important qualifications. Even if the DPRK has the necessary technology, the reliability and yield of a miniaturized North Korean nuclear weapon will be in question until it is actually tested.

Fuels – Plutonium and the Potential for Uranium

There has also been speculation about whether – and how soon -- the DPRK can create bombs using uranium. Scientists believe that first two nuclear tests conducted used bombs made of plutonium, although no radioactive gas signatures were able to be collected after the second test. In a CSIS assessment, Victor Cha and Ellen Kim commented,[270]

> A uranium-fueled test would suggest several disturbing new problems in the effort to denuclearize North Korea. First, it would mean that the DPRK has not one, but two ways to make a bomb which doubles the problem. Second, highly enriched uranium is much easier to hide than plutonium. It can be made in [sic] from centrifuges operating in buildings the size of a warehouse unlike the big and easily identifiable footprint of a plutonium nuclear plant facility. Third, the North can potentially produce a lot more uranium than it can plutonium and proliferate horizontally to others (like Iran) who may not need to test a device and feel confident that it has acquired a working device. Moreover, if this is proven to be a test of a miniaturized device as the North claims, then they will have crossed another technological threshold in [making] a nuclear warhead with a long-range ballistic missile that could threaten U.S. security and that of its allies. Basically, none of this is good at all.

As mentioned, the DPRK displayed uranium reprocessing facilities to Dr. Hecker in 2010, claiming it had the ability to convert plutonium reactor rods into uranium. According to the CRS, the DPRK has[271]

> …industrial-scale uranium mining and plants for milling, refining, and converting uranium; it also has a fuel fabrication plant, a nuclear reactor, and a reprocessing plant – in short, everything needed to produce Pu-239/ It has recently been built a uranium enrichment facility at Yongbyon that could produce HEU for weapons, or LE7U reactor fuel which could be irradiated for plutonium production. In its earlier 5 MWe nuclear reactor, North Korea used magnox fuel – natural uranium (>99%U-238) metal, wrapped in magnesium-alloy cladding to produce plutonium for weapons. About 8,000 fuel rods constitute a fuel core for the reactor.

Although the DPRK has announced it had finished reprocessing these 8,000 fuel rods, it is technically possible that the third nuclear test in February 2013 was of a uranium weapon. Like the second nuclear test, sensors were unable to pick up any gas radioactive gas signatures after the test, so no open-source information is available regarding whether the third test was of a plutonium or uranium weapon.

While the UN's Comprehensive Nuclear Test Ban Treaty Organization announced on April 23, 2013 that it had detected traces of radioactive materials from the February 2013 test, giving the first conclusive evidence that the test was of a nuclear weapon – and not just a large amount of

conventional explosives – it remains unclear what type of fuel was used.[272] One ROK analyst at a government-sponsored think tank, Korea Institute for Defense Analyses, wrote that "it is more likely that North Korea detonated HEU-based nuclear weapons in the third nuclear test."[273]

In addition to the 8,000 claimed reprocessed fuel rods, the DPRK still has 2,400 5-MWt and 12,000 50-MWt fresh fuel rods stored at Yongbyon.[274] It is also assessed that, if the February 2013 test was a plutonium weapon, the DPRK has used up a significant amount of their available plutonium, and would thus need to produce more or make sure its uranium enrichment programs were working.

Future Nuclear Capabilities

On February 26, 2015, the Institute for Science and International Security (ISIS) published a report by David Albright that analyzed estimated inventories of separated plutonium and weapons-grade uranium to forecast three possible scenarios of DPRK's future nuclear arsenal through 2020. He drew from previous assessments of possible stockpiles and analyzed current construction of facilities and reactors, the evolution of recent nuclear weaponization efforts, and Kim Jong-un's stance on nuclear weapons development – among other factors – to provide the following projections:[275]

> Over the next several years, North Korea could pursue quantitative and qualitative improvements in its nuclear weapons stockpile. This section lays out a set of projections through 2020 that capture the boundaries of North Korea's possible nuclear arsenal futures.
>
> Regardless of the specific projections, North Korea is expected to continue developing its nuclear weapons capabilities. At the March 31, 2013 plenary meeting of the Workers' Party of Korea, Kim Jong Un said that North Korea "should increase the production of precision and miniaturized nuclear weapons and the means of their delivery and ceaselessly develop nuclear weapons technology to actively develop more powerful and advanced nuclear weapons." He implied in this speech that North Korea would seek more precise nuclear-tipped ballistic missiles able to reach the United States.
>
> In this context, North Korea's nuclear program may focus on:
>
> - Increasing production of fissile material and the size of its overall stockpile;
> - Conducting more nuclear tests;
> - Increasing the explosive yield of its nuclear weapons, including more advanced designs using composite cores or thermonuclear materials to achieve higher yields;
> - Achieving additional miniaturization of warheads without sacrificing yield;
> - Reducing the amount of plutonium or WGU needed in a nuclear weapon;
> - Increasing the safety, security, and reliability of its nuclear weapons although it is highly unlikely to achieve the levels, for example, in the US arsenal;
> - Continuing seeking a range of goods abroad for its nuclear programs, including classified and proprietary information; and
> - Increasing level of self-sufficiency in order to avoid restrictions imposed by sanctions and export controls.
>
> Key factors that will affect their ability to make these improvements are:
>
> - Level of political and economic commitment;
> - Overcoming technical barriers; and
> - Level of foreign assistance.

Three projections through 2020 are developed in this section:

- **Low-End Projection through 2020**: Progress is slow as economic and technical constraints are numerous (including no further nuclear tests); difficulties are encountered in advancing current nuclear efforts and the North's political commitment wanes.
- **Medium Projection through 2020**: This projection assumes moderate growth based on a continuation of its current nuclear trajectory and development practices as well as political and economic commitment. The program is a mixture of successes and failures. Efforts to acquire technology/assistance from abroad make slow progress as does Pyongyang's effort to achieve self-sufficiency.
- **High-End Projection through 2020**: The general assumption underlying this projection is that nuclear weapons progress is steady and successful. North Korea steps up its commitment to build a nuclear arsenal, vigorously pursues technology development through, in part, increasing the number of nuclear tests and faces few economic constraints. Pyongyang also achieves a high level of success in acquiring technology/assistance from abroad as well as in achieving self-sufficiency.

Low-End Projection through 2020

North Korea's production of fissile material is limited to the 5 MWe reactor and centrifuge plant at Yongbyon. It either does not or cannot militarize the ELWR to make weapons-grade plutonium. The centrifuge plant is limited to 3,000-4,000 P2-type centrifuges, and North Korea does not deploy any more advanced than the P2-type. Moreover, the North will need to produce LEU for the ELWR. The centrifuges operate with poor efficiency, as they have done up through 2014. The 5 MWe reactor will experience outages and poor operational efficiencies, limiting production to an average of 2-3 kg per year of weapons-grade plutonium.

In this scenario, Pyongyang does not conduct any further nuclear tests. Nonetheless, it would make limited advances in its nuclear weapons skills and designs, such as achieving some additional miniaturization of warheads without sacrificing the explosive yield. However, the North would not be able to reduce the amount of plutonium or WGU needed in a nuclear weapon. Marginal improvements would be made in the safety, security and reliability of its nuclear weapons. Finally, without testing there would be limits to developing more advanced weapons. The North would be limited in using shells of fissile material or other shapes for the core that would permit significant additional miniaturization. It would be unable to develop boosted or thermonuclear weapons as well as a reliable source of tritium for thermonuclear devices.

North Korea's arsenal would be limited to fission-only weapons made from either plutonium or WGU. The explosive yields would not be high, likely on order of 10 kilotons. Its arsenal would involve a small number of weapon designs, or physics packages, and they would be adapted to various delivery systems, such as the Nodong and possibly longer-range missiles.

While Pyongyang will require foreign goods for its various nuclear programs, such as vacuum equipment, pumps, instrumentation, sophisticated computer-numerical control (CNC) machine tools and specialized chemicals and metals, it will experience difficulty procuring them. These procurement challenges will reduce the efficiency of its centrifuges and 5 MWe reactor. Moreover, the North will not succeed in procuring nuclear weapons data or designs overseas that would help further modernize its stockpile. Any nuclear cooperation with other countries—such as Iran—would be minimal and achieve few results.

Low-End Nuclear Arsenal. By 2020, North Korea would modestly increase the size of its nuclear arsenal, which would be comprised of fission weapons with explosive yields of about 10 kilotons. Miniaturization would allow the North to mount nuclear weapons on ballistic missiles but limited to existing types like the Nodong and a Taepodong deployed as an ICBM. Each weapon would be made from either separated plutonium or weapons-grade uranium. The stockpile would not include any composite cores or thermonuclear nuclear weapons.

To derive the total amounts of plutonium and weapons-grade uranium through 2020, the amounts of plutonium and weapons-grade uranium produced through 2014 under Scenario 2 (one centrifuge plant) are added to the values from the period 2015-2020, where the assumptions above are used to derive inventories in the latter period with the Crystal Ball™ software.

The median of the total plutonium estimates through 2020 is 50 kg with a standard deviation of 2 kg. The median of the WGU estimate through 2020 is 280 kg with a standard deviation of 60 kg. Assuming that each weapon contains either plutonium or WGU, the median of the number of nuclear weapon equivalents is 29 with a standard deviation of 5. About half of these weapons contain plutonium and half contain WGU. From 2014 through 2020, the number of weapon equivalents grows at an average rate of about 2.3 weapons equivalent per year.

Only a percentage of plutonium and WGU is used in the actual weapons—some will be tied up in the manufacturing process, lost to waste, or held in a reserve. In the low-end projection, with about 70 percent of the plutonium and WGU used in the weapons, the DPRK's total arsenal will consist of approximately 20 fission nuclear weapons at the end of 2020.

Medium Projection through 2020

North Korea operates the 5 MWe reactor reasonably well, producing an average of about 3-4 kg of weapons-grade plutonium per year. The ELWR is partially militarized and makes a moderate amount of weapons-grade plutonium—5 to 10 kg—each year. The plutonium from the ELWR will become available starting in 2018.

North Korea operates two centrifuge plants limited to a total of 6,000-7,000 P2-type centrifuges throughout this period. Moreover, the Yongbyon plant will need to produce LEU for the ELWR. The centrifuges will continue to work with relatively poor efficiency, but better than in the low-end projection. North Korea will conduct development work on a centrifuge similar to the Pakistani P3-type centrifuge, which has four maraging steel segments and three bellows, giving an output double the P2-type centrifuge. Nonetheless, during this period the North does not deploy any advanced centrifuges.

In this scenario, North Korea conducts nuclear tests at its current rate of about one every 3-4 years. Advances are made in nuclear weapons development skills and designs, such as achieving additional miniaturization of warheads without sacrificing explosive yield. The North makes progress in using shells of fissile material instead of solid core designs and developing non-spherical shapes of the plutonium or WGU core, allowing further miniaturization. However, it does not reduce the amount of plutonium or WGU needed in a weapon. Improvements are also achieved in the safety, security and reliability of the North's stockpile.

The North develops and deploys an additional weapon design that contains plutonium and weapons-grade uranium in the same core, allowing a significant increase in the weapon's explosive yield up to 50 kilotons. Fission weapons with either plutonium or weapons-grade uranium will remain the majority of its stockpile. However, their yields are larger on average, in the range of 10-20 kilotons, another benefit of continued nuclear testing and advances in design skills.

By the end of 2020, advances in miniaturization will result in a stockpile of warheads that can be deployed on missiles of various ranges beyond those in the low-end projection, including shorter-range ballistic missiles for battlefield use or more modern intermediate-range ballistic missiles (IRBMs) and ICBMs such as the Musudan and KN-08 road-mobile missiles.

In addition, Pyongyang will develop a more advanced nuclear weapon design although it will not be fully tested or deployed by 2020. It will develop a reliable but small source of tritium and deuterium. Both could be used to boost the explosive yield of a fission weapon and to achieve a one-stage thermonuclear weapon, which uses tritium, deuterium and lithium within a composite core of plutonium and weapons-grade uranium. The North will be able to test these designs, likely with a reduced yield because of test site limitations.

North Korea will continue to require foreign goods for its various nuclear programs but will experience only mixed success in procuring them. Progress will be made in producing some key materials and equipment domestically. Nonetheless, overseas procurement failures will reduce the efficiency of its centrifuges, reactors, and nuclear weapons program, but not as severely as in the low-end projection. While the North will not succeed in procuring nuclear weapons data or designs overseas, it will benefit from limited nuclear cooperation with Iran, which will aid Pyongyang's centrifuge program and procurement efforts.

Medium Nuclear Arsenal. By 2020, North Korea would increase the size of its nuclear arsenal several fold. The arsenal would consist of mostly fission weapons with explosive yields of about 10-20 kilotons. Several will have composite cores. These weapons could be mounted on a wide range of delivery systems.

The total amounts of plutonium and weapons-grade uranium is based on the amount of plutonium and weapons-grade uranium produced through 2014 under Scenario 1 (two centrifuge plants) added to the values from the period 2015-2020, where the assumptions above are used to derive inventories in the latter period with Crystal Ball™ software. The median of the total plutonium estimates through 2020 is 80 kg with a standard deviation of 5 kg. The median of the WGU estimate through 2020 is 790 kg with a standard deviation of 105 kg. Assuming that each weapon contains either plutonium or WGU, the median of the number of nuclear weapon equivalents is 69 with a standard deviation of 8. About one-third of these weapons contain plutonium and two-thirds contain WGU. From 2014 through 2020, the number of weapon equivalents grows at an average rate of almost eight weapons equivalent per year.

In this scenario, less fissile material is assumed to be tied up in-process or lost in waste than in the low-end estimate. In addition, some of the plutonium and WGU will be in nuclear weapons composite cores (say <5 weapons), reducing the total number of weapons as derived above, where each weapon is assumed to contain only plutonium or WGU. On balance, in the medium projection, the number of nuclear weapons is assumed to be about 75 percent of the nuclear weapons equivalent, giving an arsenal of about 50 nuclear weapons.

High-End Projection through 2020

In this projection, North Korea operates the 5 MWe reactor efficiently, making use of overseas procurements that allow an increase in reactor power to 25 MWth and effective maintenance. The result is an average production of about 5-6 kg of weapons-grade plutonium per year. Pyongyang militarizes the ELWR, enabling it to produce more weapons-grade plutonium than in the previous scenario, 15-20 kg each year. Also, the plutonium would become available two years earlier, starting in early 2016.

North Korea will operate two centrifuge plants with a combined 8,000-9,000 P2-type centrifuges. One will be the Yongbyon centrifuge plant with a capacity of 4,000 P2-type centrifuges starting at the beginning of 2015. The other will be an upgraded centrifuge plant at another location containing 4,000-5,000 P2-type centrifuges operating at this level in early 2015. As before, the Yongbyon centrifuge plant will need to produce LEU for the ELWR. The reactor will achieve higher capacity factors than in the medium scenario. The centrifuges will work with better efficiency than in the previous projections. Moreover, the North will complete development work on a new centrifuge similar to the Pakistani P3-type, with an output that is double that of the P2-type centrifuge. The first 2,000 P3-type centrifuges will become operational at the start of 2019. These centrifuges will be in addition to 8,000-9,000 P2-type centrifuges already in operation.

Under this scenario, nuclear weapons tests are increased to a rate of one per year enabling the North to make significant advances in its nuclear weapons skills and designs. It develops smaller diameter, lighter-weight nuclear weapons able to fit an increasing variety of shorter range missiles for battlefield use. Pyongyang is able to make further reductions in the amount of plutonium and WGU used in a nuclear weapon. It makes significant improvements in the safety, security and reliability of its nuclear weapons, allowing nuclear weapons to be deployed more easily.

As in the medium scenario, additional designs that contain plutonium and weapons-grade uranium in the same core are developed and deployed, allowing a significant increase in explosive yield up to 50 kilotons. The North also continues to field weapons with either plutonium or weapons-grade uranium, as in the two other projections. But in the high-end scenario, it increases the average yield of its fission weapons to 20 or more kilotons.

While developing a reliable source of tritium and deuterium for nuclear weapons development, the North makes significant progress in using both to boost the explosive yield of a fission weapon. A new boosted yield design is tested and incorporated into a significant number of composite core weapons although the bulk of the stockpile remains centered on weapons using either plutonium or uranium.

Pyongyang also develops a one-stage thermonuclear weapon, which uses tritium, deuterium and lithium within a composite core of plutonium and large quantities of weapons-grade uranium. One such device is tested by 2020, with a yield of about 100 kilotons. However, this one-stage weapon is too large for missile

delivery, but North Korea is aiming to make it deployable as soon as possible. Work is done on designing and developing a two-stage thermonuclear weapon but not tested by 2020.

North Korea will be very successful in procuring foreign goods for its various nuclear programs and will achieve greater self-sufficiency in making key materials and equipment domestically. Procurements, whether domestic or abroad, will be adequate and not interfere with the programs' progress. Moreover, Pyongyang will succeed in procuring nuclear weapons data and an advanced weapon design overseas, making an important contribution to speeding up the North's nuclear weapons developments. It cooperates actively with Iran on all nuclear areas, reducing inefficiencies in facilities and bottlenecks in procurements.

High-End Nuclear Arsenal

By 2020, North Korea would increase the size of its nuclear arsenal many fold. The arsenal would still consist of mostly fission weapons but the explosive yields would average 20 kilotons or more, which is greater than in the medium estimate. Several will have composite cores and North Korea will be working to deploy one-stage thermonuclear weapons with yields of about 100 kilotons. With the exception of thermonuclear weapons, the North's arsenal could be mounted on a wide range of delivery systems from short-range ballistic missiles (SRBMs) to the newer road-mobile Musudan IRBM to possibly the KN-08 ICBM currently under development.

To derive the total amounts of plutonium and weapons-grade uranium through 2020, plutonium and weapons-grade uranium produced through 2014 under Scenario 1 (two centrifuge plants) are added to the values from the period 2015-2020, where the above assumptions are used to calculate inventories in the latter period. The median of the total plutonium estimates through 2020 is 154 kg with a standard deviation of 8 kg. The median of the WGU estimate through 2020 is 1,230 kg with a standard deviation of about 110 kg. Assuming that each weapon contains either plutonium or WGU, the median of the number of nuclear weapon equivalents is about 125 with a standard deviation of 13. About 40 percent of these weapons contain plutonium and 60 percent contain WGU. From 2014 through 2020, the number of weapon equivalents grows at an average rate of about 17 per year.

In this projection, much less fissile material is assumed to be tied up in-process, lost to waste, or held in reserve than in the medium scenario. However, a couple factors reduce the number of weapons made from plutonium and WGU. An increased number of composite cores, namely 5-10, will contain plutonium and WGU, and one test of a single-stage thermonuclear device will have used several tens of kg of WGU. On balance, the number of nuclear weapons is taken as 80 percent of the nuclear weapons equivalent. The end result is an arsenal of about 100 nuclear weapons.

It is highly uncertain what the DPRK's nuclear weapons posture will look like in five years, but David Albright's assessment provides a spectrum of possibilities that would give a greater chance of predicting its nuclear arsenal in the coming decade. While an assessment of Pyongyang's push for improved nuclear technology and weaponization could be seen as part of its overall escalated rhetoric, it is important to note that such a capability could be used on various delivery systems and pose a significant threat to the ROK and Japan.[276]

Command and Control

Experts estimate that no DPRK nuclear bombs have been transferred to the KPA. Kim Jong-un apparently maintains control of all fissile material, possibly through the Second Economic Committee, which is responsible for the production of weapons and military equipment – including missiles and nuclear weapons.[277]

DPRK Nuclear Facilities

Figure V.14 to **Figure V.17** show the DPRK possesses numerous known and suspected nuclear facilities – completed, under construction, or in planning. Most of the facilities are in Yongbyon county, including a small nuclear research reactor (the IRT-2000), a 5 MW(e) gas-graphite moderated reactor, an unfinished 50 MW(e) reactor, waste storage sites, and a spent fuel reprocessing facility. The cooling tower of the 5MW(e) facility was demolished in 2008, but construction of a light water reactor and uranium enrichment facility have since begun. There is also a testing site at Punggye and an unfinished, abandoned 200 MW(e) reactor in Taechon country (the same province as Yongbyon, North Pyongan Province).[278]

The DPRK's newest facilities are working with uranium enrichment – such as the facility revealed in 2010. A light-water reactor is also under construction near Yongbyon and could be operational by 2014. As **Figure V.17** shows, there are also a variety of milling, mining, testing, research/development, industrial, and educational facilities around the country.[279]

According to the World Nuclear Association,[280]

> The Democratic People's Republic of Korea (DPRK, aka North Korea) generated 34 TWh in 2002 and 19 TWh in 2003, 71% from hydro and 29% from fossil fuels. Per capita consumption in 2002 was 1364 kWh. Recent estimates suggest that operable generating capacity is 2000-3000 MWe. In 1985, it brought into operation a small gas-cooled, graphite-moderated, natural-uranium (metal) fueled "Experimental Power Reactor" of about 25 MW (thermal) at Yongbyon. It exhibited all the features of a plutonium production reactor for weapons purposes and produced only about 5 MWe as an incidental feature. North Korea also made substantial progress in the construction of two larger reactors designed on the same principles, a prototype of about 200 MWt (potentially 50 MWe) at Yongbyon, and a full-scale version of about 800 MWt (potentially 200 MWe) at Taechon.

DPRK Nuclear Reactors[281]

The DPRK has an 8 MWth-capacity nuclear research reactor, the IRT-2000, constructed by the USSR and completed in 1965. It originally used 10% enriched uranium as fuel, but was upgraded to use highly enriched uranium; the USSR provided fuel rods until 1973. In 1992, DPRK officials admitted that 300 mg of plutonium had been separated in 1975; since 1992, due to a lack of fuel, the IRT-2000 has operated only intermittently. As it was not covered by the 1994 Agreed Framework, it was not frozen and continues to operate on occasion.

Construction on the Yongbyon 5 MWe reactor began in 1979, and the reactor was operational by 1986. It uses natural uranium as a fuel source. Although the DPRK claimed it was for electricity generation, it can easily produce weapons-grade plutonium – with which the DPRK has conducted nuclear weapons tests in 2006, 2009, and 2013. The reactor was shut down under the 1995 Agreed Framework, and the cooling tower was demolished in 2008 as part of a 2007 Six Party agreement. As of 2010, it appears to be inactive – though DPRK officials told US experts

that it was in stand-by status and received regular maintenance. The DPRK has threatened to restore the reactor, most recently in April 2013.

The Yongbyon 50 MWe reactor was started in 1985/1986 and was due to be completed in 1995. It would have been able to produce approximately 55 kg of plutonium per year. Construction was frozen within a year of completion under the 1994 Agreed Framework. Dr. Hecker reported in 2010 that it was being dismantled with large cranes and remains unfinished and abandoned.

The DPRK began construction of a 200 MWe reactor in Taechon in 1989 with an expected completion date of 1996. When completed, it could have been capable of producing about 220 kg of plutonium annually. Construction was frozen in 1994 under the US-DPRK Agreed Framework, and it appears to remain unfinished, without any significant changes since 2002.

The Geumho-Jigu Light Water Reactor site in Hamgyeongnam province was part of the 1994 Agreed Framework between the DPRK and the US. The Korean Peninsula Energy Development Organization (KEDO) was established to oversee the construction of two 1,000 MWe light water reactors (LWRs). While excavation began in 2001 and construction in mid-2002, the project was suspended in late 2003 due to the DPRK's suspected uranium enrichment and expelling of IAEA inspectors. The project, only 35% completed, was officially terminated in May 2006.

An experimental LWR (25-30 MWe / 100 MWth) at Yongbyon is apparently under construction. According to visiting US experts in 2010, the site was described as a "large excavated pit... roughly 40 meters by 50 meters by 7 meters deep" where "a concrete foundation 28 meters square with round concrete preforms for the reactor containment vessel was visible." Construction was reportedly begun in July 2010 with a target completion of 2012, though experts saw this as highly optimistic and instead projected an operational start date of 2014-15. The reactor will be fueled with 4.5% enriched U02 fuel, and all components of the reactor – and the fuel – will be manufactured domestically. The DPRK says this reactor will be used for electricity production.

A US expert analysis of satellite imagery on May 2, 2013 indicated that the DPRK was in the final "cleanup" stage of completing the reactor, and it appeared that the DPRK could begin startup activities "in the coming weeks."[282]

Recent Developments

The visit by Dr. Hecker to the DPRK in November 2010 shed additional light on developments in the DPRK's nuclear program, especially regarding the DPRK's potential uranium enrichment programs. Highlights of the information gleaned from his trip included:

> A small, recently completed, industrial-scale uranium-enrichment facility. The sight of 2,000 centrifuges and an ultramodern control room stunned Dr. Hecker. "Instead of finding a few dozen first-generation centrifuges, we saw rows of advanced centrifuges, apparently fully operational."[283]
>
> Initial construction on a small, experimental LWR designed to deliver roughly 25 to 30 megawatts of electric power. "The construction of the reactor raises a number of policy issues: an LWR requires enriched uranium, and once enrichment capabilities are established for reactor fuel, they can be readily reconfigured to produce HEU bomb fuel.…The centrifuge facility…is most likely designed to make reactor, not bomb, fuel, because it would not make sense to construct it in a previously inspected site and show it to foreign visitors. However, it is highly likely that a parallel covert facility capable of HEU production exists elsewhere in the country."[284]
>
> The 5 MWe reactor had not been restarted since it was shut down in July 2007. No new fuel had been produced and the fresh fuel produced prior to 1994 (sufficient for one more reactor core) is still in storage.

> Pyongyang apparently decided not to make more plutonium or plutonium bombs for the time being. Dr. Hecker's assessment was that they could resume all plutonium operations within approximately six months and make one bomb's worth of plutonium per year for some time to come.[285]

Dr. Hecker's report was followed by press reports that the IAEA suspected that the DPRK had at least one additional covert centrifuge site and might have significant additional sites.[286] These reports mean that the DPRK may have sizeable stocks of enriched uranium as well as plutonium. A December 2010 CRS report held that, all together, with all facilities operating, the DPRK could produce approximately 6 kg of plutonium per year and an unknown amount of HEU per year, depending on the status of their uranium enrichment program.[287]

On July 21, 2016, a report released by Institute for Science and International Security claimed that there might be such a secret enrichment facility at the Panghyon Aircraft Plant, 45 kilometers west of Yongbyon. According to an undisclosed official, the site could potentially house some 200 to 300 centrifuges. In addition, the hypothetical site partially matches the statements of defector Chun Sun Lee, a former DPRK general. While the report cautions that these findings are not confirmed or conclusive, it maintains that multiple government sources have indicated that the Panghyon Aircraft Plant is a likely enrichment site. The facility itself would presumably be located in an underground mountain complex, the entrances of which the report identifies with satellite imagery.[288]

Significant future growth in North Korea's arsenal would be possible only if larger reactors were completed and operating, and growth would also depend on any progress in the reported uranium enrichment program. At a minimum, this means the DPRK's future production of weapons-grade material is impossible to foresee, and that both targeting and arms control are far more difficult because of the inability to predict how many dispersed centrifuge facilities the DPRK may have.

Figure V.14: North Korean Nuclear Power Reactor Projects (as of January 2011)

Location	Type/Power Capacity	Status	Purpose
Yongbyon	Graphite-moderated Heavy Water Experimental Reactor/5 MWe	Currently shut-down; cooling tower destroyed in June 2009 as part of Six-Party Talks; estimated restart time would be 6 months	Weapons-grade plutonium production
Yongbyon	Graphite-moderated Heavy Water Power Reactor/50 MWe	Never built; Basic construction begun; project halted since 1994	Stated purpose was electricity production; could have been used for weapons-grade plutonium production
Yongbyon	Experimental Light-Water Reactor/100 MWT (25-30 MWe)	US observers saw basic construction begun in November 2010	Stated Purpose was electricity production; could have been used for weapons-grade plutonium production
Taechon	Graphite-moderated Heavy Water Power Reactor/200 MWe	Never built; Basic construction begun; project halted since 1994	Stated purpose was electricity production; could have been used for weapons-grade plutonium production
Sinp'o	4 Light-water reactors/440 MWe	Never built; part of 1985 deal with Soviet Union when DPRK signed the NPT; canceled by Russian Federation in 1992	Stated purpose is electricity production; could have been sued for weapons-grade plutonium production
Sinp'o	2 Light-water reactors (turn-key)/1000 MWe	Never built; part of 1994 Agreed Framework, reactor agreement concluded in 1999; Project terminated in 2006 after DPRK pulled out of Agreed Framework	Electricity production

Source: Mary Beth Nikitin, *North Korea's Nuclear Weapons: Technical Issues*, Congressional Research Service, February 12, 2013, 7.

Figure V.15: List of Major North Korean Nuclear Sites

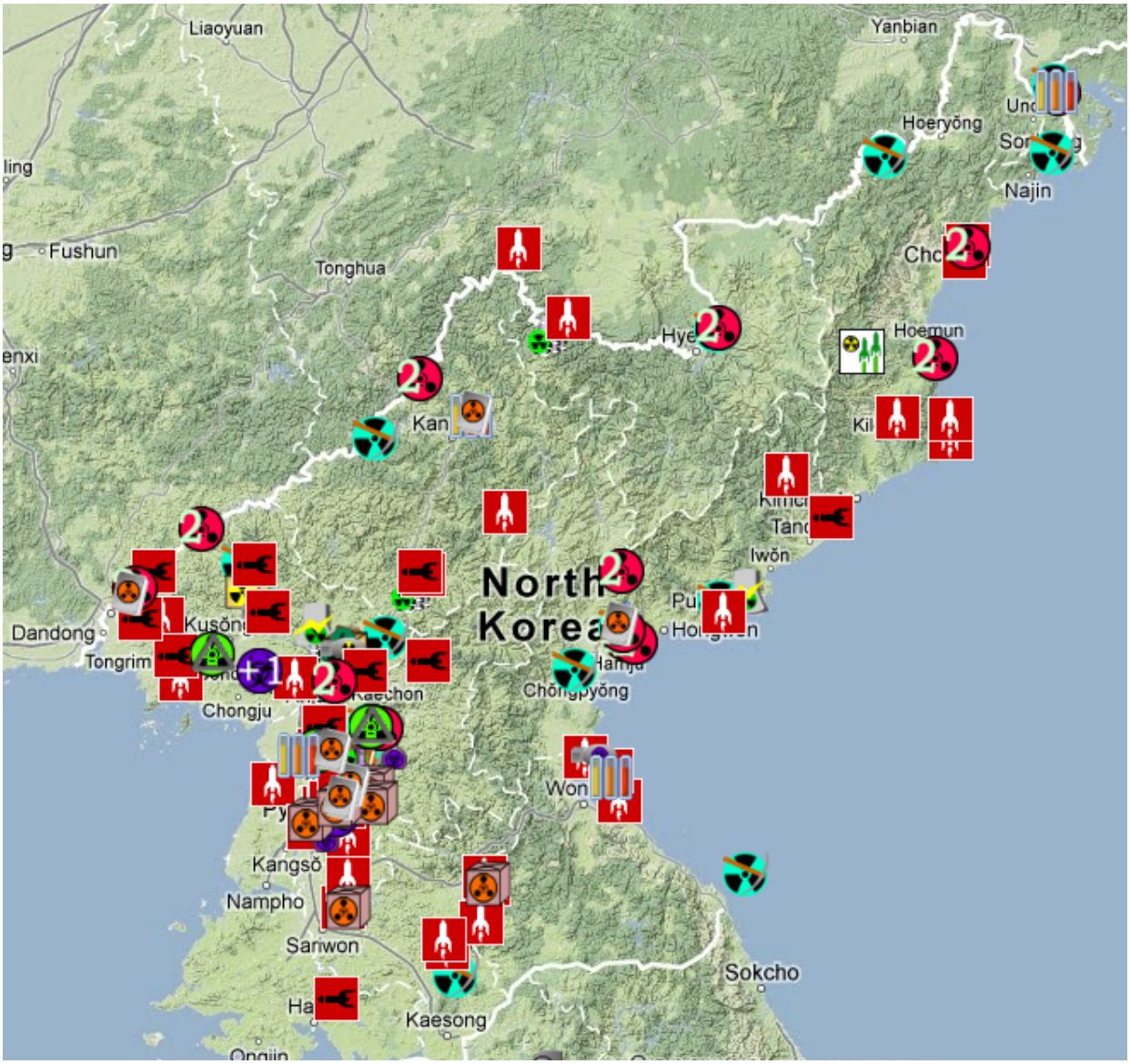
Hagap	The US Defense Intelligence Agency reported an underground nuclear-facility under construction in 1993, to be finished possibly by 2003. Commercial satellite images show tunnel entrances, but not other indications of the facility's use.
Hamhung	This branch of the Academy of Defense Science is known for training engineers and chemists, and is also near a site with uranium deposits.
Musudan	On the east coast, a long-range rocket was fired from here in April 2009.
Pakchon	Location of uranium mine and milling facility (known as the April Industrial Enterprise), declared to the IAEA in 1992. The uranium milling facility reportedly processes ore from mines in the Sunchon area. Current status is unknown.
Punggye	This is the site of the DPRK's underground nuclear tests in 2006, 2009, 2013, and 2016.
Pyongsan	Location of uranium mining and a uranium milling facility, which reportedly processes ore from the Pyongsan and Kumchon uranium mines. Current status is unknown.
Pyongyang	Laboratory-scale hot cells provided by the Soviet Union in the 1960s where believed to be used to extract small quantities of uranium; also in Pyongyang are the Colleges of Nuclear Physics at Kim Il Sung University and Kim Chaek University of Technology.
Sinpo	Location of two 1,000 MWe light water reactors constructed by the Korean Energy Developmental Organization (KEDO); under the terms of the Agreed Framework, given to the DPRK in return for freezing its nuclear program. Construction was halted and site abandoned after the outbreak of another crisis in late 2002.
Sunchon	Location of an important uranium mine.
Taechon	Location of incomplete 200MWe graphite-moderated nuclear power reactor. Construction began in 1989 and was frozen in 1994 (under the 1994 Agreed Framework). Current status is unknown.
Tongchang-ri	This site, on the Northwest coast, is where the new Sohae launch pad is located. The DPRK is getting ready to fire long-range rockets from this launch pad, and fired a rocket mounted with a satellite (SLV) from here in April, 2012.
Yongbyon	Location of a Nuclear Research Center, comprising a 5MWe graphite moderated prototype power reactor, reprocessing facility, uranium conversion plant, fuel fabrication plant, and spent fuel and waste storage facilities. Also location. Also Location of a Soviet-supplied IRT research reactor and radioisotope laboratory, and where the DPRK revealed a uranium enrichment facility under development in 2009. Satellite imagery from early 2012 showed progression in construction. Also located here are a 5 MWe, a 50 MWe reactor, and a plutonium reprocessing facility that has been shut down.
Youngdoktong	Reported location of site (active in the 1990s) for nuclear weapons-related high-explosive testing. In 2003, the CIA reportedly detected an advanced nuclear testing site, but ROK experts were skeptical.

Source: Chipman, *North Korea's Weapons Programs*, 46; Carnegie Endowment for International Peace, http://www.ceip.org; Federation of American Scientists, http://www.fas.org; NTI, http://www.nti.org; and David Albright and Kevin O'Neill, *Solving the North Korean Nuclear Puzzle*, Institute for Science and International Security, 2000); "North Korea nuclear test prompts neighbors to mobilize militaries and scientists," CRS, February 2013.

Figure V.16: Map of Major North Korean Nuclear Sites

Note: Locations on map are approximate.
Source: Chipman, *North Korea's Weapons Programs,* 45.

Figure V.17: Map of Possible DPRK Nuclear, Biological, Missile, and Chemical Sites



Source: "Interactive North Korea Facilities Map," http://www.nti.org/gmap/?place=39.1195,127.2055,8&layers=nuclear,missile,biological.

MISSILE
- Base (15)
- Production (10)
- R&D (1)

BIOLOGICAL
- Dual-use infrastructure (1)
- Research & Development (10)
- Production (1)
- Weaponization (1)

ROK and US Response to DPRK Nuclear Programs

As part of its new (pro) active deterrence strategy – the ROK has responded in kind to the DPRK's elevated rhetoric. While dismissing DPRK threats as propaganda, the ROK MoD told reporters that, "If North Korean attacks South Korea with a nuclear weapon, Kim Jong-un's regime will perish from the earth."[289]

The ROK military also warned that if it was provoked by the DPRK, it would strike the North's "command leadership."[290] At the same time, many analysts, as well as the ROK government, believe that Kim Jong-un is attempting to create an atmosphere of crisis within his country in order to enhance his own prestige and consolidate his leadership.[291]

ROK President Park Geun-hye stated in early April 2013 that, "Our military exists to defend our nation and its people from such threats… If [the North] stages any provocation against our people, you [the ROK MoD] should make a strong and swift response in initial combat without any political considerations." The ROK MoD also unveiled a plan to accelerate the setup of a missile system called "Kill Chain" that works to pre-emptively detect, target, and destroy missile and military installations in the DPRK, as well as its command structure – in the event signs of an attack are detected. Although there was no update on the timeframe for deployment of the system, the ROK had previously announced it would be implemented by the end of 2015. The ROK also announced it would strengthen Cyberwarfare forces and develop measures to counter DPRK cyberattacks.[292]

To underscore its commitment to the ROK, the US flew B-52 bombers over the Peninsula in mid-March 2013, leading the DPRK to threaten to attack US military bases in Japan and Guam. Several days later, the DPRK announced that all of its long-range artillery and strategic rockets "are assigned to strike bases of the U.S. imperialist aggressor troops in the U.S. mainland and on Hawaii and Guam and other operational zones in the pacific as well as all the enemy targets in South Korea and its vicinity."[293]

In response, the ROK MoD vowed a "thousandfold, ten-thousandfold retaliation" against any *Cheonan*-like provocation, while government officials stated that the ROK would retaliate by, among other measures, launching missiles at gigantic statues of Kim Il-sung and Kim Jong-il – to which the DPRK strongly reacted, saying that the monuments were "symbols of the dignity of the supreme leadership" and that the DPRK would in return "destroy the den of confrontation, including Chongwadae [the ROK presidential office], hotbed of all evils."[294]

Following the 2016 testing, the US and ROK again demonstrated this policy of harsh reaction to developments in the DPRK nuclear program, responding with a B-52 flyover, a larger annual military exercise, the closing of the Kaesong Industrial Complex, and a greater focus on THAAD deployment.

These developments highlight the risk that the ROK may eventually deploy nuclear-armed aircraft and missiles. Few argue that the ROK and Japanese lack the capability to build long-range missiles and nuclear weapons, and doing so with minimal – if any – testing. In fact, the ROK would already have nuclear weapons if the US had not pressed the ROK to not continue its nuclear development, reaching an agreement on the matter with South Korea in 1975 – as previously discussed.

If the US wishes to prevent this, it may have to find new ways to support the ROK. The US faces the reality that the risks of a growing DPRK nuclear force – coupled to a large stock of

chemically armed bombs and missiles and possible biological weapons – means it cannot simply let a key ally like the ROK bear a one-sided threat or leave Japan in the position where it, too, has no balancing force. While arms control options are not impossible, it is also all too clear that they offer even less chance of success than negotiations with Iran.

This leaves the US with several alternatives, none of which offer the prospect of lasting stability, but which are similar to the options the US might use against Iran and would put pressure on both North Korea and China:

- The US could turn to China and say the US will offer extended nuclear deterrence to Japan and the ROK unless China can persuade the DPRK to halt and roll back its nuclear programs. It could confront China and aid the ROK with two major options:
    - The most "quiet" or discrete extended deterrence option would be nuclear armed submarine- or surface-launched cruise missiles backed with the deployment of conventionally armed cruise or ballistic missiles with terminal guidance systems capable of point attacks on North Korea's most valuable civil and military assets.
    - The most decisive extended deterrence options would be the equivalent of the combination of Pershing II and ground-launched cruise missiles that were land-based, had US operating crews both deep inside South Korea and in or near its major cities, and had both nuclear and precision conventional warheads. The DPRK would be faced with the inability to strike at key ROK population centers without striking at US forces and still see mobile US nuclear armed forces in reserve. It also could not use conventional warheads without facing a more accurate and reliable US strike force in return.
- The US could work with the ROK to create the same kind of layered defenses against missiles and rockets being developed in Israel, and use the ROK model to help create layered defenses in the Gulf, allowing an indirect form of cooperation between Israel and the Gulf states without overt ties or relations.

As is the case in the Gulf, the US does not have to support proliferation by either South Korea or Japan. Experts may argue the timing, but none argue over ROK and Japanese capability in building long-range missiles and nuclear weapons, and doing so with minimal – if any – testing. In fact, the ROK would already have nuclear weapons if the US had not pressed the ROK to not continue its nuclear development, reaching an agreement on the matter with South Korea in 1975 – as previously discussed.

The US can put pressure on both the DPRK and China in ways that would allow several years for negotiation while not seriously opposing the ROK in any way that would bind or sanction its ally. While Japan is far less likely to take a decision to go nuclear, particularly in the near-term, the US could decide that the Missile Technology Control Regime had essentially outlived its usefulness – binding the US without binding China – and encourage Japan to create precision strike conventional missiles as well as missile defenses.

This would confront both the DPRK and China with the reality that once such a Japanese force was created, Japan could quickly arm them with nuclear weapons if it came under increasing North Korean or Chinese pressure. Such options would give the US, the ROK, and Japan growing leverage to pressure China to restrain the DPRK as well as deter and contain the expansion of Chinese nuclear forces.

In fact, one way to put pressure on China would be to start a dialogue that could be either official or think tank, including discussions of both missile defense and extended deterrence, and encourage the ROK and Japan to surface the nuclear option. If this succeeded in pushing China into far more decisive pressure on North Korea, there would be no need for either extended

deterrence or ROK or Japanese nuclear forces. Along these lines, and in response to recent ROK Foreign Ministry suggestions, on April 25, 2013 China signaled that it was "positively" considering holding a trilateral, informal US-China-ROK "1.5-track" security dialogue – which would include both government officials and academics – to discuss policy and security issues related to the DPRK.[295]

Moreover, such options could be used to lever Chinese restraint in transferring missile technology to Iran. There also is no reason that the US, the ROK and Japan could not offer quid pro quos in terms of incentives for a North Korean roll back, including some formal agreement on all sides for a local WMD-free zone and economic incentives for a more open DPRK.

At the same time, the US may have to at least tacitly encourage ROK and Japanese creation of at least precision-guided conventional missile forces and possibly nuclear forces as a local regional counterbalance to the Chinese nuclear effort. This is scarcely a desirable option, or one that can easily be kept stable, but the DPRK is only part of the problem and the US should not passively allow itself to be trapped into a Chinese-US nuclear relationship. It should be clear to China that it faces other potential nuclear powers if its nuclear forces grow too much and are even indirectly linked to Chinese pressure on maritime and island disputes in the Pacific.

The Japanese Response to DPRK Nuclear Programs

Japan has also made it clear that it feels threatened by the DPRK's actions, but Japan is less likely to take a decision to go nuclear than the ROK, particularly in the near-term. Once again, extended deterrence is an option, but the US could also decide that the Missile Technology Control Regime had essentially outlived its usefulness and encourage Japan to create precision strike conventional missiles as well as missile defenses.

Such a Japanese action would confront both the DPRK and China with the reality that once such a Japanese force was created, Japan could quickly arm them with nuclear weapons if it came under increasing North Korean or Chinese pressure. Such options would give the US, the ROK, and Japan growing leverage to pressure China to restrain the DPRK as well as deter and contain the expansion of Chinese nuclear forces.

Missile defense is another important option. In March 2013 the Japanese government was reportedly planning to give orders to intercept any DPRK missiles, while *Aegis* destroyers carrying SM-3 missiles were deployed to the northwest of Japan – as has happened in all previous DPRK missile launches.[296]

In early April 2013, Prime Minister Abe put the Self-Defense Forces (SDF), already mobilized for missile defense, on "full alert status" due to the DPRK threat. The Navy deployed two *Aegis* destroyers to the Sea of Japan, and the Air Force readied its land-based PAC-3 missile interceptors. This is the fourth time that Japan has undertaken its highest state of defense readiness in response to DPRK missile threats, with the first in March 2009 and the second and third in response to 2012 missile launches. The April 2013 orders were the first time Japan had gone to full alert status without any DPRK-stated intention to launch a missile.[297]

The DPRK's bellicosity has also allowed Abe to call for a build-up in Japan's military – a move the US has encouraged, so that Japan can play a larger role in the region's security. According to Abe, Japan would be unable to shoot down any potential DPRK-launched missile aimed at the US, as it would not be in self-defense – and thus against the Japanese constitution. Other potential scenarios that are constitutionally forbidden but Abe argues should be permissible

include defending US military vessels under attack during joint US-Japan operations and providing logistical support to nations and/or protecting allied troops under attack while engaged in peacekeeping missions.[298]

According to Abe, Japan's military should have more latitude to fight a broader range of threats to Japan's allies in a new doctrine of "collective self-defense." Abe has other proposals, in addition to building up the Japanese military – including increasing Japanese military spending for the first time in 11 years (by .8%) and increasing the number of SDF personnel.

Japan's new military budget also calls for enhanced weapons – including F-35s, an attack submarine, amphibious troop carriers, and funding to develop new anti-ship missiles. Increased Japanese command and control in joint US-Japan military exercises is one manifestation of this trend. One newspaper poll found that 54% of respondents supported Abe's moves to increase the defense budget, while 36% were opposed. Military officials in both Japan and the US say that new DPRK threats justify a broader re-examination of long-standing Japanese regional defense policies. Japan is also worried about increasing tensions with China over disputed islands.[299]

The Russian and Chinese Response to DPRK Nuclear Programs

Russia has not taken a strong stand against DPRK nuclear weapons, but has expressed concern about the risk of escalation on the Korean Peninsula – at least in the period before the Ukraine crisis in 2014. Prime Minister Vladimir Putin remarked in early April 2013 that, "I would make no secret about, we are worried about the escalation on the Korean peninsula because we are neighbors… And if, God forbid, something happens, Chernobyl which we all know a lot about, may seem like a child's fairy tale. Is there such a threat or not? I think there is… I would urge everyone to calm down… and start to resolve the problems that have piled up for many years there at the negotiating table."[300] The country has retained its relatively moderate stance following the 2016 nuclear test, releasing a statement in response to North Korean anger over ROK-US military exercises that warned the DPRK against provocative actions. It specifically hypothesized that such moves would create a legal basis for invasion and regime change; however, the statement also criticized the ROK and US for launching the exercises in the first place.[301]

As has been discussed previously, there seems to be a debate among Chinese citizens, government officials, and academics as to how much the DPRK's nuclear program should affect China's support of the DPRK. While one Chinese academic was suspended from his job after publishing an article pushing for abandonment of the DPRK – as discussed previously in this chapter – Xi Jinping, China's new president, said in an early April speech that no Asian country "should be allowed to throw a region and even the whole world into chaos for selfish gain," an indirect though clear criticism of the DPRK.[302]

According to US Joint Chiefs of Staff Chairman General Martin E. Dempsey, the Chinese government wants to limit the DPRK's nuclear ambitions though it remains unclear what China would do to realize that goal. General Dempsey stated, "Chinese leadership is as concerned as we are with North Korea's march toward nuclearization and ballistic missile technology. And they have given us an assurance that they are working on it, as we are. But I didn't gain any insights into particularly how they would do that."[303] His interlocutor, Chief of the General Staff

Gen. Fang Fenghuim, said Beijing is firmly opposed to the DPRK's nuclear weapons program and believes it should be addressed through dialogue.[304]

It was also reported that the Chinese and ROK Foreign Ministers agreed in late April 2013 to set up a 24-hour hotline to facilitate policy consultations on the DPRK.[305]

ROK Chemical Weapons Developments

The ROK has the technology base to create advanced chemical and biological weapons. It has conducted research on defense in both areas, and much of such research is indistinguishable from research on weapons. There are no meaningful indicators, however, that the ROK now has, or is seeking, stockpiles of such weapons.

The ROK signed the Chemical Weapons Convention (CWC) in 1993, ratified it in April 1997, and began destroying its CW stocks in 1999. It completed the destruction of its stockpile in July 2008 – the second CWC member to do so.[306]

The South's destruction of its CW stocks has largely gone unnoticed because Seoul has a confidentiality agreement with the Organization for the Prohibition of Chemical Weapons (OPCW) and neither confirms nor denies the existence of its abandoned CW program.[307] The issue is sensitive in the ROK, and the government is divided. Diplomats in the Foreign and Trade Ministries generally favor disclosure, but the Defense Ministry prefers ambiguity because of the supposed residual deterrent effect on Pyongyang.[308]

According to many reliable sources, the ROK declared possession of several thousand metric tons of chemical warfare agents and one chemical weapons production facility to the OPCW upon its ratification of the CWC.[309] Paul Walker, security and sustainability chief at Global Green USA, said that discussions with informed sources and his own research indicate that the ROK probably held between 3,000 and 3,500 metric tons of chemical warfare material, likely including 400 to 1,000 metric tons of sarin nerve agent in artillery shells.[310] The rest could have been binary agents that would have become dangerous when mixed together.[311]

After the Yeonpyeong Island shelling, the South Korean National Emergency Management Agency provided 1,300 gas masks for the residents of the islands near the NLL and an additional 610,000 masks for the civil defense corps. The agency also reported that it would renovate subway stations and underground parking structures to better provide shelter in the case of a chemical attack. Yet, these measures could be more to mitigate public fears than legitimately protect civilians, as the gas masks would not be of much use in that the masks do not protect against many of the chemical weapons believed to be possessed by the DPRK.[312]Moreover, the US chemical warfare battalion returned to South Korea in 2013, after previously being deployed elsewhere in 2004.[313]

ROK Biological Weapons Developments

The ROK ratified the Biological and Toxin Weapons Convention (BTWC) in June 1987, and while the country possesses a well-developed pharmaceutical and biotech infrastructure – the ROK was the 12th largest pharmaceutical market in the world in 2005 valued at USD 7.7 billion – which could serve as the basis for a biological weapons program, there is no evidence that Seoul has an offensive biological weapons (BW) program.[314] Though the 2006 Defense White Paper, citing a biological threat from North Korea, stated the need for the ROK to conduct

defensive BW research and development, including the development of vaccines against anthrax and smallpox, this research was not discussed in the 2010 Defense White Paper.[315]

ROK Nuclear Developments

As has been touched earlier, nuclear weapons present a different case. The ROK once had an ambitious nuclear weapons program of its own, although it currently does not seem to have one.

Initial Weapons Research

The ROK formally initiated nuclear activities when it became a member of the International Atomic Energy Agency in 1957. In 1958 the Atomic Energy Law was passed, and in 1959 the Office of Atomic Energy was established by the government. The first nuclear reactor to achieve criticality in South Korea was a small research unit in 1962.[316]

The ROK apparently began considering developing nuclear weapons in the late 1960s when it began to have worries about the strength of its US alliance guarantees as a result of the US's problems in Vietnam and regional reductions in the US military presence under the Nixon Doctrine.[317] ROK President Park Chung Hee reportedly decided in 1970 to begin a nuclear weapons program, including the creation of a "Weapons Exploitation Committee," after US President Richard Nixon announced the withdrawal of 26,000 American troops from the ROK.[318] Park is said to have decided to pursue a plutonium bomb, and in 1973 the ROK sought to acquire a reprocessing facility from France and a research reactor and heavy water reactor from Canada to produce bomb-grade plutonium.[319]

Seoul's weapons program ran into difficulties, however, when some of its supply arrangements fell through amidst international concern over India's 1974 nuclear test – which, inconveniently for Seoul, was just the sort of misappropriation of dual-use plutonium technology that the ROK hoped to achieve for itself.[320]

US officials soon threatened to cancel US alliance guarantees if Seoul continued its weapons program and pressured France into not delivering the reprocessing facility, effectively ending the ROK's attempt to develop nuclear weapons.[321] Soon thereafter, the ROK ratified the NPT under pressure from the US. Seoul formally abandoned its program and signed the Treaty on the NPT in April 1975 before it had produced any fissile material and later became a state party to the Comprehensive Nuclear Test Ban Treaty (CTBT). President Park also stated in 1977 that Seoul would not develop nuclear weapons so long as the US nuclear umbrella continued to cover Seoul against Soviet and DPRK aggression, although it is believed he continued a clandestine program that only ended with his assassination in October 1979.[322]

Some ROK nuclear activities seem to have continued despite US security assurances and Park's assassination. The Korea Atomic Energy Research Institute (KAERI) contracted with the Youngnam Chemical Corporation to import phosphate compounds with a high level of uranium in the early 1980s. KAERI specifically selected phosphate rock with high uranium content for extraction and conversion, and between 1981 and 1984, yellow cake (U3O8) was converted to uranium oxide (UO2), which was used to produce fuel rods for the Wolsong-1 Nuclear Power Reactor in 1985.[323]

Reprocessing and Enrichment Activities

Seoul continued to conduct several nuclear-related experiments in the 1990s dealing primarily with reprocessing and uranium enrichment. ROK scientists conducted a series of laboratory-scale experiments, allegedly without the government's knowledge, up to 2000, all without properly declaring them to the IAEA.[324]

Once the IAEA discovered these experiments, Seoul cooperated with the IAEA and no evidence emerged that the work had formed part of a possible nuclear weapons program, that the program had been continued since the 1970s, or that anything more than basic research was involved.[325] According to interviews of US diplomats conducted in 2004 by the *Washington Post,* during these experiments, ROK scientists enriched uranium to levels four times higher than had their counterparts in Iran (as of 2004).[326]

Further information on the ROK's nuclear efforts was brought to light in August 2004 when the ROK's Ministry of Science and Technology (MOST) reported to the IAEA that South Korea had conducted experiments to enrich uranium, extract plutonium, and had produced uranium metal.[327] The Laboratory for Quantum Optics at KAERI conducted experiments to enrich uranium three times during January and February 2000.[328] The experiments yielded about 0.2 grams of uranium enriched to an average of 10% in the three experiments, with the peak level of enrichment in the experiments reaching 77%.[329]

The ROK is interested in developing an indigenous, plutonium fuel cycle for its civilian power program and had negotiated with the IAEA and the US Department of Energy over safeguards for a "partially constructed, pilot pyroprocessing facility" that it wanted to complete by 2012, with a semi-commercial facility in place by 2025. While ROK officials have claimed that the desire for such a facility was the result of "scientific curiosity" or part of plans to localize the production of nuclear fuel, it should be noted that these actions do have applications for weapons development, and questions remain about past activities that appear to have had more direct weapons applications.

The ROK's experiments in plutonium extraction and uranium enrichment were technically violations of Seoul's NPT safeguards commitments that had been in effect since 1975 as well as a violation of the 1992 North and South Korean Joint Declaration on the Denuclearization of the Korean Peninsula, but it is important to understand that they do not appear to have been part of a robust program to develop nuclear weapons.

As Daniel Pinkston has observed, while the experiments "provided data and experience that could be applied to a bomb program or to a peaceful nuclear fuel cycle that could later be part of a 'virtual bomb program' under certain contingencies, […] the experiments were insignificant in terms of bomb production."[330] However, the ROK's past and current experiments, along with the recent ROK development of long-range land-attack cruise missiles[331] and pursuit of a space-launch capability,[332] will not help alleviate suspicions in Pyongyang or the region. This is another factor making it difficult to achieve a non-nuclear Korean peninsula.

2010-2016 and the ROK Nuclear Development Debate

The creation of an ROK nuclear weapons program became the subject of a new political debate after the DPRK's new military provocations in 2010. Conservatives of the Saenuri party wanted the US to redeploy tactical nuclear weapons, while an August 2011 survey of 2,000 South

Koreans revealed that 63% supported the idea that the ROK should indigenously develop nuclear weapons to counteract the DPRK.

A similar survey in 2010 reported that 56% supported such development. In 2012, 66% were in favor of a weapons program; approximately the same results were seen in a 2013 poll that was taken several weeks after the DPRK's third nuclear test. From 2010 to 2012, the number of those who "strongly supported" such a program rose from 13% to 25%. At the same time, the 2013 poll results show that the "most salient" issue facing the country was job creation (40%), not North-South relations (8-15%).[333]

Outgoing President Lee Myung-bak gave qualified support for the idea in mid-February, saying, "There are some people saying South Korea should also have nuclear weapons. Those remarks are patriotic and I think highly of them. I don't think the comments are wrong because they also serve as a warning to North Korea and China." Yet Lee still added, "It is premature and improper for our government to discuss nuclear armament because the ultimate goal is for Pyongyang to give up its nuclear program through international cooperation, in spite of the DPRK announcement that it was no longer interested in denuclearization. [334] This announcement meant the ROK could make a case that the 1992 Korean Peninsula denuclearization agreement was dead.

Some ROK analysts have argued that the DPRK's third nuclear test was the ROK's Cuban missile crisis. Many in the South are now convinced that the DPRK may never give up its nuclear weapons, leading some to argue that the ROK should either develop its own or the US should restore the nuclear balance on the Peninsula by reintroducing US nuclear weapons, which had been removed in 1991.[335]

A small but growing number of South Koreans are concerned that the US, either because of budget cuts or a lack of will, might not provide its nuclear umbrella indefinitely – perhaps even pulling out of the country, like in Vietnam. Koreans are also frustrated that the US and international community has been unable to end the DPRK's nuclear program.[336]

One prominent national assemblyman (and the controlling interest in Hyundai) recently spoke at the April 2013 Carnegie International Nuclear Policy Conference, arguing that the ROK could potentially think about temporarily withdrawing from the NPT. As the US was not stopping the DPRK's development of nuclear weapons, and the US would not trade Seattle for Seoul, Chung argued that the ROK might need to develop nuclear capabilities of its own. It has also been noted that if there was not powerful (government) support for his comments in the ROK, he would not be saying such things in a public forum.[337]

> Facing an extraordinary threat to national security, South Korea may exercise the right to withdraw from the NPT as stipulated in Article X of the treaty. South Korea would then match North Korea's nuclear program step by step, while committing to stop if North Korea stops… South Korea should be given this leeway as a law-abiding member of the global community who is threatened by a nuclear rogue state…. The alliance has failed to stop North Korea from acquiring nuclear weapons. Telling us not to consider any nuclear weapons option is tantamount to telling us to simply surrender.

The 2016 test reignited the debate. Won Yoo-chul, the ruling party' floor leader in parliament, openly called for either the development of nuclear weapons or the redeployment of US nuclear weapons to the ROK, stating that "We can't borrow umbrellas from next-door every time it rains. We should wear a raincoat of our own". Furthermore, a poll taken in the aftermath of the test found that 2/3 of South Korean citizens were in favor of their government developing nuclear weapons.[338]

There have also been new calls for the ROK to be given the same right as Japan to build up plutonium levels from spent reactor fuels. At the same time, other prominent government officials like Prime Minister Hwang Kyo-ahn have maintained that the ROK's principle focus remained the complete denuclearization of the Korean Peninsula, and Defense Minister Han Min-koo insisted that the government was not planning on pursuing the development of nuclear weapons. [339][340]

Yet, developing nuclear weapons would create major problems for the ROK's nuclear program and energy security. The ROK would run out of nuclear fuel and might not be able to access imported fossil fuels, while the US might remove its security guarantee as punishment. The ROK would also have to drop out of the NPT, freezing relations with China, Japan, and Russia, and correspondingly increasing the likelihood of a DPRK attack.[341]

The ROK possesses a large and extensive civilian nuclear power industry –with 25 reactors providing one third of the ROK's electricity.[342] It has plans for a total of 40 reactors providing 59% of the ROK's electricity by 2030. Coupled with past weapons research, some estimate this technology could serve as a basis for any plans to develop nuclear weapons in the future should it feel that DPRK nuclear threats or a potential downturn in the US-ROK alliance warrant such a move.

The ROK is also interested in developing an indigenous, plutonium fuel cycle for its civilian power program and had negotiated with the IAEA and the US Department of Energy over safeguards for a "partially constructed, pilot pyroprocessing facility" that it wanted to complete by 2012, with a semi-commercial facility in place by 2025.[343] While ROK officials have claimed that the desire for such a facility was the result of "scientific curiosity" or part of plans to localize the production of nuclear fuel, it should be noted that these actions do have applications for weapons development, and questions remain about past activities that appear to have had more direct weapons applications.[344]

Bill Gates visited the ROK in April 2013 to meet with President Park Geun-hye in order to promote his project of developing a next-generation nuclear reactor. His plan is for his nuclear start-up (TerraPower) and the Korea Atomic Energy Research Institute to jointly develop a 600 megawatt prototype by 2022, after which a final decision could be made on the feasibility of more large-scale production. Gates argued that it could be an effective means of dealing with the ROK's nuclear waste stockpiles – discussed further in the following sections – and that TerraPower was developing a safer and more economical next-generation reactor.

One ROK nuclear expert with links to the current administration said it agreed to do a three-month feasibility study with Gates. The reactor is called a "traveling wave reactor," similar to the ROK's sodium-cooled fast reactor development project. Both types use spent fuel from conventional reactors, and can greatly reduce the volume of nuclear waste and its toxicity, compared to existing reactors.[345]

Civilian Facilities and the 123 Agreement

It is important to understand just how developed the ROK's nuclear power program is. The ROK possesses a large and extensive civilian nuclear power industry – the world's fifth-largest, with 25 reactors providing one third of the ROK's electricity. It has plans for a total of 40 reactors providing 59% of the ROK's electricity by 2030.[346]

It is projected that ROK nuclear energy capacity will increase by 56% to 27.3 GWe by 2030 and 43 GWe by 2030. Korea Hydro & Nuclear Power (KHNP) expects to spend 4.7 trillion won ($3.68 billion) on nuclear plants in 2009 and complete 18 nuclear power plants by 2030 at a cost of 40-50 trillion won ($32 to 40 billion).[347] The country plans to invest $1.3 billion in research and development of a 150 megawatt fourth-generation reactor by 2028.[348] Currently, the ROK has four nuclear power reactor complexes and four nuclear research reactors.

Nuclear Power Reactors[349]

The Kori Complex, located near Busan, houses eight reactors, though only five are currently operational. Three more are under construction, and an additional two are currently projected to be start construction in 2014. Kori-1, which commenced operation in 1978 and is planned to be closed in 2017, is a 576 MWe two-loop pressurized light water reactor (PWR). It was South Korea's first nuclear power reactor.

Kori-2 (1983) is a 637 MWe two-loop PWR and the ROK's second nuclear power reactor. Kori-3 (1985) produces 1007 MWe and is a three-loop PWR, as is Kori-4 (1986). Shin (New) Kori-1 (2011) is a 1000 MWe PWR, as is Shin Kori-2 (2011). Shin Kori-3, the ROK's first advanced PWR with a 1400 MWe capacity, is expected to begin operations in the end of fall 2013. Shin Kori-4, also an advanced PWR with a 1400 MWe capacity, is expected to commence operations by the end of 2014.

The Uljin Complex, located in North Gyeongsang province, is comprised of six power reactors, all of which are operational. Ulchin-1 (1988 – 945 MWe) and Ulchin-2 (1989 - 942 MWe) are both three-loop PWRs. Ulchin-3 (1998) is a two-loop PWR, as is the 998 MWe Ulchin-4 (1998). Ulchin-5 (2004) is a 1001 MWe PWR, and Ulchin-6 (2005) is a 996 MWe PWR.

Wolsong Complex is also located in North Gyeongsang province and has six reactors, four of which are operational and two of which are under construction. Wolsong-1 (1983) is a 597 MWe pressurized heavy water reactor (PHWR), Wolsong-2 (1997) is a 710 MWe PHWR, Wolsong-3 (1998) is a 707 MWe PHWR, and Wolsong-4 (1999) is a 708 MWe PHWR.

Shin (New) Wolsong-1 (2011) is an indigenously designed 960 MWe PWR, as is Shin Wolsong-2, which was expected to commence in late 2012 but does not yet seem to be connected to the grid. Plans for Shin Wolsong-3 and Shin Wolsong-4 are in place, but construction has not yet been scheduled. They will be Advanced Pressurized Reactors with a 1400 MW(e) generating capacity and have estimated operational dates of 2020 and 2021, respectively.

Yonggwang Complex, located in South Jeolla province, also has six reactors, all of which are operational. Yonggwang-1 (1986) is a 953 MWe PWR, Yonggwang-2 (1987) is a 947 MWe PWR, Yonggwang-3 (1989) is a 997 MWe PWR, Yonggwang-4 (1996) is a 994 MWe PWR, Yonggwang-5 (2002) is a 988 MWe PWR, and Yonggwang-6 (2002) is a 996 MWe PWR.

Nuclear Research Reactors[350]

The Training, Research, Isotope, General Atomics Mark II (TRIGA-Mark II) Research Reactor was the ROK's first research reactor and is located in Seoul at the former location of the Korea Atomic Energy Research Institute (KAERI). The reactor began operations in 1960 and cost $73,000 (of which $35,000 was provided by the US). The original 100 KWth capacity was upgraded to a 250 KWth capacity in 1969. It used 20% enriched uranium for fuel. It was shut down at the end of 1995 and currently is part of a memorial display.

TRIGA-Mark III was South Korea's second research reactor, also under the aegis of KAERI; it used 70% enriched uranium fuel and had a capacity of 2 MWth. In the early 1980s, ROK scientists conducted plutonium extraction experiments in violation of the ROK'S NPT commitments, extracting .7 grams of fissile PU-239. Along with TRIGA-Mark II, TRIGA-Mark III was shut down in 1995 and completely dismantled by 2009.

The Aerojet General Nucleonics Model Number 201 (AGN-201) Research Reactor, located at Kyung Hee University (Suwon), was the ROK's first educational research reactor, donated by Colorado State University in 1976, becoming operational in 1982. The reactor uses 20% enriched uranium for fuel and has a 0.1 MWe capacity. The High-Flux Advanced Neutron Application Reactor (HANARO) has a capacity of 30 MWth. It began operations in 1996, and uses low-enriched uranium as fuel (19.75%).

Figure V.18 shows the reactors currently operating in the ROK, along with their type, date of initial operation, and net capacity. **Figure V.19** shows the ROK reactors that are either under construction or in the planning process, along with their type, start date of construction, projected date of operation, and capacity. Because the previous discussion of reactors and the figures below come from different sources, the declared net capacity of the various reactors may be slightly different.

The 123 Agreement

The possibility of an ROK weapons program could also affect the implementation of the ROK-US peaceful nuclear cooperation agreement. The 123 Civil Nuclear Agreement was initially signed 40 years ago and was renewed in April 2014.[351] Under the existing regime, the ROK works with US government agencies and companies to build a nuclear power infrastructure, including almost 20 reactors that generate 30% of the nation's electricity. [352]

The ROK is building more reactors and also has facilities for nuclear waste treatment, disposal, equipment manufacture, engineering, research, medicine, and fuel fabrication – all together, the ROK's nuclear assets are likely worth several billion dollars. Korean firms are now partnering with American businesses to develop nuclear power plants based on US technology in the ROK, China, and the US, as well as working to sell to other countries. The ROK currently has a contract to build reactors in the UAE.[353]

One ROK Assemblyman asked Bill Gates, during the latter's April 2013 trip to the ROK, to play a role in persuading the US government to let the ROK have more capabilities in its peaceful use of nuclear energy; without the revision in the 123 Agreement, Gates' plan to cooperate with the ROK in the development of next-generation nuclear technology would be difficult.[354]

However, an updated agreement was not reached despite two years of negotiations. The ROK asked it be allowed to extract uranium and plutonium from its thousands of tons of spent fuel, which originally came from the US. The ROK argued that reprocessing would be useful in reducing the used fuel stockpiles at its power plants, producing new fuel, and gaining public acceptance for building new reactors by showing it has a solution for nuclear waste issues.[355]

South Korea also argued that even though the ROK had no current plans to build a pyroprocessing facility, it wanted a US commitment that when the ROK does decide to start construction, the US would support it.[356] Furthermore, the ROK asserted that this capability – the ability to offer full nuclear fuel cycle services – is key to its competitiveness in the strategic

export of nuclear services.[357] President Park Geun-hye's Foreign Minister noted that the negotiations would be an important test of "trust" between the two countries.[358]

The ROK plans that nuclear services will become a significant export for the country in the future,[359] with the government claiming that South Korea can enrich uranium more cheaply than others and that it plans to export 80 nuclear power reactors over the next 20 years (equivalent to 20% of the international market). Industry leaders, alternatively, believe it is more likely that approximately 10 reactors could be exported over that time frame. Especially in a post-Fukushima context, the market for reactors is saturated, and the industry is not a huge money-maker in any event.[360] It is unlikely that the ROK would be able to reach the government's export goals; but, if the US refuses to allow pyroprocessing, the US becomes the scapegoat when the export goal fails, resulting in increased alliance tensions and hurting ROK public opinion of the US.[361]

The US has several problems with the ROK's request. It is unsure if pyro-processing is the most suitable method for the ROK to treat nuclear waste,[362] and it does not want other countries enriching spent fuel because the same technology allows countries to produce the explosive core of a nuclear weapon.[363] It has never granted reprocessing consent to countries that did not already have prior enrichment and reprocessing facilities.

Allowing the ROK to add this capability would set a precedent that others – like Taiwan, which also has a significant civilian nuclear program and waste issues – would also want to be allowed this capacity. Also, if the ROK is allowed to develop reprocessing, the DPRK (and Iran) could use this as an excuse to keep their programs, claiming equal treatment.

China's reaction to such an increase in ROK nuclear capabilities is uncertain. Continuation of the DPRK's program also pressures the ROK and Japan to withdraw from the NPT and develop their own nuclear deterrent – and ROK defense officials see a reprocessing capability as a shortcut to a potential nuclear option if future ROK-DPRK relations become worse.[364] The US would like to wait for the results of the 10-year joint feasibility study recently undertaken and then revisit the issue.[365]

There are also significant elements of pride and nationalism. South Korea argues that just because it did not have these capabilities 30 years ago when the initial agreement was negotiated, that shouldn't mean that they remain denied the capabilities – what the ROK sees as being relegated to a permanent second class status.[366]

Furthermore, the US-Japan nuclear cooperation agreement gives Japan the right to separate the plutonium from its spent fuel, and thus the ROK believes that it should be given the same right. On the other hand, the US-Japan agreement was signed in 1988 – when the Asia-Pacific had fewer nationalized territorial conflicts, the Cold War superpowers worked together against nuclear proliferation, and the DPRK was an NPT member without nuclear weapons.[367] The ROK also likely sees India as another case that should be applicable to its situation.[368]

It was announced on April 24, 2013 that the deadline to renegotiate the agreement had been delayed until 2016, though unconfirmed reports of the deadline delay had been circulating for several days in the ROK. While a spokesman for the ROK Foreign Ministry said that the two countries had agreed to a treaty extension in order to give the negotiators more time to sort out "the complexity of details and technologies," the ROK media was not as supportive. One editorial in the *JoongAng Ilbo* stated, "Washington does not seem to trust South Korea as much

as it reiterates blood-tight relations… Just because the pact has been extended for two years does not assure that the two will narrow their differences. It is merely a makeshift move to avoid a dispute."[369]

The new agreement was eventually signed in June 2015. Under its provisions, South Korea is now permitted to enrich uranium civilian energy purposes "in the future through consultations with the United States".[370] It attempted to bypass the controversial issue of advanced consent over reprocessing and enrichment by setting up a bilateral commission to negotiate all potential developments in these areas.[371]

Figure V.18: Nuclear Power Reactors Operating in the ROK

Reactor	Type	Net Capacity	Commercial Operation	Planned Close
Kori 1	PWR (Westinghouse)	576 MWe	4/1978	2017
Kori 2	PWR (Westinghouse)	640 MWe	7/1983	2023
Wolsong 1	PHWR (Candu 6)	657 MWe	4/1983	2022 or 2036
Kori 3	PWR (Westinghouse)	1011 MWe	9/1985	2025
Kori 4	PWR (Westinghouse)	1010 MWe	4/1986	
Yonggwang 1	PWR (Westinghouse)	961 MWe	8/1986	
Yonggwang 2	PWR (Westinghouse)	977 MWe	6/1987	
Ulchin 1	PWR (Framatome)	963 MWe	9/1988	
Ulchin 2	PWR (Framatome)	965 MWe	9/1989	
Yonggwang 3	PWR (Syst 80)	1000 MWe	12/1995	
Yonggwang 3	PWR (Syst 80)	998 MWe	3/1996	
Wolsong 2	PHWR (Candu)	650 MWe	7/1997	
Wolsong 3	PHWR (Candu)	665 MWe	7/1988	
Wolsong 4	PHWR (Candu)	669 MWe	10/1999	
Ulchin 3	OPR-1000	997 MWe	8/1998	
Ulchin 4	OPR-1000	999 MWe	12/1999	
Yonggwang 5	OPR-1000	994 MWe	5/2002	
Yonggwang 6	OPR-1000	993 MWe	12/2002	
Ulchin 5	OPR-1000	998 MWe	7/2004	

Ulchin 6	OPR-1000	997 MWe	4/2005	
Shin Kori 1	OPR-1000	999 MWe	2/2011	
Shin Kori 2	OPR-1000	1000 MWe	7/2012	
Shin Kori 3	APR1400	1340 MWe	(5/2016)	
Shin Wolsong 1	OPR-1000	998MWe	7/2012	
Shin Wolsong 2	OPR-1000	10,000 MWe	7/2015	
Total: 25		**23,017 MWe**		

Source: "Nuclear Power in South Korea," World Nuclear Association, updated June 2016, http://www.world-nuclear.org/info/Country-Profiles/Countries-O-S/South-Korea/.

Figure V.19: ROK Nuclear Power Reactors under Construction or Planned

Reactor	Type	Gross Capacity	Construction Start	Commercial Operation (Planned)
Shin Kori 4	APR-1400	1400 MWe	August 2009	2/2017
Shin Ulchin 1	APR-1400	1400 MWe	July 2012	4/2017
Shin Ulchin 2	APR-1400	1400 MWe	June 2013	2/2018
Shin Kori 5	APR-1400	1400 MWe	September 2016	3/2021
Shin Kori 6	APR-1400	1400 MWe	September 2017	3/2022
Shin Ulchin 3	APR-1400	1400 MWe	2018	12/2022
Shin Ulchin 4	APR-1400	1350 MWe	2019	12/2023
Cheonju 1	APR+	1500 MWe	2022	12/2026
Cheonju 2	APR+	1500 MWe	2023	12/2027
Shin Kori 7	APR+	1500 MWe		
Shin Kori 8	APR+	1500 MWe		
Total:11		**11,600MWe (~11,580 MWe net)**		

Note: "Start construction" in bold means the reactors are already under construction.

Source: "Nuclear Power in South Korea," World Nuclear Association, updated June 2016, http://www.world-nuclear.org/info/Country-Profiles/Countries-O-S/South-Korea/.

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During the late 1960s and early 1970s, the DPRK received assistance from both the Soviet Union and China in developing its nascent chemical industry. The U.S. Defense Intelligence Agency (DIA) estimated in May 1979 that the DPRK had only a defensive capability in CW… Estimates vary as to when North Korea is believed to have acquired the capability for independent CW production.
Some sources suspect it was not until the early 1980s, and others speculate it was as early as the 1970s. By the late 1980s, the DPRK was capable of producing substantial amounts of CW agents and deployed a large number of chemical weapons munitions. In January 1987, the South Korean MND reported that the DPRK possessed up to 250 metric tons of chemical weapons, including blister (mustard) and some nerve agents, and by 2010, the MND's estimate had climbed to 2,500 to 5,000 metric tons of chemical agents, including nerve agents…" http://www.nti.org/country-profiles/north-korea/chemical/.
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