

A Comprehensive History of North Korea's Nuclear Program and Lessons Learned

**Siegfried S. Hecker, Robert L. Carlin
and Elliot A. Serbin**

**Center for International Security and Cooperation
Stanford University**

May 23, 2018

A comprehensive technical and political history of North Korea's nuclear program over the past 26 years – S.S. Hecker, R.L. Carlin, and E.A. Serbin

Center for International Security and Cooperation, Stanford University

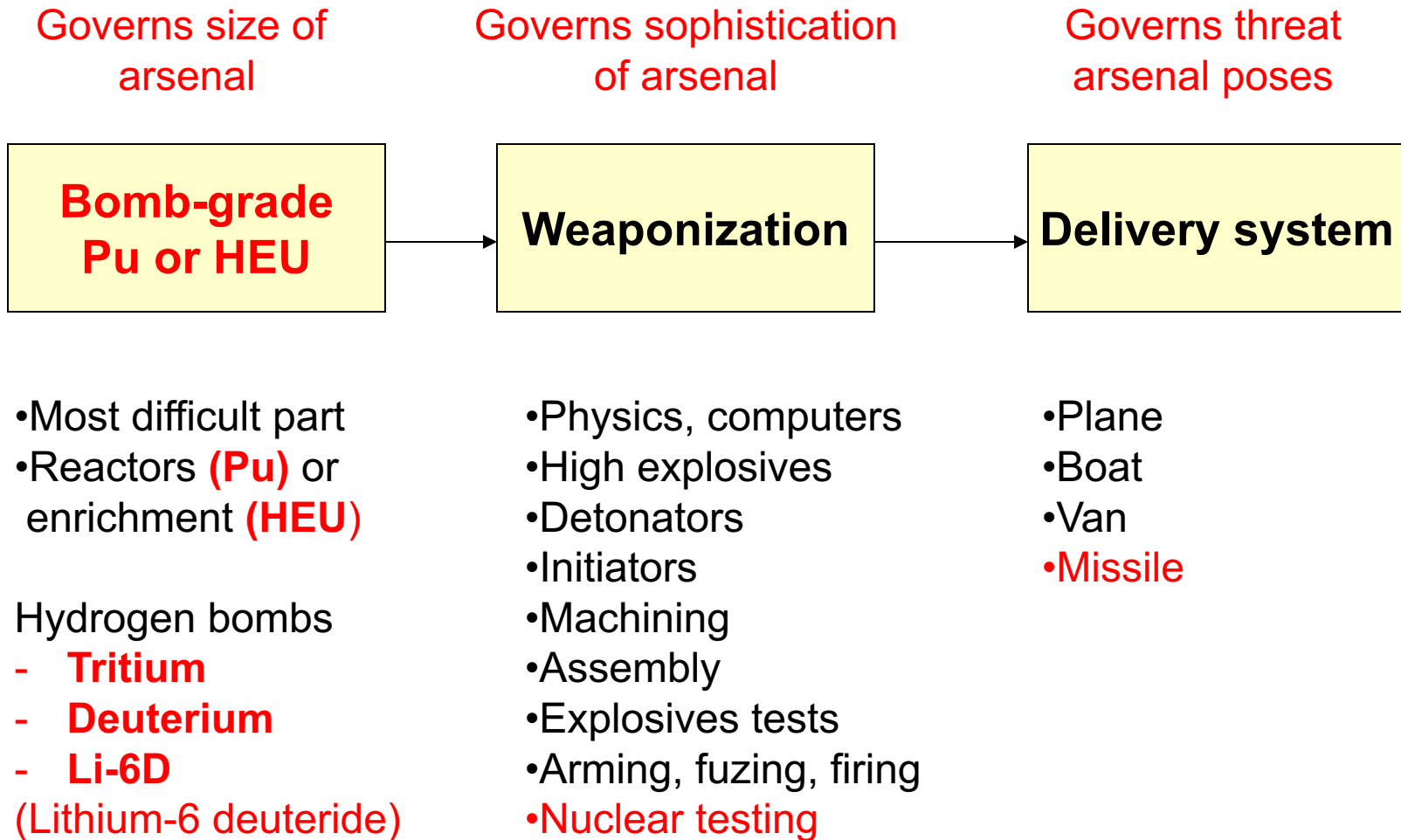
- This history is based on an extensive literature review combined with expert analysis of diplomatic and political developments by R.L. Carlin and technical developments by S.S. Hecker. It was also informed by numerous interviews and inputs from other subject-matter experts in the U.S. and abroad.
- The objective is to present an overarching comprehensive picture of the evolution of North Korea's nuclear program to help understand the relationship among politics, diplomacy and technical developments during the entire time frame.
- The analysis helps to illuminate how critical decisions, either technical or political, affected the direction of the nuclear program. It points to numerous "hinge points" that proved critical in the evolution of the program and relations between North Korea and the United States.
- The history is presented in color charts to provide easy-to-follow visual interpretations year-by-year of technical and political developments and their relationships. We use three shades of red denoting negative effects (for example, nuclear buildup or lack of diplomacy – the darker the more negative) and three shades of green denoting positive effects (serious diplomacy, for example, or lesser nuclear advances – the darker the more positive). We have defined rigorous coding criteria for each color shade in each category.
- The charts are supplemented with a separate written narrative that provides detailed explanations of the key developments on an annual basis. We do not cite the many dozens references that we used because the final judgments on the narrative and the color coding were made by the authors.

Lessons learned from the comprehensive history

- Pursuit of weapons was deliberate and determined – not responsive/reactive or triggered by provocations. It was patient, not a surprise, not the most secretive.
- Program slowed, sometimes reversed, but never abandoned during diplomacy. Most important element was a US/IAEA presence in Yongbyon.
- US diplomacy since 2000 has been sporadic and reactive. Resulted in avoiding risk instead of managing risk.
- Nuclearization was a massive enterprise – took 25 years to go to dark red, going to dark green (denuclearization) will take time.
- Besides what does denuclearization mean? No weapons, no deployed weapons, no fissile materials, no missiles, no people, no civilian nuclear program...?
- As bad as it was in 2017, stop it from getting worse. Several opportunities missed in the past by not managing the incremental risks.
- The narrative that North Korea “has cheated on every agreement” is neither accurate nor useful. Need to better understand history so as not to repeat mistakes.

Fielding a nuclear arsenal requires three components:

1) Bomb fuel, 2) Weaponization (design, build, test), and 3) Delivery systems



The individual requirements for the three components will constitute the columns in the technical parts of the charts.

Explanation of column headings

US Diplomacy

A measure of US initiatives and efforts to support diplomatic engagement with North Korea. It is a metric of effort and does not necessarily depend on definite progress toward US goals of limiting or terminating the North Korean nuclear and ballistic missile programs.

North Korea Diplomacy

A measure of North Korean initiatives and efforts to support diplomatic engagement with the US, though not necessarily in support of common goals. The metric does not depend on definite progress toward US goals of limiting or terminating the North Korean nuclear and ballistic missile programs.

US/IAEA Presence at Yongbyon Nuclear Center

A measurement of the presence of US and/or International Atomic Energy Agency (IAEA) personnel at the Yongbyon Nuclear Complex.

Plutonium

A measurement of the state of plutonium production facilities and the current stockpile of weapons-grade plutonium.

Uranium Enrichment

A measurement of the state of uranium enrichment program and facilities and the current stockpile of highly enriched uranium (HEU).

Tritium/Lithium-6

The heavy isotopes of hydrogen, deuterium and tritium, are required for fusion (hydrogen bombs). Deuterium is easily separated from normal hydrogen in water. Tritium is produced by exposing Lithium-6 to neutrons (such as in a reactor or in a bomb). This column represents a measurement of the state of production of fusion bomb fuels and the current stockpiles of tritium and Lithium-6.

Weaponization

A measurement of the level of nuclear weapons development (design, build and test) achieved and in progress.

Nuclear Weapons Summary

A measurement of the level of nuclear weapons development achieved and in progress, encompassing fissile and fusion material production and weaponization, including nuclear tests.

Missiles Summary

A measurement of the level of missile development and deployment achieved and in progress, encompassing all aspects of delivery system development.

Examples of color shade coding criteria:

US Diplomacy

A measurement of US initiatives and efforts to support diplomatic engagement with North Korea.

G3: Sustained and serious US engagement at every level with North Korea intended to conclude and implement agreements.

G2: Continued engagement and efforts to implement agreements reached with North Korea, but without serious, demonstrated intent to push beyond the current levels.

G1: Limited engagement, no new initiatives, difficulties dealing with implementation of existing agreements for reasons of internal political or bureaucratic opposition.

R1: Episodic engagement for forms sake but no serious overtures; some actions that reverse or undermine existing agreements.

R2: Rare, sporadic pro forma contact, limited communication, no realistic proposals. Failure to explore North Korean initiatives. Failure to implement or abrogation of existing agreements.

R3: Minimal or no engagement. Overt expressions of hostility.

Missiles

A measurement of the level of missile development and deployment achieved and in progress (encompassing all aspects of delivery system development).

G3: No missile development or significant rollback of missile capabilities.

G2: Complete missile and space launch rocket testing moratorium or roll back of missile deployment.

G1: Ongoing rocket/missile R&D and component testing. In case of previous missile deployments, observing a long and intermediate missile or space-launch testing moratorium.

R1: Short and medium (SCUD and Nodong) missile component procurement, manufacturing and deployment with flight tests. Possible development of space-launch rockets, IRBMs or ICBMs but no flight tests. Space launch possible.

R2: Significant increase in missile tests. In addition to SCUD and Nodong deployment and testing, also test IRBMs and continued vigorous development of long-range missiles and technologies.

R3: In addition to R2, also test ICBM and continue vigorous development and testing of advanced IRBM and ICBMs.

A complete list of coding criteria is provided in the Appendix

North Korea Nuclear Program– Technical Focus (Stanford University CISAC)
3 shades of green (dark best), 3 shades of red (dark worst) –Hecker/Carlin/Serbin

Year	US Diplomacy	DPRK Diplomacy	Yongbyon Presence	Plutonium	U enrichment	Tritium/Li6	Weaponize Design/build/test	Nukes (Summary)	Missiles
1992	G1	G1	G1	G2	G1	G1	R1	R1	R1
1993	G2	G2	G1	G2	G1	G1	R1	R1	R1
1994	G3	G3	G1	G2	G1	G1	R1	R1	R1

The beginning of diplomatic outreach from both sides

A sampling of narratives of the political history:

US Diplomacy: 1992: G1

The year begins on a positive note by the George H.W. Bush administration with a January meeting in New York between Undersecretary of State for Political Affairs Arnold Kanter and Korean Worker's Party Secretary for International Affairs Kim Yong Sun. The year ends with tensions rising as the IAEA moves toward demanding special inspections in the North.

DPRK Diplomacy: 1992: G1

At the January meeting in New York between Arnold Kanter and Kim Yong Sun, Kim hints that the North is willing to accept long term presence of US troops on the Korean Peninsula. North ratifies the IAEA safeguards agreement, leading to IAEA inspections. These produce evidence of cheating, and tensions rise with IAEA moves toward demanding special inspections. By then Kim Jong-il has already decided to have the North withdraw from the Nuclear Non-Proliferation Treaty (NPT) in 1993.

DPRK Diplomacy: 1993: G2

In March, North Korea gives its notice of intent to withdraw from the NPT in 90 days (as per NPT provisions). The clock is stopped in June at the last minute with a US-DPRK joint statement. In second round of talks in July in Geneva, North Korea announces a "bold decision" to give up its graphite moderated reactor (GMR) technology in return for light water reactors (LWRs). For the remainder of the year, there are frequent meetings with the US but no progress in the face of suspicions of North Korean efforts to evade IAEA monitoring.

US Diplomacy: 1994: G3

Tensions build as the North threatens to unload its 5 MWe reactor without IAEA monitoring. When it does so, the first nuclear crisis ensues as the Clinton administration reviews options for a possible military response. The crisis is resolved diplomatically as full-scale diplomacy resumes in July, is interrupted by the death of Kim Il Sung, then resumes again for meetings in August and September, culminating in the Agreed Framework (AF) signing in October. US midterm elections in November bring a wave of conservative lawmakers into Congress, impeding the Clinton administration's efforts at AF implementation.

North Korea Nuclear Program– Technical Focus (Stanford University CISAC)
3 shades of green (dark best), 3 shades of red (dark worst) –Hecker/Carlin/Serbin

Year	US Diplomacy	DPRK Diplomacy	Yongbyon Presence	Plutonium	U enrichment	Tritium/Li6	Weaponize Design/build/test	Nukes (Summary)	Missiles
1992	G1	G1	G1	G2	G1	G1	R1	R1	R1
1993	G2	G2	G1	G2	G1	G1	R1	R1	R1
1994	G3	G3	G1	G2	G1	G1	R1	R1	R1

A sampling of narratives of the technical history for 1992:

Plutonium: G1

The 5 MWe reactor is operating. The plutonium reprocessing facility is operational. North Korea declares a plutonium inventory of reprocessed 90 grams of plutonium from previous operations. It gives IAEA inspectors access to verify its claim, but the inspectors discover a discrepancy of multiple, not only one, previous reprocessing campaigns. Plutonium inventory is likely between 100s of grams to a few kilograms rather than the 90 grams declared.

Uranium enrichment: G1

North Korea has industrial scale uranium processing and fabrication facilities at Yongbyon for the uranium metal alloy fuel elements for the 5 MWe reactor (GMR). It has abundant uranium ore supply from two mines. North Korea likely has some centrifuge R&D activity based on small number of Urenco centrifuges, but slows down that effort in favor of plutonium production. It has requisite uranium chemical facilities and processes to make UF₄ (in large quantities because of its use for reactor fuel manufacture) and some experimental UF₆ production (required only for enrichment activities).

Weaponization: R1

North Korea most likely had an active nuclear weapons R&D program in the 1980s. This effort is believed to have included weapon physics design and engineering, including explosive cold tests for implosion (Nagasaki-style) nuclear fission devices. It also likely included materials R&D on special nuclear materials such as plutonium and uranium, and high explosives. Initial efforts on nuclear device fabrication and preparations for possible underground nuclear tests had likely been underway.

Missiles: R1

North Korean missile efforts date back to 1960s and 1970s in collaboration with Soviet Union and to some extent China. An extensive North Korean missile program prior to 1992 focused primarily on SCUD short-range missiles (SCUD-B with 300 km range) and components imported from Soviet Union. During the 1987-92 period, North Korea begins developing longer range missiles and space launch vehicles. North Korea continues to contract with a Russian missile design bureau and is believed to employ a large number of Russian missile specialists in Pyongyang following the dissolution of the Soviet Union. There is also evidence of major missile sales from North Korea to countries such as Iran, resulting in US sanctions on North Korean companies for missile proliferation. There are some reports of North Korean missile specialists being trained in China. Continued suspected imports of missiles, rocket technologies, components, materials and know-how from Russia – most likely by Russian individuals and institutes, rather than the Russian government.

1994 Crisis resolved by diplomacy: The Agreed Framework



- Replace graphite-moderated reactors with two light water reactors for 2000 MWe. In return for heavy fuel oil, North Korea will freeze its GMR and related facilities, allow IAEA inspection, and dismantle as progress is made on LWRs. Two sides will move toward full normalization of economic and political relations.
- Both sides will work toward peace and security of a nuclear-free peninsula.
- U.S. will provide formal assurances to the North Korea, against the threat or use of nuclear weapons by the US.
- North Korea will consistently take steps to implement the 1992 N/S Declaration.

North Korea Nuclear Program– Technical Focus (Stanford University CISAC)
3 shades of green (dark best), 3 shades of red (dark worst) –Hecker/Carlin/Serbin

Year	US Diplomacy	DPRK Diplomacy	YB Presence	Plutonium	U enrichment	Tritium/Li6	Weaponize Design/build/test	Nukes (Summary)	Missiles
1992	G1	G1	G1	G2	G1	G1	R1	R1	R1
1993	G2	G2	G1	G2	G1	G1	R1	R1	R1
1994	G3	G3	G1	G2	G1	G1	R1	R1	R1
1995	G3	G3	G3	G3	G1	G1	R1	G3	R1
1996	G3	G3	G3	G3	G1	G1	R1	G3	R1
1997	G2	G2	G3	G3	R1	G1	R1	G3	R1
1998	G2	G2	G3	G3	R1	G1	R1	G3	R1
1999	G3	G3	G3	G3	R1	G1	R1	G3	G1
2000	G3	G3	G3	G3	R1	G1	R1	G3	G1

Although AF has some difficult moments, diplomacy continues throughout the Clinton administration's term:

DPRK Diplomacy: 1998: G2

North Korea participates in working and ambassadorial level meetings on AF implementation, but these are increasingly difficult because of complaints by both sides on implementation. The Agreed Framework appears moribund by August when North Korea launches a satellite, shrugging off US warnings. Missile and Four Party talks in the fall make no progress. In November, US-DPRK talks in Pyongyang discuss US concerns about a suspected nuclear site at Kumchang-ri.

DPRK Diplomacy: 1999: G3

North Korea continues to engage in multiple meetings on AF implementation and KEDO (Korea Energy Development Organization) affairs. Four party talks are held in April. No progress is made but the US and North Korean delegations use the opportunity to deal with details for a US "visit" to the Kumchang-ri site. In May, the inspection of Kumchang-ri is completed with North Korean cooperation. Pyongyang accepts a visit by US presidential envoy William Perry. North Korea's reaction to the trip is positive. In September during talks in Berlin, North Korea agrees to a long-range missile launch moratorium in return for US commitment to lift some economic sanctions.

Missiles: 1998: R1

On August 31 North Korea attempted to launch a satellite using a Taepodong-1 rocket, possibly testing staging technology. Foreign assistance, primarily from Russia and Ukraine, but also Iran, was instrumental in Taepodong development. Earlier in April, US imposes sanctions on North Korea and Pakistan in response to Pyongyang's transfer of missile technology and components to Pakistan's Khan Research Laboratory. US and North Korea hold the first missile talks in Berlin in April. Evidence of continued transfer of Nodong missile technologies to Iran, possibly the sale of as many as 150 Nodongs.

Uranium Enrichment: 1998: R1

Centrifuge interest continues to increase. North Korea has covert procurement efforts for centrifuge technologies, materials and equipment. Likely scale-up of equipment for production of UF₆ – the feed material for centrifuges. Around this time, North Korea reportedly receives a centrifuge starter kit from A.Q. Khan comprised of twenty P-1 centrifuges and four P-2 centrifuges, along with flow meters and control devices. Also around this time, North Korean engineers visit Khan Research Laboratories to help Pakistan with missile technology and manufacture. Former President of Pakistan, Pervez Musharraf, confirmed in his memoirs that the North Koreans were regular guests at KRL and that Khan supplied them centrifuges so that they may gain experience in the operation of centrifuges, as well as with computer software.

1998 – Missiles and the Perry Process

North Korean medium and long-range missile programs raise concerns in Washington.

Former Secretary of Defense William Perry undertakes a North Korean Policy Review at the behest of President Clinton after North Korean space launch attempt.



Taepodong-1 launch (August 31, 1998)
Space launch attempt

(KCNA/AP)



(Courtesy William J. Perry)

“United States policy must, therefore, deal with the North Korean government as it is, not as we might wish it to be” (1999 Perry Report)



(Courtesy William J. Perry)

Almost there with diplomacy in Oct. 2000?



(Courtesy Deborah C. Gordon)

2000 US-DPRK Joint Communiqué pledges fundamental improvement in bilateral relations.

- to “fundamentally improve their bilateral relations” and “build a relationship free from past enmity.”
- Reference to missile issue and Kumchang-ri access important



(David Scull/The White House)

Vice Marshal Jo Myong-rok and President Bill Clinton at the White House



(David Guttenfelder/AP)

Kim Jong-il and Secretary of State Madeleine Albright in Pyongyang.

A sampling of narratives for 2000:

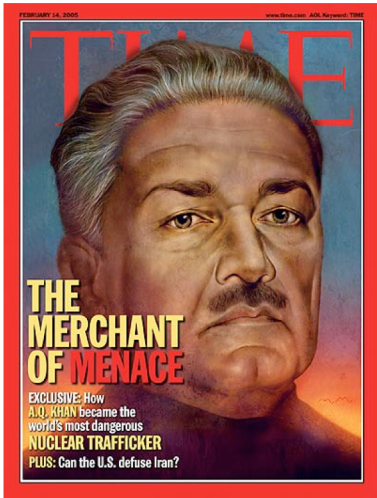
DPRK Diplomacy: 2000: G3

Progress in US-DPRK talks slows as the two Koreas work behind the scenes for their first summit. In June, at talks in Rome, North Korea agrees to repeat its commitment to a missile launch moratorium as a condition for the US fulfilling its commitment to lift some sanctions. In September, the North informs the US that it will send Vice Marshal Jo Myong Rok to Washington, reciprocating the Perry visit of May 1999. Jo arrives in October, meets with President Clinton and other US officials. The two sides release a joint communiqué, discussed at meetings since the beginning of the year, pledging to “fundamentally improve their bilateral relations,” not to have “hostile intent toward the other and... build a relationship free from past enmity.” Weeks later Secretary of State travels to Pyongyang for several hours of meeting with Kim Jong Il. Kim Jong Il proposes ideas during the Albright visit for limiting the North’s missile program, but talks to flesh this out in November make no progress.

US Diplomacy: 2000: G3

A key year. In January, the US passes to North Korea a draft of a document that eventually becomes a joint communiqué. In June, the US asks the North to reiterate its missile moratorium in return for US lifting some sanctions. On October 6, both countries issue the US-DPRK joint statement on the terrorism issue. On October 10, First Vice Chairman of the National Defense Commission Jo Myong Rok visits Washington DC. The Joint Communiqué is signed. On October 25, Secretary of State Madeleine Albright travels to Pyongyang, meets with Kim Jong Il, and holds discussions focused on the missile issue. A visit by President Clinton is raised as a possibility if progress is made on the latter.

Late 1990s - Uranium enrichment



- Covert global procurement network – centrifuge technologies, materials and equipment.
- Centrifuge starter kit from A.Q. Khan comprised of twenty P-1 centrifuges and four P-2 centrifuges – and possibly an implosion nuclear device design.
- North Korean engineers visit Khan Research Laboratories and receive hands-on training in centrifuge facilities.
- Likely scale-up of equipment for production of UF₆ – the feed material for centrifuges – later exported to Libya.

A sampling of narratives for 1998-2000 in which North Korea accelerates its uranium centrifuge program:

Uranium Enrichment: 1998: R1

Centrifuge interest continues to increase. North Korea has covert procurement efforts for centrifuge technologies, materials and equipment. Likely scale-up of equipment for production of UF₆ – the feed material for centrifuges. Around this time, North Korea reportedly receives a centrifuge starter kit from A.Q. Khan comprised of twenty P-1 centrifuges and four P-2 centrifuges, along with flow meters and control devices. Also around this time, North Korean engineers visit Khan Research Laboratories to help Pakistan with missile technology and manufacture.

Uranium Enrichment: 1999: R1

Covert procurement efforts increase. North Korea likely receives additional help from Khan including blueprints for centrifuge equipment and processes. Facilities for UF₆ production likely increase as it is preparing to sell tons of natural (un-enriched) UF₆ to Libya for its clandestine centrifuge program. This activity is most likely conducted outside of the Yongbyon complex because IAEA and US technical teams have access to Yongbyon. It is also likely that A.Q. Khan supplied North Korea with an HEU implosion bomb design similar to what he sold to Libya. Such a design could also have increased North Korea's interest in developing centrifuge capabilities.

Uranium Enrichment: 2000: R1

Covert centrifuge procurement efforts continue to increase. Shipments of small canisters of UF₆ made to Libya in September (per information received when M. Gaddafi gave up his clandestine centrifuge program). North Korea has a technical team at Pakistan's KRL to learn how to operate centrifuge cascades.

Plutonium production scaled back dramatically during AF



5 MWe reactor

Operations halted.

- ~6 kg/yr Pu potential.
- Did not operate 1995 through 2003.



50 MWe reactor

Construction halted – never completed.

(Pu forfeit ~ 56 kg/yr)



200 MWe reactor Taechon

Construction never completed.

(Pu forfeit ~ 220 kg/yr)

A sampling of narratives for 2000 for plutonium:

Plutonium: 1998: G3

In keeping with the AF, Yongbyon facilities remain frozen and monitored by IAEA inspectors. No plutonium is produced in reactor or reprocessed. Construction of two larger reactors remains halted. US technical team is at Yongbyon to facilitate placing the 8,000 spent fuel rods (containing an estimated 25 kg of plutonium) present in the spent-fuel pool into new canisters to avoid serious safety problems. US suspects North Korea has built a nuclear reactor complex inside Kumchang-ri mountain and requests inspection.

Plutonium: 1999: G3

Same conditions at the Yongbyon nuclear complex as in 1998. Access is granted to US team to inspect Kumchang-ri mountain tunnel, which finds no indication of nuclear facilities.

Plutonium: 2000: G3

Yongbyon nuclear complex remains frozen and under IAEA inspection with presence of US technical team. North Korea is believed to have signed contract to build a clandestine gas-graphite plutonium production reactor for Syria. Construction on 50 and 200 MWe reactors still halted since 1994. Yongbyon freeze greatly limits plutonium production capacity for the present and future. In fact, several years later, North Korea decides the reactors are not salvageable and their construction is permanently abandoned. Consequently, North Korea forfeits the ability to produce nearly 300 kg of plutonium per year and settles for the less than 6 kg per year potential of the 5 MWe reactor – a serious setback for the North Korean weapon program.

North Korea Nuclear Program– Technical Focus (Stanford University CISAC)
3 shades of green (dark best), 3 shades of red (dark worst) –Hecker/Carlin/Serbin

Year	US Diplomacy	DPRK Diplomacy	YB Presence	Plutonium	U enrichment	Tritium/Li6	Weaponize Design/build/test	Nukes (Summary)	Missiles
1992	G1	G1	G1	G2	G1	G1	R1	R1	R1
1993	G2	G2	G1	G2	G1	G1	R1	R1	R1
1994	G3	G3	G1	G2	G1	G1	R1	R1	R1
1995	G3	G3	G3	G3	G1	G1	R1	G3	R1
1996	G3	G3	G3	G3	G1	G1	R1	G3	R1
1997	G2	G2	G3	G3	R1	G1	R1	G3	R1
1998	G2	G2	G3	G3	R1	G1	R1	G3	R1
1999	G3	G3	G3	G3	R1	G1	R1	G3	G1
2000	G3	G3	G3	G3	R1	G1	R1	G3	G1

Year 2000 ends on a high note. Diplomacy is progressing and the nuclear and missile activities have for the most part been slowed and, for the case of plutonium, significantly reversed. North Korea has sacrificed significant plutonium production potential, but it is covertly pursuing a hedging strategy with the acquisition of uranium enrichment capabilities with an assist from Pakistan's A.Q. Khan. It is also likely that North Korea continues its nuclear weapon design, research and development activities at some level during the 1990s.

The Clinton administration is aware of the covert enrichment efforts but on balance these are still considered nascent enough to be dealt with in a way that preserves the broader benefits of the Agreed Framework, including the plutonium freeze.

The missile program is also kept in check with a missile testing moratorium resulting from the 1999 Perry Process.

North Korea Nuclear Program– Technical Focus (Stanford University CISAC)
3 shades of green (dark best), 3 shades of red (dark worst) –Hecker/Carlin/Serbin

Year	US Diplomacy	DPRK Diplomacy	YB Presence	Plutonium	U enrichment	Tritium/Li6	Weaponize Design/build/test	Nukes (Summary)	Missiles
1992	G1	G1	G1	G2	G1	G1	R1	R1	R1
1993	G2	G2	G1	G2	G1	G1	R1	R1	R1
1994	G3	G3	G1	G2	G1	G1	R1	R1	R1
1995	G3	G3	G3	G3	G1	G1	R1	G3	R1
1996	G3	G3	G3	G3	G1	G1	R1	G3	R1
1997	G2	G2	G3	G3	R1	G1	R1	G3	R1
1998	G2	G2	G3	G3	R1	G1	R1	G3	R1
1999	G3	G3	G3	G3	R1	G1	R1	G3	G1
2000	G3	G3	G3	G3	R1	G1	R1	G3	G1
2001	R2	G2	G3	G3	R1	G1	R1	G3	G1
2002	R3	G2	G3	G3	R1	G1	R1	G3	G1

Transition from 2000 to 2001 represents a major hinge point. It ended US diplomacy with North Korea.

US Diplomacy: 2001: R2

Progress stops abruptly. The George W. Bush administration assumes power with a contingent of hardline officials highly critical of the Agreed Framework and intent on ending it. Diplomatic contacts are severely cut back but not ended completely as the US government undertakes a policy review during the first half of the year.

DPRK Diplomacy: 2001: G2

North Korea ambassador comes to Washington to signal to the new administration that it is prepared to continue engagement with the US. Talks continue on KEDO implementation. Pyongyang expresses frustration at the new administration ignoring the October Joint Communiqué and limiting engagement.

US Diplomacy: 2002: R3

President Bush includes North Korea in the "axis of evil" in his State of the Union address. US begins cutback of support for KEDO. In October, US delegation led by A/S Kelly to Pyongyang confronts North Korea with issue of uranium enrichment. Kelly is under instructions to lay out the US position and then leave. There are no negotiations and only a limited exchange of ideas. In November, Kim Jong Il sends oral message to US signaling effort to put things back on track. White House rejects immediately. Under US pressure, KEDO suspends HFO deliveries. North Korea warns that will end the freeze of facilities at Yongbyon. In December, the North asks IAEA inspectors to leave.

Yongbyon facilities become operational in 2003

At end of 2002, North Korea expels IAEA inspectors from Yongbyon. In 2003, it withdraws from the NPT and restarts Yongbyon facilities.

In October 2003, Pyongyang states it “is making a switchover in the use” of its reprocessing facilities to produce a nuclear deterrent.



North Korea's
5 MWe reactor

Pyongyang likely built its first nuclear device in 2003

North Korea Nuclear Program– Technical Focus (Stanford University CISAC)
3 shades of green (dark best), 3 shades of red (dark worst) –Hecker/Carlin/Serbin

Year	US Diplomacy	DPRK Diplomacy	YB Presence	Plutonium	U enrichment	Tritium/Li6	Weaponize Design/build/test	Nukes (Summary)	Missiles
1992	G1	G1	G1	G2	G1	G1	R1	R1	R1
1993	G2	G2	G1	G2	G1	G1	R1	R1	R1
1994	G3	G3	G1	G2	G1	G1	R1	R1	R1
1995	G3	G3	G3	G3	G1	G1	R1	G3	R1
1996	G3	G3	G3	G3	G1	G1	R1	G3	R1
1997	G2	G2	G3	G3	R1	G1	R1	G3	R1
1998	G2	G2	G3	G3	R1	G1	R1	G3	R1
1999	G3	G3	G3	G3	R1	G1	R1	G3	G1
2000	G3	G3	G3	G3	R1	G1	R1	G3	G1
2001	R2	G2	G3	G3	R1	G1	R1	G3	G1
2002	R3	G2	G3	G3	R1	G1	R1	G3	G1
2003	R2	R2	R3	R3	R1	R1	R2	R2	G1
2004	R2	R1	R3	R3	R1	R1	R2	R2	G1

2002 – 2003 transition represents another major hinge point. Following US ending AF, North Korea builds the bomb.

DPRK Diplomacy: 2003: R2

In January, North Korea announces its withdrawal from the NPT. In March, North Korean jets intercept a US reconnaissance plane over the East Sea. China arranges a trilateral meeting (PRC-US-DPRK) that produces no results. In June, the North announces intention to build a "nuclear deterrent" unless US changes its position. In August, the first round of Six Party talks occur with no progress. The North sends a lower ranking official to head its delegation. In October, North Korea engages in a slow public acknowledgment of its nuclear intentions, with the Foreign Ministry stating that the North is "making a switchover in the use" of its reprocessing facilities to produce a nuclear deterrent and that it will display the deterrent at "the appropriate time."

US Diplomacy: 2003: R2

Bush administration takes no serious actions to counter North Korea's likely bomb production. It does participate in the Six Party talks, which begin in August but generate no progress. US ends funding for KEDO and the KEDO board suspends the LWR project.

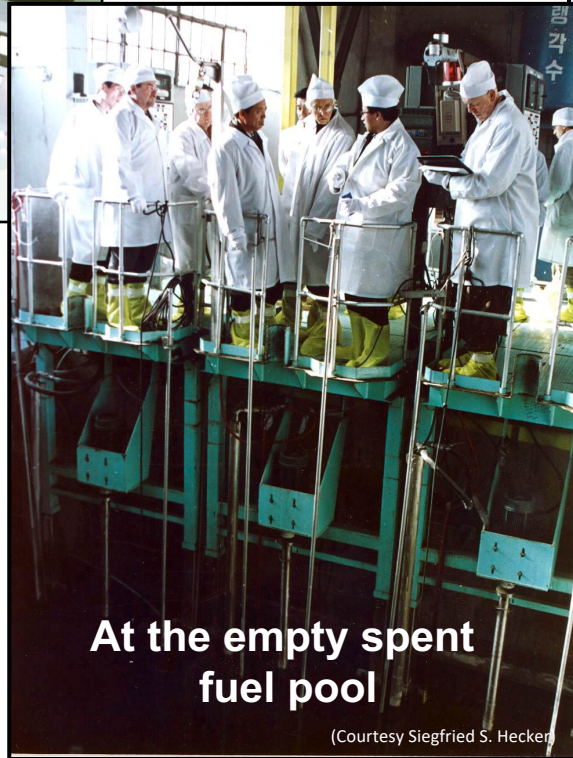
John Lewis Stanford delegation Track II visit to Yongbyon, Jan. 2004

Reactor control room



(Courtesy Siegfried S. Hecker)

5 MWe Reactor was operating.



At the empty spent fuel pool

(Courtesy Siegfried S. Hecker)



Radiochemical Laboratory

(Courtesy Siegfried S. Hecker)

8000 spent fuel rods reprocessed.
Contained ~25 – 30 kg plutonium.

Upon return to the US, Hecker concludes North Korea can build the bomb

North Korea Nuclear Program– Technical Focus (Stanford University CISAC)
3 shades of green (dark best), **3 shades of red** (dark worst) –Hecker/Carlin/Serbin

Year	US Diplomacy	DPRK Diplomacy	YB Presence	Plutonium	U enrichment	Tritium/Li6	Weaponize Design/build/test	Nukes (Summary)	Missiles
1992	G1	G1	G1	G2	G1	G1	R1	R1	R1
1993	G2	G2	G1	G2	G1	G1	R1	R1	R1
1994	G3	G3	G1	G2	G1	G1	R1	R1	R1
1995	G3	G3	G3	G3	G1	G1	R1	G3	R1
1996	G3	G3	G3	G3	G1	G1	R1	G3	R1
1997	G2	G2	G3	G3	R1	G1	R1	G3	R1
1998	G2	G2	G3	G3	R1	G1	R1	G3	R1
1999	G3	G3	G3	G3	R1	G1	R1	G3	G1
2000	G3	G3	G3	G3	R1	G1	R1	G3	G1
2001	R2	G2	G3	G3	R1	G1	R1	G3	G1
2002	R3	G2	G3	G3	R1	G1	R1	G3	G1
2003	R2	R2	R3	R3	R1	R1	R2	R2	G1
2004	R2	R1	R3	R3	R1	R1	R2	R2	G1

Plutonium: 2003: R3

In January, North Korea announces its withdrawal from NPT and restarts 5 MWe reactor and re-activates rest of Yongbyon nuclear facilities. Reprocessing of 8,000 fuel elements complete by end of June. Plutonium metal processing line, which was removed from Yongbyon during the AF, is re-installed in the Reprocessing Facility. North Korea now has roughly 20 to 30 kg of weapon-grade plutonium metal available and is producing nearly 6 kg more annually. No access for US or IAEA inspectors.

2004: R3

In January, North Korea shows Hecker and Stanford delegation (John W. Lewis and Charles (Jack) Pritchard) it has reprocessed and fabricated plutonium metal and that the rest of its Yongbyon facilities are operating. Hecker is convinced that North Korea has ability to make plutonium weapon components based on the piece he was shown and discussions with the Yongbyon technical team. Devices most likely of Nagasaki-type fission bomb design with approximately 6 kg plutonium. Increased preparation of nuclear test site, including mining, stemming and test diagnostics likely. Design and engineering team likely explores advanced fission design concepts beyond Nagasaki-style. North Korea also likely begins to explore tritium production with the possibility of eventually being able to produce a hydrogen bomb.

Stanford delegation is likely given remarkable access to Yongbyon to help convince the Bush administration and the world that North Korea has the bomb and now possesses a nuclear deterrent to keep the US out of the North.

North Korea Nuclear Program– Technical Focus (Stanford University CISAC)
3 shades of green (dark best), 3 shades of red (dark worst) –Hecker/Carlin/Serbin

Year	US Diplomacy	DPRK Diplomacy	YB Presence	Plutonium	U enrich	Tritium/Li6	Weaponize Design/build/test	Nukes (Summary)	Missiles
1992	G1	G1	G1	G2	G1	G1	R1	R1	R1
1993	G2	G2	G1	G2	G1	G1	R1	R1	R1
1994	G3	G3	G1	G2	G1	G1	R1	R1	R1
1995	G3	G3	G3	G3	G1	G1	R1	G3	R1
1996	G3	G3	G3	G3	G1	G1	R1	G3	R1
1997	G2	G2	G3	G3	R1	G1	R1	G3	R1
1998	G2	G2	G3	G3	R1	G1	R1	G3	R1
1999	G3	G3	G3	G3	R1	G1	R1	G3	G1
2000	G3	G3	G3	G3	R1	G1	R1	G3	G1
2001	R2	G2	G3	G3	R1	G1	R1	G3	G1
2002	R3	G2	G3	G3	R1	G1	R1	G3	G1
2003	R2	R2	R3	R3	R1	R1	R2	R2	G1
2004	R2	R1	R3	R3	R1	R1	R2	R2	G1
2005	R1	R1	R3	R3	R1	R1	R2	R2	R1

US Diplomacy: 2005: R1

Six Party joint statement released on September 19. North Korea agrees to abandon all nuclear weapons and existing nuclear programs. It calls for normalization of US-DPRK relations, the promotion of economic relations and energy assistance, a permanent peace regime, and consideration of an LWR at an appropriate time.

Within hours, Washington reneges on a key section (possibility of future LWRs for North Korea) and announces Treasury Department sanctions against a Macau-based Banco Delta Asia bank that, in effect, threaten any bank dealing with North Korea. US announces that KEDO will be dismantled by year's end.

DPRK Diplomacy: 2005: R1

In February, in a high-level Foreign Ministry statement, Pyongyang declares that it has manufactured nuclear weapons. Six Party talks resume in an extended 4th session; by September, an agreement is reached on a joint statement. North Korea's Foreign Ministry issues a statement rebutting the position taken in Ambassador Hill's closing remarks and criticizing US Treasury sanctions against Banco Delta Asia that result in freezing North Korean accounts in the bank. A 5th round of Six Party talks in November ends with no results.

Sept. 19, 2005 Six-Party Joint Statement

Could have opened door to return of IAEA

- North Korea agrees to abandon all nuclear weapons and existing nuclear programs
- Normalization of US-DPRK relations
- Promoting economic relations, energy assistance, and a permanent peace regime
- Consideration of LWR at an appropriate time


Agreement derailed by US Treasury sanctions and walk-back on LWR by the US



The fourth round of the Six Party Talks in Beijing.



North Korea Nuclear Program– Technical Focus (Stanford University CISAC)
3 shades of green (dark best), 3 shades of red (dark worst) –Hecker/Carlin/Serbin

Year	US Diplomacy	DPRK Diplomacy	YB Presence	Plutonium	U enrichment	Tritium/Li6	Weaponize Design/build/test	Nukes (Summary)	Missiles
1992	G1	G1	G1	G2	G1	G1	R1	R1	R1
1993	G2	G2	G1	G2	G1	G1	R1	R1	R1
1994	G3	G3	G1	G2	G1	G1	R1	R1	R1
1995	G3	G3	G3	G3	G1	G1	R1	G3	R1
1996	G3	G3	G3	G3	G1	G1	R1	G3	R1
1997	G2	G2	G3	G3	R1	G1	R1	G3	R1
1998	G2	G2	G3	G3	R1	G1	R1	G3	R1
1999	G3	G3	G3	G3	R1	G1	R1	G3	G1
2000	G3	G3	G3	G3	R1	G1	R1	G3	G1
2001	R2	G2	G3	G3	R1	G1	R1	G3	G1
2002	R3	G2	G3	G3	R1	G1	R1	G3	G1
2003	R2	R2	R3	R3	R1	R1	R2	R2	G1
2004	R2	R1	R3	R3	R1	R1	R2	R2	G1
2005	R1	R1	R3	R3	R1	R1	R2	R2	R1
2006	R1	R2	R3	R3	R1	R1	R2	R2 	R1

In 2006, the BDA sanctions restrain diplomatic dialogue, but in January the North participates with the US and China in Beijing to work toward resuming Six Party Talks. In June, North Korea invites Amb. Hill to Pyongyang, but the Bush administration declines.


North Korea conducts its first nuclear test on Oct. 9. The test was only partially successful with an explosion yield of less than one kiloton. Stanford delegation including Hecker is told during Pyongyang visit three weeks later that the test was successful and North Korea is filled with pride.

In spite of its limited success, the test changed everything, including how North Korea looked at itself and what it told its people. It also got the attention of the Bush administration as Amb. Hill meets with Vice Minister Kim Kye Gwan in Beijing shortly after the test.

Transition from 2006 to 2007 represents another hinge point as the Bush administration decides to pursue diplomacy for the rest of its second term.

North Korea Nuclear Program– Technical Focus (Stanford University CISAC)

3 shades of green (dark best), 3 shades of red (dark worst) –Hecker/Carlin/Serbin

Year	US Diplomacy	DPRK Diplomacy	YB Presence	Plutonium	U enrichment	Tritium/Li6	Weaponize Design/build/test	Nukes (Summary)	Missiles
1992	G1	G1	G1	G2	G1	G1	R1	R1	R1
1993	G2	G2	G1	G2	G1	G1	R1	R1	R1
1994	G3	G3	G1	G2	G1	G1	R1	R1	R1
1995	G3	G3	G3	G3	G1	G1	R1	G3	R1
1996	G3	G3	G3	G3	G1	G1	R1	G3	R1
1997	G2	G2	G3	G3	R1	G1	R1	G3	R1
1998	G2	G2	G3	G3	R1	G1	R1	G3	R1
1999	G3	G3	G3	G3	R1	G1	R1	G3	G1
2000	G3	G3	G3	G3	R1	G1	R1	G3	G1
2001	R2	G2	G3	G3	R1	G1	R1	G3	G1
2002	R3	G2	G3	G3	R1	G1	R1	G3	G1
2003	R2	R2	R3	R3	R1	R1	R2	R2	G1
2004	R2	R1	R3	R3	R1	R1	R2	R2	G1
2005	R1	R1	R3	R3	R1	R1	R2	R2	R1
2006	R1	R2	R3	R3	R1	R1	R2	R2 	R1
2007	G2	G1	G3	G1	R1	R1	R1	R1	R1
2008	G2	G1	G3	G1	R1	R1	R1	R1	R1

2007-2008:

With the Bush administration's decision to resume diplomatic activity, North Korea attends multiple meetings with US to discuss implementation of the 2005 Joint Statement. In the first phase in 2007, North Korea agrees to disable its Yongbyon facilities and provide a declaration of nuclear activities while the US agrees to provide energy aid and remove North Korea from the list of state sponsors of terrorism. Implementation is delayed until June, when the North receives its BDA funds. North Korea begins to disable Yongbyon nuclear facilities.

North Korea allows IAEA inspectors and US technical team back into the Yongbyon complex to verify the disablement activities. Hecker and Stanford colleagues are given access to previously closed laboratories. In June 2008, North Korea blows up the 5 MWe reactor cooling tower as a measure of good faith. However, declarations and verification issues turn problematic as US moves the goalposts in what it asks North Korea to do and North Korea complains about unreasonable US requests, particularly since during the year North Korea handed over samples of aluminum that it acquired from abroad for its missile program, which the US suspected to have been acquired for its covert centrifuge program. North Korea also supplied the US with copies of 18,000 pages of operational records of the Yongbyon plutonium facilities.

Perhaps more importantly, internal events may have dramatically changed North Korea's direction. Kim Jong Il suffered a severe stroke in mid-August 2008, opening the need for succession planning. Concern that outsiders would try to take advantage of the North at such a vulnerable period apparently triggered a decision that the moment for reconciliation had passed and that the North must now proceed with its nuclear program. On top of the list most likely actions was the need for a second nuclear test to demonstrate that North Korea, in fact, had a working nuclear device and would be able to mount an effective deterrent to the US.

Disablement efforts in 2007-2008: Serious, but reversible.

IAEA inspectors and US technical team allowed back into Yongbyon. Hecker visits in 2007 and 2008.

- 5 MWe reactor is not operating. No plutonium being produced.
- Disablement efforts are verified but are reversible.
- Likely increase in clandestine effort to build uranium enrichment facility.



Pyongyang heads into 2009 determined to enhance nuclear program



August 2008





Time runs out for Amb. Chris Hill - 2008

- In Feb./March 2009 visit, Stanford delegation is told by Amb. Ri Gun of North Korea's plans for upcoming space launch.
- When the delegation asks Amb. Ri why welcome the Obama administration so harshly, he tells them that is the way it is and you have no idea of how bad it is going to get.
- The April 5 space launch (which failed) is followed by UNSC sanctions. North Korea responds by expelling international inspectors and US technical team.
- On May 25 North Korea conducts its second nuclear test – this one is successful with an explosion yield of 4 to 7 kilotons.

North Korea Nuclear Program– Technical Focus (Stanford University CISAC)

3 shades of green (dark best), 3 shades of red (dark worst) –Hecker/Carlin/Serbin

Year	US Diplomacy	DPRK Diplomacy	YB Presence	Plutonium	U enrichment	Tritium/Li6	Weaponize Design/build/test	Nukes (Summary)	Missiles
1992	G1	G1	G1	G2	G1	G1	R1	R1	R1
1993	G2	G2	G1	G2	G1	G1	R1	R1	R1
1994	G3	G3	G1	G2	G1	G1	R1	R1	R1
1995	G3	G3	G3	G3	G1	G1	R1	G3	R1
1996	G3	G3	G3	G3	G1	G1	R1	G3	R1
1997	G2	G2	G3	G3	R1	G1	R1	G3	R1
1998	G2	G2	G3	G3	R1	G1	R1	G3	R1
1999	G3	G3	G3	G3	R1	G1	R1	G3	G1
2000	G3	G3	G3	G3	R1	G1	R1	G3	G1
2001	R2	G2	G3	G3	R1	G1	R1	G3	G1
2002	R3	G2	G3	G3	R1	G1	R1	G3	G1
2003	R2	R2	R3	R3	R1	R1	R2	R2	G1
2004	R2	R1	R3	R3	R1	R1	R2	R2	G1
2005	R1	R1	R3	R3	R1	R1	R2	R2	R1
2006	R1	R2	R3	R3	R1	R1	R2	R2 	R1
2007	G2	G1	G3	G1	R1	R1	R1	R1	R1
2008	G2	G1	G3	G1	R1	R1	R1	R1	R1
2009	R1	R1	R2	R1	R2	R2	R2	R2 	R1
2010	G1	R1	R3	R1	R2	R2	R2	R2	R1

North Korea proceeded with a controversial space launch attempt in April 2009, which as they likely anticipated was met with UNSC sanctions. That provided an excuse to conduct the second nuclear test, which was successful.

2009 – 2010: North Korea accelerates its nuclear weapon program

In April 2009 expels IAEA inspectors. After the second nuclear test in May, North Korea announces that it would pursue building its own light water reactor and begin uranium enrichment efforts to be able to produce its own reactor low enriched uranium fuel.

In 2010, diplomatic efforts by Amb. Steve Bosworth come close to more talks with the North but that is derailed as tensions flare between North and South Korea with North Korea's sinking of the South Korean naval corvette Cheonan and the shelling of Yeonpyeong Island.

In November, North Korea shows Lewis/Hecker/Carlin Stanford delegation a modern centrifuge facility housing 2000 P-2 type centrifuges, which apparently had just become operational. Hecker concluded that covert facilities must exist, which allowed North Korea to demonstrate working cascades and form the basis for the Yongbyon facility. With this revelation, Pyongyang sent a message to the US government and the world that it now has both paths to the bomb – plutonium and highly enriched uranium. The additional twist was to also send the message that the outside will never know how much they have since unlike plutonium production, uranium centrifuges are not observable from afar.

The Yongbyon centrifuge facility appears sufficiently large to produce LEU to fuel the new Experimental Light Water Reactor, the construction of which was also shown to the Stanford delegation. It could also be configured to produce approximately 40 kg of HEU annually. Total annual HEU production capacity is not known because of lack of knowledge about covert facilities. It is believed, however, that at this time North Korea has an HEU inventory of only a few tens of kilograms.

Yongbyon visit by Stanford team on Nov. 12, 2010

“We will convert our center to an LWR and pilot enrichment facility”



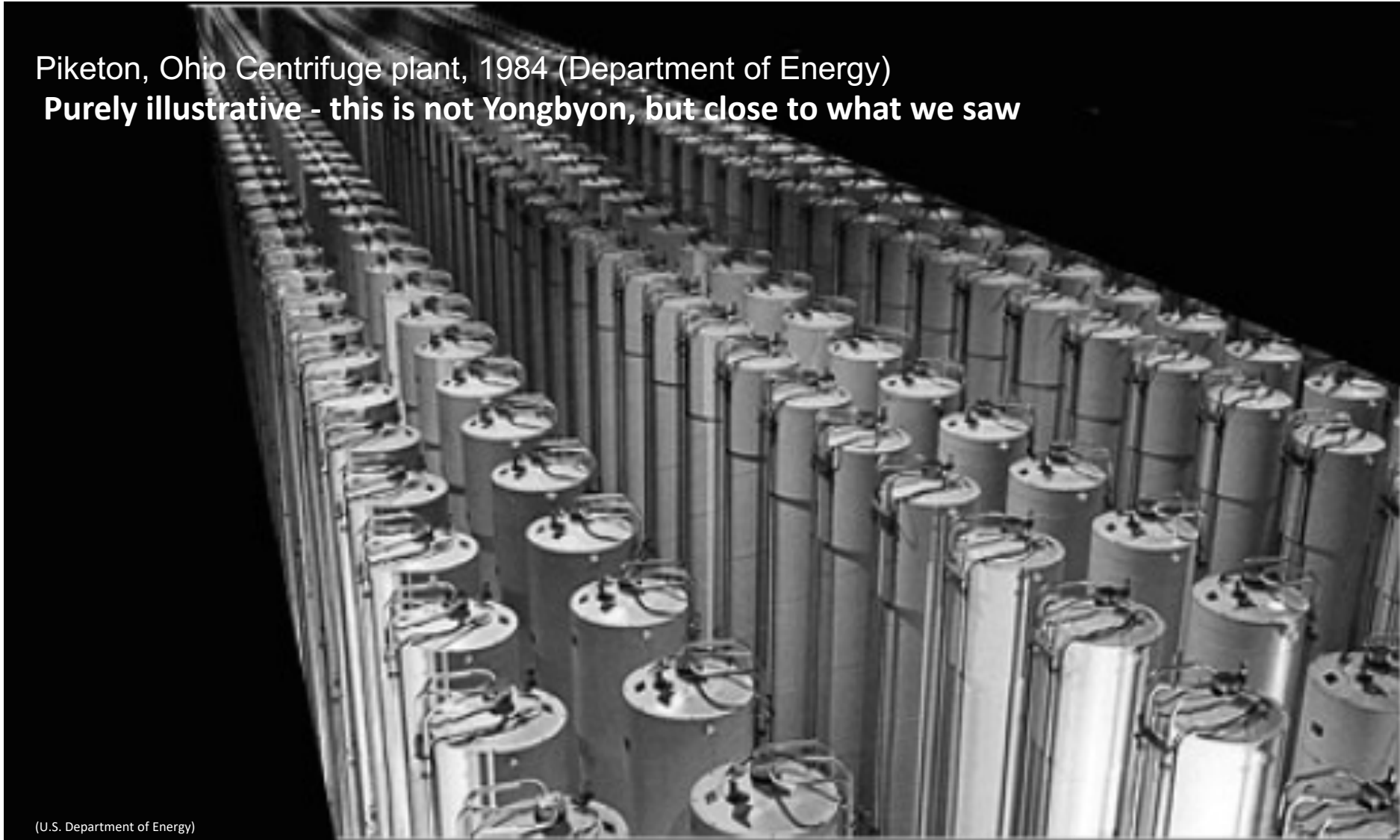
“No one believed us when we announced this in 2009 - including you, Dr. Hecker,” Ri Yong-ho (VM MFA)

Pyongyang reveals modern uranium centrifuge facility to Lewis/Hecker/Carlin in Nov. 2010

North Korea demonstrates second path to the bomb – makes assessment difficult

Piketon, Ohio Centrifuge plant, 1984 (Department of Energy)

Purely illustrative - this is not Yongbyon, but close to what we saw



(U.S. Department of Energy)

No outsiders have been in Yongbyon since Nov. 2010

North Korea Nuclear Program– Technical Focus (Stanford University CISAC)
3 shades of green (dark best), 3 shades of red (dark worst) –Hecker/Carlin/Serbin

Year	US Diplomacy	DPRK Diplomacy	YB Presence	Plutonium	U enrichment	Tritium/Li6	Weaponize Design/build/test	Nukes (Summary)	Missiles
1992	G1	G1	G1	G2	G1	G1	R1	R1	R1
1993	G2	G2	G1	G2	G1	G1	R1	R1	R1
1994	G3	G3	G1	G2	G1	G1	R1	R1	R1
1995	G3	G3	G3	G3	G1	G1	R1	G3	R1
1996	G3	G3	G3	G3	G1	G1	R1	G3	R1
1997	G2	G2	G3	G3	R1	G1	R1	G3	R1
1998	G2	G2	G3	G3	R1	G1	R1	G3	R1
1999	G3	G3	G3	G3	R1	G1	R1	G3	G1
2000	G3	G3	G3	G3	R1	G1	R1	G3	G1
2001	R2	G2	G3	G3	R1	G1	R1	G3	G1
2002	R3	G2	G3	G3	R1	G1	R1	G3	G1
2003	R2	R2	R3	R3	R1	R1	R2	R2	G1
2004	R2	R1	R3	R3	R1	R1	R2	R2	G1
2005	R1	R1	R3	R3	R1	R1	R2	R2	R1
2006	R1	R2	R3	R3	R1	R1	R2	R2 	R1
2007	G2	G1	G3	G1	R1	R1	R1	R1	R1
2008	G2	G1	G3	G1	R1	R1	R1	R1	R1
2009	R1	R1	R2	R1	R2	R2	R2	R2 	R1
2010	G1	R1	R3	R1	R2	R2	R2	R2	R1
2011	G1	G1	R3	R1	R2	R2	R2	R2	R1
2012	R1	R1	R3	R1	R2	R2	R2	R2	R1

2012 Leap Day Agreement – classic case of different views and opportunity missed



US Special Representative for North Korean Affairs Glyn Davies briefs reporters after a meeting with Kim Kye Gwan in February.

Opportunity for:

- Missile and nuclear test moratorium
- Resolving uranium enrichment issue
- Freezing nuclear work and allowing inspectors back in Yongbyon

- No joint statement or agreement – each side makes its own announcement
- US claims moratorium for long-range missiles
- North Korea – only ban long-range missiles, not space launches (claims priority of Space Treaty over UNSC resolutions)

As a result of April 13 satellite launch, US walks away from deal and North Korea nuclear buildup continues unabated

2011 – 2012: Diplomacy in fits and starts. Nuclear program increases slowly.

In July 2011, US Special Representative for North Korea, Amb. Steve Bosworth, and VFM Kim Kye Gwan hold talks in New York. A second meeting takes place in Geneva in October as two sides make progress on key issues aiming for a new agreement. Talks set for December are cancelled with death of Kim Jong Il. Bosworth is replaced by Amb. Glyn Davies.



On Feb. 29, 2012, US and North Korea in separate and slightly different press statements announce an agreement (the "Leap Day Agreement") in which North Korea would suspend nuclear activities at Yongbyon with IAEA verification and institute a moratorium on nuclear and missile tests, though it does not itself pledge to halt space launches. US will provide the North with 240,000 metric tons of food. Within weeks, the North announces it will launch a satellite in April. The Obama administration sends secret mission to Pyongyang in a failed effort to dissuade the North from launching. US announces cancellation of the Leap Day deal as a result of April 13 launch attempt.

Lost in the Leap Day Deal withdrawal by the US.

In retrospect, passing up instituting a nuclear and missile testing moratorium and getting access to Yongbyon facilities (including the centrifuge facility at that site) was an important opportunity lost. North Korea likely possessed only a few tens of kilograms of plutonium and a like amount of highly enriched uranium. Its reactor was not operating. The Yongbyon centrifuge facility would have been opened for inspection and prevented HEU production there (although a limited level of enrichment could have continued at the covert site(s)). North Korea had not conducted successful long-range missile tests and no successful space launch. As the follow-on charts show, North Korea made rapid progress in subsequent years because they were not impeded by agreements or an international presence in Yongbyon.




The 5 MWe reactor is restarted in August 2013 to once again produce plutonium at a rate of somewhat less than 6 kg annually. Commercial overhead satellite imagery suggests that the size of the Yongbyon centrifuge facility is likely doubled that year. Construction is also found consistent with the potential production and extraction of tritium (fuel necessary for fusion bombs).

North Korea Nuclear Program– Technical Focus (Stanford University CISAC)
3 shades of green (dark best), 3 shades of red (dark worst) –Hecker/Carlin/Serbin

Year	US Diplomacy	DPRK Diplomacy	YB Presence	Plutonium	U enrichment	Tritium/Li6	Weaponize Design/build/test	Nukes (Summary)	Missiles
1992	G1	G1	G1	G2	G1	G1	R1	R1	R1
1993	G2	G2	G1	G2	G1	G1	R1	R1	R1
1994	G3	G3	G1	G2	G1	G1	R1	R1	R1
1995	G3	G3	G3	G3	G1	G1	R1	G3	R1
1996	G3	G3	G3	G3	G1	G1	R1	G3	R1
1997	G2	G2	G3	G3	R1	G1	R1	G3	R1
1998	G2	G2	G3	G3	R1	G1	R1	G3	R1
1999	G3	G3	G3	G3	R1	G1	R1	G3	G1
2000	G3	G3	G3	G3	R1	G1	R1	G3	G1
2001	R2	G2	G3	G3	R1	G1	R1	G3	G1
2002	R3	G2	G3	G3	R1	G1	R1	G3	G1
2003	R2	R2	R3	R3	R1	R1	R2	R2	G1
2004	R2	R1	R3	R3	R1	R1	R2	R2	G1
2005	R1	R1	R3	R3	R1	R1	R2	R2	R1
2006	R1	R2	R3	R3	R1	R1	R2	R2 	R1
2007	G2	G1	G3	G1	R1	R1	R1	R1	R1
2008	G2	G1	G3	G1	R1	R1	R1	R1	R1
2009	R1	R1	R2	R1	R2	R2	R2	R2 	R1
2010	G1	R1	R3	R1	R2	R2	R2	R2	R1
2011	G1	G1	R3	R1	R2	R2	R2	R2	R1
2012	R1	R1	R3	R1	R2	R2	R2	R2	R1

2012 is considered another hinge point because of the opportunity lost by the decision to abandon the Leap Day Deal and the fact that the nuclear and missile programs accelerated subsequently.

North Korea Nuclear Program– Technical Focus (Stanford University CISAC)
3 shades of green (dark best), 3 shades of red (dark worst) –Hecker/Carlin/Serbin

Year	US Diplomacy	DPRK Diplomacy	YB Presence	Plutonium	U enrichment	Tritium/Li6	Weaponize Design/build/test	Nukes (Summary)	Missiles
1992	G1	G1	G1	G2	G1	G1	R1	R1	R1
1993	G2	G2	G1	G2	G1	G1	R1	R1	R1
1994	G3	G3	G1	G2	G1	G1	R1	R1	R1
1995	G3	G3	G3	G3	G1	G1	R1	G3	R1
1996	G3	G3	G3	G3	G1	G1	R1	G3	R1
1997	G2	G2	G3	G3	R1	G1	R1	G3	R1
1998	G2	G2	G3	G3	R1	G1	R1	G3	R1
1999	G3	G3	G3	G3	R1	G1	R1	G3	G1
2000	G3	G3	G3	G3	R1	G1	R1	G3	G1
2001	R2	G2	G3	G3	R1	G1	R1	G3	G1
2002	R3	G2	G3	G3	R1	G1	R1	G3	G1
2003	R2	R2	R3	R3	R1	R1	R2	R2	G1
2004	R2	R1	R3	R3	R1	R1	R2	R2	G1
2005	R1	R1	R3	R3	R1	R1	R2	R2	R1
2006	R1	R2	R3	R3	R1	R1	R2	R2 	R1
2007	G2	G1	G3	G1	R1	R1	R1	R1	R1
2008	G2	G1	G3	G1	R1	R1	R1	R1	R1
2009	R1	R1	R2	R1	R2	R2	R2	R2 	R1
2010	G1	R1	R3	R1	R2	R2	R2	R2	R1
2011	G1	G1	R3	R1	R2	R2	R2	R2	R1
2012	R1	R1	R3	R1	R2	R2	R2	R2	R1
2013	R2	R1	R3	R2	R2	R2	R2	R2 	R1
2014	R2	R1	R3	R2	R3	R3	R2	R2	R1
2015	R1	G1	R3	R3	R3	R3	R2	R2	R2

Not much diplomatic activity in 2013 to 2015 while nuclear and missile capabilities increase.

Another possible opportunity lost in January 2015 when Obama administration rejects Kim's proposal for nuclear testing halt.

North Korean diplomatic overtures in 2015

In January, North Korea announces a formal suspension for suspension proposal

- Nuclear test suspension for US-South Korea joint military exercises suspension

Later in the year, Pyongyang and Washington exchange views on linkage between peace agreement and nuclear issue.







ASIA PACIFIC

North Korea Offers U.S. Deal to Halt Nuclear Test

By CHOE SANG-HUN JAN. 10, 2015

North Korea Nuclear Program– Technical Focus (Stanford University CISAC)
3 shades of green (dark best), 3 shades of red (dark worst) –Hecker/Carlin/Serbin

Year	US Diplomacy	DPRK Diplomacy	YB Presence	Plutonium	U enrichment	Tritium/Li6	Weaponize Design/build/test	Nukes (Summary)	Missiles
1992	G1	G1	G1	G2	G1	G1	R1	R1	R1
1993	G2	G2	G1	G2	G1	G1	R1	R1	R1
1994	G3	G3	G1	G2	G1	G1	R1	R1	R1
1995	G3	G3	G3	G3	G1	G1	R1	G3	R1
1996	G3	G3	G3	G3	G1	G1	R1	G3	R1
1997	G2	G2	G3	G3	R1	G1	R1	G3	R1
1998	G2	G2	G3	G3	R1	G1	R1	G3	R1
1999	G3	G3	G3	G3	R1	G1	R1	G3	G1
2000	G3	G3	G3	G3	R1	G1	R1	G3	G1
2001	R2	G2	G3	G3	R1	G1	R1	G3	G1
2002	R3	G2	G3	G3	R1	G1	R1	G3	G1
2003	R2	R2	R3	R3	R1	R1	R2	R2	G1
2004	R2	R1	R3	R3	R1	R1	R2	R2	G1
2005	R1	R1	R3	R3	R1	R1	R2	R2	R1
2006	R1	R2	R3	R3	R1	R1	R2	R2 	R1
2007	G2	G1	G3	G1	R1	R1	R1	R1	R1
2008	G2	G1	G3	G1	R1	R1	R1	R1	R1
2009	R1	R1	R2	R1	R2	R2	R2	R2 	R1
2010	G1	R1	R3	R1	R2	R2	R2	R2	R1
2011	G1	G1	R3	R1	R2	R2	R2	R2	R1
2012	R1	R1	R3	R1	R2	R2	R2	R2	R1
2013	R2	R1	R3	R2	R2	R2	R2	R2 	R1
2014	R2	R1	R3	R2	R3	R3	R2	R2	R1
2015	R1	G1	R3	R3	R3	R3	R2	R2	R2
2016	R1	R3	R3	R3	R3	R3	R3	R3 	R2

2016 was a bad year.

Obama administration reevaluates its North Korea policy, but with no resulting progress or steps toward engagement. Two North Korean nuclear tests result in tougher UN Security Council and US sanctions, including sanctions on Kim Jong Un. The North reacts by closing the New York channel.

On Jan. 6, North Korea conducts its fourth nuclear test with explosion yield of 7 to 14 kt. It claims to have detonated a hydrogen bomb, but the yield is not consistent with a hydrogen device. However, it is possible that North Korea achieved some fusion yield by testing a boosted fission device. The test may have been a proof-of-principle hydrogen bomb. On Sept. 9, North Korea conducts its fifth nuclear test with explosion yield of 15 to 25 kt (fully contained), makes no mention of hydrogen bombs, but rather claims miniaturization, which likely was the primary intent of the test.

By this time, North Korea likely produced all the components for perhaps as many as a dozen nuclear devices based on its nuclear test results and had sufficient plutonium and HEU for as many as 25 nuclear devices. Five nuclear tests over 10 years likely enables North Korea to mount a nuclear warhead on its Scud and Nodong missiles capable of reaching all of South Korea and Japan with the destructive power similar to Hiroshima and Nagasaki. At this point, North Korea should have been viewed as possessing an effective deterrent to US aggression since it had the capability to inflict unacceptable damage on US assets and its allies (although not yet be able to reach the US mainland with a nuclear tipped missile).

Nuclear Capability	December 2016 (Hecker-rough estimates)
Plutonium	20 – 40 kg
HEU (highly uncertain)	300 – 450 kg
Tritium	Very limited (Multi-grams)
Nuclear devices (sufficient material)	~25
Fit and robust for: SCUD & Nodong	Yes
IRBM & ICBM	Only space launchers. No IRBM or ICBM
Fit on long-range missiles	No

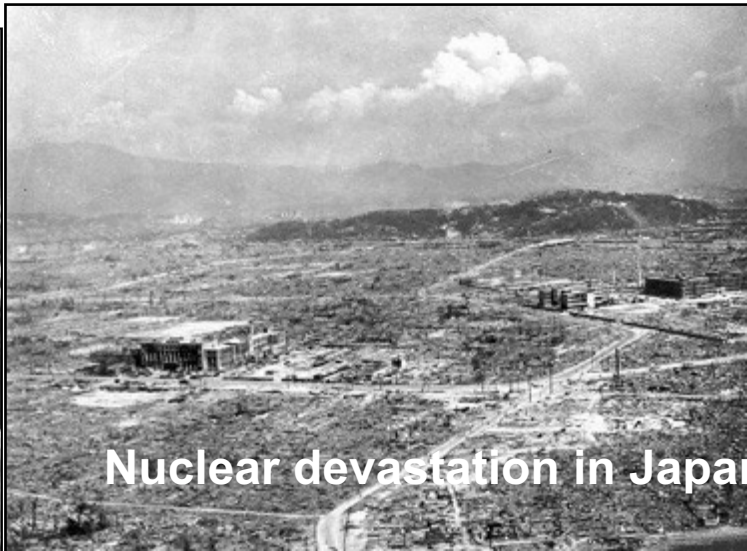
Nuclear tests history

- Oct. 9, 2006: Close to 1 kiloton
- May 25, 2009: ~ 2 to 7 kilotons
- Feb. 12, 2013: ~ 7 to 14 kilotons
- Jan. 6, 2016: ~ 7 to 14 kilotons
 - Claim of H bomb not likely to be true.
 - Possible proof-of-principle H-bomb?
- Sept. 9, 2016: ~ 15 to 25 kilotons
 - Likely made progress in miniaturization

?








(Charles Levy)



Nuclear devastation in Japan – August 1945

North Korea Nuclear Program– Technical Focus (Stanford University CISAC)
3 shades of green (dark best), 3 shades of red (dark worst) –Hecker/Carlin/Serbin

Year	US Diplomacy	DPRK Diplomacy	Yongbyong Presence	Plutonium	U enrichment	Tritium/Li6	Weaponize Design/build/test	Nukes (Summary)	Missiles
1992	G1	G1	G1	G2	G1	G1	R1	R1	R1
1993	G2	G2	G1	G2	G1	G1	R1	R1	R1
1994	G3	G3	G1	G2	G1	G1	R1	R1	R1
1995	G3	G3	G3	G3	G1	G1	R1	G3	R1
1996	G3	G3	G3	G3	G1	G1	R1	G3	R1
1997	G2	G2	G3	G3	R1	G1	R1	G3	R1
1998	G2	G2	G3	G3	R1	G1	R1	G3	R1
1999	G3	G3	G3	G3	R1	G1	R1	G3	G1
2000	G3	G3	G3	G3	R1	G1	R1	G3	G1
2001	R2	G2	G3	G3	R1	G1	R1	G3	G1
2002	R3	G2	G3	G3	R1	G1	R1	G3	G1
2003	R2	R2	R3	R3	R1	R1	R2	R2	G1
2004	R2	R1	R3	R3	R1	R1	R2	R2	G1
2005	R1	R1	R3	R3	R1	R1	R2	R2	R1
2006	R1	R2	R3	R3	R1	R1	R2	R2 	R1
2007	G2	G1	G3	G1	R1	R1	R1	R1	R1
2008	G2	G1	G3	G1	R1	R1	R1	R1	R1
2009	R1	R1	R2	R1	R2	R2	R2	R2 	R1
2010	G1	R1	R3	R1	R2	R2	R2	R2	R1
2011	G1	G1	R3	R1	R2	R2	R2	R2	R1
2012	R1	R1	R3	R1	R2	R2	R2	R2	R1
2013	R2	R1	R3	R2	R2	R2	R2	R2 	R1
2014	R2	R1	R3	R2	R3	R3	R2	R2	R1
2015	R1	G1	R3	R3	R3	R3	R2	R2	R2
2016	R1	R3	R3	R3	R3	R3	R3	R3 	R2
2017	R3	R3	R3	R3	R3	R3	R3	R3 	R3

2017 was a very bad year.

It begins with Kim Jong Un announcing in his New Year's speech that North Korea was in the "final stage" for testing an ICBM, and President-elect Trump tweeting "It won't happen."

There is no serious US-DPRK diplomatic engagement. After a policy review in the spring, the new US administration announces a policy of "maximum pressure and engagement." The administration is able to significantly strengthen sanctions and pressure on North Korea, but there is little engagement although the New York channel was opened and low-level exchanges were restarted between the two sides. No serious initiatives result. Tensions rise with the North's successful launch of longer-range missiles in the summer and threats traded between the two leaders, although in July Kim gives the first hint that under some circumstances he could put the nuclear and missile programs "on the negotiating table." In September, the situation deteriorates further with the President Trump's UN General Assembly speech, which contains what the North considers threats and insults to Kim Jong Un and threatens to totally destroy the country. In November, the US puts the North back on the list of state sponsors of terrorism.

In spite of maximum US pressure and increased sanctions, North Korea makes rapid progress with all of its missile capabilities trying to demonstrate Kim Jong Un's promise that they will be able to launch missiles from anywhere at any time. By the end of the year, North Korea demonstrates the ability to launch rockets of intermediate range (IRBMs capable of 4,500 km) and intercontinental range (ICBMs up to 13,000 km) although these are all launched on a lofted trajectory achieving high altitudes but not normal range. In addition, on September 3, North Korea detonates a nuclear device with an explosion yield in the range of 200 to 250 kilotons, which may have been a two-stage thermonuclear (hydrogen) bomb. That was followed by the ICBM-capable Hwasong-15 missile launch on Nov. 29.

By the end of 2017, North Korea still has only modest plutonium and tritium inventories, but growing HEU inventories. It demonstrates the ability to develop ICBMs, but requires more missile tests and nuclear tests to mount a nuclear warhead on a missile to reach the US mainland.

Nov. 29, 2017 Hwasong-15 ICBM-capable



Launch date and time: Nov 29, at 2:47a.m. (North Korean) local time.

Range and altitude: 950km and 4,475km on a 'lofted' trajectory. On a standard trajectory it could cover the entire US (over 13,000km).

Launch site: Pyongsong

Flight time: 53min 49sec



Nuclear tests history

- Oct. 9, 2006: Close to 1 kiloton
 - Likely Pu
- May 25, 2009: ~ 2 to 7 kilotons
 - Likely Pu
- Feb. 12, 2013: ~ 7 to 14 kilotons
 - Either Pu or HEU
- Jan. 6, 2016: ~ 7 to 14 kilotons
 - H bomb claim not likely true. Possible proof-of-principle H-bomb?
- Sept. 9, 2016: ~ 15 to 25 kilotons
 - Likely made progress in miniaturization
- Sept. 3, 2017: 200 to 250 kilotons
 - Possibly a two-stage thermonuclear bomb



Nuclear Capability	December 2016 (Hecker-rough estimates)	December 2017 (Hecker-rough estimates)
Plutonium	20 – 40 kg	20 – 40 kg
HEU (highly uncertain)	300 – 450 kg	250 - 500 kg
Tritium	Very limited (Multi-grams)	Very limited (Multi-grams)
Nuclear devices (sufficient material)	~25	~25-30
Fit and robust for: SCUD & Nodong	Yes	Yes
IRBM & ICBM	Only space launchers. No for IRBM or ICBM.	Hwasong-12 Hwasong-14 Hwasong-15
Fit on missiles	No	No - need more tests

Before looking at 2018, we provide additional analysis of political developments. For this purpose we collapse the technical analysis into two columns, and expand other columns as defined below.

US Diplomacy

A measure of US initiatives and efforts to support diplomatic engagement with North Korea. The metric does not depend on definite progress toward US goals of limiting or terminating the North Korea nuclear and ballistic missile programs.

North Korea Diplomacy

A measure of North Korean initiatives and efforts to support diplomatic engagement with the United States, though not necessarily in support of common goals. The metric does not depend on definite progress toward US goals of limiting or terminating the North Korean nuclear and ballistic missile programs.

US/IAEA Presence at Yongbyon Nuclear Center

A measurement of the presence of US and/or IAEA personnel at Yongbyon.

Nuclear Weapons Summary

A measurement of the level of nuclear weapons development achieved and in progress, encompassing fissile material production and weaponization, including nuclear tests.

Missiles Summary

A measurement of the level of missile development and deployment achieved and in progress, encompassing all aspects of delivery system development.

North Korea/South Korea Relations

A measurement of the state of relations between North Korea and South Korea.

North Korea/China Relations

A measurement of the state of relations between North Korea and China.

Sanctions

A measurement of the level of combined US. and U.N. sanctions levied against North Korea.

North Korean Economy

A measurement of the level of economic output and general status of North Korea's economy. Observations based on official statistic, but mostly on assessments of foreign visitors to North Korea. This measure is more about relative change in economy than absolute measure of the economy.

US Financial Aid to North Korea

A measurement of U.S. dollar amounts going to North Korea in the form of food and fuel. Contributions to KEDO added an additional \$450 million.

North Korea Nuclear Program– Policy Focus (Stanford University CISAC)
3 shades of green (dark best), 3 shades of red (dark worst) –Hecker/Carlin/Serbin

Year	US Dipl.	DPRK Dipl.	YB Presence	Nukes	Missiles	N/S Relation	N/Sino Rel.	Sanctions	NK Economy	US Fin. Aid
1992	G1	G1	G1	R1	R1	G3	R2	R1	R2	\$0
1993	G2	G2	G1	R1	R1	G2	R1	R1	R2	\$0
1994	G3	G3	G1	R1	R1	R2	R1	R1	R3	\$0
1995	G3	G3	G3	G3	R1	R1	R1	R1	R3	\$9.7M
1996	G3	G3	G3	G3	R1	R1	R1	R1	R3	\$30.3M
1997	G2	G2	G3	G3	R1	G1	R1	R1	R3	\$82.4M
1998	G2	G2	G3	G3	R1	G1	R1	R1	R3	\$122.9M
1999	G3	G3	G3	G3	G1	G3	G1	R1	R3	\$287.2M
2000	G3	G3	G3	G3	G1	G3	G2	R1	R2	\$138.7M
2001	R2	G2	G3	G3	G1	G1	G2	R1	R2	\$132.97M
2002	R3	G2	G3	G3	G1	G2	G2	R1	R2	\$140.9M
2003	R2	R2	R3	R2	G1	G1	G2	R1	R1	\$27.78M
2004	R2	R1	R3	R2	G1	R1	G1	R1	R1	\$36.4M
2005	R1	R1	R3	R2	R1	G1	G1	R1	R1	\$5.7M
2006	R1	R2	R3	R2	R1	G1	R1	R1	R1	\$0
2007	G2	G1	G3	R1	R1	G3	R1	R1	R1	\$45.1M
2008	G2	G1	G3	R1	R1	R1	G1	R1	R1	\$224.7M
2009	R1	R1	R2	R2	R1	R2	G1	R1	R2	\$24.6M
2010	G1	R1	R3	R2	R1	R3	G2	R1	R1	\$3.5M
2011	G1	G1	R3	R2	R1	R3	G2	R1	R1	\$0.9M
2012	R1	R1	R3	R2	R1	R3	G2	R1	G1	\$0
2013	R2	R1	R3	R2	R1	R2	R2	R2	G1	\$0
2014	R2	R1	R3	R2	R2	R2	R2	R2	G1	\$0
2015	R1	G1	R3	R2	R2	R2	R2	R2	G2	\$0
2016	R1	R3	R3	R3	R3	R3	R2	R2	G2	\$0
2017	R3	R3	R3	R3	R3	R2	R2	R3	G2	\$0.9M

North Korea Nuclear Program– Policy Focus (Stanford University CISAC)

3 shades of green (dark best), 3 shades of red (dark worst) –Hecker/Carlin/Serbin

Year	Nukes	Missiles	Sanctions
1992	R1	R1	R1
1993	R1	R1	R1
1994	R1	R1	R1
1995	G3	R1	R1
1996	G3	R1	R1
1997	G3	R1	R1
1998	G3	R1	R1
1999	G3	G1	R1
2000	G3	G1	R1
2001	G3	G1	R1
2002	G3	G1	R1
2003	R2	G1	R1
2004	R2	G1	R1
2005	R2	R1	R1
2006	R2	R1	R1
2007	R1	R1	R1
2008	R1	R1	R1
2009	R2	R1	R1
2010	R2	R1	R1
2011	R2	R1	R1
2012	R2	R1	R1
2013	R2	R1	R2
2014	R2	R2	R2
2015	R2	R2	R2
2016	R3	R3	R2
2017	R3	R3	R3

We track the severity of sanctions over the years and examine their effects on the nuclear and missile programs.

No green coding since all sanctions try to impose a penalty on North Korea. North Korea has been under US bilateral sanctions since 1950. Sanctions in the 1990s and early 2000s were primarily aimed at North Korean missile trade and cooperation with others. Severity of sanctions is indicated by increasing shades of red.

In September 2005, the US Treasury Department imposes Banco Delta Asia sanctions.

In July 2006, the UNSC adopts Resolution 1695 in response to North Korea's missile launches on July 4.

Resolutions 1718 (2006) and 1874 (2009) place special emphasis on inhibiting the ability of the North Korea to acquire, and to provide to others materials, equipment, goods, technology and technical know-how with regard to nuclear weapons and other weapons of mass destruction as well as ballistic missiles.

In November 2016, the UN Security Council passes UNSCR 2321, expanding sanctions following North Korea's fifth nuclear test in September. The sanctions include an export ban on minerals and other items.

In June 2017, the United States imposes unilateral sanctions on North Korean entities and individuals. In addition, the Trump administration is able to get China to agree to significantly increase the stringency of its sanctions implementation. China had increasingly implemented UNSC sanctions since the advent of Xi Jinping to the presidency in 2013.

The results indicate that North Korea's nuclear and missile programs advanced in spite of increasing severity of sanctions.

North Korea Nuclear Program– Policy Focus (Stanford University CISAC)

3 shades of green (dark best), 3 shades of red (dark worst) –Hecker/Carlin/Serbin

Year	Nukes	Missiles	Sanctions	NK Economy	US Fin. Aid
1992	R1	R1	R1	R2	\$0
1993	R1	R1	R1	R2	\$0
1994	R1	R1	R1	R3	\$0
1995	G3	R1	R1	R3	\$9.7M
1996	G3	R1	R1	R3	\$30.3M
1997	G3	R1	R1	R3	\$82.4M
1998	G3	R1	R1	R3	\$122.9M
1999	G3	G1	R1	R3	\$287.2M
2000	G3	G1	R1	R2	\$138.7M
2001	G3	G1	R1	R2	\$132.97M
2002	G3	G1	R1	R2	\$140.9M
2003	R2	G1	R1	R1	\$27.78M
2004	R2	G1	R1	R1	\$36.4M
2005	R2	R1	R1	R1	\$5.7M
2006	R2	R1	R1	R1	\$0
2007	R1	R1	R1	R1	\$45.1M
2008	R1	R1	R1	R1	\$224.7M
2009	R2	R1	R1	R2	\$24.6M
2010	R2	R1	R1	R1	\$3.5M
2011	R2	R1	R1	R1	\$0.9M
2012	R2	R1	R1	G1	\$0
2013	R2	R1	R2	G1	\$0
2014	R2	R2	R2	G1	\$0
2015	R2	R2	R2	G2	\$0
2016	R3	R3	R2	G2	\$0
2017	R3	R3	R3	G2	\$0.9M

We examine the relationship between sanctions and the state of North Korea’s economy, which we assess from numerous literature sources and several frequent foreign visitors to North Korea.

The dire state of North Korea’s economy in the 1990s had little to do with sanctions, but rather resulted from the difficult times it suffered after the dissolution of the Soviet Union and the distancing of its relationship with China. These difficulties were exacerbated by intense periods of drought with intermittent devastating floods.

As the economy recovered in the 2000’s, there appears to be little effect of sanctions on North Korea’s economy, but it is difficult to measure since the overall development of North Korea’s economy is the result of a multitude of causes, of which sanctions are just one.

It is possible that the significant tightening of sanctions, particularly more stringent enforcement by China, may have had an effect on the economy beginning in mid-2017.

We also provide a listing of US financial assistance in the form of food and energy over the years. The figures show that the total aid was sufficiently small as to have played little or no role in the nuclear program.

North Korea Nuclear Program– Policy Focus (Stanford University CISAC)
3 shades of green (dark best), 3 shades of red (dark worst) –Hecker/Carlin/Serbin

Year	US Diplomacy	N/S Relations	DPRK Diplomacy	Nukes	Missiles
1992	G1	G3	G1	R1	R1
1993	G2	G2	G2	R1	R1
1994	G3	R2	G3	R1	R1
1995	G3	R1	G3	G3	R1
1996	G3	R1	G3	G3	R1
1997	G2	G1	G2	G3	R1
1998	G2	G1	G2	G3	R1
1999	G3	G3	G3	G3	G1
2000	G3	G3	G3	G3	G1
2001	R2	G1	G2	G3	G1
2002	R3	G2	G2	G3	G1
2003	R2	G1	R2	R2	G1
2004	R2	R1	R1	R2	G1
2005	R1	G1	R1	R2	R1
2006	R1	G1	R2	R2	R1
2007	G2	G3	G1	R1	R1
2008	G2	R1	G1	R1	R1
2009	R1	R2	R1	R2	R1
2010	G1	R3	R1	R2	R1
2011	G1	R3	G1	R2	R1
2012	R1	R3	R1	R2	R1
2013	R2	R2	R1	R2	R1
2014	R2	R2	R1	R2	R2
2015	R1	R2	G1	R2	R2
2016	R1	R3	R3	R3	R3
2017	R3	R2	R3	R3	R3

We find no clear pattern between North/South relations and the progress of the North's nuclear program.

It appears that US/North Korea relations and North/South relations were for the most part uncoordinated, thereby preventing a common front.

Since the beginning of 2018, positive developments in N/S relations have begun to influence US/North Korean relations.

We also examined North Korea's import and export record as shown in the subsequent chart.

Imports

A measurement of the import of technologies, materials, and equipment for all nuclear- and missile-related programs.

Exports

A measurement of the technologies, materials, and equipment of all nuclear- and missile-related exports.

Findings:

Imports have continued to be important to North Korea's nuclear and missile programs, particularly its uranium enrichment and missile programs.

Imports for the centrifuge program began to increase substantially after 1997 and North Korea's ties to Pakistan's A.Q. Khan.

Imports for the missile programs played a critical role throughout the entire period, with strong ties to Russian entities as well as cooperation with Chinese entities and Iran.

Exports have been an important part of North Korea missile and nuclear programs. The 1990s saw primarily significant missile exports to countries such as Iraq, Iran, Pakistan, Libya and others.

In the nuclear technology arena, North Korea's most egregious exports were the sale of uranium hexafluoride to Libya's centrifuge program in 2001 and 2002 and the construction of a plutonium production reactor in Syria, which was close to completion in September 2007 when it was destroyed by an Israeli air attack. Both of these were meant to be long-term business opportunities for North Korea that could have amassed billions of dollars income.

Both imports and exports have become more difficult in recent years because of UN sanctions and measures such as the Proliferation Security Initiative. However, North Korea has become more adapt at circumventing the sanctions as their severity has increased.

[illegible]



In his 2018 New Year's speech on state TV, Kim stated, "We achieved the goal of completing our state nuclear force in 2017. The entire United States is within range of our nuclear weapons, a nuclear button is always on my desk. This is reality, not a threat." With that announcement Kim signaled that he was prepared to talk and entered a new era of N/S relations.



(ABC News)



(Associated Press)



(Charlie Riedel/AP)



(AFP/Getty Images)

Kim, Moon Pledge Denuclearization Of Peninsula And End To Korean War

April 27, 2018 · 12:39 AM ET



(Reuters)



(Korea Summit Press Pool/AP)

(Korea Summit Press Pool/AP)



(Korea Summit Press Pool/AP)



(KCNA)

Rapidly evolving political landscape





Donald J. Trump 
@realDonaldTrump



The highly anticipated meeting between Kim Jong Un and myself will take place in Singapore on June 12th. We will both try to make it a very special moment for World Peace!

7:37 AM - May 10, 2018

2018 has been a year of surprise and potential opportunity.

With Kim's New Year's statement "We achieved the goal of completing our state nuclear force in 2017," he signaled that he was prepared to talk. At the same time, President Moon Jae-in reached out to Kim to have North Korea participate in the PyeongChang 2018 Winter Olympics.

North and South Korean athletes marched under one Korean flag and over the next three months the two Koreas engaged in diplomacy resulting in the April 27 Moon-Kim summit and setting up the potential Kim-Trump summit with two visits by Secretary Mike Pompeo to Pyongyang.

The overriding question in Washington is whether the North is serious this time, whereas we are concerned whether Washington is prepared.

We developed this comprehensive history of the North's nuclear program and political events to help inform the process of preparing for the summit and beyond. History on the Korean peninsula has been so ill understood and misrepresented that a final accommodation will not be possible without correcting that problem.

Lessons learned from the comprehensive history

- Pursuit of weapons was deliberate and determined – not responsive/reactive or triggered by provocations. It was patient, not a surprise, not the most secretive.
- Program slowed, sometimes reversed, but never abandoned during diplomacy. Most important element was a US/IAEA presence in Yongbyon.
- US diplomacy since 2000 has been sporadic and reactive. Resulted in avoiding risk instead of managing risk.
- Nuclearization was a massive enterprise – took 25 years to go to dark red, going to dark green (denuclearization) will take time.
- Besides what does denuclearization mean? No weapons, no deployed weapons, no fissile materials, no missiles, no people, no civilian nuclear program...?
- As bad as it was in 2017, stop it from getting worse. Several opportunities missed in the past by not managing the incremental risks.
- The narrative that North Korea “has cheated on every agreement” is neither accurate nor useful. Need to better understand history so as not to repeat mistakes.

North Korea “has cheated on every agreement” narrative is neither accurate nor helpful. Need to better understand history so as not to repeat mistakes.

- 1992 North/South Joint Denuclearization Declaration – North did not comply, but superseded by Agreed Framework.
- 1994 Agreed Framework – “cheating” is technically not correct because it was not an agreement. Certainly covert uranium enrichment activities were not in the spirit of the AF as well as contrary to 1992 N/S Joint Declaration.
- 2000 Joint US-DPRK Communiqué – voided by the Bush administration
- Sept. 19, 2005 Joint Statement – never really got off the ground because of US back peddling on LWR and applying BDA sanctions. Not a matter of cheating, but rather North Korea terminated its participation.
- Feb. and Oct. 2007 agreements on disablement followed by dismantlement. North claimed US was moving goal posts on verification. However, the North appeared to be determined to terminate –not really an issue of cheating, rather one of Pyongyang walking away from the agreements.
- Leap Day 2012 deal – very poorly consummated deal with actions not clearly spelled out. Two sides had different interpretations of what was permitted.

Appendix

Color Shade Coding Criteria

US Diplomacy

A measurement of US initiatives and efforts to support diplomatic engagement with North Korea.

G3: Sustained and serious US engagement at every level with North Korea intended to conclude and implement agreements.

G2: Continued engagement and efforts to implement agreements reached with North Korea, but without serious, demonstrated intent to push beyond the current levels.

G1: Limited engagement, no new initiatives, difficulties dealing with implementation of existing agreements for reasons of internal political or bureaucratic opposition.

R1: Episodic engagement for forms sake but no serious overtures; some actions that reverse or undermine existing agreements.

R2: Rare, sporadic pro forma contact, limited communication, no realistic proposals. Failure to explore North Korean initiatives. Failure to implement or abrogation of existing agreements.

R3: Minimal or no engagement. Overt expressions of hostility.

North Korea Diplomacy

A measure of North Korean initiatives and efforts to support diplomatic engagement with the United States, though not necessarily in support of common goals. The metric does not depend on definite progress toward US goals of limiting or terminating the North Korean nuclear and ballistic missile programs.

G3: Sustained and serious North Korean engagement at every level with the US intended to conclude and implement agreements to establish normalized relations with US.

G2: Serious attempts to engage the US to develop and implement agreements to establish normalized relations with US. Or, continued engagement and efforts to implement prior agreements reached with the US, but without serious, demonstrated intent to push beyond the current levels.

G1: Limited engagement or re-engagement, but with difficulties dealing with implementation of existing agreements, while potentially hedging to retain nuclear capabilities. Or, exploring re-engagement with serious dialogue and proposal.

R1: Actions that reverse or undermine existing agreements combined with episodic overtures or engagement with insufficient follow-through or countered by episodic threatening actions. Rare, sporadic pro forma contact, limited communication, no realistic proposals.

R2: Actions that reverse or undermine existing agreements. Rare, sporadic pro forma contact, limited communication, no realistic proposals. Failure to explore US initiatives. Failure to implement or abrogation of existing agreements.

R3: Minimal or no engagement. Deliberate actions that threaten US and/or allies. Overt and sustained, authoritative-level expressions of hostility.

Color Shade Coding Criteria

North/South Relations

A measurement of the state of relations between North Korea and South Korea.

G3: Sustained high level engagement by both sides, confidence building measures, joint initiatives such as joint statements and agreements.

G2: High level engagement on both sides, confidence building measures, and joint initiatives (less intensity than G3)

G1: Commitment to engagement accompanied by confidence building action(s) on both sides. Lack of provocative actions.

R1: No serious commitment to engage, but also no serious effort to antagonize (i.e. the window stays open to explore dialogue). Some provocative actions as well as some exploration of dialogue possible.

R2: The window for engagement is mostly closed. One of the sides may take a limited set of antagonizing actions or explore dialogue – but the relations are mostly strained.

R3: No engagement, both sides take antagonizing actions, including possibly military actions.

North Korea/China Relations

A measurement of the state of relations between North Korea and China.

G3: Positive engagement, strengthening of alliance. Close interactions between high-level officials. Economic ties and China defends North Korea's interests at UNSC.

G2: Positive, successful engagement, with good economic relations and good support by China for North Korea at the UN.

G1: Relations still overall positive, but much less support from China and less outreach by North Korea.

R1: Official government relations are strained, limited engagement and little economic support. Or, China's willingness to agree to some UNSC sanctions, but not very stringent implementation of sanctions.

R2: Increasingly strained relations, minimal engagement. Significantly reduced economic relations, and China's increasing support for UNSC sanctions. Stronger implementation by China of sanctions.

R3: Seriously strained relations with minimal official contact and dialogue. Both sides keep official relations to a minimum. China's willingness to approve more stringent UNSC sanctions. Also, implements sanctions more strictly.

Color Shade Coding Criteria

US/IAEA Presence at Yongbyon Nuclear Center

A measurement of the presence of US and/or IAEA personnel at Yongbyon.

G3: Sustained access by US and/or IAEA inspectors and cooperation for inspections in key facilities. Adequate verification of agreements for Yongbyon operations.

G2: Limited access by IAEA inspectors with good cooperation.

G1: Limited access by IAEA inspectors with disputed cooperation.

R1: Access to IAEA inspectors for a large part but not the entire year.

R2: Access for a small portion of the year.

R3: No US visitors or technical team allowed. No IAEA inspectors allowed.

Sanctions (US and UN Security Council)

A measurement of the level of combined U.S. and U.N. sanctions levied against North Korea.

G3, G2, G1: Not applicable since all sanctions try to impose a penalty on North Korea, which has been under US bilateral sanctions since 1950. Sanctions in the 1990s were primarily aimed at North Korean missile trade and cooperation. Severity of sanctions is indicated by shades of red.

R1: Low-level US bilateral sanctions and sanctions on a few North Korean commercial or government entities. UNSC sanctions on a few North Korean entities.

Also used to designate low-level nuclear sanctions with ineffective enforcement, especially by China.

R2: UNSC sanctions on more North Korean entities, with better enforcement, including by China. Additional US government sanctions.

R3: Very stringent UNSC sanctions and greatly improved enforcement by China. Additional strict US government sanctions.

Color Shade Coding Criteria

North Korea Economy

A measurement of the level of economic output and general status of North Korea's economy. Observations based on official statistics, but mostly on assessments of foreign visitors to North Korea. This measure is more about relative change in economy than absolute measure of the economy.

G3: Very positive indicators of improving economy from frequent foreign visitors. Very positive economic statistics such as GDP or state budget growth (for example > 6%) and very positive trends in trade volume.

G2: Positive indicators of improving economy from frequent foreign visitors. Positive economic statistics such as GDP or state budget growth (for example > 3%) and positive trends in trade volume.

G1: Some positive indicators from frequent foreign visitors. Some positive economic statistics in budget and/or trade.

R1: Somewhat negative indicators from frequent foreign visitors. Slowly declining economic statistics.

R2: Negative indicators from frequent foreign visitors and signs of food shortages and famine. Generally negative economic statistics.

R3: Economy in great difficulty. Serious signs of food shortage and famine. Declining economic indicators.

US Financial Aid to North Korea

A measurement of U.S. dollar amounts going to North Korea in the form of food, fuel, and KEDO contributions. An overall estimate of South Korean aid is also provided at the end.

Neutral Gray: There is no color code for financial aid. Actual U.S. financial support for fuel and food is shown in dollars.

Color Shade Coding Criteria

Plutonium

A measurement of the state of plutonium (Pu) production facilities and current stockpile of weapon-grade plutonium

G3: Very limited suspected Pu inventory (< a few kg quantities). No additional plutonium being produced with facilities under IAEA inspection with presence of US technical teams. Two large Pu production reactors frozen and becoming non-operational or completely abandoned. Significant loss in Pu production potential. Likely to conduct Pu metallurgy, chemistry and manufacturing R&D.

G2: Very limited suspected Pu inventory (< a few kg quantities). Pu reactor operating, but no reprocessing. Limited access for IAEA inspectors. Likely Pu metallurgy, chemistry and manufacturing R&D.

G1: Likely Pu metallurgy, chemistry and manufacturing R&D, with moderate Pu inventory (< 40 kg). No additional plutonium being produced. Pu reactor and reprocessing facility not operating, and under IAEA inspections and US technical teams.

R1: Moderate Pu inventory (< 40 kg) with reprocessing facility possibly operational for reprocessing campaigns with no access to any Yongbyon facilities for IAEA inspectors. Pu production reactor not operating, but likely full-scale Yongbyon operations to prepare for resumed operations (such as fuel rod fabrication). Pu weapons component manufacture along with R&D.

R2: Pu production reactor restarted along with expansion of Yongbyon complex, including progress on Experimental LWR. Pu inventory of many 10s of kg. Ongoing weapon component fabrication.

R3: All Yongbyon plutonium facilities operational including Pu production reactor and reprocessing facility as required. Total Pu inventory produced > 50 kg with available inventory of 20 to 40 kg. Ongoing weapon component fabrication, likely of greater sophistication.

Uranium Enrichment

A measurement of the state of uranium enrichment program and facilities, and the current stockpile of highly enrichment uranium.

G3: No uranium enrichment effort, including no R&D (likely in 1970s).

G2: R&D on potential civilian centrifuge technologies, likely not limited to uranium. Acquisition of centrifuge materials and equipment (likely in the 1980s).

G1: Uranium centrifuge R&D. Limited procurement activities of centrifuge materials, equipment and technologies.

R1: Uranium centrifuge R&D and greatly increased attempts to procure key materials, equipment and know-how on uranium enrichment. Possible operation of dozens of centrifuges. Likely foreign training of engineers/technicians on centrifuge cascade operations.

R2: Centrifuge development and demonstration with focus on operating limited cascades of centrifuges. Production of HEU in centrifuge cascades to demonstrate process. Construction of modern centrifuge facilities.

R3: Expansion of centrifuge facilities both at Yongbyon and covert site. Operational centrifuge cascades with ability to produce 10's of thousands SWU per year likely. Production of hundred or more kilograms of HEU annually.

Color Shade Coding Criteria

Tritium/Lithium-6

A measurement of the state of fusion (hydrogen bomb) fuel (i.e. tritium/Li-6D) production facilities and current stockpile of tritium/lithium-6.

G3: No tritium production or R&D.

G2: Tritium R&D for potential civilian applications.

G1: Tritium R&D for potential dual-use fusion applications. Developing capacity for reactor tritium production and separation.

R1: Tritium R&D for potential military applications. Lithium isotope separation and production of fusion fuels - Li6D (lithium deuteride, which can be used to produce tritium in situ in a hydrogen bomb device).

R2: Tritium production in reactors. Tritium separation in hot cell facilities. Expansion of tritium and Li6 production and separation facilities.

R3: Greater expansion of tritium and Li6D production capabilities and production in reactors. Possible utilization of tritium and Li6D in nuclear devices. Small, but important, annual tritium production capacity greater than multi-grams of tritium.

Weaponization

A measurement of the level of nuclear weapons development achieved and in progress, including nuclear tests.

G3: No R&D on nuclear weapons. No dual-use facilities that could readily be transferred to weapons R&D.

G2: No R&D specific to nuclear weapons, but existence of dual-use facilities.

G1: No R&D specific to nuclear weapons, but existence of dual-use facilities.

R1: Existence of dual-use nuclear facilities, indications of R&D on nuclear weapon design, including explosives and cold tests. Likely construction of weapons production and manufacturing facilities. R1 can also signify halting or rolling back from **R2:** category.

R2: Definitive proof of nuclear weapons R&D, production and manufacture, but at low level and likely of relatively primitive design. Can include nuclear tests of such designs. Possible deployment of nuclear weapons with stated development of strategic rocket forces and command and control.

R3: Expansion of facilities for R&D, testing and production. Testing of more sophisticated nuclear designs, including miniaturized fission and possible fusion devices. Production and deployment of nuclear weapon arsenal.

Color Shade Coding Criteria

Nuclear Weapons (Nukes) Summary (same for diplomacy chart)

A measurement of the level of nuclear weapons development achieved and in progress (encompassing fissile material production and weaponization, including nuclear tests).

G3: Primary weapons facilities verifiably shut. North Korea takes positive steps to roll nuclear program back (such as verifiable freeze of Yongbyon plutonium facilities and discontinuation of larger reactor construction).

G2: Partial freeze on nuclear weapon facilities. Restraint in operations and/or testing.

G1: No known expansion of nuclear weapon facilities. Restraint in operations and/or testing.

R1: Ongoing research/procurement efforts for weapon facilities. Or intermittent operation of nuclear facilities to produce nuclear materials or make test preparations. Show restraint in facility or device construction and testing.

R2: Nuclear facility restart. Continued production of fissile material, and/or fission nuclear device production. Nuclear test site activity and nuclear tests. Show very little restraint in facility or device construction or testing.

R3: Nuclear facilities fully operational. Expansion of nuclear facilities and test sites, production of fissile material, production and testing of advanced fission and possibly fusion devices. No restraint.

Missiles Summary (same for diplomacy chart)

A measurement of the level of missile development and deployment achieved and in progress (encompassing all aspects of delivery system development).

G3: No missile development or significant rollback of missile capabilities.

G2: Complete missile and space launch rocket-testing moratorium or roll back of missile deployment.

G1: Ongoing rocket/missile R&D and component testing. In case of previous missile deployments, observing a long and intermediate missile or space-launch testing moratorium.

R1: Short and medium (SCUD and Nodong) missile component procurement, manufacturing and deployment with flight tests. Possible development of space-launch rockets, Intermediate Range Ballistic Missiles (IRBMs) or ICBMs but no flight tests. Space launch possible.

R2: Significant increase in missile tests. In addition to SCUD and Nodong deployment and testing, also test IRBMs and continued vigorous development of long-range missiles and technologies.

R3: In addition to R2, also test ICBM and continue vigorous development and testing of advanced IRBM and ICBMs.

Color Shade Coding Criteria

Imports (nuclear and missile related)

A measurement of the import of technologies, materials, and equipment for all nuclear- and missile-related programs.

G3, G2, G1: Not applicable because North Korea has been importing nuclear and missile-related technologies and materials during the time frame covered.

R1: Import of some nuclear-related materials, equipment and technology, particularly centrifuge technologies and possible reactor-related equipment and technologies. But mostly import or missile-related technologies, materials and equipment. Or, also used to indicate a temporary halt or rollback of imports from an R2 condition.

R2: Continuing efforts to import nuclear-related materials, equipment and technology, including centrifuge technologies, material, equipment and know-how. Major efforts to import missile-related technologies, materials and equipment.

R3: Major and almost unimpeded efforts to import components and materials for both nuclear and missile-related programs.

Exports (nuclear and missile-related)

A measurement of technologies, materials, and equipment of all nuclear- and missile-related exports.

G3, G2, G1: Not applicable because North Korea has been exporting nuclear and missile-related technologies and materials during the time frame covered.

R1: Steady export of short-range missiles, technologies and know-how, primarily in states of concern (Pakistan, Iraq, Iran, Libya, Syria, possibly Myanmar) or low-level export of nuclear technologies.

R2: Continuing significant export of missile technologies and possible export of nuclear technologies. Potential collaboration in these technologies with other states.

R3: Egregious export of nuclear technologies – such as sale of UF6 to Libya and construction of plutonium production reactor for Syria. Potential collaboration with other states.