

“A technical and political history of North Korea’s nuclear program over the past 26 years”

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May 24, 2018

This history of North Korea’s nuclear program is based on an extensive review of the literature and news reports 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 US and abroad. It begins in 1992 at a time when serious diplomatic outreach between the US and North Korea began. Both the nuclear program and the missile program began long before that time. These efforts have been previously reviewed by several authors.¹

The objective of this study 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 specific 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 We do not cite the many dozens references that we used because the summaries in this document represent the authors’ final judgments on the narrative and the color-coding.

The charts are organized to present assessments year by year from 1992 through 2017 representing the rows and the various technical and political topics representing the columns. The first set of charts has a technical focus that describes the evolution of the three components of a nuclear program (bomb fuel, weaponization and delivery systems)

¹ Siegfried S. Hecker, “Lessons learned from the North Korean nuclear crises,” *Daedalus*, Winter 2010, pp. 44–56.

- Joseph S. Bermudez Jr., “A History of Ballistic Missile Development in the DPRK,” Occasional Paper No. 2, Center for Nonproliferation Studies, Monterey Institute of International Studies, 1999.

- Center for Strategic and International Studies, “Missiles of North Korea.”

<https://missilethreat.csis.org/country/dprk/>

- The James Martin Center for Nonproliferation Studies North Korea Missile Test Database, Nuclear Threat Initiative, <http://www.nti.org/analysis/articles/cns-north-korea-missile-test-database/>

along with three diplomatic columns. The latter charts focus on more of the political developments such as North/South relations, North/China relations, sanctions, the North Korean economy, and US financial aid. We conclude with observations of lessons learned from this historical study, which has helped us to formulate a path forward to address the nuclear issues on the Korean peninsula that we will address in a follow-on presentation.

The Color Chart

	US Diplomacy	DPRK Diplomacy	DPRK/ROK Relations	DPRK/PRC Relations	US Presence at Yongbyon	Plutonium	Uranium Enrichment	Tritium/Li-6	Weaponization	Nuclear Weapons (Summary)	Missiles (Summary)	Import	Export	Sanctions	North Korean Economy	US Financial Aid (Millions)
1992	G1	G1	G3	R2	G1	G2	G1	G1	R1	R1	R1	R1	R1	R1	R2	\$0
1993	G2	G2	G2	R1	G1	G2	G1	G1	R1	R1	R1	R1	R1	R1	R2	\$0
1994	G3	G3	R2	R1	G1	G2	G1	G1	R1	R1	R1	R1	R1	R1	R3	\$0
1995	G3	G3	R1	R1	G3	G3	G1	G1	R1	G3	R1	R1	R1	R1	R3	\$9.70
1996	G3	G3	R1	R1	G3	G3	G1	G1	R1	G3	R1	R1	R1	R1	R3	\$30.30
1997	G2	G2	G1	R1	G3	G3	R1	G1	R1	G3	R1	R2	R1	R1	R3	\$82.40
1998	G2	G2	G1	R1	G3	G3	R1	G1	R1	G3	R1	R2	R1	R1	R3	\$122.90
1999	G3	G3	G3	G1	G3	G3	R1	G1	R1	G3	G1	R2	R3	R1	R3	\$287.20
2000	G3	G3	G3	G2	G3	G3	R1	G1	R1	G3	G1	R2	R3	R1	R2	\$138.70
2001	R2	G2	G1	G2	G3	G3	R1	G1	R1	G3	G1	R2	R3	R1	R2	\$132.97
2002	R3	G2	G2	G2	G3	G3	R1	G1	R1	G3	G1	R2	R3	R1	R2	\$140.90
2003	R2	R2	G1	G2	R3	R3	R1	R1	R2	R2	G1	R2	R3	R1	R1	\$27.78
2004	R2	R1	R1	G1	R3	R3	R1	R1	R2	R2	G1	R2	R3	R1	R1	\$36.40
2005	R1	R1	G1	G1	R3	R3	R1	R1	R2	R2	R1	R2	R3	R1	R1	\$5.70
2006	R1	R2	G1	R1	R3	R3	R1	R1	R2	R2	R1	R2	R3	R1	R1	\$0
2007	G2	G1	G3	R1	G3	G1	R1	R1	R1	R1	R1	R1	R3	R1	R1	\$45.10
2008	G2	G1	R1	G1	G3	G1	R1	R1	R1	R1	R1	R1	R2	R1	R1	\$224.70
2009	R1	R1	R2	G1	R2	R1	R2	R2	R2	R2	R1	R2	R2	R1	R2	\$24.60
2010	G1	R1	R3	G2	R3	R1	R2	R2	R2	R2	R1	R2	R2	R1	R1	\$3.50
2011	G1	G1	R3	G2	R3	R1	R2	R2	R2	R2	R1	R2	R2	R1	R1	\$0.90
2012	R1	R1	R3	G2	R3	R1	R2	R2	R2	R2	R1	R2	R2	R1	G1	\$0
2013	R2	R1	R2	R2	R3	R2	R2	R2	R2	R2	R1	R2	R1	R2	G1	\$0
2014	R2	R1	R2	R2	R3	R2	R3	R3	R2	R2	R2	R2	R1	R2	G1	\$0
2015	R1	G1	R2	R2	R3	R3	R3	R3	R2	R2	R2	R2	R1	R2	G2	\$0
2016	R1	R3	R3	R2	R3	R3	R3	R3	R3	R3	R3	R2	R1	R2	G2	\$0
2017	R3	R3	R2	R2	R3	R3	R3	R3	R3	R3	R3	R2	R1	R3	G2	\$0.90

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US Diplomacy

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

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

G2: Continued engagement and efforts to implement agreements reached with the DPRK, 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 DPRK initiatives. Failure to implement or abrogation of existing agreements.

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

1992: G1

The year begins on a positive note following George H.W. Bush's announcement of the worldwide withdrawal of US tactical nuclear weapons. Undersecretary of State for Political Affairs Arnold Kanter and Korean Worker's Party Secretary for International Affairs Kim Yong Sun meet in New York in January to discuss North Korea's acceptance of IAEA safeguards. The year ends with tensions rising as the IAEA moves toward demanding special inspections in the North to resolve discrepancies uncovered during its first three inspections.

1993: G2

The year begins on a negative note, as the North announces its decision to withdraw from the NPT. The US and North Korea meet in June, issuing a joint statement that suspends the North's withdrawal; that becomes the basis for continuing talks on the nuclear issue. In July, at a second round of talks, the North proposes substituting LWRs for its existing graphite-moderated reactors. Subsequently, however, diplomacy deadlocks.

1994: G3

Tensions build as the North threatens to unload its 5 MWe reactor in the spring. When it does so, Washington reviews options for a possible military response. Full-scale diplomacy resumes in July, is interrupted by the death of Kim Il Song, then resumes again for meetings in August and September, culminating in Agreed Framework signing in October. US midterm elections in November bring a wave of conservative lawmakers into Congress, impeding Administration efforts at Agreed Framework implementation.

1995: G3

There is frequent US-DPRK interaction at all levels to implement the Agreed Framework, especially its nuclear-related sections. The US successfully begins implementation efforts, including the delivery of heavy fuel oil. The US joins South Korea and Japan to form the Korean Peninsula Energy Development Organization (KEDO) in March. Working-level meetings continue throughout the year to discuss the canning and storage of spent fuel, heavy fuel oil shipments, the provision of light water reactors, KEDO technical issues, and the opening of liaison offices in both countries.

1996: G3

There is frequent US-DPRK interaction at all levels to implement the Agreed Framework, especially its nuclear-related sections. Working-level meetings continue to discuss the provision of light water reactors (LWRs) and KEDO technical issues and protocols.

The first US-DPRK talks on the missile issue are held in Berlin. After a North Korean submarine beaches itself in South Korean waters, US holds several rounds of talks in New York with the North and obtains an apology. During the fall, in informal discussions US officials appear to convince the North to cancel a planned missile launch.

1997: G2

There is frequent US-DPRK interaction to implement the Agreed Framework and deal with North Korea's missile activities. The Four Party Talks (US, China, North Korea, South Korea) begin in December, designed to replace the Armistice Agreement with permanent peace arrangements. The new forum shifts some focus away from the Agreed Framework. In the end, Four Party Talks bear little fruit.

1998: G2

Implementation progress slows and complaints accumulate about the Agreed Framework. The North's attempted launch of a satellite in August and reports appearing in US media about a secret nuclear site put the Agreement in peril. Talks begin on access to the suspect site at Kumchang-ri. Former Defense Secretary William Perry is asked by President Clinton to initiate a thorough review of US policy on North Korea.

1999: G3

US inspection of Kumchang-ri finds no evidence of nuclear use. Perry completes his review and in May travels to Pyongyang to present North Korean leadership with the results. In September, US-DPRK talks result in the North agreeing to a long-range missile test moratorium. At the same time, the US agrees to a partial lifting of economic sanctions.

2000: G3

In January, US passes to the North a draft of a document that eventually becomes a joint communiqué. In a June meeting in Rome, the US asks the North to reiterate its missile moratorium in return for US lifting some sanctions. In October, the two sides issue a joint statement on terrorism. The same month, First Vice Chairman of the National Defense Commission Jo Myong Rok visits Washington DC and the two sides issue a communiqué

stating the two sides would “fundamentally improve their bilateral relations” and that ... “neither government would have hostile intent towards the other” and would “build a relationship free from past enmity;” At the end of the month, Secretary of State Madeleine Albright travels to Pyongyang, and holds hours of discussions with Kim Jong Il. A visit by President Clinton is raised as a possibility if progress is made on the missile issue.

2001: R2

The progress built over the last year stops abruptly. The 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 are not ended completely as the US government undertakes a policy review during the first half of the year.

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. The Nuclear Posture Review specifically mentions of North Korea on a list of countries that could be targeted with US nuclear weapons. In October, US delegation led by A/S Kelly to Pyongyang confronts the North with issue of uranium enrichment. Kelly is under instructions to lay out the US position and then leave, and there are no negotiations and only a limited exchange of ideas. The administration concludes that North Korea admitted to a uranium enrichment program during the meeting. In November, Kim Jong Il sends an oral message to US signaling effort to put things back on track, which the White House rejects immediately. Under US pressure, KEDO suspends HFO deliveries, leading North Korea to warn that it will end the freeze of facilities at Yongbyon. In December the North asks IAEA inspectors to leave, effectively ending the Agreed Framework.

2003: R2

North Korea restarts operations at the Yongbyon Nuclear Complex and withdraws from the Nuclear Non-Proliferation Treaty (NPT). At China's urging, North Korea and the United States begin diplomatic efforts to resume negotiations, holding trilateral talks in April and the first round of the Six Party Talks in Beijing. The US ends funding for KEDO and the KEDO board suspends the light water reactor project.

2004: R2

North Korea and the United States continue a multilateral engagement effort through the Six Party Talks, which achieve no progress. North Korea suspends its participation in the Six Party Talks following the June meeting, resulting in US overtures in November and December to get North Korea to return.

2005: R1

North Korea and the United States continue engagement through the Six Party Talks, which results in the September 19th Joint Statement. Within hours, Washington reneges on a key section (possibility of light water reactors for North Korea) and announces Treasury sanctions against a Macau-based Banco Delta Asia bank that, in effect, threaten

any bank dealing with North Korea. The US announces that KEDO will be dismantled by year's end.

2006: 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. KEDO withdraws its last workers from the LWR construction site in North Korea, ending the last remnant of the Agreed Framework. 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 Lewis, Carlin and Hecker is told during Pyongyang visit three weeks later that the test was successful and North Korea is filled with pride. Following the first, the US moves quickly to open bilateral talks with North Korea.

2007: G2

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 considers unreasonable US requests.

2008: G2

There are frequent US-DPRK meetings on implementation of the Joint Statement. In June President Bush promises to remove North Korea from the list of state sponsors of terrorism after receiving its nuclear declaration. Then in August the US changes its policy; it conditions removing North Korea from the terrorism list upon implementation of a strong verification regime to monitor disablement. Pyongyang reacts angrily and announces its intent to restart Yongbyon. 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. In October, Hill travels to Pyongyang in an unsuccessful effort to save the Six Party process.

2009: R1

The US engages in only limited diplomatic contact with North Korea. The Obama Administration in its first months decides it must change North Korean “behavior” and break the “cycle of provocation and reward.” However, in a February/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. When former President Clinton travels to Pyongyang to secure the release of two American journalists, he is instructed to stay within his limited brief and resist Kim Jong Il’s efforts to engage. In December, US Special Representative to North Korea, Stephen Bosworth, meets with First VFM Kang Sok Ju and VFM Kim Kye Gwan in Pyongyang to ask North Korea to resume its involvement in the Six Party Talks, the first such senior level meeting between the two countries since 2002. Bosworth delivers a letter from President Obama to Kim Jong Il.

2010: G1

The US demonstrates an occasional willingness to engage with North Korea but the Administration fails to put forth a comprehensive effort. Diplomatic efforts by Amb. 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 that apparently had just become operational

2011: G1

The US begins limited high-level meetings with North Korea. Talks held in July in New York between Amb. Bosworth and VFM Kim Kye Gwan. A second meeting takes place in Geneva in October as two sides make progress on key issues. Talks set for December are cancelled with death of Kim Jong Il. Bosworth is replaced by Ambassador Glyn Davies.

2012: R1

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 a 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. 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.

2013: R2

There are no substantive meetings between the US and North Korea. The New York channel remains open primarily to discuss American prisoners in North Korea. The US does not respond positively to a high-level North Korean proposal in June to hold talks on the nuclear issue.

2014: R2

There are no substantive meetings between US and North Korea; the New York channel remains open primarily to discuss American prisoners in North Korea. The US puts preconditions on talks and rejects North Korea's offer to talk without preconditions. In December, Director of National Intelligence James Clapper makes an unannounced visit to Pyongyang to bring home two American prisoners.

2015: R1

The US engages in minimal diplomacy with North Korea and puts forth no comprehensive engagement effort. The US quickly rejects North Korea proposal in January for suspending US-ROK exercises in return for North Korea's suspension of nuclear tests. Later in the year, Pyongyang and Washington have a month's-long exchange of views on the linkage between a peace agreement and the nuclear issue.

2016: R1

The 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.

2017: R3

The year 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. There is not serious engagement, although the New York channel is re-opened and low-level exchanges are resumed. 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, despite Kim's first hint, in July, that under some circumstances he could put the nuclear and missile programs "on the negotiating table." In September, the situation deteriorates further as

North Korea conducts its sixth and by far largest nuclear test. At the UN General Assembly President Trump delivers a stern warning to North Korea including what the North considers threats and insults to Kim Jong Un. 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 its missile capabilities, as if to demonstrate Kim Jong Un's promise that they will be able to launch missiles from anywhere at any time.

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 DPRK 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.

1992: G1

In 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, Kim hints that the North is willing to accept long term presence of US troops on the Korean Peninsula. The North ratifies IAEA safeguards agreement, leading to IAEA inspections. These produce evidence of cheating, and tensions rise as the IAEA moves toward demanding special inspections. By then Kim Jong Il has already decided to have the North withdraw from the NPT in 1993.

1993: G2

In March, North Korea gives notice of its intent to withdraw from NPT in 90 days (as per NPT provisions). The clock is stopped in June at the last minute with a US-DPRK joint statement, following a round of diplomacy in New York. In second set of talks in July in Geneva, North Korea announces a "bold decision" to give up graphite moderated reactor

technology in return for light water reactors. For remainder of year, there are frequent meetings with the US but no progress in the face of suspicions of North Korean efforts to evade IAEA monitoring.

1994: G3

The year begins with tension. In early spring, First VFM Kang signals that without US engagement, there will be trouble ahead. In May, a serious crisis erupts when the North unloads irradiated fuel rods from its 5MWe reactor without allowing IAEA monitoring. In June, Jimmy Carter goes to Pyongyang and meets Kim Il Sung. The North agrees to refreezing Yongbyon and no reprocessing. The US and North Korea meet in July, but the talks are cut short by Kim's death. The two sides meet again for substantive negotiations in August, September, and October when they sign the Agreed Framework. Pyongyang moves quickly to take the first implementation steps. North Korea shoots down a US helicopter in December but the situation is resolved in a little over a week.

1995: G3

North Korea demonstrates serious and sustained engagement to implement the Agreed Framework. There are frequent DPRK-US talks on implementation, including technical discussions for storage of spent fuel, heavy fuel oil shipments, and the possible opening of liaison offices in both capitals. The North moves slowly in accepting KEDO plans for South Korean-model light water reactors.

1996: G3

North Korea demonstrates serious and sustained engagement to implement the Agreed Framework. The first US-NK missile talks occur in Berlin in April. Working level meetings continue to discuss LWRs and KEDO technical issues and protocols. North Korea continues to implement non-proliferation aspects of the Agreed Framework, holding a meeting with the IAEA in September to discuss the safeguards and inspections. In September, a North Korean submarine runs aground off South Korean east coast, sparking inter-Korean tensions. The episode is resolved in December after more than a week of US-DPRK talks, at the end of which the North issues a public apology.

1997: G2

North Korea continues engagement but progress slows. In June, the second round of bilateral missile talks in New York fail to achieve any progress. There are several rounds of US-ROK proposed preparatory talks for the Four Party talks (US, China, South and North Korea), with the first plenary level meeting held in December. North Korea takes part at the insistence of Washington in order to maintain progress in the overall relationship, not because of its interest in the issues under discussion. US-DPRK bilateral meetings continue at the working and ambassadorial level on Agreed Framework implementation.

1998: G2

North Korea participates in working and ambassadorial level meetings on Agreed Framework 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 autumn make no progress. In November, US-DPRK talks in Pyongyang discuss US concerns about a suspected nuclear site at Kumchang-ri. The North tells the US that it will find nothing there, which turns out to be the case.

1999: G3

North continues to engage in multiple meetings on Agreed Framework implementation and KEDO affairs. Four party talks are held in April. No progress is made but the US and North Korea 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 Bill Perry. The North Korean reaction to the trip is positive. In September, at talks in Berlin, North Korea agrees to a long-range missile launch moratorium in return for US commitment to lift some economic sanctions.

2000: G3

Progress in US-North Korea 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 previous 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 May 1999 Perry visit. Jo arrives in October and 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 Madeleine Albright travels to Pyongyang for several hours of meetings with Kim Jong Il. Kim Jong Il proposes ideas during the Albright visit for limiting the North’s missile program and supports a visit by President Clinton to Pyongyang, but talks to flesh this out in November make no progress. Time runs out on the Clinton administration as the US elects George W. Bush as the next president. On election day, the North Korean party newspaper carries an article pledging to continue cooperation.

2001: G2

In January, before the new administration takes power, the North sends signals it is prepared to continue engagement with the US. Talks continue on KEDO implementation. Throughout the year Pyongyang expresses frustration at the new administration ignoring the October 2000 joint communiqué and limiting engagement. There is low-level engagement through the New York channel.

2002: G2

North Korea criticizes the State of the Union Speech for including North Korea in the “axis of evil,” and condemns US Nuclear Posture Review as a violation of the Agreed Framework for designating the North Korea as a target for nuclear attack. Low-level meetings continue in New York to discuss resumption of dialogue. In October, during talks in Pyongyang, A/S Kelly accuses the North of a clandestine enrichment program. The North neither confirms nor denies. In November, Kim Jong Il sends an oral message

to the US trying to put things back on track. When the US pressures KEDO to suspend heavy oil shipments, Pyongyang warns that the end of HFO shipments means the end of the freeze at Yongbyon, as the two are linked in the Agreed Framework. In December, the North tells IAEA inspectors to leave and makes preparations to restart Yongbyon.

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."

2004: R1

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. North Korea continues operation of its nuclear facilities and engages in a gradual public acknowledgement of its intent to build a nuclear deterrent. Two additional rounds of the Six Party talks are held, with the North boosting its participation as VFM Kim Kye Gwan becomes head of the delegation. The talks make no significant progress. Following the June meeting, North Korea delays its participation in the next round, stating that it will wait for a clarification of the Bush administration's policies before resuming negotiations

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 and the parties issue a joint statement. The day after Ambassador Hill's closing remarks back away from the statement's reference to supplying LWRs, North Korea's Foreign Ministry issues a statement warning that the North will not move on dismantling its nuclear weapons until it gets an LWR. The US Treasury Department also imposes 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.

2006: R2

North Korea continues to press for the removal of the Banco Delta Asia sanctions before resuming serious engagement with the US. In January, KEDO withdraws from its construction site. The North honors personnel safety provisions as withdrawal takes place. North Korea participates in trilateral talks with US and China in Beijing to work toward a resumption of the Six Party Talks. In March, a working level meeting in New

York discusses the Banco Delta Asia sanctions. In June, the North invites Ambassador Chris Hill to Pyongyang but Washington turns it down. North Korea conducts its first nuclear test in October. Soon after, Ambassador Hill and VFM Kim Kye Gwan meet in Beijing.

2007: G1

Serious diplomatic activity resumes. North Korea attends multiple meetings with US to discuss implementation of the 2005 Joint Statement. The two sides agree on a first phase and second phase agreement on implementing the Joint Statement—shutting down Yongbyon facilities and providing a declaration of nuclear activities while the US agrees to provide energy aid and remove the North from the list of state sponsors of terrorism. Implementation delayed until June, when the North receives its BDA funds. The seventh round of the Six Party talks occur in the fall, and the US and North Korea agree to move on to the second phase of implementation.

2008: G1

From January to October, the US and North Korea hold meetings on an almost monthly basis to discuss implementation of the Joint Statement. In February, North Korea receives the New York Philharmonic for a concert in Pyongyang and allows playing of US national anthem. In May, it provides a nuclear declaration to a US delegation in Pyongyang. In June, after long delays, North Korea delivers its formal declaration of its nuclear programs. The US responds by pledging to lift restrictions under the Trading with the Enemy Act, and to remove North Korea from the list of state sponsors of terrorism. In June, North Korea blows up the 5MWe cooling tower in front of international media as part of its disablement steps. Progress abruptly stops when in August North Korea responds to US decision not to remove North Korea from the state sponsors of terrorism list until verification has been achieved. The North suspends work on disabling Yongbyon facilities. Kim Jong Il suffers 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 triggers a decision that the moment for reconciliation has 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. Ambassador Hill travels to Pyongyang in October to attempt to put things back on track; the talks result in no progress.

2009: R1

Pyongyang rejects advice from two unofficial American delegations to give the new Obama administration breathing space. In April the North launches a satellite and in May conducts its second nuclear test. By summer, Pyongyang appears intent on reviving dialogue. When former President Clinton visits in August, Kim Jong Il tries to engage him on possible resumption of US-DPRK talks. A US delegation led by Ambassador Stephen Bosworth arrives in Pyongyang in December for talks and to press North Korea to resume its involvement in the Six Party process.

2010: R1

Possible progress in resuming talks with the US is knocked off track with Cheonan's sinking in March. In November, North Korea shows a centrifuge hall for uranium enrichment to a Stanford delegation. Soon after, when plans for picking up the pace on US-DPRK talks are nearing fruition, they are undercut by the North's shelling of Yeonpyong Island.

2011: G1

In March, after meeting with the Russian deputy foreign minister Aleksei Borodavkin, North Korean Foreign Ministry announces that it "can go out to the Six Party Talks without preconditions, that it does not oppose the discussion of the issue of uranium enrichment at the Six Party Talks" and that "other issues raised by the Russian side" (i.e. the North Korea's temporary suspension of the nuclear test and launch of ballistic missiles, and access of IAEA experts to the uranium enrichment facilities in the Yongbyon District) can also be "discussed and resolved during the process of implementing the 19 September Joint Statement..." North Korea begins limited reengagement, holding its first high-level meeting with the US since 2009. Ambassador Bosworth and Kim Kye Gwan hold talks in New York. Afterwards, the North Korean Foreign Ministry notes: "Both sides recognized that the improvement of the bilateral relations and the peaceful negotiated settlement of the denuclearization of the Korean Peninsula conform with the interests of the two sides and agreed to further dialogue. North Korea remains unchanged in its stand to resume the six-party talks without preconditions at an early date and comprehensively implement the September 19 joint statement on the principle of simultaneous action." Talks continue in October in Geneva, with more progress. In December Kim Jong Il dies and his son, Kim Jong Un, assumes power.

2012: R1

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. The US announces cancellation of the Leap Day deal as a result of April 13 launch attempt. After this incident, there are no high-level bilateral meetings during the rest of the year, although the New York channel remains open.

2013: R1

The US and North Korea do not hold any high-level bilateral meetings during the year, though the New York channel remains open. In February, the North conducts its third nuclear test. In June, a National Defense Commission statement proposes "high-level talks" with the US without preconditions to "defuse tensions on the Korean Peninsula and ensure peace and security in the region." The statement goes on to recognize that the goal of denuclearizing the Korean Peninsula had received the blessing of Kim Il Sung and Kim Jong Il.

2014: R1

In April, a North Korean official floats the idea of the US stopping exercises in return for the North taking a step on the nuclear issue, explicitly citing the 1992 precedent. In November, North Korea again indicates willingness to resume Six Party Talks without preconditions. Throughout the year, there are no high-level bilateral meetings, though the New York channel remains open.

2015: G1

In January, North Korea announces it has formally proposed that the US temporarily suspend joint military exercises in return for temporary suspension of its nuclear tests, adding, "If the United States needs a dialogue concerning this problem, we are prepared to sit face to face with the United States at any time." Later in the year, Pyongyang and Washington exchange views on linkage between a peace agreement and the nuclear issue. There are no high-level bilateral meetings throughout the year although the New York channel remains open. And although North Korea makes what appear to be two serious proposals in pursuit of engagement, the US rejects both.

2016: R3

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. In July, the North Koreans shut down the New York channel following US sanctions that personally target Kim Jong Un. North Korea conducts its fifth nuclear test in September. Following the US presidential election in November, Pyongyang indicates that as long as the winter US-ROK joint exercises are dialed back, it will pause in its nuclear/missile testing until it sees the results of an anticipated US policy review. It also signals the way might be opened for resuming the New York channel.

2017: R3

There is no sustained contact from January through December. Plans to give visas to a North Korean delegation to attend a March meeting in New York are scuttled by North Korea's assassination of Kim Jong Nam in Kuala Lumpur. Another attempt to find traction through a meeting in Oslo falls apart with the death of Otto Warmbier. In May, North Korea tests its Hwasong-12 missile, demonstrating Intermediate-Range Ballistic Missile (IRBM)-relevant technology. In July, following the test launch of a Hwasong-14—demonstrating ICBM capabilities—Pyongyang calls the launch the "final gate to rounding off the state nuclear force." In August, following President Trump's "fire and fury" comments, North Korea announces that Kim Jong Un is reviewing plans to bracket Guam with missiles, though Kim ultimately takes the exit ramp and announces that he will not order the launch but instead wait for the United States' next move. North Korea conducts its sixth nuclear test in September with an explosion yield between 200 and 250 kt, which appears to be consistent with a hydrogen bomb. Following President Trump's UN General Assembly speech, Kim Jong Un releases an unusually tough statement under his own name directed at the US President, calling him a "dotard." North Korea test launches the Hwasong-15 ICBM in November and declares it has completed the state nuclear force.

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.

1992: G1

In 1992, following the North's ratification of its safeguards agreement, the IAEA conducts inspections to verify the completeness of the North Korea's declaration of its nuclear activities.

1993: G1

During 1993 and 1994 the IAEA is permitted by North Korea to conduct safeguards activities with a limited scope only (containment, surveillance and maintenance) with the sole purpose of ensuring, the North phrased it, the "continuity of safeguards" versus "full implementation" demanded by the Agency. The Director General reports as early as December 1993 to the Board that the kind of limited safeguards permitted by North Korea could no longer be said to provide any meaningful assurance of the peaceful use of the North Korea's declared nuclear installations.

1994: G1

Based on the Director General's report, the UN Security Council, on 31 March, again calls upon North Korea to enable the inspectors to complete their required activities. In May, North Korea hastily discharges the fuel from the 5 MWe reactor in such a way that the IAEA is not able to conduct the verification activities that could have clarified the history of the core. In June, the Board of Governors concludes that North Korea is continuing to widen its non-compliance with its safeguards agreement. On 13 June, the North, which had been an IAEA Member State since 1974, withdraws from the Agency. The crisis is defused by the visit of former President Carter in June and in the subsequent negotiations that lead to the Agreed Framework between the US and North Korea on October 21, 1994, which called for a freeze of the Yongbyon nuclear facilities.

1995 - 2002: G3

The Agreed Framework stipulates that the IAEA will be allowed to monitor the freeze. At the request of the UN Security Council the IAEA maintains a continuous presence in Yongbyon to verify the freeze. The IAEA views its activities under the Agreed

Framework as a subset of activities normally performed under the Safeguards Agreement. The facilities subject to the freeze are the 5MWe reactor, the Radiochemical Laboratory (reprocessing facility), the fuel fabrication plant and the partially built 50 and 200MWe nuclear power plants. The IAEA has physical presence at Yongbyon supplemented by placing locks and seals on key equipment and remotely monitoring some facilities and equipment.

The US and North Korea negotiate an agreement on access to Yongbyon and re-canning of spent fuel rods. The magnesium-clad spent fuel rods were unloaded from the reactor and placed in the cooling pool in 1994. North Korea has inadequate water chemistry control leading to severe corrosion of the cladding leading to potential safety hazards. A US technical team leads the project to place the fuel rods into stainless steel canisters supplied by the US. The canning process, conducted with US financing, begins April 27, 1996, and is finished in April 2000. This resulted in a significant US presence in some Yongbyon facilities.

The demise of the Agreed Framework results in North Korea asking the IAEA inspectors to leave on December 27, 2002. No additional access is granted to the US technical team as the spent fuel rods are removed from the canisters and reprocessed in 2003.

2003 - 2006: R3

Yongbyon remains off limits to IAEA and US government officials. The Stanford team of John Lewis, Siegfried Hecker, and Charles (Jack) Pritchard is given access in January 2004 (accompanied by US Senate staffers Keith Luse and Frank Jannuzzi). They are given tours and detailed briefings at the 5 MWe reactor, the spent fuel pool, and the reprocessing facility.

2007: G3

In February, parties to the Six Party Talks announce agreed actions following their latest round of discussions in Beijing. Among the agreed actions is that "the DPRK will shut down and seal for the purpose of eventual abandonment the Yongbyon nuclear facility, including the reprocessing facility" and that North Korea "will invite back IAEA personnel to conduct all necessary monitoring and verifications as agreed between IAEA and the DPRK."

On July 14-18, 2007, IAEA inspectors arrive and confirm the shutdown of five nuclear facilities in Yongbyon: the Yongbyon Experimental Nuclear Power Plant No. 1, the Radiochemical Laboratory, the Yongbyon Nuclear Fuel Fabrication Plant, the Yongbyon Nuclear Power Plant No. 2, and the Nuclear Power Plant at Taechon. The team applies the necessary seals and other surveillance and monitoring measures as appropriate.

A US technical team is given access to Yongbyon to verify the agreed-upon disablement actions. This team has a near continuous presence in Yongbyon and is given good access to key facilities. The Stanford team of Lewis/Hecker/Carlin visits in August 2007. The team is given access even beyond that afforded to the IAEA and US technical team.

2008: G3

IAEA carries out its monitoring and verification activities at the Yongbyon facilities for most of 2008. During 2008, US technical teams continue to have access to Yongbyon for verification of the 2007 agreements. The Track II team of S.S. Hecker, W.K. Luse and J. Wit visits in February 2008 and confirms many of the disablement actions taken by North Korea. However in September the IAEA is asked to remove seals and surveillance from the reprocessing plant in Yongbyon. Subsequently no more IAEA seals and surveillance equipment are in place at the reprocessing facility. North states that IAEA inspectors would have no further access to the reprocessing plant. IAEA continues to have access to other Yongbyon facilities during the rest of the year.

2009: R2

However, subsequent to UNSC sanctions following North Korea's space launch attempt, IAEA inspectors at the Yongbyon nuclear facilities are asked to remove safeguards equipment and leave the country on April 16, per North Korea's decision to cease all cooperation with the IAEA.

2010 – 2017: R3

No further IAEA inspections or official US visits or inspections are allowed from 2010 through 2017. In November 2010, Jack Pritchard is permitted to visit the construction site of the new Experimental Light Water Reactor (ELWR) in Yongbyon. Also, in November 2010, the Stanford Lewis/Hecker/Carlin team is allowed to visit the reactor construction site and is shown the new centrifuge facility in Yongbyon. To our knowledge, no outsiders have been in the Yongbyon Nuclear Complex since 2010.

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 Yonbyon 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.

1992: G2

5 MWe reactor operating. Reprocessing facility operational. North Korea declares plutonium inventory of 90 grams from a single prior reprocessing campaign. Allows IAEA inspections, but inspectors discover a discrepancy of multiple, not only one, previous reprocessing campaigns. Plutonium inventory is likely between 100s of grams to a few kilograms. Plutonium chemistry, metallurgy and fabrication R&D likely throughout this and prior years.

1993: G2

5 MWe reactor operating. Reprocessing facility is operational but likely not operating. Limited access by IAEA inspectors. CIA reports that Pu inventory may be as large as 12 kg. This appears much too large. David Albright in April 2017 estimates inventory of at

most 4 kg at that time. Our estimate based on 2004 visit to Yongbyon is a Pu inventory between 100s of grams to a few kilograms in 1993.

1994: G2

5 MWe reactor shuts down in May. Spent fuel rods unloaded and placed in cooling pool without IAEA supervision leading to nuclear crisis. But as a result of October Agreed Framework (AF), nuclear facilities in Yongbyon are frozen albeit with maintenance allowed. Spent fuel rods stored in cooling pool are monitored by IAEA. Construction of the 50 MWe reactor in Yongbyon and 200 MWe reactor in nearby Taechon are halted. IRT-2000 research reactor built by Soviets in 1960s also not operating.

1995: G3

No plutonium produced in reactor and none reprocessed. Construction of two larger reactors halted. Yongbyon nuclear facilities frozen, including fuel fabrication facility, and monitored by IAEA inspectors. No fresh fuel rods being produced, but approximately 12,000 existing fuel rods are kept in storage. Possible indications of prior removal of glove boxes from the Yongbyon facility that would be an indication of previous plutonium purification and metallurgy research. These may have been moved offsite to permit such research during the freeze.

1996: G3

No plutonium produced in reactor or reprocessed. Yongbyon facilities frozen and monitored by IAEA inspectors. Construction of two larger reactors halted.

1997: G3

No plutonium produced in reactor or reprocessed. Yongbyon facilities frozen and monitored by IAEA inspectors. Construction of two larger reactors halted. US technical team present for repackaging spent fuel in cooling pool for safety reasons and eventual disposition.

1998: G3

No plutonium produced in reactor or reprocessed. Yongbyon facilities frozen and monitored by IAEA inspectors. Construction of two larger reactors halted. Continued presence of US technical team. US suspects North Korea has built a nuclear reactor complex inside Kumchang-ri mountain and requests inspection.

1999: G3

No plutonium produced in reactor or reprocessed. Yongbyon facilities frozen and monitored by IAEA inspectors. Construction of two larger reactors halted. Continued presence of US technical team. Access is granted to Kumchang-ri mountain tunnel by US inspection team, which finds no indication of nuclear facilities.

2000: G3

No plutonium produced in reactor or reprocessed. Yongbyon facilities frozen and monitored by IAEA inspectors. Construction on 50 and 200 MWe reactors has been

halted since 1994. Yongbyon freeze greatly limits plutonium production capacity for the present and future.

Continued presence of US technical team. North Korea is believed to have signed contract to build a clandestine gas-graphite (gas cooled and graphite moderated) plutonium production reactor for Syria.

2001: G3

No plutonium produced in reactor or reprocessed. Yongbyon facilities frozen and monitored by IAEA inspectors. Construction of two larger reactors halted. Continued presence of US technical team. North Korea keeps a reactor design and manufacture team busy with reactor construction project in Syria during next six years.

2002: G3

No plutonium produced in reactor or reprocessed. Yongbyon facilities frozen and monitored by IAEA inspectors. Construction of two larger reactors halted. Continued presence of US technical team. December 31, all IAEA inspectors expelled after US accuses North Korea of serious violation of its commitments under the AF and halts shipments of heavy fuel oil following the visit of US delegation led by Assistant Secretary James Kelly to Pyongyang in October.

2003: R3

January – North Korea announces withdrawal from Nuclear Nonproliferation Treaty (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 re-installed in Yongbyon. 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

January – North Korea shows Hecker and Stanford University delegation it has reprocessed and fabricated plutonium metal and that rest of 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 Yongbyon technical team, which he found very well versed in plutonium metallurgy. Hecker is told that resumption of 50 MWe reactor construction is being evaluated. 200 MWe reactor considered not salvageable. No access for US or IAEA inspectors.

2005: R3

5 MWe reactor unloaded in April 2005 and refueled in June. North Korea conducts second plutonium reprocessing campaign that is completed by Oct. 2005 to extract 10 to 14 kg of weapon-grade plutonium. Hecker is told that resumption of construction of 50 MWe reactor is still under study. No access for US or IAEA inspectors.

2006: R3

5 MWe reactor operating. North Korea conducts first nuclear test in October, which utilizes between 2 and 6 kg plutonium. Lower figure claimed by North Korea, but

unrealistic. No access for US or IAEA inspectors. Hecker is told that construction of both 50 MWe and 200 MWe reactors construction is abandoned. No access for US or IAEA inspectors.

2007: G1

Following Feb. 13 six-party joint action statement, IAEA returns to Yongbyon in May to confirm 5 MWe reactor has shut down. Spent fuel remains in reactor. No additional plutonium being produced. IAEA inspections resume and US monitoring team gets access to Yongbyon. North Korea takes steps to disable Yongbyon facilities. US, Russian, Chinese technical team given access to Yongbyon in September to confirm disablement. Hecker was taken to the plutonium research lab in the Radiochemical Laboratory complex (Reprocessing Facility). The visit convinced him that plutonium operations are still quite small scale and that the actual plutonium pit manufacture is likely done outside the Yongbyon complex.

Plutonium production reactor being constructed for Syria is almost complete, but destroyed by Israeli bombing raid in September 2007. Since no signs of fuel fabrication or fuel reprocessing facility construction were found in Syria, it remains a puzzle as to how the plutonium was to be extracted and for whom it was to be produced.

2008: G1

No reactor operation. No plutonium reprocessing. Spent fuel is slowly moved to cooling pool during the year. During a February visit, Hecker confirms North Korea has taken serious disablement steps, but concludes that these could be reversed in short order. May 8: North Korea provides US with about 18,000 pages of documentation detailing history of operations of the 5 MWe reactor and the reprocessing facility dating back to 1986. The copies of the operating records were mysteriously found to be contaminated with traces of HEU. June 26: North Korea delivers declaration of its nuclear programs to China, the six-party talks chair. The declaration reportedly indicates that North Korea separated a total of about 30 kilograms of plutonium, and claims that about 2 kilograms were used for its 2006 nuclear test. June 28: North Korea blows up reactor cooling tower in good-faith disablement action.

Total Pu inventories estimated by Hecker to be 40 to 50 kg and by David Albright of the Institute of Science and International Security to be in the range of 28 to 50 kg. Plutonium metallurgy and fabrication R&D likely proceeding. IAEA inspectors and US monitoring teams have access to Yongbyon in spite several interruptions by North Korea because of diplomatic disagreements.

2009: R1

IAEA inspectors and US monitoring team expelled in April when North Korea formally leaves six-party talks. Spent fuel rod removal completed, followed by reprocessing campaign that is finished by end of August, extracting roughly 8 kg weapon-grade plutonium. North Korea announces it will reprocess spent fuel for weapons and begin construction of Experimental LWR reactor of 100 MW-thermal capacity (About four times larger than 5 MWe reactor). May 25, North Korea most likely utilizes 4 to 6 kg plutonium in second nuclear test. 5 MWe reactor is not put back in operation during the year.

2010: R1

5 MWe reactor not operating. Cooling system being rebuilt. No reprocessing because no spent fuel available. Significant construction activity at Yongbyon Fuel Fabrication Facility (FFF). Likely fabrication of new metallic fuel elements for 5 MWe reactor and oxide fuel elements for ELWR. Hecker and colleagues shown beginning of construction of ELWR and confirm 5 MWe reactor still on hold, but are told by Yongbyon technical specialists that it can be restarted. No access for US or IAEA inspectors.

2011: R1

5 MWe reactor not operating; no reprocessing. Significant activity at FFF. Most likely preparations made for 5 MWe and ELWR fuel fabrication. No access for US or IAEA inspectors. Possible reactivation and construction of old and new fuel element assembly facilities outside the FFF in the North area as inferred from satellite imagery.

2012: R1

5 MWe reactor not operating; no reprocessing. Significant activity observed at FFF. Most likely fuel fabrication activities for 5 MWe and ELWR and continued activity in the North area at buildings associated with fuel rod production for the 5MWe reactor. No access for US or IAEA inspectors.

2013: R2

North Korea possibly expends 4 to 6 kg plutonium in third nuclear test on Feb. 12. 5 MWe reactor restarted in August and operating during rest of year. No access for US or IAEA inspectors. Most of ELWR exterior construction complete. Hecker estimates that North Korea has produced between 40 and 60 kg of plutonium metal, and has a remaining inventory of 24 to 42 kg at this time accounting for processing and testing losses. Plutonium metallurgy and fabrication R&D continues. Significant activity observed at FFF.

2014: R2

5 MWe reactor operates somewhat intermittently. No reprocessing. Plutonium metallurgy and fabrication R&D continues. ELWR not operational. The North area 5MWe reactor fuel rod production buildings are up and running. No access for US or IAEA inspectors.

2015: R3

5 MWe reactor operates most of the year. No reprocessing. Reactor shut down in late 2015 (between October and December, defueled and refueled). Plutonium metallurgy and fabrication R&D continues. ELWR still not operational. Continued work on cooling for both the 5 MWe and ELWR reactors. No access for US or IAEA inspectors.

2016: R3

North Korea conducts its fourth nuclear test on Jan. 6 with unknown amount of plutonium or HEU. Claims that test was a hydrogen bomb, which is unlikely but could be a proof-of-principle hydrogen bomb. North Korea conducts another test on Sept. 9 with unknown amount of plutonium or HEU. 5 MWe reactor restarted in early 2016 and

operates intermittently rest of the year. Reprocessing campaign completed by summer – likely to have separated 5.5 to 8 kg weapon-grade plutonium. ELWR still not operational. No access for US or IAEA inspectors. Possible production of tritium in Lithium-6 targets in 5 MWe reactor during past few years. If so, that will decrease plutonium production somewhat.

2017: R3

5 MWe reactor operating except for two stoppages in May and October. Likely no additional reprocessing. On Sept. 3, North Korea conducts its sixth nuclear test with yield between 200 and 250 kilotons, in hydrogen bomb range. Total estimated plutonium inventory may still be in 20 to 40 kg range accounting for the fact that plutonium may have been used in some 2016 and 2017 tests. ELWR still not operational. No access for US or IAEA inspectors.

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.

1992: 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. It has abundant uranium ore supply from two mines. D 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 it is required for reactor fuel manufacture) and some experimental UF₆ production (a step required only for enrichment activities).

1993: G1

Minimal centrifuge effort, but Kim Il-sung receives sensitive centrifuge technology information on a CD delivered by PM Benazir Bhutto during visit to Pyongyang, ostensibly in return for North Korea aiding Pakistan's missile program.

1994: G1

Minimal centrifuge effort.

1995: G1

Minimal centrifuge effort.

1996: G1

Likely still minimal centrifuge effort, but Pakistan's A.Q. Khan is believed to have made first visit to North Korea and likely renewed its interest in centrifuge technologies.

1997: R1

Interest in centrifuge technology increases through contact with A.Q. Khan.

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 first 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.

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 Yongbyon complex since IAEA and US technical teams have access to Yongbyon at this time. 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.

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 technical team at Pakistan's KRL to learn how to operate centrifuge cascades.

2001: R1

Covert centrifuge procurement efforts continue from around the globe. Shipment of 1.6 tons of UF₆ made to Libya. North Korea technical team receives training on centrifuge cascade design and operation at KRL.

2002: R1

Technical team training at KRL likely continues and North Korea steps up its centrifuge equipment and materials procurement from countries such as Germany and Russia.

2003: R1

Technical specialists likely withdrawn from KRL as the Khan proliferation network is exposed through its Libya ventures. Major procurement efforts continue including high-

strength aluminum shipment attempt from Germany and successful shipment from Russia. Also vacuum and electrical equipment from Japan and likely specialty metals for ring magnets from China. Indigenous centrifuge efforts likely increase.

2004: R1

North Korea builds indigenous centrifuge capabilities (likely outside of Yongbyon), but also continues to use covert procurement efforts. Likely steps up uranium processing in Yongbyon to produce fuel for Syrian reactor or to ship uranium yellow cake (raw material for uranium metal fabrication).

2005: R1

North Korea increases indigenous centrifuge capabilities likely outside of Yongbyon, but continues to use covert procurement efforts. North Korea likely has a one or two cascades of centrifuges operational, based on Pakistani cascades design. Enriched uranium inventory likely quite small.

2006: R1

North Korea continues indigenous centrifuge development and its covert procurement efforts. Appears to have produced an indigenous first-generation flow-forming machine for the fabrication of centrifuge rotors. North Korea likely improving its centrifuge cascades and gaining experience. It appears to have decided to leapfrog over first-generation centrifuge design and concentrate on design similar to Pakistani P-2 design.

2007: R1

Indigenous centrifuge fabrication efforts continue outside of Yongbyon. IAEA and US team has access to Yongbyon as a result of US and six-party diplomatic initiative. Uranium chemical facilities to produce UF₄ (uranium compound used for 5 MWe reactor fuel fabrication and for the precursor compound to obtain UF₆ for enrichment) in Yongbyon has been re-established, but with makeshift equipment. Reports of 45 tons of uranium yellow cake apparently shipped to Syria (for likely fuel element fabrication) and subsequently shipped out of the country to unknown destination. US team finds traces of HEU on samples of aluminum tubes provided by North Korea during a visit to missile factory, indicating that North Korea has produced some unknown quantities of HEU.

2008: R1

Little activity in Yongbyon because of IAEA and US team presence. Indigenous program likely increases outside of Yongbyon with likely pilot plant construction. Covert procurement efforts for centrifuge equipment and materials continue. Acquisition of flow-forming machines likely from Europe. More traces of HEU found on copies of 18,000 pages of Yongbyon operating records given to US as part of declaration agreement. Design of centrifuges for the planned Uranium Enrichment Facility in Yongbyon probably frozen and production of commercial centrifuges for the facility begins.

2009: R2

In June, subsequent to North Korea's departure from six-party talks, it announces for the first time that it will pursue uranium enrichment for fuel elements for an indigenous LWR to be built. In September, North Korea tells UNSC "experimental uranium enrichment has been successfully conducted to enter into the completion phase." Procurement of high-strength steels and foreign flow forming machines and production of second-generation of indigenous centrifuges continues. North Korea has likely developed capacity to produce lower-strength (250 and possibly 300) grades of high-strength maraging steels for rotors which are simpler to produce than 350 grade used in many commercial centrifuges. Reports indicated that North Korea was exporting such steel-making equipment to Syria. Major construction apparent at Yongbyon FFF, later determined to be for centrifuge program. Pilot plant operation and centrifuge manufacture likely in full swing to prepare for new facility to be built at Yongbyon. Total HEU inventory at this time may be tens of kilograms.

2010: R2

Construction at Yongbyon continues, including complete gutting of Building 4 in FFF (uranium metal fuel fabrication facility) and reconfiguration for centrifuge halls. New facilities for production of UF₄ completed (anhydrous compared to previous aqueous). In November, North Korea shows Lewis/Hecker/Carlin Stanford delegation a modern centrifuge facility housing 2000 what are believed to be 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.

2011: R2

Centrifuge equipment and material procurements continue. Major construction activities at the FFF, some likely associated with uranium enrichment and some with fuel fabrication for both metal alloy fuel for the 5 MWe reactor and ceramic fuel required for the ELWR.

2012: R2

Centrifuge equipment and material procurements continue. Major construction activities at the FFF, some likely associated with uranium enrichment and some with fuel fabrication.

2013: R2

Construction at the Yongbyon centrifuge facility continues. The size of the centrifuge hall building is doubled, most likely indicating a doubling of the centrifuge capacity at Yongbyon. State news media publicize photo of Kim Jong-un with new generation flow-forming machine, apparently one that originated in Europe. North Korea continues R&D on centrifuge technologies, including exploring fiber-wound rotor materials.

2014: R3

Construction at the FFF continues. It is quite likely that the Yongbyon centrifuge facility is used to enrich UF₆ to LEU levels (3 to 5 % U-235) and then shipped to covert facility (or facilities) most likely off-site to top off to 90 % U-235.

2015: R3

Operations continue at Yongbyon centrifuge facility, plus likely at the covert facility(ies). North Korea is potentially able to produce 250-grade maraging steel to make its own rotors. It likely still imports certain materials such as ring magnet materials and equipment for centrifuge operations. We estimate the annual production rate possibly as high as 150 to 175 kg, however with great uncertainty. The second centrifuge building probably is operating. HEU inventories – possibly 300 kg (Hecker) and 110 – 320 kg (Albright).

2016: R3

All centrifuge facilities are operating. Continued R&D and procurements probable.

2017: R3

All centrifuge facilities are likely operating. Continued R&D and procurements probable. HEU inventories – possibly 250 – 500 kg (Hecker) and 250 – 650 kg (Albright).

Tritium/Lithium-6 (fusion device fuels)

A measurement of the state of fusion (hydrogen bomb) fuels, 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.

1992: G1

North Korea likely produced tritium and separated tritium for R&D in the IRT-2000 reactor complex in the 1970s and 1980s. It likely developed tritium handling capabilities and tritium separation in the hot cell facilities at the Isotope Production Laboratory at the IRT-2000 reactor complex. Also likely developed ability for isotope separation of Li-6 from natural lithium.

1993-1994: G1

Likely no additional tritium activities.

1995-2002: G1

No tritium production because no reactors were operating. Likely no additional tritium activities.

2003: R1

Possibly restart tritium R&D, refurbish tritium separation facilities at IRT-2000 reactor complex, and possibly produce small amounts of tritium from Li-6 targets in 5 MWe reactor.

2004: R1

Possibly continued tritium R&D, refurbish tritium separation facilities at IRT-2000 reactor complex, and possibly produce small amounts of tritium from Li-6 targets in 5 MWe reactor although there are tradeoffs of tritium production and plutonium production.

Li-6 targets in reactor decreases plutonium production in 5 MWe reactor because finite reactor core size.

2005: R1

Likely tritium R&D, some limited production in 5 MWe reactor and separation.

2006: R1

Likely tritium R&D, some limited production in 5 MWe reactor and separation.

2007-2009: R1

Likely tritium R&D continues, but no tritium production because 5 MWe reactor is shut down and IAEA inspectors and US technical team are present in Yongbyon. IRT-2000 reactor is mostly dormant during these years due to lack of HEU fuel elements and hence not able to produce tritium.

2010: R2

No tritium produced. May 12, KCNA reports North Korea has made nuclear fusion energy breakthrough – a claim that can readily be dismissed, but likely indicates that North Korea has tritium and is doing tritium and fusion research. The hydrogen isotope, deuterium, required for fusion reactions is assumed to be easily within North Korea's domestic production capabilities.

2011: R2

No tritium produced. Tritium handling and fusion R&D likely.

2012: R2

No tritium produced. Expansion of Li-6 production with procurements/construction for Li-6 plant at Hungnam Fertilizer Complex (Albright). Tritium handling and fusion R&D likely.

2013: R2

5 MWe reactor is restarted in August. Possible tritium production in Li-6 targets.

2014: R3

Construction started near FFF on what appears to be hot cells for tritium separation. Activity at Reprocessing Facility in September possibly related to unloaded Li-6 targets, then possibly sent to IRT-2000 facility hot cells for tritium separation.

2015: R3

Construction continues at FFF on the new facility. Possible extraction of tritium from Li-6 targets in IRT-2000 facility hot cells.

2016: R3

Possible continued production of tritium in 5 MWe reactor. North Korea claimed to have detonated hydrogen bomb in January. Claim is unlikely to be true, but could possibly

have been a proof-of-principle test of prospective hydrogen bomb possibly based on tritium/deuterium boosted fission bomb.

2017: R3

Possible continued production of tritium in 5 MWe reactor. North Korea claims to have detonated a hydrogen bomb. Yield estimates of 200 to 250 kilotons are consistent with possible hydrogen bomb. North Korea likely used tritium and/or Li-6D if the device was a hydrogen bomb. Total inventory of tritium is highly uncertain, but likely multiple grams, greatly limiting the number of hydrogen bomb devices that can be produced. Tritium also decays with half-life of 12 years, so it must be replenished on a regular basis.

Weaponization (R&D, design, manufacture, testing)

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.

1992: 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 at Punggye-ri also were likely underway by this time.

1993-1994: R1

Nuclear weapon R&D team likely continued to work on all aspects of nuclear weapons.

1995-1997: R1

Nuclear weapon R&D team likely continued to work on all aspects of nuclear weapons. Explosives testing curtailed and plutonium and uranium R&D limited by Yongbyon closure during AF.

1998: R1

Nuclear weapon R&D team likely continued to work on all aspects of nuclear weapons. Explosives testing curtailed and plutonium and uranium R&D limited by Yongbyon closure during AF. Interest in nuclear weapons R&D and manufacture likely picks up through contact with A.Q. Khan.

1999: R1

Nuclear weapon R&D likely expanding. Contact with A.Q. Khan provides possibility of having obtained centrifuge equipment and materials. The likely receipt of implosion weapon design for HEU weapon fuel from A.Q. Khan, possibly along with nuclear test data, increases interest and effort on nuclear weapons. Such a design could also prove helpful for North Korean efforts for plutonium-fueled implosion device.

2000: R1

Continuing nuclear weapon R&D with likely exploration of HEU implosion designs in addition to ongoing efforts on plutonium implosion designs.

2001: R1

Continuing nuclear weapon R&D. Likely restarted nuclear test site preparations. Test tunnel preparations and tunnel stemming R&D may have been aided by Pakistani information – possibly both clandestine and open-source information.

2002: R1

Nuclear weapon R&D likely increases resulting from successful centrifuge materials and equipment procurements and what were viewed as the hostile policies of the incoming Bush administration.

2003: R2

In concert with restart of Yongbyon nuclear facilities and withdrawal from the NPT, nuclear weapons R&D and production are scaled up. Plutonium metal facilities at Yongbyon reconstituted and plutonium metal prepared for plutonium bomb cores (pits). Same for high explosives synthesis and manufacture. Preparations made for possible underground nuclear test.

2004: R2

Full effort to manufacture plutonium nuclear devices from the roughly 25 kg plutonium extracted from the 8,000 spent fuel rods. 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. Design and engineering team likely explores advanced fission design concepts beyond Nagasaki-style.

2005: R2

Nuclear device R&D and device manufacture continue. On February 10, North Korea's Foreign Ministry announces that Pyongyang has "produced nuclear weapons." It may have produced all components for several nuclear devices, but likely not fully assembled. Significant effort on test site preparation and test diagnostics likely.

2006: R2

Nuclear device R&D and manufacture continue. Full preparation for first nuclear test followed by Oct. 9 underground detonation at Punggye-ri nuclear test site. North Korea informed Chinese government four hours before the test that the expected explosion yield would be 4 kilotons. Actual yield of somewhat less than one kiloton indicates device was

only partially successful. Test was likely a plutonium device. (Yongbyon director Ri Hong-sop told Hecker during subsequent visit that the test was of a plutonium device). Although the test was contained in the East tunnel, prompt leakage of some radionuclides apparently led to the subsequent abandonment of that tunnel. All subsequent tests have been conducted in what now is called the North tunnel.

2007: R1

Weapon design and engineering focused on learning from the partial failure of the first nuclear test. North Korea conducts drill-back at test site for nuclear yield determination and test analysis. Some weapon R&D efforts slowed down by re-opening Yongbyon to IAEA inspectors and US technical team.

2008: R1

Weapon design and engineering focused on learning from the partial failure of the first nuclear test. New design likely completed and readied for second nuclear test. Some weapon R&D efforts slowed by re-opening Yongbyon to IAEA inspectors and US technical team. Halt in plutonium production may result in major design effort for HEU designs, possibly aided by having obtained such a design from A.Q. Khan. Nuclear test site preparations likely continued during 2007 and 2008 to prepare for a second nuclear test conducted in 2009. North Korea likely had components for several nuclear devices, but likely not fully assembled, particularly since design was not verified in first test.

2009: R2

With inspectors expelled in April, full effort directed at preparation for second nuclear test conducted on May 25, 2009. Explosion yield of 2 to 7 kilotons indicates that North Korea successfully detonated a fission bomb, most likely using a plutonium core. The test was successfully contained, this time in a tunnel under Mt. Mantap through the North portal. Strong similarities were noted with Pakistani practices in test tunnel construction and containment openly revealed by Pakistani government from 1998 to 2000.

2010: R2

North Korea likely continued to refine fission bomb designs to utilize HEU pits and to miniaturize plutonium devices for missile delivery. It also possibly established a hydrogen bomb design team around this time. North Korea claimed to have successfully achieved fusion energy in May most likely indicating that North Korea has experimented with tritium. At the same time, some analysts claimed that North Korea conducted a low-yield nuclear test on May 10 based on subsequent analysis of weak seismic signals and noble fission gases detected nearly two months subsequent to date. These findings remain inconclusive.

2011: R2

North Korea likely continued to refine fission bomb designs to utilize HEU pits and to miniaturize plutonium devices for missile delivery. Test site activity continued. North Korea likely produced all the components for several nuclear weapons based on the 2009 nuclear test.

2012: R2

North Korea likely continued to refine fission bomb designs to utilize HEU pits and to miniaturize plutonium devices for missile delivery. Test site activity increased in preparation for Feb. 2013 nuclear test.

2013: R2

North Korea conducts third nuclear test with explosion yield between 7 and 14 kt. It may have been a third plutonium device test or the first test of an HEU device. The test was again successfully contained.

2014: R2

Nuclear weapons R&D continues on advanced bomb designs, likely including hydrogen bombs. Test site activity continues. Likely additional manufacture of all components for several additional nuclear bombs based on what was learned from devices tested in 2009 and 2013. On March 30, North Korea threatens to carry out a 'new form' of nuclear test, possibly alluding to working on boosted fission bombs or hydrogen bombs.

2015: R2

North Korea proposes a nuclear test and missile test moratorium in exchange for cancelation of joint military exercises. Proposal is dismissed by the Obama administration. North Korea continues nuclear weapons R&D on advanced designs. Possibly accelerated work on hydrogen bomb design. Test site activity continues. Likely additional manufacture of all components for several additional nuclear bombs based on what was learned from devices tested in 2009 and 2013. Significant design effort and testing effort likely to determine if nuclear devices can withstand the rigors of missile launch and re-entry for short to long-range missiles. Activity at nuclear test site continues.

2016: R3

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 it achieved some fusion yield by testing a boosted fission device (most likely with plutonium). 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. The device could have been an HEU or a plutonium device. By this time, North Korea likely produced all the components of perhaps as many as a dozen nuclear devices based on its nuclear test results. Five nuclear tests over 10 years likely enables it to mount a nuclear warhead in its SCUD and Nodong missiles capable of reaching all of South Korea and Japan.

2017: R3

Nuclear weapons R&D continues, most likely directed at miniaturized boosted fission and fusion (hydrogen bomb) devices. On Sept. 3, North Korea conducts its sixth nuclear test with an explosion yield between 200 to 250 kt, consistent with a hydrogen bomb. Test is fully contained in the system of tunnels through the North portal (used for all but

the first test) in spite of high yield explosion and significant rock movement. The test may have been of a two-stage modern thermonuclear device, but it is uncertain if test device is consistent with the design revealed by the North Korea a few hours before the test. Two other tunnel networks (through South and West portals) appear to have been excavated over the years and together with the North tunnel complex can likely accommodate future nuclear tests.

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).

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.

1992: 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. Plutonium inventory is likely in the 100s of grams to a few kilograms. North Korea has no uranium enrichment capacity and is unlikely to have acquired HEU. Hence, it has insufficient fissile materials for a nuclear bomb.

1993: R1

North Korea's 5 MWe nuclear reactor is operating, but there is no new reprocessing campaign, hence, no additional plutonium is available. North Korea has no uranium enrichment capacity. A US National Intelligence Estimate is said to have concluded that there is a "better than even" chance that North Korea already has a nuclear bomb. That conclusion is disputed by the State Department and is likely not correct. North Korea likely continues nuclear weapons R&D.

1994: R1

The 5 MWe reactor is unloaded but spent fuel is not reprocessed. The Agreed Framework signed in October. North Korea likely continues nuclear weapons R&D.

1995 - 1999: G3

Yongbyon nuclear facilities are shut down and monitored by IAEA as part of the implementation of the Agreed Framework. There is also a significant presence of US technical teams at Yongbyon. Construction on 50 and 200 MWe reactors is also halted. The Yongbyon freeze greatly limits plutonium production capacity for the present and future. 8,000 spent fuel rods believed to contain between 20 and 30 kg plutonium are stored in the spent fuel pool under continuous monitoring by IAEA. Some nuclear weapons R&D likely continues.

2000 – 2002: G3

Yongbyon facilities stay shut and construction of larger reactors remains dormant. Clandestine procurement of centrifuges and centrifuge materials and equipment has picked up since 1998, but enrichment capacity is still in the R&D stage at best. UF₆ is shipped to Libya as part of contacts with A.Q. Khan's network. Khan provides North Korea with technical details of centrifuges design and possibly nuclear weapons designs. Some nuclear weapons R&D likely continues. Larger reactors subsequently judged to be not salvageable. Hence, North Korea gave up a potential plutonium production capacity of nearly 300 kg with the Agreed Framework construction freeze.

2003: R2

IAEA inspectors are expelled from Yongbyon at the end of 2002. North Korea withdraws from the NPT and restarts Yongbyon nuclear facilities including the 5 MWe reactor and reprocessing facility. Roughly 25 kg of plutonium is extracted from the 8,000 fuel rods that had been stored in the pool. The plutonium metal facilities at Yongbyon are reconstituted (these appear to have been moved out of Yongbyon during the Agreed Framework) and plutonium metal prepared for plutonium bomb cores (pits). The same goes for high explosives synthesis and manufacturing. Preparations are made for a possible underground nuclear test. Centrifuge technology acquisition and R&D likely increases.

2004: R2

The 5 MWe reactor is operating, producing somewhat less than 6 kg of plutonium annually. A full effort is made to manufacture plutonium nuclear devices from the roughly 25 kg weapon-grade plutonium extracted from the 8,000 spent fuel rods. The first devices built are most likely of the Nagasaki-type fission bomb design with approximately 6 kg plutonium. There is increased preparation of nuclear test site, including mining, stemming and test diagnostics. A design and engineering team likely explores advanced fission design concepts beyond Nagasaki-style. North Korea continues its centrifuge efforts.

2005: R2

The operation of the 5 MWe reactor is halted temporarily to unload the fuel and to conduct North Korea's second post-Agreed Framework reprocessing campaign to extract 10 to 14 kg of weapon-grade plutonium. Nuclear device R&D and device manufacture continue. On February 10, the Foreign Ministry announces that Pyongyang has "produced nuclear weapons." It may have produced all components for several nuclear

devices, but likely not fully assembled. North Korea mounts a significant effort on test site preparation and test diagnostics. North Korea continues its centrifuge efforts.

2006: R2

Nuclear device R&D and manufacture continue. North Korea continues full preparation for its first nuclear test, which culminates in the October 9 underground detonation at Punggye-ri. Pyongyang informs the Chinese government hours before the test that the expected explosion yield would be 4 kilotons. The actual yield of somewhat less than one kiloton indicates test was only partially successful. The test is likely of a plutonium device. Although the test is contained in the East tunnel, prompt leakage of some radionuclides apparently leads to the subsequent abandonment of that tunnel. All subsequent tests are conducted in the North tunnel. Uranium centrifuge efforts continue at an unknown location. Tritium production in the 5 MWe reactor is likely during the past few years, with tritium extraction occurring in the IRT-2000 reactor complex hot cells.

2007: R1

The operation of the 5 MWe reactor is halted as a result of the February 13 agreement. No new plutonium is produced for the rest of the year. Weapon design and engineering is focused on learning from the partial failure of the first nuclear test. Some weapon R&D efforts slowed down by re-opening Yongbyon to IAEA inspectors and US technical team. There is continued centrifuge effort at an unknown site with possible development of small pilot centrifuge facility.

2008: R1

The 5 MWe reactor not operating and no plutonium is produced. A new design is likely completed and readied for a second nuclear test. Re-opening Yongbyon to IAEA inspectors and US technical team likely slows some weapon R&D efforts. The halt in plutonium production may result in a major effort for HEU designs, but likely no significant HEU inventory by this time. Nuclear test site preparations likely continue during 2007 and 2008 to prepare for a second nuclear test in 2009. North Korea likely has components for several nuclear devices, but likely not fully assembled, particularly since the design was not verified in first test.

2009: R2

With inspectors expelled in April, a full effort is directed at preparation for the second nuclear test conducted on May 25, 2009, in the North tunnel under Mt. Mantap. Explosion yield of 2 to 7 kilotons indicates that North Korea successfully detonated a fission bomb, most likely using a plutonium core. Uranium centrifuge efforts progress to pilot-plant stage. Roughly 8 kg of weapon-grade plutonium is extracted from the spent fuel in the third reprocessing campaign. However, 5 MWe reactor is not restarted, hence no additional plutonium is produced. International inspectors and US technical teams do not return to Yongbyon as of end of 2017.

2010: R2

North Korea likely continues to refine fission bomb designs to utilize HEU pits and to miniaturize plutonium devices for missile delivery. It also possibly establishes a

hydrogen bomb design team around this time. North Korea claims to have successfully achieved fusion energy in May, most likely indicating that it is experimenting with tritium. North Korea shows a Stanford team a surprisingly modern 2,000-centrifuge facility at the Yongbyon Fuel Fabrication Facility (FFF). The visit provides the first definitive indication that North Korea has decided to pursue both HEU and plutonium bomb arsenals. The 5 MWe reactor is not operating. Construction begins on new 100 MW (thermal) experimental light water reactor (ELWR).

2011: R2

North Korea likely continues to refine fission bomb designs to utilize HEU pits and to miniaturize plutonium devices for missile delivery. Test site activity continues. North Korea likely produces all the components for several nuclear weapons based on the 2009 nuclear test. The 5 MWe reactor is not operating, consequently no additional plutonium or tritium is being produced.

2012: R2

North Korea likely continues to refine fission bomb designs to utilize HEU pits and to miniaturize plutonium devices for missile delivery. Test site activity increases in preparation for Feb. 2013 test. 5 MWe reactor is not operating.

2013: R2

North Korea conducts its third nuclear test with explosion yield between 7 and 14 kt. It may have been a third plutonium device test or the first test of an HEU device. The Yongbyon centrifuge hall is doubled in size and the 5 MWe reactor is restarted in August. This reactor produces plutonium and possibly tritium.

2014: R2

Nuclear weapons R&D continues on advanced designs, likely including hydrogen bombs. Test site activity continues. North Korea likely manufactures all components for several additional nuclear bombs based on what was learned from devices tested in 2009 and 2013. The 5 MWe reactor is operating. Uranium enrichment capacity at Yongbyon and covert location(s) possibly increases to 100 kg annually, and possibly more, later.

2015: R2

North Korea continues nuclear weapons R&D on advanced designs and possibly accelerates work on a hydrogen bomb design. Test site activity continues. North Korea likely manufactures all components for several additional nuclear bombs based on what was learned from devices tested in 2009 and 2013. North Korea likely engages a significant design effort and testing effort to determine if nuclear devices can withstand the rigors of missile launch and re-entry for short to long-range missiles. Activity at the nuclear test site continues. The 5 MWe reactor and centrifuge facilities are operating.

2016: R3

On January 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 (most likely with plutonium). The test may have been a proof-of-principle hydrogen bomb. On September 9, North Korea conducts its fifth nuclear test with explosion yield of 15 to 25 kt (fully contained) and makes no mention of hydrogen bombs, but rather claims miniaturization, which likely was the primary intent of the test. The device could have been an HEU or a plutonium device. By this time, North Korea likely has produced all the components of perhaps as many as a dozen nuclear devices based on its nuclear test results. Five nuclear tests over 10 years likely enables North Korea to mount a nuclear warhead in its Scud and Nodong missiles capable of reaching all of South Korea and Japan. Operation of the 5 MWe operation is halted temporarily to unload spent fuel, which is reprocessed in a fourth campaign to yield 5.5 to 8 kg weapon-grade plutonium. Significant increased activity in Yongbyon is evident, related to new facilities for the final stages of fuel elements fabrication for the 5 MWe Reactor and for the ELWR, and possibly related to Li-6D manufacture for hydrogen weapons.

2017: R3

Nuclear weapons R&D continues, most likely directed at miniaturized boosted fission and fusion (hydrogen bomb) devices. On September 3, North Korea conducts its sixth nuclear test with an explosion yield between 200 to 250 kt, consistent with a hydrogen bomb. The test may have been of a two-stage modern thermonuclear device, but it is uncertain if test device is consistent with the design revealed by the North Korea a few hours before the test. The 5 MWe reactor and Yongbyon centrifuge facility are operational for most of the year. North Korea is estimated to have a plutonium inventory of 20 to 40 kg, an HEU inventory of 250 to 500 kg, sufficient for 25 to 30 nuclear devices. It is estimated to have a very small inventory of tritium, limiting the number of potential hydrogen bombs to a few. Its plutonium production remains limited to less than 6 kg annually. Its tritium production is also severely limited. Production of both could be increased substantially if the ELWR becomes operational and is dedicated primarily for plutonium and tritium production. ELWR was targeted to start operating in 2012 but has not started operation as of May 2018. HEU production estimates are highly uncertain but may be in the 150 to 175 kg/year range.

North Korea claimed that the September 3 test was of a thermonuclear design capable of being mounted and delivered to anywhere in the US. That claim is likely incorrect because the ICBMs, both the Hwasong-14 and 15, will require more testing to ensure performance and reliability. In addition, much more testing will be required to ensure the warheads are sufficiently robust to survive launch and reentry into the atmosphere.

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, 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.

1992: R1

North Korea's ballistic missile efforts date back to the 1970s. Initial cooperation with China collapsed quickly because of China's domestic problems. North Korea then turned to the Soviet Union, although the early import of Soviet missiles, primarily the Scud-B (named the *Hwasong-5*) with range to 300 km, appeared to be routed through Egypt because of strained Moscow-Pyongyang relations. North Korea also began developing the *Hwasong-6* (a North Korean version of the Soviet Scud-C). The limited number of flight tests and rapid deployment of these missiles suggest that North Korea either purchased the missiles or acquired the production facilities to produce them from the Soviet Union. North Korea also explored a range of longer-range missiles in the five years before 1992 that were subsequently developed and tested in the 1990s and early 2000s. These included early development of a space launcher. North Korea also engaged in exporting these missiles. In fact, Washington sanctioned North Korean companies for missile proliferation in March 1992 based on evidence of major missile sales to Iran in late 1980s.

Although collaboration in nuclear technologies with Russia stopped following the breakup of the Soviet Union, imports of missiles, rocket technologies, components, materials and know-how from Russia appeared to continue. For example, in May 1992, Igor Velichko, general designer of the V.P. Makeyev Engineering Design Office, signed a \$3 million contract with the Korea Yŏn'gwang Trading Company in Pyongyang.

1993: R1

North Korea receives continued assistance from Russian missile specialists, including likely purchases of missiles and components. In May, North Korea launches several Hwasong-5 and 6 missiles and a Nodong-1 (a scaled-up version of the Scud-B with a range of roughly 1,000 km) into the East Sea. This is the first successful test of the Nodong-1. Missile and nuclear information exchange with Pakistan occurs via visits of North Korean military staff to Pakistan in 1992 and visit of Benazir Bhutto to Pyongyang in December 1993. There are also credible reports indicating that the Iranians attended the 1993 launch of the Nodong.

1994 to 1997: R1

Collaboration with Russian missile specialists likely continues. Preparations for space launch with development of Taepodong-1 (*Paektusan*) space launcher (based on a Nodong first stage and Scud second stage and small solid fuel third stage). Reported development of a next-generation space launcher, the Unha, also called the Taepodong-2 probably began. Missile exports likely continue, to Syria (Scud C and D) Pakistan and Iran (Nodong). There are reports of Nodong deployments and foreign sales in 1995 and 1997, in spite of limited flight tests.

1998: R1

On August 31, North Korea launches a Paektusan/Taepodong-1 rocket from the Tonghae test range that fails to orbit a satellite. Its flight path over Japan, a sensible trajectory considering test site location, causes an international incident. Foreign assistance, primarily from Russia and Ukraine, but also Iran, was instrumental in Taepodong development. Earlier in April, the 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. There is evidence of continued transfer of Nodong missile technologies to Iran, possibly the sale of as many as 50 to 150 Nodongs. Also continued transfer to Pakistan.

1999 to 2004: G1

In September 1999, North Korea agrees to missile test moratorium subsequent to the Perry Process diplomacy. There are no short or medium range missile tests during this time and no space launches. The missile test moratorium is confirmed in the October 2000 Joint Communiqué with US as well as the North Korea-Japan Pyongyang Declaration in September 2002. Technical work on Unha/Taepodong-2 SLV continues. The Tonghae gantry tower is modified to handle the larger Unha SLV. Missile trade and cooperation with Pakistan, Iran, Iraq, Libya, Syria and Yemen continue. Several missiles, later called Hwasong-10/Musudan, are reportedly photographed in Pyongyang in 2003 at Mirim Airfield display area.

2005: R1

The North Korean flight-test moratorium is technically ended on May 1 with the launch of the short range KN-02, a solid-fueled ballistic missile with a range of 120-170km (suitable for conventional, chemical and possibly nuclear payloads), apparently based on

the Tochka (SS-21) Soviet missile. It is test fired three times with one success. North Korea also apparently develops a new extended-range Scud-ER missile with an estimated range of 600-1000km. Reports of DPRK–Iran cooperation on potential flight-testing of the Musudan (BM-25) intermediate-range ballistic missile (IRBM) are based on the sale of 18 or 19 BM-25 kits to Iran in 2005. There is no evidence that any test occurred. The Musudan is liquid-fueled with a range of 2,500-4,000km, believed to be a road-mobile version of the Russian SS-N-6 SLBM. North Korea is reported to have deployed about 15-20 Musudan missiles in 2007.

2006: R1

In July, over the course of a few hours, North Korea test fires seven ballistic missiles, including its space launch vehicle (SLV), the Unha/Taepodong-2 from Tonghae. The first stage of this satellite launch vehicle consists of four Nodong engines together, the second stage is probably a Nodong and the third stage is similar to the Iranian Safir upper stage. The other six tests include a combination of short- and medium-range Scud-C and Nodong ballistic missiles, launched from the Kittaraeyong test site. Although the tests of the six short-range missiles appeared to be successful, the Unha/Taepodong-2 failed less than a minute after launch.

By early 2006, North Korea is believed to have deployed over 600 Scud-B and Scud-C (Hwasong-5/6) missiles and possibly as many as 200 Nodong missiles, according to testimony from General B.B. Bell on March 9, 2006.

2007 – 2008: R1

Several short-range missile launches (KN-02 with range of 70 km). The KN-02 and Musudan are displayed to domestic audience during a military parade in Pyongyang on April 25, 2007. Missile component exports continue, including to Iran. The new rocket test range at Sohae becomes partially operational with a rocket engine test of the probable Unha-2 first stage engines.

2009: R1

On April 5, North Korea conducts an unsuccessful space launch of three-stage Unha2/Taepodong-2 rocket from Tonghae, likely a modified version of the rocket launched in 2006. The third stage fails to inject the satellite into orbit. The Tonghae range had previously tested short-range and medium-range missiles and one space launch vehicle. The last large rocket launched from Tonghae was the 2009 Unha-2. In 2012, UN Panel of Experts assess that the third stage of the Unha resembles the upper stage of the Iranian missile Safir, which was first launched in February 2007. In July, North Korea launches 5 Scuds and 2 Nodongs, followed by five KN-02 short-range missiles in October.

2010 – 2011: R1

The 2010 Parade in Pyongyang displays to the West the Hwasong-9/Nodong and Hwasong-10/Musudan missiles and their TELs for the first time. Likely major efforts continue to procure materials and components for missiles (including missile technology information from Ukraine and industrial truck beds to be converted to TELs from China) in addition to a major effort for indigenous missile component production. Up to 2011

North Korea's missile testing is limited to systems and carrier rockets that rely on Scud-type technologies. North Korea's missile arsenal (Scuds and Nodongs) is reported to be over 1,000. With only two nuclear tests, North Korea likely is not able to mount a nuclear warhead in any of its missiles. In 2011, North Korea completes a 10-year initial construction project at the Sohae Satellite Launching Station.

2012: R1

On April 13, North Korea attempts to launch the Kwangmyongsong-3 satellite using the Unha-3, a three-stage liquid-fueled rocket, from its Sohae Satellite Launching Station. It failed after approximately 90 seconds. The Sohae site has far more capabilities than outpaces North Korea's Tonghae facility near Musudan-ri. On December 12, North Korea successfully launches the Unha-3 and places a Kwangmyongsong-3 satellite into orbit although it appears not to function. Kim Jong Un directs this launch at Sohae. The 2014 UN Panel of Experts report indicates that recovered Unha-3 rocket parts originated in countries such as the United Kingdom, China, Switzerland, Republic of Korea, United States, and former USSR, although most parts were not sanctioned items. On March 16, Kim Jong Un is shown visiting the Strategic Rocket Forces Command, believed to be the first time this organization is mentioned publicly. Analysts find it to be 39 km northeast of Pyongyang at the offices of the Second Economic Committee.

2013: R1

North Korea tests two KN-02 short-range missiles in March and six short-range missiles in May. North Korea also conducts three tests of probable Hwasong-13/KN-08 long-range rocket engines at its Sohae facility during 2013. A successful nuclear test in February likely brings North Korea closer to being able to mount a nuclear warhead in its short and medium-range missiles. The Sohae Satellite Launching Station's gantry tower undergoes significant additional construction to accommodate rockets up to fifty meters in length and a moveable processing structure is added that makes it increasingly difficult for outsiders to detect launch preparations.

2014: R2

Missile tests increase dramatically. North Korea conducts 17 short-range missile tests and two extended-range Scud (considered medium-range of approximately 1,000 km) missile tests. Commercial satellite imagery shows North Korea expands its main rocket-launching site at Sohae continued and tested rocket engines believed to be its first road-mobile intercontinental ballistic missile (ICBM), the KN-08. As of early 2018 it has never been launched and may be a canceled program.

2015: R2

Rapid missile testing continues with 12 short-range missiles and three KN-11 (Pukguksong-1) launching from a submerged platform or submarine, with one success. On March 9, North Korea releases photographs showing Kim Jong Un with a mockup of what it claims to be a miniaturized implosion-type nuclear weapon capable of fitting on one of its missiles. It also showed what it claimed to be a successful test of a heat shield for a re-entry vehicle.

2016: R3

On February 7, North Korea successfully launches the Kwangmyongsong-4 earth observation satellite, which does not work in orbit. Kim Jong Un directs the launch from the new facilities at Sohae. North Korea also misses its target orbital parameters, which if translated into ICBM accuracy, suggests a target miss distance of tens of kilometers. During the year, North Korea launches 8 Musudan intermediate-range ballistic missiles (IRBMs), apparently based on the Soviet R-27 SLBM; only the June 21 launch appears successful. North Korea test launches three KN-11 (Pukguksong-1) submarine launch ballistic missile with two successes. North Korea launches 8 medium-range missiles, six of them successfully. Three Hwasong-6ER/SCUD-ERs are launched on September 5 and are successfully fired nearly simultaneously with Kim Jong Un present. The missiles travel about 1,000 kilometers. In April, North Korea tests 14 short-range missiles. With successful nuclear tests in January and September, North Korea now likely has the ability to successfully mount a nuclear warhead on its Scud and Nodong missiles, putting all of South Korea and most of Japan within reach.

The Musudan failures represent a significant puzzle. It is believed that the main components were procured from Russia, most likely prior to 2003. North Korea abandoned these missiles as it was determined to move ahead with IRBM and ICBM capabilities. It experimented with an engine test of a previously unseen liquid-propellant engine that would become the engine of choice for its new IRBM, the Hwasong-12, to be flight tested in 2017 with what appeared to be a derivative of the Soviet-era RD-250 engines.

2017: R3

The rapid pace of missile launches continues, including several new missiles, three of them with ICBM capability, totaling 23 launches in 2017. On February 12, North Korea tests a new ballistic missile, the Pukguksong-2, which flies about 500 kilometers on a lofted trajectory. Imagery suggests that the Pukguksong-2 is a solid-fueled, medium-range, land-based version of the Pukkuksong-1. Its second successful launch is on May 21, after which Kim Jong Un declares it ready for production. On March 6, with Kim Jong Un present, North Korea test fires a salvo of four ER Scuds into the East Sea from the Sohae test facility. In 2017, North Korea tests 4 short-range missiles (one failure) and 6 medium-range missiles (including the four ER Scuds) successfully.

Three new long-range missiles start testing in 2017. The first is the Hwasong-12 IRBM. Four are seen in the April 15 parade in Pyongyang. Launches of this IRBM include three in April 2017, all of which fail. From several photos it is known Kim Jong Un was at least the failed 5 April launch. The fourth launch on May 14 is successful and flies on a lofted trajectory to an altitude of 2114km. Two more Hwasong-12 launches take place, both from the military side of the Sunan International Airport, and both overfly northern Japan. The missile launched on August 29 appears to have broken up during reentry. The launch on September 15 appears to have been a success. In August, the North threatens to bracket Guam with the Hwasong-12 missiles, but after theatrically viewing the matter at Strategic Forces HQ, Kim Jong Un postpones the plan.

The Hwasong-14/KN-20 is not shown in the 2017 parade. The first look at it is from the video released of the first launch on July 4. More video is released with the second launch on July 28. Kim Jong Un attends both launches. Both are successful flight-tests of North Korea's first ICBMs on lofted trajectories of 2802km and 3725km, respectively. The tests indicate that the missile can reach much of the US mainland.

On November 28, North Korea successfully launches its largest ever mobile liquid fuel missile, the Hwasong-15/KN-22, much to the surprise of most missile experts. The missile was not shown in the 2017 parade so the propaganda video is the first look the West has of the missile. It is launched on a lofted trajectory with an altitude of 4475km. The missile is also launched at night, from a field launch site, and probably by a military crew. This missile has two stages and is carried by a 9-axel TEL, probably produced in the North Korea. Kim Jong Un directs the launch from the Pyongsong area.

Much speculation continues about the engines for the Hwasong-12, 14 and 15 missiles, but the consensus is that these missiles use the Russian RD-250 engine, which was likely imported from Russia or Ukraine. The RD-250 engines have two engine chambers but the Hwasong 12 and 14 have only one. If these engines are RD-250s, they have been extensively modified. The Hwasong 15 has two engine chambers and is a stronger candidate for the RD-250 engine.

The Hwasong-15 has a potential range of 13,000 km, putting the entire US within reach. In 2017 North Korea verifies its claim to be able to launch missiles at any time from any place. However, its claims of being able to reach all of mainland US with a nuclear-tipped missile are not substantiated. Significant missile testing and more nuclear tests will be necessary to improve the reliability and performance of a nuclear-tipped ICBM.

Imports (nuclear and missile related)

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

G3 to 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.

1992: R1

By 1992 North Korea had significant assistance with its short-range missile programs from the Soviet Union. Low number of flight tests and rapid progress in missile development indicates a high level of foreign technical assistance. The Musudan missile seems to derive from the Soviet R-27 (SS-N-6) liquid-fueled SLBM, which the Soviets deployed from the 1960s to the 1980s and had a range of up to 2,500km. Some of the Soviet scientists who had worked on the R-27 program worked in North Korea following the Soviet collapse, and North Korea may have also procured some of the program's surplus hardware. In October, Russian security officials at Sheremetyevo Airport detain more than 50 Russian missile experts bound for North Korea.

North Korea likely made exploratory attempts at uranium enrichment prior to 1992 based on the procurement-related evidence. For example, North Korea possibly acquired some centrifuges from Almelo (Urenco) and obtained vacuum equipment from European vendors in the 1980s. Nuclear technology imports from Russia following the breakup of the Soviet Union appeared to stop because Russia wanted payment and North Korea was not in a position to pay. Replacement HEU fuel rods for the IRT-2000 reactor are one such example. No new fuel rods were acquired from Russia post 1992.

1993 – 1996: R1

Missile technology imports continued as well as collaboration with countries such as Iran and Pakistan. There is possible ongoing collaboration between North Korea and Russian missile scientists and companies, including the possible presence of Russian missile experts in Pyongyang in the years following the collapse of the Soviet Union.

Most likely continued attempts for nuclear-related materials and technology imports, but not believed to be massive. It was reported that Pakistani PM Benazir Bhutto delivered

CDs with centrifuge design and operations information to Kim Il Sung during a visit in October 1993. North Korean technicians possibly had access to the Khan Research Laboratory in Pakistan as early as 1993 and 1994. Imports of additional nuclear technologies to Yongbyon are likely limited by the presence of IAEA inspectors and US technical team.

1997 – 2002: R2

Collaboration on uranium centrifuges with Pakistan's A.Q. Khan network begins to pick up with Khan's visits to North Korea and North Korean engineers and technicians visiting Pakistan. Khan reportedly provides North Korea with nearly two-dozen P1 and P2 centrifuges for a trial enrichment project. North Korea mounts major covert procurement efforts for centrifuge materials and equipment in Europe and Russia, obtaining or likely attempting to obtain high-strength aluminum, maraging steel, vacuum equipment, ring magnets, and UF₆ storage containers. It appears to have benefitted greatly from the contacts obtained from the A.Q. Khan network. North Korea likely procures a variety of materials and equipment for its plutonium program. For example, it appears to have been able to procure significant quantities of tributyl phosphate, required for plutonium separation from spent nuclear fuel, from China in 2002. Missile-related imports most likely continue during this time with contacts in Russia, Ukraine and China likely.

2003 – 2006: R2

Nuclear and missile-related imports likely continue at a significant level. North Korea continues attempts at procuring possible components of a uranium enrichment program, including vacuum pumps, high-strength aluminum, high-strength steel, CNC items, and specialized power supply devices. These procurements are reported as possibly sufficient for about 8,000-10,000 P2-type centrifuges. Cooperation with countries such as Pakistan and Libya declines dramatically as the A.Q. Khan proliferation network is exposed.

2007 – 2008: R1

North Korea likely holds back its import business somewhat while there is active diplomacy with the Bush administration and while IAEA inspectors and US technical teams are present in Yongbyon.

2009 – 2017: R2

North Korea resumes significant efforts to import missile-related technologies. Continued imports of rocket engines from Russia and Ukraine are possible, as are transporter-erector-launcher (TEL) vehicles from China. During this period, UN Security Council sanctions and the US-led Proliferation Security Initiative make it more difficult for North Korea to acquire sensitive materials and equipment on the black market, but these resulted in North Korea becoming increasingly clever in circumventing these measures. The annual reports of the UN Panel of Experts established subsequent to the UNSC resolutions on North Korea provide excellent reports on North Korea's import attempts and successes.

Exports (nuclear and missile-related)

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

G3 to 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.

1992: R1

Prior to 1992, North Korea had already entered into contracts with countries in the Middle East to supply Scud-B (Hwasong-5) missiles. Pyongyang began to provide technology transfers, and even turnkey Scud factories, to countries in the Middle East. North Korea appears not to have attempted nuclear-related exports or was not in a position to market such prior to 1992.

1993 – 1998: R1

North Korea reportedly was able to obtain Nodong sales contracts with Libya, Iran, and possibly Syria and Pakistan before the Nodong was successfully flight-tested in late May 1993. The Nodong was later flight-tested in Iran and Pakistan. Pyongyang likely began discussions on building a plutonium production reactor for Syria and began making procurements for the Syrian project. This cooperation possibly began as early as 1997.

1999 – 2007: R3

North Korea apparently had made sufficient progress in its plutonium program that it was able to market these capabilities. North Korea entered into contract with Syria's president Hafez al-Assad to build a plutonium production reactor for Syria. During this period, it nearly completed construction of a gas-graphite reactor with some 50 percent greater plutonium production capacity than its own 5 MWe reactor in Yongbyon. The reactor deal was an egregious violation of its NPT commitments (prior to North Korea's 2003 withdrawal) as well as being contrary to the spirit of the Agreed Framework. An Israeli bombing raid destroyed the reactor in September 2007. Many questions remain about the Syrian reactor project. For example, no evidence has been found of the construction of a reprocessing facility needed to separate the plutonium from the spent fuel. Syria also had no fuel fabrication facilities, hence making it likely that North Korea was to be the long-term fuel supplier. It is not clear who was to be the ultimate customer for the reactor's plutonium.

During the same time, North Korea engaged in the export of uranium enrichment materials and supplies. While A.Q. Khan was masterminding an international covert effort to provide Libya with a centrifuge facility, North Korea began to export natural (un-enriched) UF₆ to Libya with a small shipment in 2000 and 1.6 tons in 2001. This effort was also likely meant to provide significant repeat business for North Korea to supply natural UF₆ for Libyan HEU production, but it came to an end when Muammar Gaddafi agreed to terminate his nuclear program. The Libya revelations were just one indicator that North Korea's claims during the 2000s that it had no uranium enrichment program were not credible. In addition there were some reports of possible nuclear-related equipment having been exported to Myanmar, but these have not been substantiated. However, some form of cooperation with Iran in missile technologies and possibly in nuclear-related technologies.

During these years, North Korea also continued major missile exports for hard currency. For example, in December 2002, Spanish and US forces intercept a ship carrying a shipment of North Korean Scud missiles to Yemen. There is possible ongoing collaboration between Russian, Iranian, and North Korea missile experts. For example, a Russian textbook, published for a training course for rocket production in Iran in 2001, demonstrates similarities in the design of the Nodong engine, the Iranian Shahab-3 engine, and Soviet-Russian designs.

2008 – 2013: R2

Missile exports and cooperation with countries such as Iran continue. Nuclear exports are likely significantly reduced because of the lessons of Syria, increased UNSC sanctions, and implementation of the Proliferation Security Initiative.

2014 – 2017: R1

Exports of nuclear and missile-related technologies have become increasingly more difficult, although North Korea continues to become more sophisticated in circumventing UN and US sanctions. Exports in the nuclear arena are also curtailed by the loss of customers such as Iraq, Syria, and Libya. In addition, Pakistan has greatly curtailed all of its dealings in these areas with North Korea since the A.Q. Khan network was dissolved. Also, Iran is more constrained in working with North Korea while it adheres to the Iran nuclear deal (the Joint Comprehensive Plan of Action).

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.

1992: G3

On January 20, North and South Korea sign the Joint Declaration of the Denuclearization of the Korean Peninsula, which, among other things, enshrines the denuclearization of the Korean peninsula as the goal of both parties. There is slow progress on implementation of the North-South accords, although diplomatic meetings continue, including high level talks in Seoul in May.

1993: G2

Both sides maintain an interest in communication and engagement but accomplish little during the year. Kim Young Sam becomes President of South Korea. Low-level exchanges occur throughout the year but do not reach the working level in Panmunjom until October. This working level meeting lasts for three days but "without results."

1994: R2

There are no serious talks until June. The two sides agree very quickly on a July summit meeting, but Kim Il Sung dies before it can take place, and the door closes again as Seoul (Kim Young Sam) sees the transition to the new leader—Kim Jong Il—has led to weakness in Pyongyang that can be exploited. The momentum gained in improving North/South relations between 1991 and 1993 is lost.

1995: R1

Both sides take actions to explore the possibility of dialogue. Early in the year, North Korea publicly mentions the possibility of resuming negotiations. But there is no serious

commitment to implementing joint accords. The 1995 Team Spirit joint exercise is planned but not executed for the second consecutive year.

1996: R1

Both sides at times explore the possibility of dialogue but there is no serious commitment to implementing joint accords. The 1996 Team Spirit joint exercise is planned but not executed for the third consecutive year. A North Korean submarine beaches on the ROK coast and resulting manhunt for the crew and a North Korean recon team by South Korean forces leads Seoul to suspend diplomatic and humanitarian engagement until North Korea issues an apology in December.

1997: G1

North Korea and South Korea begin participation in the Four Party Talks to discuss a peace agreement, although the North Koreans adopt a confrontational attitude toward the South Koreans much of the time during the talks. The Four Party Talks are a desperate effort by South Korea to get back into the game after taking a backseat during the Agreed Framework negotiation and implementation. Both North and South take part in some confidence building actions, such as the inter-Korean food talks that result in the provision of grain to North Korea via the Red Cross.

1998: G1

Kim Dae Jung becomes ROK President and institutes his “sunshine policy” to promote cooperation and reconciliation with North Korea. However, the first year of his administration sees almost no progress in North/South relations as North Korea is not initially positive to Kim Dae Jung and South Korea is consumed by the Asian financial crisis. North/South engagement is mostly limited to Four-Party talks, but the Mount Kumgang site in North Korea is opened for South Korean tourists.

1999: G3

North and South Korea continue high-level engagement and confidence building measures, including participation in the unproductive Four Party Talks (which are largely irrelevant to North-South relations), the opening of Mount Kumgang to South Korean tourism, and joint ventures between North Korea and South Korean companies. A naval clash in June does not escalate or seriously impinge positive trends.

2000: G3

North and South Korea engage in secret bilateral meetings between January and April to finalize plans for a presidential summit in June in Pyongyang. Following the summit, four rounds of formal ministerial talks authorize a wide range of cooperative activities, including cultural exchanges, reunification of families, infrastructure improvements, trade and investment. Hyundai and North Korea reach an agreement to begin construction of the industrial park at Kaesong.

2001: G1

The hardline policies of the new Bush administration threaten the progress that had been made in inter-Korean relations. During the first half of the year, planned diplomatic

engagement is cancelled as North Korea postpones previously scheduled bilateral talks. Ministerial level talks resume in the fall but make no significant progress.

2002: G2

In April Lim Dong Won, Kim Dae Jung's special envoy, travels to Pyongyang to meet with Kim Jong Il, revitalizing inter-Korean relations after a downturn in 2001. The two sides agree to more family reunions and economic cooperation. After a naval clash in the West Sea in June, Pyongyang immediately sends a hot line message of regret to Seoul stating the clash was "unintended." North-South ministerial-level talks are held in August. In late October, despite the revelations about the suspected uranium enrichment program, North and South Korea hold ministerial level meetings in Pyongyang to primarily talk about economic cooperation. Kim Dae Jung sends a note in support of dialogue and the Agreed Framework, which is delivered to Kim Jong Il via Chung Se Hyon during his visit to Pyongyang. North Korea sends a high-level economic delegation to the South led by Jang Song Taek to tour industrial facilities, learn about ROK economy, and explore cooperation.

2003: G1

In February, Roh Moo Hyun becomes ROK President and continues reconciliation efforts with North Korea, which he terms the "Policy for Peace and Prosperity." The two sides continue efforts to improve inter-Korean relations despite the ongoing issue of North's nuclear program and confrontation with the US.

2004: R1

North and South Korea participate in multiple rounds of the Six Party Talks to resolve the nuclear issue, but these have no bearing on the state of North-South relations. The two countries fail to agree on a proposal for resuming a new round of inter-Korean talks. In July, a large wave of North Korea refugees arrives in Seoul, prompting a negative reaction from Pyongyang and causing inter-Korean relations to decline further.

2005: G1

North and South Korea continue to participate in multiple rounds of the Six Party Talks, which have little bearing on the state of North-South relations. South Korea remains unhappy with US policy toward North Korea. In June, the ROK Unification Minister visits Pyongyang and meets with Kim Jong Il, indicating a continuing commitment to engagement. Neither side engages in provocative actions, but not much constructive dialogue occurs.

2006: G1

Early in the year, both sides display a willingness to engage, but North Korea's missile tests in July and nuclear test in October prompt South Korea to suspend aid shipments and support punitive UNSC resolutions. Certain inter-Korean cooperative initiatives such as Mt. Kumgang tourism and the Kaesong Industrial Complex continue.

2007: G3

North and South Korea participate in the Six Party Talks, which make progress on the first phase of implementation of the 2005 Joint Statement. Joint cooperative ventures continue and a second summit meeting occurs in Pyongyang in October. Roh Moo Hyun and Kim Jong Il agree on a declaration with specific measures for improving inter-Korean relations. In November, the prime ministers meet in Seoul.

2008: R1

In February, Lee Myung Bak becomes ROK president and unravels many of the 2007 summit agreements. Pyongyang responds with heavy criticism of Lee. Although many of the North-South engagement and projects continue, relations deteriorate quickly after a South Korean tourist is shot at Kungang. In December, North Korea takes unilateral actions to constrain certain inter-Korean engagement activities.

2009: R2

In January, North Korea pulls out of all agreements with South Korea, citing the policies of the Lee Myung Bak government. North Korea conducts a satellite launch in April and its second nuclear test in May. South Korea supports international condemnation and sanctions through the UN. In August, following Kim Dae-jung's death, Kim Jong Il sends senior party officials to Seoul with a proposal for a summit. The Kaesong Industrial Complex remains open. The two sides begin wary discussions in Singapore, but talks collapse a few months later after negative shifts in South Korea's position and naval clash in West Sea.

2010: R3

In March, North Korea sinks the South Korean navy corvette Cheonan. South Korea ends economic cooperation with North Korea with the exception of the Kaesong Industrial Complex. South Koreans are banned from visiting North Korea. In November, North artillery bombards the South Korean island of Yeonpyeong, killing four South Koreans.

2011: R3

There is a minimal level of engagement throughout the year, although neither side initiates seriously provocative actions. South Korea rejects an early overture for dialogue from North Korea, demanding that North Korea first take responsibility for the Cheonan and Yeonpyeong incidents. A series of talks (some secret) fail to move beyond the 2010 incidents.

2012: R3

There are no diplomatic talks between North and South Korea as the relationship remains under strain and engagement is limited. Lingering unresolved issues from previous provocative actions undermine the potential for dialogue.

2013: R2

In February, Park Geun Hye becomes ROK president and advocates a policy of trustpolitik, which emphasizes more effort toward dialogue as a form of trust building. North Korea conducts its third nuclear test in February and closes the Kaesong Industrial Complex in April, sending South Korean workers home. Over the summer, North and

South Korea make a gradual return to dialogue, restarting some joint initiatives and continuing sporadic inter-Korean talks.

2014: R2

There is no serious exploration of dialogue on both sides and relations remain strained. A series of sporadic inter-Korean talks result in a family reunion at Mount Kumgang in February. Kim Jong Un signals ahead of the Asian games that the games can serve as a means of improving relations. A high-level North Korean delegation visits South Korea for the closing ceremony of the Asian Games, but the opportunity is mishandled by Seoul.

2015: R2

In his New Year address, Kim Jong Un states that he is open to talks with South Korea and would even consider a presidential summit. However, there are no serious efforts toward dialogue. An incident at the DMZ in August leads to a spike in tensions and then to a round of high-level inter-Korean talks at Panmunjon to relieve tensions.

2016: R3

Following North Korea's fourth nuclear test in January, South Korea indefinitely shuts down the Kaesong Industrial Complex in February, one of the last vestiges of North-South cooperation. South Korea announces plans to deploy THAAD in July. North Korea conducts its fifth nuclear test in September.

2017: R2

In May, Moon Jae In becomes ROK president. While rejecting Moon's initiatives throughout the year, Pyongyang holds the door open to engagement by not criticizing him by name. In December, the two sides begin to lay the groundwork for North Korean participation in the Olympics, which culminates in a direct overture by Kim Jong Un in his 2018 New Year speech.

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 DPRK interests at UNSC.

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

G1: Relations still overall positive, but much less supportive by China and less outreach by DPRK.

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.

1992: R2

In August, China affords South Korea full diplomatic recognition, causing a serious strain in relations with Pyongyang for the next several years. There are no high-level bilateral meetings.

1993: R1

The relationship remains strained due to China's normalization of relations with South Korea, reflected by a decline in bilateral trade volume. China refrains from taking on a mediating role to resolve the North Korean nuclear issue, but continues to support North Korea in the UN by promising to veto any UN Security Council attempt to levy sanctions on North Korea. There are no high-level bilateral meetings.

1994: R1

The relationship remains strained due to the China's normalization of relations with South Korea. China continues to support North Korea in the UN Security Council and receives a high-level DPRK military delegation in June. Kim Il Sung dies in July, and is replaced by his son, Kim Jong Il, who does not have the same close ties with high-level Chinese officials. North Korea removes its representative of the Chinese People's Volunteers from the Military Armistice Committee.

1995: R1

Concerned about serious economic and social problems in the North resulting from the famine, China increases grain exports to the North. Chinese Vice Foreign Minister Tang Jiaxuan visits Pyongyang in June. Overall, there is limited engagement between China and North Korea and official political and economic relations are strained.

1996: R1

China increases grain exports to North Korea during the height of the famine. North Korean Vice Premier Hong Song Nam meets with Chinese Vice Premier Li Lanqing in Beijing in June, reportedly agreeing on the provision of large quantities of grain, petroleum, and coal over the next five years. Overall, there is limited engagement between China and North Korea and official political and economic relations are strained, though by 1996 North Korea has begun to actively seek and obtain improvements in its relations with China.

1997: R1

Overall, limited engagement and official political and economic relations are strained, but China does provide a large quantity of food aid to help alleviate the effects of the famine and recent flooding in North Korea. There are no high-level bilateral meetings. China and North Korea begin their participation in the first round of the Four Party talks, which continue until 1999 but have little bearing on the state of relations between the two countries. Pyongyang objects when Beijing allows high-level North Korea defector Hwang Jang Yop to safely depart China for South Korea.

1998: R1

There is limited bilateral engagement—no high-level meetings—between China and North Korea. China continues to provide humanitarian aid to North Korea as famine and economic hardship intensify.

1999: G1

There is an increase in positive contact between China and North Korea due in part to Pyongyang's pursuit of an improved relationship. Following a brief suspension of high-level meetings in 1997 and 1998, Chinese Foreign Minister Tan Jiaxuan visits North Korea in April. Kim Jong Il meets with Chinese ambassador Wan Yongxiang in May, and a North Korean delegation visits China in June to successfully secure the provision of additional Chinese food aid. Tan Jiaxuan attends celebrations in Pyongyang to commemorate the 50th anniversary of the establishment of diplomatic relations between China and North Korea.

2000: G1

High-level, positive engagement between China and North Korea indicates a steady improvement in relations. In March, Kim Jong Nam travels with a large delegation to China. In May, in his first visit to China since taking power, Kim Jong Il visits China in advance of his June summit with Kim Dae Jung. In October, on the 50th anniversary of the entry of Chinese troops into the Korean War, the Chinese defense minister meets with Kim Jong Il in Pyongyang but is forced to wait until US Secretary of State Madeleine Albright has departed from Pyongyang.

2001: G2

High-level, positive engagement between China and North Korea reflects steady improvement in relations. Kim Jong Il takes his second trip to China in January and meets with Jiang Zemin in Beijing. His tour through China demonstrates a possible interest in learning about Chinese economic development and reform. Jiang Zemin makes his first official visit to North Korea in September, promising additional humanitarian aid. Trade volume between China and North Korea continues to grow.

2002: G2

High-level, positive engagement between China and North Korea indicates improved relations. North Korea's Foreign Minister Kim Yong Il visits China in March and Kim Jong Il receives a high-level Chinese delegation in May. Trade volume between China and North Korea continues to grow.

2003: G2

High-level, positive engagement between China and North Korea continues, though China expresses growing concern about North Korea's confrontation with the United States over its nuclear program. North Korea and China engage in multiple bilateral meetings to address concerns. Both countries participate in the first round of the Six Party Talks in Beijing in August, which have little bearing on the state of relations between China and North Korea. Trade volume between China and North Korea continues to grow.

2004: G1

China reportedly pledges economic and energy assistance to North Korea to help secure its participation in the Six Party talks. High-level, PRC-DPRK bilateral meetings continue to discuss the nuclear issue and Sino-North Korean cooperation. Kim Jong Il visits China in April to meet with Hu Jintao and senior Chinese officials. Trade volume between China and North Korea continues to grow. A slight downturn in relations reflect China's concern over the North's nuclear program. China and North Korea continue to participate in the Six Party talks.

2005: G1

Trade volume between China and North Korea continues to grow and positive high-level engagement between the two countries continues. In October, Hu Jintao visits Kim Jong Il in Pyongyang. The two leaders sign an accord on technical and economic cooperation. Chinese and North Korean participation in the Six Party talks.

2006: R1

High-level, bilateral engagement between China and North Korea continues. Kim Jong Il visits China in January, touring the country over the course of a week. Trade volume between China and North Korea continues to grow, and China and North Korea reportedly agree to a five-year economic aid and development plan. North Korea conducts missile tests in July and its first nuclear test in October despite persistent Chinese efforts to convince it to forgo the nuclear test. China does not veto UNSCR 1695,

which levies sanctions in response. The Six Party talks continue to have little influence on the overall DPRK-PRC relationship.

2007: R1

High-level, bilateral engagement between China and North Korea continues. Yang Jiechi visits North Korea in July. Trade volume between China and North Korea continues to grow.

2008: G1

Xi Jinping, recently elected vice president, meets with Kim Jong Il in Pyongyang in June during an official goodwill tour. There is an uptick in party-to-party ties following Kim Jong Il's stroke in August possibly due to growing uncertainties about the succession process. Trade between China and North Korea continues to grow. The CIA issues a WMD report to Congress in which it notes that "private Chinese businesses continue to sell materials, manufacturing equipment, and components suitable for use in ballistic missile, chemical weapon and nuclear weapon programs in North Korea."

2009: G1

Positive, successful engagement accelerates between China and North Korea. Hu Jintao and Kim Jong Il declare 2009 to be the "year of China-DPRK friendship" to mark 60 years of Sino-DPRK diplomatic relations. Following North Korea's satellite launch and second nuclear test, China votes for UNSCR 1874, but not long after there is an exchange of high-level visits that starts the relations on a new phase. Wen Jiabao visits Pyongyang in October with a plane full of Chinese businessmen. Both countries agree to expand economic and technological cooperation, including the construction of a bridge across the Yalu River.

2010: G2

Positive engagement continues between China and North Korea, including two visits by Kim Jong Il to China in May and August. Beijing fails to condemn the North for the sinking of the Cheonan and the shelling of Yeonpyeong Island. Trade volume between China and North Korea continues to grow. Chinese companies move into the North in large numbers.

2011: G2

Positive engagement continues between China and North Korea as Kim Jong Il seeks to further strengthen ties in preparation for the political succession. Kim Jong Il visits China in May for meetings with Hu Jintao and senior Chinese leadership. Kim dies in December and is succeeded by his son, Kim Jong Un, who has not at this point developed his own personal relations with Chinese officials. China expresses strong support for the Kim Jong Un regime. Bilateral trade volume grows, as does Chinese economic activity in the North.

2012: G2

Overall, positive and successful engagement continues between China and North Korea, despite the strain induced at the beginning of the year by North Korea's satellite launch

and international condemnation through the UNSC. The satellite launch occurs following a dearth of timely communication with Beijing. After not appearing to place much emphasis on its relationship with China, the Kim regime adopts a warmer attitude and renews positive engagement over the summer, which results in trips by Chinese officials to Pyongyang in August and November. Trade volume between China and North Korea continues to grow.

2013: R2

The relationship between China and North Korea deteriorates rapidly over the course of the year. In January, China votes for a UNSC resolution condemning the North's 2012 satellite launch and goes along with a move to strengthen sanctions after the North's third nuclear test in February. China's Minister of Foreign Affairs issues a blunt warning that China would not permit anyone "to make a disturbance on China's doorstep." Jang Song Thaek, Kim Jong Un's uncle and a key conduit between the North Korean government and China, is purged and executed in December. Despite downturn in relations, PRC-DPRK trade continues to grow.

2014: R2

The relations between China and North Korea continue to deteriorate. There is a noteworthy increase of public questioning of the value of China's strategic relationship with North Korea by commentators in Chinese state media. Despite downturn in relations, trade volume between China and North Korea continues to grow, though the Yalu River bridge, expected to be completed in 2014, remains unfinished.

2015: R2

PRC-DPRK relations continue to deteriorate. Official relations are strained, with a lack of high-level engagement. PRC efforts to engage are rebuffed, except for a visit by a Chinese delegation to Pyongyang in October to deliver a note from Xi Jinping and celebrate the 70th anniversary of the founding of the Workers' Party of Korea.

2016: R2

Relations between China and North Korea continue to deteriorate. There are no high-level contacts. Though its implementation of UN sanctions remains incomplete (PRC-DPRK trade volume increases slightly from 2015), China supports international condemnation of the North for its nuclear and missile tests throughout the year.

2017: R2

The relations between China and North Korea continue to deteriorate. North Korean papers carry high-level commentaries critical of China. Xi Jinping fails to send a message to Kim Jong Un on DPRK National Day; Kim reciprocates and sends none to Xi on PRC National Day. China begins more effective implementation of sanctions, backing multiple UN Security Council resolutions condemning North Korea and increasing sanctions following multiple missile tests and a nuclear test in September.

Sanctions (US and UN Security Council)

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

G1-G3: There is no green coding 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 the 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 DPRK commercial or government entities. UNSC sanctions on a few DPRK entities. This coding also indicates low-level nuclear sanctions with ineffective enforcement, especially by China.

R2: UNSC sanctions on more DPRK 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.

Note: All sanctions data is taken from Arms Control Association's "*Chronology of US-North Korean Nuclear and Missile Diplomacy*,"
<https://www.armscontrol.org/factsheets/dprkchron>

1992: R1

March: The United States imposes sanctions on two North Korean companies for their missile proliferation activities.

1993: R1

No additional sanctions implemented.

1994: R1

No additional sanctions implemented.

1995: R1

No additional sanctions implemented.

1996: R1

May: The United States sanctions North Korea and Iran for missile technology transfers, prohibiting imports and exports to sectors of North Korea's economy that are missile related.

1997: R1

August: The United States government imposes new sanctions on two North Korean entities for activities related to missile proliferation.

1998: R1

April: The United States government imposes unilateral sanctions on North Korea (and Pakistan) in response to the transfer of missile-related technology from Pyongyang to Khan Research Laboratories.

1999: R1

September: During high level talks in Berlin concerning North Korea's missile program, the North agrees to a missile testing moratorium in exchange for a partial lifting of US economic sanctions.

2000: R1

April: The United States imposes sanctions on a North Korean entity (Changgwang Sinyong Corporation, or CYC) for transferring Missile Technology Control Regime (MTCR) Category I material to Iran.

June: The United States relaxes some economic sanctions on North Korea allowing for easier trade and investment, although missile and terrorism related sanctions remain.

2001: R1

January: The United States imposes sanctions on CYC for violation the Iran Nonproliferation Act of 2000.

June: The United States imposes additional sanctions on CYC for violation the Iran Nonproliferation Act of 2000.

2002: R1

August: The United States imposes additional sanctions on CYC and the North Korean government for missile-related transfers to Yemen.

2003: R1

March: The United States imposes additional sanctions on CYC for transfers of missile technology to Khan Research Laboratories.

2004: R1

July: Tokyo imposes sanctions on North Korea following its missile tests on July 4.

2005: R1

September: The US Treasury Department imposes Banco Delta Asia sanctions.

2006: R1

July: The UNSC adopts Resolution 1695 in response to North Korea's missile launches on July 4.

September: Japan and Australia target multiple foreign entities with sanctions. These entities are tied to North Korea's missile and CBN weapons activities and many are already under US sanctions.

October: The UNSC adopts Resolution 1718, in response to North Korea's first nuclear test on October 9. The resolution demands that North Korea give up its nuclear weapons and return to the Six Party Talks while also increasing sanctions beyond UNSCR 1695.

2007: R1

April: The US agrees to unfreeze the \$25 million in Banco Delta Asia assets that were frozen in September 2005.

2008: R1

February: Christopher Hill negotiates partial sanctions relief for North Korea in exchange for continued disablement activities at Yongbyon.

June: President Bush signs the Supplemental Appropriations Act of 2008, which contains a provision allowing the president to waive certain sanctions on North Korea imposed after its 2006 nuclear test.

2009: R1

June: In response to North Korea's nuclear test in May, the UN Security Council passes UNSCR 1874, expanding sanctions against North Korea. It intensifies the inspection regime, increases financial restrictions, and institutes a "nearly comprehensive" arms embargo.

2010: R1

July: The United States imposes additional sanctions on North Korea following the Cheonan incident.

2011-2012: R1

April 2012: The UNSC condemns North Korea's satellite launch on April 13, declaring the act in violation of UNSCR 1718 and UNSCR 1874, but does not impose additional sanctions.

2013: R2

January: The UN Security Council passes UNSCR 2087 in response to North Korea's satellite launch in December 2012. It strengthens and expands already existing sanctions and freezes the assets of additional North Korean individuals.

March: The UN Security Council passes UNSCR 2094 in response to North Korea's nuclear test in February 2013. It strengthens existing sanctions, expands their scope and blocks bulk cash transfers and freezes the assets of additional individuals.

2014: R2

No additional sanctions implemented.

2015: R2

January: The United States expands its unilateral sanctions on North Korean entities.

December: The United States designates additional North Korean entities for economic sanctions, including North Korea's Strategic Rocket Force and banks associated with proliferation financing.

2016: R2

March: The UN Security Council passes UNSCR 2270, which condemns North Korea's nuclear test in January 2016 and imposes additional sanctions, adding to the list of individuals and entities and expanding the scope of sanctioned material. It also attempts to enhance the inspection obligations of UN member states.

November: 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.

2017: R3

June: The United States imposes unilateral sanctions on North Korean entities and individuals.

August: In response to North Korea's ICBM tests in July, the UN Security Council passes UNSCR 2371, which imposes additional sanctions, including a complete ban on exports of North Korean coal, iron, seafood, and lead.

September: Following North Korea's test of an alleged hydrogen bomb, the UN Security Council passes UNSCR 2375, imposing additional sanctions which include a ban on North Korea textile exports and a cap on refined petroleum product imports.

September: The United States imposes additional sanctions on North Korea, targeting entities "that facilitate financial transactions and trade with North Korea."

December: The UN Security Council adopts UNSCR 2397, which increases sanctions on North Korea, including cutting the cap on its refined petroleum product imports by 90 percent, limiting its crude oil exports, and mandating the return of North Koreans working abroad in two years.

North Korea Economy

A measurement of the level of economic output and general status of North Korea's economy. All estimates of North Korea's economy, including our own, are fraught with great uncertainty. Official statistics are unreliable at best, and almost certainly misleading. Although we quote some of those statistics, the overall coding of the North's economy is based primarily on the assessments of frequent Western foreign visitors to North Korea who we have interviewed as well as anecdotal accounts from the literature. The primary purpose of our economic assessment is not to make an absolute measure of the economy but rather to highlight the general trend of North Korea's economy moving from negative to positive growth over time.

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.

1992: R2

By 1992, North Korea is in the midst of its Third Seven-Year Plan (1987-1993) to advance the goals of self-reliance, modernization, scientification, and the development of foreign trade and joint ventures. The plan faces difficulties because of the collapse of the socialist bloc in the late 1980s. By this date, all aid from Moscow has ceased, and China makes North Korea pay market prices for goods instead of selling them at "friendship prices." By early 1990s, the agricultural system is already insufficient and unable to produce the food needed to feed the population, with grain demand exceeding supply by 1 million tons. North Korea's GDP growth rate is -6 percent, according to the Bank of Korea.

1993: R2

North Korea admits that its Third Seven-Year Plan was not successful, and since this time has not issued a formal plan for the economy. Premier Kang Song-san states on December 8, "Due to the collapse of socialist countries and the socialist market, our

country's economic cooperation and trade have faced setbacks. This has brought serious damage to our economic construction, and therefore our Third Seven-Year Plan has had a hard time achieving its goals." North Korea's GDP growth rate is -4.2 percent, according to the Bank of Korea.

1994: R3

North Korea's GDP growth rate continues to decline, resulting in a 2.4 percent decline in 1994, according to the Bank of Korea. North Korea begins to suffer the effects of a growing economic crisis and receives its first food aid from abroad.

1995: R3

The summer floods destroy the year's harvest. It makes its first international request for food aid. It is estimated that about 600,000 to 1 million people, or about 3-5 percent of North Korea's population, die during the famine period. The economy experiences marketization from the bottom up during this period, as small-scale social units engage in entrepreneurial activity to survive. North Korea's GDP growth rate is -4.4 percent, according to the Bank of Korea.

1996: R3

Summer floods occur again and the famine continues. The economy continues to see small-scale social units engage in entrepreneurial activity to survive. North Korea's GDP growth rate is -3.6 percent, according to the Bank of Korea.

1997: R3

A severe drought follows the 1996 floods and the famine continues. The economy continues to see small-scale social units engage in entrepreneurial activity to survive. North Korea's GDP growth rate is -6.3 percent, according to the Bank of Korea.

1998: R3

The famine continues into 1998 as the drought and minor snowfall during the 1997-1998 lead to a grain shortfall in 1998. In September, North Korea institutes some constitutional revisions to formally permit the private ownership of assets and institutes government administrative reform that results in the delegation of administrative responsibilities to local authorities. North Korea also establishes its second special economic zone, the Mount Kumgang Tourist Zone near the DMZ, in an effort to provide tax and tariff incentives to attract foreign investment, with the goal of improving employment and the development of technologies and infrastructure. North Korea's GDP growth rate is -1.1 percent, according to the Bank of Korea.

1999: R3

The famine continues but North Korea begins its economic recovery. The Bank of Korea attributes GDP growth to increased grain production and expanded aid from South Korea and the international community. Although this year reverses the trend of nine years of negative growth (with a growth rate of 6.1 percent), North Korea's 1999 GDP was only about three quarters of its 1989 GDP, according to the Bank of Korea.

2000: R2

Massive food aid—the highest amount ever—arrives in North Korea. The agricultural sector begins to “stabilize.” North Korea’s GDP growth rate is 0.4 percent, according to the Bank of Korea.

2001: R2

North Korea benefits from its third year in a row of positive economic growth, estimated at 3.7 percent by the Bank of Korea. North Korea possibly sees a boost in agricultural production, which represents a large share of the economy. It continues to see increasing marketization from below, with one estimate placing the number of farmers’ markets in the country at about 300 by 2001. North Korea establishes its third special economic zone, the Sinuiju Special Administrative Region along the border with China, though Chinese actions quickly derail it.

2002: R2

The North pursues significant economic changes in July 2002, calling them economic “adjustments” rather than economic “reforms.” The “7-1 Measures” possibly introduce some features of a market economy, including microeconomic and macroeconomic changes and economic zones to attract foreign investment. The state still owns the major enterprises and retains methods for controlling the workers, but an economy with some private ownership and market activity appears to emerge. These reforms, part of a series of changes since 1998, do not lead the transition to some market elements but instead appear to be a response to entrepreneurial activity established during the famine years. In August, SPA President Kim Yong Nam states, “We are directing our whole efforts to restructure our economic base to be in line with the information technology revolution... we are reforming the economic system on the principle of profitability.” North Korea establishes its fourth special economic zone, the Kaesong Special Industrial Zone near the DMZ. Its GDP growth rate is estimated at 1.2 percent, according to the Bank of Korea.

2003: R1

North Korea possibly exhibits increasing awareness that it must integrate the state distribution system with the free market. For instance, the People’s Korea New Year’s Joint Editorial notes, “We should manage and operate the economy in such a way as to ensure the largest profitability while firmly adhering to the socialist principles.” North Korea had maintained farmers’ markets for many years, though they rose in number and prominence during and after the famine years. By 2003, the function of the markets expands to include some industrial goods in addition to agricultural products. This expansion demonstrates that the efforts to solve the food distribution problem through some free market principles likely had extraneous effects. The GDP growth rate is estimated at 1.8 percent, according to the Bank of Korea.

2004: R1

North Korea continues to see the growth of market activity and increased inflation. The GDP growth rate is estimated at 2.1 percent, according to the Bank of Korea. The Supreme People’s Assembly passes a law that loosens some restrictions on foreign investment and allows for full foreign ownership of some ventures.

2005: R1

Reforms from 2005 onward suggest an effort to reverse previous reforms. The North Korean government confiscates grains harvests, bans private trade in grain, starts the Public Distribution System, and expels the World Food Program. This appears to be an effort by the government to reassert control over the food economy. The regime also goes after other market activities. The North Korean government asks aid agencies to shift to development cooperation. The GDP growth rate is estimated at 3.8 percent, according to the Bank of Korea.

2006: R1

This is the first negative year of GDP growth after seven consecutive years of positive growth. The decline of North Korea's international relationships due to the nuclear issue and lack of domestic resources provide difficult circumstances for the economy to thrive in 2006. There is a significant increase in inter-Korean trade in part due the provision of rice and fertilizer from South to North and the expansion of the Kaesong Industrial Complex and the inter-Korean economic cooperation project. The Kaesong Industrial Complex begins exporting in 2006. The GDP growth rate is estimated at -1.0 percent, according to the Bank of Korea.

2007: R1

The elements of the government's anti-market campaign begin. The government institutes restrictions and follows these with inspections of markets and a reduction in their hours of operation. North Korea's GDP growth rate continues to decline and is estimated at -1.2 percent, according to the Bank of Korea.

2008: R1

The GDP growth rate is estimated at 3.1 percent, according to the Bank of Korea. This positive growth, following two years of negative growth, is likely attributable to a few one-off factors, including increased agricultural production and assistance, such as the provision of raw materials and heavy crude oil, as a result of the Six Party Talks. The Mt. Kumgang tourist resort is shuttered after the shooting death of a South Korean tourist by a North Korean guard.

2009: R2

The North Korean regime undertakes currency reform in an effort to crack down on private markets and reinstitute socialist economic principles. The government replaces all currency currently in circulation in an effort to curb private trade and reassert state control. The reform is pushed on the North Korean people with little warning. There are various reasons why North Korea reversed its previous reforms. The GDP growth rate is estimated at -0.9 percent, according to the Bank of Korea.

2010: R1

North Korea's GDP growth rate is estimated at -0.5 percent, according to the Bank of Korea. North Korea's poor growth rate this year may be partially attributable to poor

weather conditions leading to poor agricultural production. The rate of inflation possibly increases as additional stresses hit the economy in the preceding years.

2011: R1

North Korea's GDP growth rate is estimated at 0.8 percent, according to the Bank of Korea. The Bank of Korea determines that this modest increase in GDP is due in part to an improvement in production from agriculture, forestry, and fishing, though light and heavy industry see a decline in production.

2012: G1

Kim Jong-un assumes power in North Korea and in June North Korea begins implementation of a reform package, officially called the "Economic Management System in Our Style," but colloquially referred to as the "June 28 Measures." The New Economic Management System is described as bringing the economy into a system of communist rule, providing for the coexistence of market and planned economies and state ownership of the means of production. What this appears to mean in practice is that while the state owns the means of production and appoints the heads of state-owned enterprises, these enterprises can exercise independent decision-making to determine how to meet the state's production targets and market needs. These changes are announced for both the agricultural and the manufacturing/services sector. North Korea's GDP growth rate is estimated at 1.3 percent, according to the Bank of Korea.

2013: G1

North Korea introduces the byungjin line of parallel development of the military and the economy. North Korea's GDP growth rate is estimated at 1.1 percent, according to the Bank of Korea. This growth may be driven in part by gains in agriculture, mining, and trade with China, with the combined value of its imports and exports registering at \$7.34 billion.

2014: G1

North Korea institutes the May 30 measures that provide some market reforms for enterprise managers, allowing them, among other things, to keep a share of their revenues, hire inputs at market prices from suppliers of their choice, sell excess output, and enter into joint ventures. These reforms might have recognized a private class of emerging entrepreneurs, though they are not fully implemented. Nevertheless, North Korea continues to see an increase in small-scale entrepreneurship. North Korea is estimated to have a GDP growth rate of 1.0 percent, according to the Bank of Korea.

2015: G2

North Korea is estimated to have a GDP growth rate of -1.1 percent, its lowest growth rate since 2007, according to the Bank of Korea. A bad drought in 2015 negatively impacts North Korea's economic growth. The results of the small-scale entrepreneurship are noticeable as that activity continues to grow. Trade with China continues to grow.

2016: G2

North Korea's GDP is estimated at \$28.5 billion in 2016 with the largest growth in nearly twenty years of 3.9 %, according to the Bank of Korea. This impressive gain in GDP may be partially attributable to the recovery from the bad drought in 2015. The Kaesong Industrial Complex is closed.

2017: G2

Market activity and entrepreneurial growth have continued, especially in Pyongyang. Street vendors, luxury cars, high-rises, and modern supermarkets are all much more present in Pyongyang. The private sector may now be producing up to half of North Korea's GDP. The international community imposes additional sanctions on North Korea and China begins more effective implementation and enforcement of sanctions. However, in 2017 the sanctions do not have a noticeable effect on North Korea's economy. The black market exchange rate for North Korea's currency and the price of rice, for example, remain flat, whereas conventional economic theory holds that if the economy were in distress, these values would be expected to rise. North Korea touts the revitalization of local production, which has been a key policy of Kim Jong Un.

US Financial Aid to North Korea

A measurement of US 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.

We provide no color code and use a neutral gray. Actual US financial support for fuel and food is shown in dollars. KEDO support is summarized at the end.

We cite the numbers reported by the Congressional Research Service in Mark E. Manyin and Mary Beth D. Nikitin, "Foreign Assistance to North Korea," Congressional Research Service, April 2, 2014. <https://fas.org/sgp/crs/row/R40095.pdf>.

1992: \$0

1995: \$9.7 M

1996: \$30.3 M

1997: \$82.4 M

1998: \$122.9 M

1999: \$287.2 M

2000: \$138.7 M

2001: \$132.97 M

2002: \$140.9 M

2003: \$27.78 M

2004: \$36.4 M

2005: \$5.7 M

2006: \$0

2007: \$45.1 M

2008: \$224.7 M

2009: \$3.5 M

2010: \$0.9 M

2011 – 2016: \$0

2017: \$0.9 M

KEDO aid: US \$0.45 B total. South Korea: \$1.45 B total.