



ISSUE BRIEF

North Korea's Ballistic Missile Program

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Introduction

The United States and its East Asian allies consider North Korea's ballistic missile program to be a major security threat, one that allows Pyongyang to threaten population centers and military assets in the region and – increasingly – in U.S. territory. It is likely that North Korea is able to equip its ballistic missiles with nuclear and chemical warheads, although it is not certain whether North Korea is yet able to fire a nuclear-armed missile as far as the mainland United States.¹ The ballistic missile program is a major point of pride and domestic regime legitimation within North Korea, with rocket imagery ubiquitous throughout the country and with successful missile tests engendering national celebrations.

North Korea has long sought to develop long-range ballistic missiles, and has sold ballistic missile technology abroad since the 1980s. In the years since Kim Jong Un assumed power, North Korea has demonstrated an intensified focus in advancing its missile capabilities, with Kim proclaiming that his “final goal is to establish the equilibrium of real force with the U.S.” and to “qualitatively consolidate the military attack capacity for nuclear counterattack the U.S. cannot cope with.”² In July 2017, North Korea conducted its first tests of a road-mobile intercontinental ballistic missile (ICBM), making significant progress toward its avowed goal of being able to strike the continental United States. Pyongyang is also developing more sophisticated regional strike capabilities, including solid-fueled medium-range ballistic missiles (MRBMs) that could be quickly launched from the ground or via submarine; high-precision short-range ballistic missiles (SRBMs) likely intended for use against U.S. and South Korean military bases and possibly naval targets; and more advanced anti-aircraft and anti-ship missiles.

Questions concerning the technical capabilities of North Korea's missile program, as well as the strategic intentions driving this program, remain the subjects of often-intense debate among experts. A paramount technical question is whether North Korea has fully overcome all of the challenges to fielding a reliable, nuclear-armed ICBM, or how soon Pyongyang will be able to reach this milestone. The role that foreign collaboration has played in the development of North Korea's missile arsenal, as well as the extent of North Korea's capacity to build key missile components domestically, also remain important questions with significant policy relevance. There is broad agreement among experts that, because Kim Jong Un's highest strategic priority is regime survival, North Korea would not launch a suicidal first strike against the United States. However, there is considerable debate over whether North Korea's nuclear and ballistic missile programs are intended primarily for deterrence against a U.S.-led attack, or if Pyongyang intends to use its nuclear-armed status to coercively change the status quo on the Korean Peninsula.

The U.S. and international community have responded to developments in North Korea's missile program through sanctions, interdictions of missile exports, direct negotiations, the deployment of missile defense capabilities, and possibly cyberwarfare or espionage efforts. These efforts may have constrained the growth of North Korea's missile program, or provided military planners with tools to partially counter it, but they have not prevented Pyongyang from significantly improving and expanding its ballistic missile capabilities.

The Early Development of North Korea's Missile Program

The origins of North Korea's ballistic missile program could be traced back to Kim Il Sung's *byungjin* policy, which emphasized the need to build up North Korea's military in conjunction with its economy and to acquire a domestic defense industry. Upon the establishment of the DPRK's National Defense University in Hamhung in 1965, Kim Il Sung reportedly said:

If a war breaks out, the United States and Japan will also be involved. In order to prevent their involvement, we have to be able to produce rockets that fly as far as Japan. Therefore, it is the mandate for the National Defense University to nurture those personnel who will develop mid- and long-range missiles.³

In the 1960s and 70s, North Korea acquired FROG artillery rockets, anti-ship missiles, and surface-to-air missiles from China and the Soviet Union, laying the foundations for Pyongyang's missile program. In 1977, North Korea began to collaborate with China in the development of the DF-61 liquid-fueled ballistic missile, but Beijing cancelled the program the following year. According to most open-source literature, North Korea received its first ballistic missile system, the Soviet Union's short-range liquid-fueled Scud-B missile, from Egypt sometime in the late 1970s or early 1980s; North Korea subsequently succeeded in reverse engineering this missile, first testing an indigenously built version in 1984 and beginning mass production a few years later.⁴

By the late 1980s to early 90s, the scope of North Korea's ballistic program expanded, as Pyongyang began development of a suite of new medium- and long-range missiles primarily using Scud-type engines. North Korea first tested the medium-range Nodong missile in 1990, and development of the multi-stage Taepodong-1 and Taepodong-2 missiles may have begun around this time as well (these latter long-range systems were not flight-tested until 1998 and 2006, respectively).⁵ Scientists and engineers from the former Soviet Union's Makeyev Design Bureau may have provided crucial assistance that enabled Pyongyang's ballistic missile program to expand during this period. Soviet scientists also reportedly transferred technology related to the Soviet Union's R-27 submarine-launched ballistic missile (SLBM) to North Korea – this technology eventually provided the basis for North Korea's Musudan intermediate-range ballistic missile (IRBM).⁶ Additionally, during the mid-1990s North Korea reportedly acquired Soviet-origin tactical ballistic missiles from Syria, which Pyongyang eventually reproduced as the KN-02 – a short-range but mobile and highly accurate missile, and the first solid-fueled missile in North Korea's arsenal.⁷

As the North Korean ballistic missile program expanded in the late 1980s, Pyongyang became a global supplier of missile technology, with a particular focus on marketing its goods in the Middle East. In addition to collaborating with Egypt in reverse-engineering the Scud-B, North Korea began selling missile technology to Iran – then in the midst of its “war of the cities” with Iraq – after 1985. In the mid-1990s, North Korea proliferated its Nodong MRBM to Iran and Pakistan, forming the basis for Iran's Shahab-3 and Pakistan's Ghauri missile programs. By the early 2000s,

North Korea's foreign missile sales began to decline due to a number of factors including a drop in demand and international pressure on recipient countries.⁸ However, North Korea has continued to collaborate with Iran in ballistic missile development, though the extent and nature of this cooperation has been a point of dispute among experts.⁹

Missile Negotiations with North Korea

As North Korea's ballistic missile program and its prominence as a missile exporter grew in the 1990s, the U.S. and other countries attempted to engage Pyongyang diplomatically to address the issue. However, until North Korea's launch of a long-range missile in 1998, U.S. concern over Pyongyang's nuclear program generally overshadowed concerns over its missile program. In 1992, Israel began talks with North Korea discussing the prospect of large-scale Israeli investment and technical assistance in exchange for North Korea ending its missile exports to the Middle East, but these negotiations ended inconclusively amidst U.S. opposition.¹⁰ During the negotiations that led to the 1994 Agreed Framework on North Korea's nuclear program, the U.S. warned Pyongyang that continued sale of missiles to Iran could undermine the possibility of improving U.S.-DPRK relations, but the final agreement did not directly mention ballistic missiles. Bilateral U.S.-DPRK missile negotiations that began in April 1996 collapsed the following year without making progress.¹¹

North Korea's launch of a multi-stage Taepodong-1 missile in August 1998 added a new sense of urgency to international efforts to address the country's missile program. Pyongyang said that it launched the Taepodong-1 to put a small satellite into orbit, a rationale that was widely interpreted as a veil for testing ballistic missile technology. Although the test was unsuccessful, it evoked international criticism, particularly because of the missile's overflight of Japanese territory. Several months after the test, however, the U.S. resumed missile talks with North Korea. By September 1999, Pyongyang agreed to a moratorium on long-range ballistic missile testing – but not foreign missile sales – so long as diplomatic talks continued.¹² The United States responded by relaxing some economic sanctions. Amid progress on missile negotiations and other issues in the waning days of the Clinton administration, Vice Marshal Jo Myong Rok visited the U.S. in October 2000, followed by a reciprocal visit by U.S. Secretary of State Madeleine Albright to Pyongyang.

The outline of the agreement under consideration would have frozen the DPRK's development, production, testing, and deployment of missiles with a range over 500 km; halted North Korea's missile exports in exchange for "in-kind" compensation; provided North Korea with a few launches of civilian satellites by third countries annually; and taken steps to improve U.S.-DPRK diplomatic relations. However, several key issues remained unresolved in these negotiations, including the extension of the testing freeze to include North Korea's Scud missiles, the elimination of existing missiles, and verification and monitoring procedures. A contemplated visit from President Clinton to Pyongyang to finalize the agreement during the final months of his presidency did not move forward due to a lack of progress on these issues.¹³

The incoming Bush administration, skeptical of the previous administration's approach to North Korea policy and the verifiability of a missile agreement, delayed the resumption of missile talks with North Korea while it initiated a comprehensive policy review.¹⁴ In response, the North Korean government warned that it would be difficult for it to maintain the unilateral testing moratorium "indefinitely."¹⁵ After Japanese Prime Minister Junichiro Koizumi's 2002 visit to Pyongyang, North Korea agreed to keep the moratorium in place, but continued to export missiles.¹⁶

In March 2005, a month after declaring itself a nuclear power and withdrawing from the Six Party Talks (a series of multilateral negotiations aimed at dismantling North Korea's nuclear weapons program), Pyongyang announced that it had ended its moratorium on missile testing.¹⁷ On July 5, 2006, North Korea tested an array of ballistic missiles, including a long-range Taepodong-2 that failed after about 40 seconds of flight. The UN Security Council adopted a resolution denouncing the test; three months later, North Korea conducted its first nuclear test, prompting the Security Council to adopt a more comprehensive sanctions resolution – marking the beginning of an ongoing pattern of North Korean nuclear or missile tests prompting new Security Council resolutions and sanctions. Although the Six Party Talks resumed in 2007, they did not directly address North Korea's missile program, and were indefinitely suspended in 2009 following North Korea's launch of an Unha-2 space launch vehicle (SLV) based on the Taepodong-2 ICBM, and a subsequent nuclear test.

The most recent U.S.-DPRK agreement on the North's ballistic missile program took place under the Obama administration in February 2012, with the two countries issuing separate statements indicating that Pyongyang would freeze uranium enrichment and cease nuclear and missile testing. In exchange, North Korea would receive 240,000 tons of nutritional assistance from Washington. However, within two weeks of the agreement's announcement, North Korea publicized its plans to launch a satellite to commemorate the 100th birthday of Kim Il Sung, using an Unha-3 SLV similarly based on the Taepodong-2. Washington argued the launch violated the terms of the agreement, and cancelled the planned aid package after it took place.

North Korea's Second Generation of Ballistic Missiles

The pace of North Korea's ballistic missile tests, and the technical sophistication of its missile arsenal, have increased considerably since Kim Jong Un's succession to power in December 2011, and his declaration of a new *byungjin* line on simultaneous economic and nuclear development in March 2013. Despite international attempts to limit North Korea's missile program through sanctions and interdictions, Pyongyang has unveiled a significant range of new capabilities, with some reportedly already deployed and others in various stages of development. This includes new long-range missiles that use a more energetic fuel and have far more military utility than the older Taepodong missiles,¹⁸ as well as various new short- and medium-range missiles that could advance Pyongyang's warfighting and second-strike capabilities.

Long-Range Missiles

In his 2017 New Year's Speech, Kim Jong Un announced that North Korea had "entered the final stage of preparation for the test launch of intercontinental ballistic missile" – indicating that North Korea was much closer to reaching this milestone than analysts had previously assumed.¹⁹ In July 2017, North Korea conducted two successful tests of the Hwasong-14, a two-stage road-mobile missile that could potentially strike the continental United States. Although both tests used a "lofted trajectory" – maximizing altitude rather than travel distance, and thus avoiding an overflight of Japanese territory – the tests demonstrated that the missile could have a range of over 10,000 kilometers.²⁰ However, experts have debated the potential payload size of this missile, as well as the capabilities of its re-entry vehicle – two crucial factors in determining the missile's ability to deliver a nuclear warhead to the continental United States.²¹ Several analysts have indicated that they expect the Hwasong-14 to be tested on a long-range trajectory in the near future, and North Korea has suggested that it might pair such a launch with an atmospheric thermonuclear warhead test, a highly provocative action which if successful would definitively prove Pyongyang's nuclear delivery capabilities.²²

The Hwasong-14 appears to be a two-stage version of the Hwasong-12 IRBM, a missile that North Korea first unveiled during a military parade on April 15, 2017 and has subsequently tested repeatedly, with at least two apparent initial failures followed by several successful launches.²³ The two most recent tests of the Hwasong-12 overflew Japan, with the second such test reaching a distance of 3,700 kilometers – demonstrating sufficient range to hit the U.S. territory of Guam. The missile appears to rely on a new engine design using the high-energy fuel UDMH; some analysts have argued that the new engine appears similar to a single-chambered variant of the Soviet RD-250 engine (and therefore possibly the result of North Korean espionage efforts or foreign assistance), while others argue that it appears to be an indigenous design.²⁴

The apparently quick development and relative testing success of the Hwasong-12 and Hwasong-14 stands in contrast to the development history of North Korea's Musudan IRBM, a ground-based missile derived from the Soviet Union's liquid-fueled R-27 SLBM. Reportedly first glimpsed by spy satellites in 2003, the Musudan was subject to considerable speculation and rumors prior to the first test of this missile on April 15, 2016.²⁵ However, a series of eight apparent tests over the next six months resulted in only one successful launch, possibly leading North Korea to abandon the Musudan program in favor of the Hwasong-12 IRBM.²⁶ Nonetheless, North Korea's development of the Musudan may have been a bridge to the country's recent advances in building new long-range missiles: the Musudan uses the same UDMH fuel as the Hwasong-12 and Hwasong-14, and a modified version of its engine appears to power the first stage of two other ICBMs North Korea is developing, the KN-08 and KN-14.

The KN-08, a road-mobile liquid-fueled ICBM, was first publicly seen at a military parade in Pyongyang in April 2012, prompting considerable debate among analysts and concern among U.S. military planners.²⁷ North Korea unveiled the KN-14, a variant of the KN-08 that incorporates a different re-entry vehicle and appears to use two stages instead of three, at a subsequent parade in October 2015.²⁸ Although neither version of the missile has been flight

tested, Pyongyang has conducted at least one static test of its engine.²⁹ While it is often difficult to predict North Korea's intentions for its missile program, it is possible that North Korea will develop a variant of the KN-08 to serve as an ICBM with a longer range than the Hwasong-14.

Submarine-Launched and Solid-Fueled Ballistic Missiles

From May 2015 through August 2016, North Korea conducted a series of tests of a two-stage, solid-fueled submarine-launched ballistic missile (SLBM), dubbed the *Pukguksong-1*.³⁰ Pyongyang achieved progressive degrees of success over the course of this test cycle, and has also begun developing a new, larger submarine from which to base this missile.³¹ (North Korea currently only has one experimental submarine capable of firing a missile.) Although North Korea's SLBM program appears to remain under development, an operational SLBM capability would present a new type of threat to the U.S., South Korea, and Japan, providing Pyongyang with a potential regional second-strike capability and the ability to evade the THAAD missile defense system in South Korea.³²

In 2017, North Korea conducted two tests of a ground-based version of its SLBM, dubbed the *Pukguksong-2*. As a solid-fueled medium-range missile, the *Pukguksong-2* would be highly mobile and capable of being launched at short notice, and thus would be difficult to preempt in a conflict. After the second test of this missile, Kim Jong Un reportedly called for its mass production and deployment.³³ North Korea has hinted at plans to develop a third generation of the *Pukguksong* missile, incorporating more advanced, lightweight materials into its airframe and therefore increasing its potential range, and Pyongyang has also signaled its long-term intention to develop a solid-fueled, road-mobile ICBM.³⁴

Advancing Tactical and Theater-Range Capabilities

In addition to developing new and more capable long-range missiles, in recent years North Korea has made a concerted effort to improve the accuracy, range, and operability of its existing arsenal of short- and medium-range missiles. Beginning in 2014, North Korea began a more aggressive testing regime for ballistic missiles than the country had previously undertaken, conducting frequent tests of its Scud arsenal and its KN-02 SRBMs, including extended-range variants of both missiles. These tests have seemed to focus increasingly on improving the operational readiness of North Korea's rocket forces, rather than technical verification of missile capabilities.³⁵ Additionally, some of these tests appeared to incorporate tactics designed to evade THAAD and other missile defense systems deployed around the Korean Peninsula, such as launching multiple missiles simultaneously or conducting launches at a trajectory that would make them more difficult to intercept. North Korea has also recently begun testing Scud variants with maneuverable re-entry vehicles, which would provide these missiles with much greater accuracy and make it more difficult for missile defense systems to defend against them.³⁶

In addition to improving the performance of its short- and medium-range missiles, North Korea has begun to develop or deploy several new cruise missiles and other conventional weapons systems. In 2015, North Korea announced that it would deploy a new generation of “ultra-modern” anti-ship missiles, which appeared to be modified versions of the Russian Kh-35 missile, on its naval vessels.³⁷ Pyongyang later unveiled a ground-launched, maneuverable variant of this missile.³⁸ In 2017, North Korea declared a new anti-aircraft surface-to-air missile system, similar to the Russian S-300, to be operational.³⁹ Additionally, North Korea has developed a new 300mm rocket artillery system capable of threatening Seoul, as well as unmanned aerial vehicles intended for reconnaissance and attack purposes.

Space Launch Vehicles

North Korea has conducted three satellite launches under Kim Jong Un, most recently in February 2016, all using the Unha-3 SLV launched from North Korea's Sohae satellite launch facility. The latter two launches appeared to have successfully placed satellites into orbit, although in both cases the satellites may have begun tumbling (and therefore become non-functional) shortly after achieving orbit.⁴⁰ North Korea has consistently claimed that its satellite launches have been for peaceful purposes, while the UN Security Council has repeatedly condemned them for the use of ballistic missile technology.

North Korea appears to maintain high ambitions for its space launch program. There is evidence that North Korea is developing a new and larger SLV, the Unha-9, to conduct future space launches, and in September 2016 North Korea tested a new rocket engine it said was designed for a “geostationary satellite rocket carrier.”⁴¹ (This engine may have been a modified version of the engine subsequently used for the Hwasong-12 and Hwasong-14 missiles.)⁴² In August 2016, an official from North Korea's National Aerospace Development Administration (NADA) said that it had begun a five-year plan to put more satellites into orbit, and planned to “plant the flag of the DPRK on the moon” within ten years.⁴³

Nuclear Operationality

The extent of North Korea's ability to arm its ballistic missiles with nuclear warheads, and the operability of its missile forces under conditions of conflict, are two crucial questions about the program. In March 2016, Kim Jong Un claimed that North Korea's “nuclear warheads have been standardized to be fit for ballistic rockets by miniaturizing them,” and North Korean state-run news outlets released photos of him standing beside a model of such a miniaturized warhead.⁴⁴ Assessments from the U.S., South Korean, and Japanese governments, as well as many independent analysts, have increasingly concurred in suggesting North Korea has indeed achieved the capability to produce fission-based nuclear warheads compact enough to fit inside its missiles.⁴⁵ North Korea has also unveiled a design for a two-stage thermonuclear warhead, and in September 2017 tested a nuclear device with a yield large enough to be consistent with such a weapon; however, it remains uncertain whether Pyongyang currently possesses the operational thermonuclear capability it claims to have.

While North Korea may be capable of producing miniaturized nuclear warheads and fielding them on medium-range missiles such as the Nodong MRBM, Pyongyang may still face some technical hurdles before it is able to reliably deliver a nuclear warhead with an ICBM. In addition to questions about the payload (and therefore the size of the warhead) that the Hwasong-12 or Hwasong-14 can carry to a long range, it is uncertain whether North Korea has fully developed a reliable re-entry vehicle that can survive atmospheric descent.⁴⁶ However, this barrier is likely far from insurmountable, particularly if North Korea were to employ a relatively simple but low-accuracy re-entry vehicle.⁴⁷

Aside from the question of its nuclear operability, North Korea's ballistic missile arsenal is increasingly mobile, allowing North Korea to launch missiles relatively quickly and making it difficult for the U.S. or allied militaries to detect their deployment – capabilities that would be critical to Pyongyang in the event of hostilities. North Korea's extensive network of tunnels and underground facilities compounds this problem of detection, providing relatively protected and hidden sites to store its missiles prior to launch. North Korea's solid-fueled ballistic missiles have greater mobility than its liquid-fueled missiles, as they do not need to be fueled prior to launch, require fewer conspicuous support vehicles, and can be driven through rugged terrain on a tracked launch vehicle and therefore avoid reliance on the country's limited road network.

Foreign Assistance and Domestic Production Capabilities

The rapid pace of recent advances in North Korea's ballistic missile program has raised questions about whether Pyongyang has received foreign assistance in developing its new missiles, but no clear answers. Analysts have speculated about the incorporation of Soviet engine technology, possibly procured clandestinely from Russia or Ukraine, in North Korea's long-range Hwasong-12 and Hwasong-14 missiles, but that claim has been a point of fierce contention among experts.⁴⁸ Similarly, speculation that North Korea may have received assistance from China or Iran in developing its solid-fueled missiles has been challenged on technical grounds.⁴⁹ North Korea's newest anti-aircraft and anti-ship missiles appear to be derived from systems that Russia has designed and sold abroad, but the global proliferation of these systems makes it difficult to ascertain how and when they may have been transferred to North Korea.

Much of the speculation regarding recent foreign assistance to North Korea's ballistic missile program centers on Iran, as the two countries have a history of collaboration on ballistic missile development and signed an agreement on scientific and technical cooperation in 2012. There are some indications of continued cooperation between Pyongyang and Tehran: in January 2016, the U.S. Treasury Department claimed that Iranian scientists have helped North Korea develop an "80-ton rocket booster" – possibly a first-stage engine for a new space-launch vehicle.⁵⁰ Certain technologies, such as a triconic-design re-entry vehicle and engines derived from the Soviet R-27 SLBM, appear to have been shared between Pyongyang and Tehran.⁵¹ Nonetheless,

there are significant differences between the ballistic missile programs of Iran and North Korea, and the full extent of current collaboration between these countries is difficult to ascertain.

In addition to its efforts to acquire missile designs or systems from overseas, North Korea has developed a sophisticated procurement network to purchase commercial dual-use items needed for its nuclear and missile programs, in violation of the UN sanctions aimed at stopping these programs.⁵² Debris recovered from North Korean rockets, most recently in February 2016, has included high-end foreign-sourced components presumably purchased by North Korean front companies or middlemen abroad.⁵³ The UN's Panel of Experts on North Korea sanctions has also reported on interdictions of foreign technology applicable to ballistic missile development, such as high-tech fibers suitable for use as solid-fuel rocket casings.⁵⁴ Additionally, North Korea has imported and modified heavy-duty truck chassis from China for use as transporter-erector-launchers (TELs) for its ICBMs, and has used other types of Chinese or Russian-produced trucks to transport SLBMs and anti-ship missiles.⁵⁵

Nonetheless, even though overseas procurement continues to play a role in advancing North Korea's ballistic missile program, Pyongyang appears to have a significant and growing capacity to manufacture key components domestically.⁵⁶ North Korean propaganda has extensively celebrated the country's Computer Numerical Control (CNC) machine tools, which can produce high-precision parts for ballistic missiles and nuclear centrifuges, among other purposes.⁵⁷ Media reports have indicated the U.S. intelligence community's belief that North Korea likely has the ability to manufacture its missile engines domestically.⁵⁸ Analysts from outside of government have argued that North Korea has the capability to produce rocket fuels domestically, and have identified several sites where this may be taking place.⁵⁹ North Korea also appears to have the capability to manufacture heavy-duty trucks to transport its short-, medium-, and intermediate-range missiles, and to produce the hydraulic systems necessary to erect and launch missiles from these trucks.⁶⁰ Additionally, North Korean media has signaled the country's intentions to produce advanced materials for use in missile re-entry vehicles and solid-fueled engines; the ability to produce such materials would represent significant steps forward for Pyongyang's ICBM program.⁶¹

International Responses and Policy Options

As North Korea's nuclear and ballistic missile programs have progressed, the U.S. and its allies have implemented a number of policies intended to impede or roll back their development and prevent their potential use. These policy tools have ranged from diplomatic efforts to re-engage Pyongyang in negotiations, to sanctions intended to pressure North Korea economically and disrupt its supply chain for WMD-related goods, to the deployment of regional and U.S.-based missile defense systems. However, while North Korea has been deterred from engaging in large-scale attacks against the U.S. or its allies, these policy efforts have been unsuccessful in compelling Pyongyang to abandon its WMD programs, or in preventing North Korea from making steady progress in its march toward acquiring a nuclear-armed ICBM.⁶²

Since 2006, the United Nations Security Council has unanimously adopted eight resolutions imposing multilateral sanctions on North Korea in an effort to both slow the development of its nuclear and ballistic missile program and to pressure the North Korean government into reentering into Six Party Talks. The United States has also implemented various unilateral sanctions measures in order to ratchet up pressure on North Korea, including through the application of “secondary sanctions” on third-country entities doing business with North Korea.⁶³ These sanctions have presumably made it more challenging for North Korea to acquire the hard currency or technology needed to advance its missile program, and have occasionally led to interdictions of missile-related components in transit to or from North Korea. However, international enforcement of UN sanctions has been uneven, and the sanctions regime has not prevented Pyongyang’s dramatic recent advances in its missile program. It remains to be seen whether enhanced pressure from the most recent UN sanctions, which prohibit most North Korean exports and attempt to cut off Pyongyang’s access to global financial and shipping networks, will impede North Korea’s ability to advance its nuclear and missile programs in a way previous efforts have not.

As North Korea’s missile capabilities have grown, the U.S., South Korea, and Japan have deployed a number of missile defense systems to counter the threat from Pyongyang. There are several ballistic missile defense systems deployed in the region, including the Terminal High Altitude Area Defense (THAAD) battery stationed in South Korea; PAC-2 and PAC-3 interceptors based in South Korea and Japan; and the Aegis Ballistic Missile Defense system deployed on U.S. and Japanese warships. The various systems deployed in the region are intended to provide a layered defense against different types of North Korean missile threats, with South Korea’s domestic Korean Air and Missile Defense (KAMD) system operating separately from assets deployed by Japan and the United States. However, these systems may be able to provide only a partial defense against North Korean missile strikes, particularly if North Korea employs tactics designed to overwhelm or otherwise evade missile defenses. The South Korean capital of Seoul, located only roughly 50 kilometers from the DMZ, remains highly vulnerable to North Korean artillery, rocket, and short-range missile strikes.

Defending the U.S. against a potential North Korean ICBM launch poses an even greater technical challenge than does regional missile defense. The Ground-based Midcourse Defense (GMD) system in the U.S., designed to protect against a limited ICBM attack, has had a limited success rate under highly scripted test conditions. In May 2017, the GMD system conducted its first successful test intercept of an ICBM target – marking an important milestone in the program – but the reliability and effectiveness of the system remain far from proven. In the event of an attack, the U.S. would likely launch multiple GMD interceptors toward each North Korean ICBM in flight toward the continental U.S.; this approach could improve the chances of a successful intercept, but without a definitive prospect of success.⁶⁴ It is likely that as North Korea develops a more robust ICBM capability, it will seek to deploy countermeasures such as decoy warheads and penetration aids that will make these missiles more difficult to intercept.⁶⁵

In addition to missile defense efforts, there have also been media reports about U.S.-led attempts to sabotage the North Korean ballistic missile program through “left-of-launch” efforts such as cyberattacks and other forms of sabotage. These reports cited the high failure rates of new North Korean missile systems, particularly the Musudan, as possible indications of such a sabotage campaign.⁶⁶ However, experts have pointed out that such failures are an expected part of a missile development process, and have argued that there is little evidence that a cyber campaign is undermining North Korea's missile program.⁶⁷

Many analysts argue that, because of the extremely high potential cost of military action, the most prudent approach to address North Korea's missile and nuclear threats would be to combine deterrence and pressure with renewed diplomatic efforts to address these threats.⁶⁸ The governments of China and Russia have advocated for a “freeze-for-freeze” agreement, under which North Korea would halt its nuclear and missile tests in exchange for the U.S. and South Korea suspending joint military exercises. The U.S. and North Korea have both distanced themselves from this proposal, but analysts have argued that a variant of it – possibly involving modifications to U.S.-ROK exercises that would not harm military readiness – would be worth pursuing as an initial step in talks with the ultimate goal of denuclearization.⁶⁹ Experts backing such an approach argue that a halt to additional nuclear and missile testing would create an opening for a broader dialogue on security issues on the Korean Peninsula, while also slowing Pyongyang's technical progress in these programs and reducing the risks of miscalculation leading to an unintended conflict.

¹ Although North Korea may have a robust biological weapons program as well, it is somewhat unlikely that these weapons would be delivered by missile. See Hyun-kyung Kim, Elizabeth Philipp, and Hattie Chung, “North Korea's Biological Weapons Program: The Known and the Unknown,” Harvard Kennedy School, Belfer Center for Science and International Affairs Report, October 2017.

² “Kim Jong Un Guides Hwasong-12 Launching Drill Again,” KCNA, September 16, 2017.

³ Statement of Young-hwan Ko, Former Official, Ministry of Foreign Affairs, North Korea, from “North Korean Missile Proliferation: Hearing before the Subcommittee on International Security, Proliferation, and Federal Services of the Committee on Governmental Affairs,” U.S. Senate, October 21, 1997.

⁴ For the history of North Korea's ballistic missile program, see Joseph S. Bermudez Jr., “A History of Ballistic Missile Development in the DPRK,” Center for Nonproliferation Studies, Occasional Paper #2 (1999), and Daniel Pinkston, “The North Korean Ballistic Missile Program,” *Strategic Studies Institute* (February 2008), p. 15. There are some skeptics of the reverse engineering hypothesis, who argue that the timeline of events leading to North Korea's development of Scud and Nodong missiles – and the high degree of similarity between these missiles and existing Soviet systems – are inconsistent with the missile development experiences of other countries. See Michael Elleman and Emily Werk, “Can a North Korean ICBM Be Prevented?” *Arms Control Today*, May 2016.

⁵ There are several competing naming systems for North Korea's ballistic missiles, which can create confusion – particularly regarding more recently-introduced missiles. This Issue Brief will try to use the missile names that English-language media use most frequently. For more on naming conventions, see Matt Korda, “The More You Know About North Korean Missiles,” *Arms Control Wonk*, July 31, 2017, <http://www.armscontrolwonk.com/archive/1203680/the-more-you-know-about-north-korean-missiles/>

⁶ Pinkston, “The North Korean Ballistic Missile Program.” This assistance likely came from “rogue” scientists and engineers, rather than with the support of the Soviet/Russian government. In 1992, the Russian government detained a large contingent of Russian scientists from the Makeyev design bureau *en route* to North Korea.

⁷ Joseph S. Bermudez Jr., "The KN-02 SRBM," *KPA Journal*, Vol. 1, No. 2 (February 2010), pp. 7-13.

⁸ Joshua Pollack, "Ballistic Trajectory: The Evolution of North Korea's Ballistic Missile Market," *Nonproliferation Review*, Vol. 18, No. 2 (July 2011). North Korea's increasing military cooperation and missile sales to Myanmar in the late 2000s may have been an exception to this trend.

⁹ See Michael Elleman, "North Korea-Iran Missile Cooperation," *38 North*, September 22, 2016, <http://www.38north.org/2016/09/melleman092216/>; Tal Inbar, "The Ballistic Axis Lives On: Tehran and Pyongyang's Missile Cooperation," *NK Pro*, October 2, 2017, <https://www.nknews.org/pro/the-ballistic-axis-lives-on-tehran-and-pyongyangs-ballistic-missile-cooperation/>

¹⁰ Leon V. Sigal, "The United States and North Korea: Cooperative Security on the Agreed Framework and Beyond," in Richard N. Haass and Meghan L. O'Sullivan, *Honey and Vinegar: Incentives, Sanctions, and Foreign Policy* (Brookings Institution, 2000), p. 87; Jon Brook Wolfsthal, "The Israeli Initiative," *Bulletin of the Atomic Scientists*, Vol. 49, No. 7 (September 1993), pp. 8-9.

¹¹ Gary Samore, "U.S.-DPRK Missile Negotiations," *The Nonproliferation Review* (Summer 2002), p. 17; "U.S. North Korean Missile Talks Collapse Following Defection," *Arms Control Today* (August 1997).

¹² The negotiations were conducted as part of the "Perry Process," a year-long review of U.S. policy options toward North Korea.

¹³ Samore, "U.S.-DPRK Missile Negotiations," p.17-18.

¹⁴ Donald G. Gross, "U.S.-Korea Relations: Slow Start in U.S. Policy toward the DPRK," *Comparative Connections* 1st Quarter 2001, Vol. 3, No. 1 (April 2001), http://csis.org/files/media/csis/pubs/0101qus_korea.pdf.

¹⁵ "Spokesman for DPRK Foreign Ministry on new U.S. administration's policy towards DPRK," *KCNA*, February 22, 2001.

¹⁶ Ministry of Foreign Affairs of Japan, "Japan-DPRK Pyongyang Declaration," September 17, 2002, http://www.mofa.go.jp/region/asia-paci/n_korea/pmv0209/pyongyang.html. A 2002 shipment of North Korean Scuds to Yemen – which was interdicted by the Spanish navy, but allowed to proceed due to the lack of international treaties governing the missile trade – prompted the creation of the Proliferation Security Initiative, a multilateral cooperative project aimed at interdicting the transfer of WMDs.

¹⁷ "North Korea ends missile-test moratorium, raising nuclear stakes," *Agence France-Presse*, March 3, 2005, <http://www.spacewar.com/2005/050303133800.odute9s2.html>

¹⁸ Although the Taepodong-2 missile (or a militarized version of the Unha SLV) could potentially reach the United States, its lengthy fueling time and requirement to be fired from a fixed launch platform would make it highly vulnerable to preemption, nullifying much of its military utility unless Pyongyang were to develop underground siloes from which to base the missile.

¹⁹ "Kim Jong Un's 2017 New Year's Address," *KCNA*, January 2, 2017.

²⁰ The second missile tested, which incorporated an additional pair of vernier engines in its second stage, reached a higher altitude and had a longer flight time than the first, demonstrating a longer potential range. David Wright, "North Korean ICBM Appears Able to Reach US Cities," *All Things Nuclear*, July 28, 2017, <http://allthingsnuclear.org/dwright/new-north-korean-icbm>; John Schilling, "What Next for North Korea's ICBM?" *38 North*, August 1, 2017, <http://www.38north.org/2017/08/jschilling080117/>

²¹ The second test flight, which reached a higher altitude and therefore demonstrated a longer potential range than the first, may have ended with the re-entry vehicle disintegrating several kilometers above the ocean's surface; however, a leaked U.S. intelligence assessment assessed that the re-entry vehicle may have survived if tested on a normal trajectory. See Michael Elleman, "Video Casts Doubt on North Korea's Ability to Field an ICBM Re-entry Vehicle," *38 North*, July 31, 2017, <http://www.38north.org/2017/07/melleman073117/>; Tal Inbar and Uzi Rubin, "Did the Hwasong-14 Really Breakup Upon Re-entry?" *NK Pro*, August 7, 2017, <https://www.nknews.org/pro/did-the-hwasong-14-really-breakup-upon-re-entry/>; and Ankit Panda, "US Intelligence: North Korea's ICBM Reentry Vehicles Are Likely Good Enough to Hit the Continental US," *The Diplomat*, August 12, 2017, <https://thediplomat.com/2017/08/us-intelligence-north-koreas-icbm-reentry-vehicles-are-likely-good-enough-to-hit-the-continental-us/>. On the payload debate, see Theodore A. Postol, Markus Schiller, and Robert Schmucker, "North Korea's 'Not Quite' ICBM Can't Hit the Lower 48 States," *Bulletin of the Atomic Scientists*, August 11, 2017, <http://thebulletin.org/north-korea%E2%80%99s-%E2%80%9Cnot-quite%E2%80%9D-icbm-can%E2%80%99t-hit-lower-48-states11012>; and Uzi Rubin, "The Hwasong-14: 'Not Quite' an ICBM?" *NK Pro*, August 28, 2017, <https://www.nknews.org/pro/the-hwasong-14-not-quite-an-icbm/>.

- ²² Hyonhee Shin and Linda Sieg, "A North Korea Nuclear Test over the Pacific? Logical, Terrifying," *Reuters*, September 16, 2017, <https://www.reuters.com/article/us-northkorea-missiles-atmospheric-test/a-north-korea-nuclear-test-over-the-pacific-logical-terrifying-idUSKCN1BX0W5>
- ²³ As of September 20, 2017, the CNS North Korea Missile Test Database cites six tests of this missile since April 2017, with at least two of them successful. See <http://www.nti.org/analysis/articles/cns-north-korea-missile-test-database/>
- ²⁴ Jonathan Landay, "UPDATE-2 – North Korea Likely Can Make Missile Engines Without Imports – U.S.," *Reuters*, August 15, 2017, <https://www.reuters.com/article/northkorea-missiles-intelligence/update-2-north-korea-likely-can-make-missile-engines-without-imports-u-s-idUSL2N1L11VL>; Michael Elleman, "The Secret to North Korea's ICBM Success," International Institute for Strategic Studies, August 14, 2017, <http://www.iiss.org/en/iiss%20voices/blogsections/iiss-voices-2017-adeb/august-2b48/north-korea-icbm-success-3abb>
- ²⁵ Jeffrey Lewis, "Origins of the Musudan IRBM," *Arms Control Wonk*, June 11, 2012, <http://www.armscontrolwonk.com/archive/205337/origins-of-the-musudan-irbm/>
- ²⁶ Analysis of the one successful test of the Musudan also indicated that it would lack the range to strike U.S. military bases on Guam, North Korea's primary operational requirement in an IRBM. See Ralph Savelsberg and James Kiessling, "North Korea's Musudan Missile: A Performance Assessment," *38 North*, December 20, 2016, <http://www.38north.org/2016/12/musudan122016/>
- ²⁷ For a skeptical view on this missile's capabilities, see Markus Schiller, Robert H. Schmucker, and J. James Kim, "Assessment of North Korea's Latest ICBM Mock-Up," Asan Institute for Policy Studies, Issue Brief, January 14, 2014, <http://en.asaninst.org/contents/assessment-of-north-koreas-latest-icbm-mock-up/>
- ²⁸ John Schilling, Jeffrey Lewis, and David Schmerler, "A New ICBM for North Korea?" *38 North*, December 22, 2015, <http://38north.org/wp-content/uploads/2015/12/38-North-ICBM-Report122215.pdf>
- ²⁹ John Schilling, "North Korea's Large Rocket Engine Test: A Significant Step Forward for Pyongyang's ICBM Program," *38 North*, April 11, 2016, <http://www.38north.org/2016/04/schilling041116/>
- ³⁰ North Korea's initial SLBM tests may have used a liquid-fueled missile – presumably based on the Soviet R-27 – but subsequent tests involved a solid-fueled missile.
- ³¹ Ankit Panda, "The Sinpo-C Class: A New North Korean Ballistic Missile Submarine Is Under Construction," *The Diplomat*, October 18, 2017, <https://thediplomat.com/2017/10/the-sinpo-c-class-a-new-north-korean-ballistic-missile-submarine-is-under-construction/>
- ³² The TPY-2 radar associated with the THAAD system has a 120 degree field of view, allowing it to detect missiles launched from North Korea but not from surrounding seas.
- ³³ "Kim Jong Un Supervises Test Fire of Ballistic Missile," *KNCA*, May 22, 2017, <https://kcnawatch.co/newstream/275064/kim-jong-un-supervises-test-fire-of-ballistic-missile/>
- ³⁴ Michael Elleman, "Kim's Visit to the Chemical Material Institute: A Peek Into North Korea's Missile Future," *38 North*, August 25, 2017, <http://www.38north.org/2017/08/melleman082517/>; Jeffrey Lewis, "DPRK Wound Filament Airframes," *Arms Control Wonk*, April 21, 2017, <http://www.armscontrolwonk.com/archive/1203086/wound-filament-airframes/>. During its April 15, 2017 military parade, Pyongyang displayed heavy trucks carrying two separate types of large launch canisters, which could host new multi-stage solid-fueled ICBMs.
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- ⁴⁶ For competing analysis on the Hwasong-14’s payload and range capabilities, see Postol et al., “North Korea’s ‘Not-Quite’ ICBM,” and David Wright, “Invited Expert Commentary,” *Bulletin of the Atomic Scientists*, August 29, 2017, <https://thebulletin.org/north-korea%E2%80%99s-%E2%80%9Cnot-quite%E2%80%9D-icbm-can%E2%80%99t-hit-lower-48-states11012>. Although the performance of the re-entry vehicles during North Korea’s Hwasong-14 tests is not entirely clear, White House Chief of Staff John Kelly has said that North Korea “has developed a pretty good ICBM capability and is developing a pretty good nuclear reentry vehicle.” See “Press Briefing by Press Secretary Sarah Sanders and Chief of Staff General John Kelly,” *The White House*, October 12, 2017.
- ⁴⁷ John Schilling, “What is True and Not True About North Korea’s Hwasong-14 ICBM: A Technical Evaluation,” *38 North*, July 10, 2017, <http://www.38north.org/2017/07/jschilling071017/>
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1874 (2009)" United Nations Security Council, Document S/2017/742, September 5, 2017, p. 16; and also Panel of Experts February 2017 report, p. 39-40.

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⁶² Although North Korea has not engaged in full-scale hostilities since the end of the Korean War, it has repeatedly engaged in lower-level provocative actions along the DMZ and the contested maritime boundary with South Korea, as well as in various kinds of covert actions and cyberattacks.

⁶³ Several other countries, including South Korea, Japan, and Australia, have also implemented various types of unilateral sanctions measures against North Korea.

⁶⁴ Laura Grego, "No, Missile Defense Will Not Work 97% of the Time," *All Things Nuclear*, Union of Concerned Scientists, October 13, 2017, <http://allthingsnuclear.org/lgrego/missile-defense-will-not-work-97-percent>

⁶⁵ Schilling, "What is True and Not True About North Korea's Hwasong-14 ICBM."

⁶⁶ David E. Sanger and William J. Broad, "Trump Inherits a Secret Cyberwar Against North Korean Missiles," *New York Times*, March 4, 2017; David E. Sanger and William J. Broad, "Hand of U.S. Leaves North Korea's Missile Program Shaken," *New York Times*, April 18, 2017.

⁶⁷ Jeffrey Lewis, "Is the United States Really Blowing Up North Korea's Missiles?" *Foreign Policy*, April 19, 2017, <http://foreignpolicy.com/2017/04/19/the-united-states-isnt-hacking-north-koreas-missile-launches/>

⁶⁸ A Congressional Research Service report indicates that North Korea's conventional artillery alone could kill up to 300,000 people in South Korea in the first days of a new Korean war. A separate report estimates that, if North Korea directed its nuclear arsenal at civilian targets in South Korea and Japan during a war, casualties could reach into the millions. See Kathleen J. McKinnis *et al.*, "The North Korean Nuclear Challenge: Military Options and Issues for Congress," Congressional Research Service, October 27, 2017, <https://fas.org/sgp/crs/nuke/R44994.pdf>; Michael J. Zagurek Jr., "A Hypothetical Nuclear Attack on Seoul and Tokyo: The Human Cost of War on the Korean Peninsula," *38 North*, October 4, 2017, <http://www.38north.org/2017/10/mzagurek100417/>

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