

The Future of North Korean Nuclear Delivery Systems

JOHN SCHILLING
HENRY KAN

APRIL 2015



NORTH KOREA'S
NUCLEAR FUTURES SERIES

US-KOREA INSTITUTE AT SAIS

John Schilling is an aerospace engineer with more than twenty years of experience, specializing in rocket and spacecraft propulsion and mission analysis. Dr. Schilling received his Ph.D. in astronautical engineering from the University of Southern California, and spent most of his career as a contractor for the Air Force Research Laboratory's Propulsion Directorate. He currently works for the Aerospace Corporation as a specialist in satellite and launch vehicle propulsion systems.

Henry (Long) Kan is a Research Assistant at the US-Korea Institute at the Johns Hopkins School of Advanced International Studies (SAIS). His work primarily focuses on nuclear security governance, nuclear command and control systems, and Asia-Pacific maritime security. He holds a B.A. in Political Science and Economics from the University of California, Irvine, where he studied East Asian politics and US national security policy.

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EXECUTIVE SUMMARY

New Delivery Systems Possible if Significant Challenges Are Solved

Pyongyang's inventory of delivery systems is a key factor in considering North Korea's nuclear future. While this inventory is currently based on old Soviet technology only able to reliably reach regional targets, North Korea is seriously pursuing the deployment of more capable, longer-range, more survivable weapons. However, the future course of this effort remains uncertain given technical, engineering and other challenges faced by the North.

Reliable Regional Force

North Korea's current delivery systems consist of about 1,000 ballistic missiles and a small number of light bombers able to reach most targets in South Korea and Japan. This force is comparatively more advanced than most countries at a similar early stage in the development of their nuclear arsenals since ballistic missiles have played an important role in Pyongyang's conventional military strategy for many years. As a result, the current force is more than able to accommodate any future growth in the North's nuclear weapons arsenal, including a worst-case projection of 100 nuclear weapons by 2020.¹

The North's regionally-focused delivery systems include: 1) the Nodong medium-range ballistic missile (MRBM), a mobile liquid-fueled missile with a range of 1,200-1,500 km and accurate enough to attack cities, ports and military bases; 2) a large stockpile of Scud ballistic missiles—also mobile and liquid-fueled—that could carry a nuclear payload 300-600 km; 3) the mobile, solid-fuel KN-02 Toksa short-range ballistic missile (SRBM), based on the old Soviet SS-21 SRBM that was able to carry nuclear, chemical and conventional warheads; and 4) up to 60 Il-28 light bombers built on a 1950s Soviet design.

ICBM in an Emergency

Pyongyang may also be able to field a limited number of long-range Taepodong missiles—a militarized version of the Unha space launch vehicle (SLV)—as an “emergency operational capability,” able to reach targets in the United States. However, such a weapon would represent more of a political statement than an operational capability since it would suffer from significant

¹ For projections, see Joel S. Wit and Sun Young Ahn, “North Korea's Nuclear Futures Project: Technology and Strategy,” US-Korea Institute at the Johns Hopkins School of Advanced International Studies, February 26, 2015, <http://38north.org/2015/02/nukefuture022615/>; and David Albright, “Future Directions in the DPRK's Nuclear Weapons Program: Three Scenarios for 2020,” US-Korea Institute at the Johns Hopkins School of Advanced International Studies, February 26, 2015, <http://38north.org/2015/02/dalbright022615/>.

problems including: 1) vulnerability to attack because of likely basing on an above-ground launch pad; 2) low reliability since its SLV counterpart has only been tested four times and only succeeded once; and 3) a limited ability to deploy an advanced reentry vehicle that would carry a nuclear warhead to its target due to lack of testing. (A possible alternative would be a crude, highly inaccurate, blunt body reentry vehicle similar to those mounted on early American intercontinental ballistic missiles.)

Goals for the Future

Pyongyang conducted a number of significant activities from 2009-2014 that are important indicators of the future direction of its missile program. These activities were:

- The development of new road-mobile missiles with greater ranges—the Musudan intermediate-range ballistic missile (IRBM) and KN-08 intercontinental ballistic missile (ICBM)—that signal an intention to withstand preemption, provide more significant retaliatory options and to target American bases in Guam and the continental United States;
- An effort to develop short-range, sea-based, land-attack missiles that increase survivability, expand the threat to theater targets and complicate defense planning since mobile platforms can launch their weapons from any direction;
- The development of a larger space launch vehicle than the existing Unha SLV—along with the upgrading of the Sohae Satellite Launching Station to launch a new system—as part of what may be an effort to deploy longer-range ballistic missiles; and
- The development of solid-fuel rocket technology through enhancing the range of the KN-02 SRBM, which could yield greater mobility and survivability for future longer-range solid-fuel missiles.

Hurdles to Overcome

The challenges Pyongyang faces in developing new delivery systems over the next five years and beyond are likely to be greater than those encountered in its nuclear program, where basic designs and production infrastructure are already largely in place. Indeed, while Pyongyang's current inventory of older liquid-fueled missiles is impressive, the history of its program, when compared to those in countries like Iran and Pakistan, is characterized by a striking lack of progress over the past few decades. While both countries relied on North Korean assistance in the 1990s to develop the mainstay of their arsenals, both have since diversified their programs by pursuing more advanced medium- and intermediate-range solid-fueled missiles. In comparison, North Korea's experience with solid rocket propellants is much more limited. In short, future challenges could result in slower than anticipated progress or even the cancellation of weapons systems under development.

Particularly important will be North Korea's ability to overcome technological and engineering hurdles that even more advanced industrialized countries would find challenging. In this context, since the North is not self-sufficient in missile production, the level of foreign assistance could

be a critical factor determining how much progress Pyongyang is able to make in technologies such as high performance liquid-fuel engines, solid-fuel rocket motors, high-speed heat shields and reentry vehicles, guidance electronics, sophisticated machine tools and high-strength, lightweight materials. Experienced engineers may also help the DPRK surmount technical hurdles. While Pyongyang has been somewhat successful in securing foreign assistance in the past, whether that will continue remains unclear.

Despite these potential hurdles, it is worth noting that North Korea may have a far less demanding definition of “success” in the development of new missiles than countries like the United States, where extensive tests are conducted before weapons become operational to ensure a high degree of reliability. Other small, emerging nuclear powers have had the same view of new missile delivery systems, deploying them with few flight tests or even though they have experienced technical problems. This practice highlights another important consideration for North Korea (and these other countries), namely that deployments of new delivery systems, even if not fully tested, can have an important political purpose in sending deterrence signals to potential adversaries.

Three Scenarios for 2020

As in the nuclear projections for this study, three scenarios for the development and deployment of delivery systems reflecting different political, economic, technological and other assumptions help define future possibilities:

- ***Minimal Modernization***: North Korea’s development of new delivery systems slows, resulting in a force that remains essentially the same as it is today. Nevertheless, Pyongyang may be able to make some improvements. First, it could deploy short-range, sea-launched cruise and ballistic missiles on surface ships or cruise missiles on submarines based on existing weapons, possibly the KN-01 naval cruise missile or the KN-02 SRBM. Second, Pyongyang could deploy the Musudan IRBM in an emergency operational capability. While the missile has not yet been flight tested, the North has already conducted extensive development activities. Indeed, the Musudan may already have been deployed in an emergency operational status during the 2013 crisis on the Korean peninsula if media reports are accurate.
- ***Steady Modernization***: North Korea continues its current development and deployment path, resulting in a greater regional threat than in the first scenario and the emergence of a more credible intercontinental threat. In the theater, greater numbers of sea-based systems would be deployed. Pyongyang may also develop an emergency operational capability to field a ballistic missile submarine. On land, the Musudan IRBM becomes an operational system after a limited number of flight tests and an enhanced range KN-02 SRBM is deployed to supplement existing Scud missiles. In addition, Pyongyang may decide to deploy countermeasures to cope with evolving theater missile defenses deployed by the United States, South Korea and Japan, most of which focus on intercepting missiles inside the atmosphere. This will require emplacing rocket-powered darts as decoys on missiles—such as the Nodong—and flight testing to ensure the system works. A more

credible intercontinental threat would consist of the KN-08 ICBM, now available on an emergency basis as it moves towards becoming an operational weapon and possibly Taepodong ICBMs deployed in more survivable hardened missile silos.

- **Maximum Modernization:** North Korea accelerates the development and deployment of new systems, resulting in a more rapidly emerging regional and intercontinental threat. In the theater, the Musudan IRBM would achieve an earlier initial operating capability and deployments of missiles would increase. A solid-fuel missile with a range of 300 kilometers intended to replace the Scud becomes operational. Pyongyang might also deploy its first operational sea-launched ballistic missile submarine armed with weapons based on the Nodong MRBM or Musudan IRBM. On the intercontinental level, the KN-08 ICBM would reach an initial operational capability with growing numbers deployed by 2020, though numbers would still probably be limited by the availability of critical components, particularly engines. Finally, since the program would achieve considerable momentum beyond 2020, further developments, previously over the time horizon, might include a longer-range ICBM utilizing new high-energy engines that could reach targets anywhere in the United States, more sophisticated guidance systems that would substantially increase accuracy and a solid-propellant replacement for the Nodong MRBM.

A Final Word

The dangers posed by North Korea's continuing effort to develop new nuclear delivery systems are clearly real, although more uncertain than nuclear weapons estimates, given the various technological hurdles Pyongyang will have to overcome in the future. Nevertheless, even if North Korea was severely limited in its ability to further develop a direct threat to the United States beyond probably a handful of ICBMs based on old Soviet technology, its existing inventory of approximately 1,000 missiles has sufficient reliability and range to cover most important targets in Northeast Asia. Moreover, the number of systems likely exceeds even the worst-case estimate for North Korea's nuclear inventory in this study—that the North could field 100 nuclear weapons by 2020. In short, North Korea has already achieved a level of delivery system development that will allow it to establish itself as a small nuclear power in the coming years.

THE FUTURE OF NORTH KOREAN NUCLEAR DELIVERY SYSTEMS

Introduction

Pyongyang's inventory of delivery systems is a key factor in considering North Korea's nuclear future. While its current inventory is well developed, although limited to old Soviet technology only able to reach regional targets, North Korea has bigger ambitions and is seriously pursuing the deployment of more capable, longer-range, more survivable weapons. However, the future of its nuclear delivery systems remains uncertain given technical, engineering and other challenges the North will have to face.

The 2014 Baseline

Pyongyang's current inventory of delivery systems, consisting largely of ballistic missiles with some light bombers, is reliable and nominally able to reach most targets in Northeast Asia. Moreover, it is comparatively more advanced than most countries at a similar early stage in the development of their nuclear arsenals. This is the result of: 1) the North's long-standing requirement to acquire ballistic missiles armed with conventional explosives and chemical warheads as part of its defense strategy; 2) the continued development of these weapons even though the North's plans to deploy large numbers of nuclear weapons were set back by the 1994 US-DPRK Agreed Framework; and 3) the long-standing perceived threat from the United States, a major driving force behind Pyongyang's efforts to build an intercontinental ballistic missile (ICBM) based on a space launch vehicle program in the 1990s.

Intercontinental Ballistic Missile (ICBM) in an Emergency

North Korea may already be able to deploy a Taepodong-2 ICBM—essentially a three-stage military version of the Unha space launch vehicle (SLV) that could carry a 500-1,000 kg warhead 10,000-15,000 km, far enough to reach the US mainland—in an “emergency operational status.”² However, such a weapon would represent more of a political statement than an operational capability since it would suffer from potentially significant problems including:

- Low reliability given the very limited number of tests of its SLV counterpart and the high percentage of failures—three out of four flights;

² If the DPRK fields a Taepodong, the Scud engine used in its second stage might result in unnecessary gravity losses that could rob the missile of as much as 800 km of range. An alternative would be to configure the ICBM with a second stage powered by the Nodong or the R-27 rocket engine likely to be used by the Musudan IRBM. Indeed, the second stage airframe has dimensions that match those of the Soviet R-27 engine.

- Vulnerability to a preemptive strike since it would probably be deployed at an above-ground facility;³ and
- A limited ability to operationally deploy a relatively advanced reentry vehicle due to lack of testing—the weapon would probably have to use a crude and highly-inaccurate blunt body reentry vehicle (RV) similar to those on early American ICBMs (the Thor and Atlas systems) in the 1950s, making it more vulnerable to missile defenses.⁴

Figure 1: Blunt body reentry vehicle on an Atlas missile.



Photo: Air Force Space and Missile Museum.

Reliable Regional Delivery Systems

The overwhelming majority of North Korea's delivery systems are about 1,000 ballistic missiles based on old Soviet technology. The backbone of its current deterrent is the Nodong medium-range ballistic missile (MRBM) with a range of 1,200-1,500 km that can reach any target in

³ Other countries, including the Soviet Union, have deployed their first ICBMs in such a manner probably in large part to send a political message to potential opponents.

⁴ Based on observations of missiles on parade in Pyongyang, the North appears focused on developing a triconic design intended to make the RV more stable during reentry into the Earth's atmosphere. Iran first tested a Shahab-3 with a triconic design in 2004 while North Korea first paraded a Nodong with a similar nose cone in 2010. The timing suggests that Iran may have transferred the design feature to North Korea. However, it is also possible that the design was first suggested by North Korea and then tested and further developed by Iran. It is worth noting that the Nodong with the triconic nose cone paraded by North Korea did not include a number of the new missile design features developed by Iran during the early to mid-2000s. The general shape is also similar to early-generation French warheads found on IRBMs. Moreover, the design allows the same warhead to be interchangeable with the Scud missile. It is also unknown how much development work has already been done using publicly available information and computer simulations.

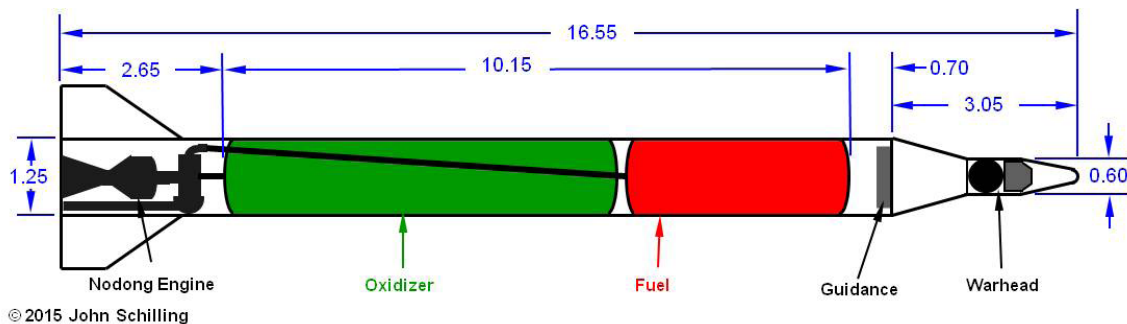
South Korea and most of Japan.⁵ While mobile and probably capable of cross-country travel, the Nodong can also be tucked away in one of the North's many underground tunnels and bunkers. Based on early 1960s Soviet technology, it is an effective, reliable weapon accurate enough to hit within one or two kilometers of targets, enough to destroy cities, ports or military bases.⁶

Figure 2: Nodong with a triconic reentry vehicle.



Photo: AP/Vincent Yu.

Figure 3: Nodong internal configuration.



In addition to the North's large stockpile of old shorter-range Scud missiles able to carry a nuclear payload 300-600 km, Pyongyang has begun to field the newer KN-02 Toksa solid-fuel, road-mobile missile. Derived from a 1980s vintage Soviet weapon and probably available in only limited numbers, the shorter-range Toksa is a more responsive, accurate and mobile

⁵ This range is based on the assumption that the Nodong would carry a 700-750 kg warhead/RV and incorporate improvements as a result of cooperation with Pakistan and Iran. North Korean engineers are believed to have been present during Pakistan and Iranian tests in the late 1990s and early 2000s. Moreover, the Nodong has been spotted in parades with the triconic RV also used by Iran, although later improvements made by Tehran do not seem to have been incorporated into the North Korean design.

⁶ Expert estimates vary on reliability from 75 to 90 percent.

system by virtue of its solid fuel. The older Soviet model was able to carry nuclear, chemical and conventional warheads, but it remains unclear whether the Toksa is intended for the nuclear mission.

Figure 4: The KN-02 Toksa.



Photo: AP/KCNA.

Finally, North Korea's up to 60 Il-28 light bombers built to a 1950s Soviet design would be a capable delivery system. Individual airplanes would have significant trouble penetrating modern air defenses, but with the element of surprise or attacking in large numbers, a few could possibly penetrate to their targets. The Il-28 might also be able to reach American installations on Guam, the site of a major air base and logistics hub currently out of range of North Korea's missiles, on a one-way mission. However, such an attack would be detected far in advance by US, Japanese and ROK air defenses.

Figure 5: Soviet Il-28 Beagle.



Photo: Aircraft Information.

Delivery Systems under Development

North Korea appears to have an ambitious development program focusing on a number of new systems including:

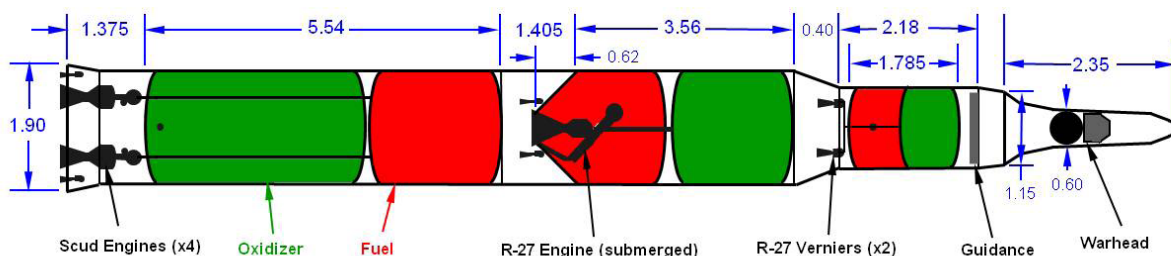
- KN-08 road-mobile intercontinental ballistic missile (ICBM):** Development of this missile began in the late 1990s or early 2000s. While the KN-08 design is original to North Korea, it likely incorporates technologies from the Musudan IRBM and Unha SLV. The KN-08's interior configuration is still subject to speculation. Recent analysis⁷ suggests a range of 7,500-9,000 km, enabling it to reach the West Coast of the United States carrying a warhead package of 500-700 kg. Accuracy would likely be barely adequate to target large cities, mobility would be limited to paved roads, and the system will require 1-2 hours for pre-launch fueling. Some analysts believe the KN-08 is part of North Korea's strategic deception effort since it has not been flight tested but there are reports of ground testing of the missile's first-stage engines. The KN-08 may achieve an "emergency operational status" by 2020 before or with very limited flight testing.

Figure 6: KN-08 mock-up from a July 2013 parade.



Photo: AP/David Guttenfelder.

Figure 7: KN-08 internal configuration.



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- Large liquid-fueled space launch vehicle:** Pyongyang has announced its intention to build an SLV larger than its existing Unha SLV over the next five years. Moreover, beginning in late 2013, the North embarked on a year-long program to upgrade the launch

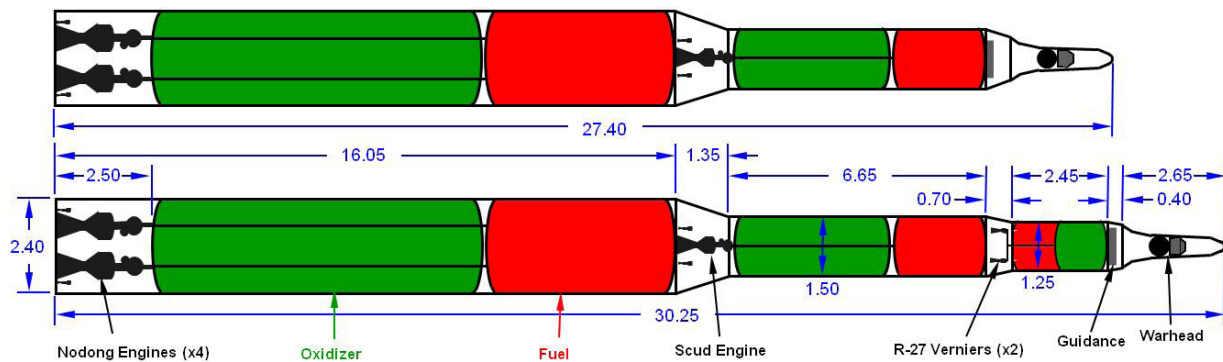
⁷ John Schilling, "Where's that North Korean ICBM Everyone was Talking About?" *38 North*, March 12, 2015, <http://38north.org/2015/03/jschilling031215/>.

gantry at the Sohae Satellite Launching Station to handle a new larger rocket.⁸ While probably intended to place larger satellites into higher orbits, the new SLV may also contribute to the further development of the North’s long-range missile program through the testing of common technologies such as high-energy rocket engines, guidance system components and even reentry vehicles (in a sub-orbital mode). A new SLV might also serve as an interim ICBM, supplementing or replacing any deployed Taepodongs.

Figure 8: Artist’s concept of a possible larger North Korean rocket.



Figure 9: Postulated military versions of the Unha-3 space launch vehicle.



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⁸ “Major Construction at the Sohae Rocket Test Site,” *38 North*, August 30, 2013, <http://38north.org/2013/08/sohae083013/>.

- Musudan road-mobile intermediate-range ballistic missile (IRBM):** Pyongyang appears to be moving towards the deployment of this single-stage missile, a slightly longer variant of the old Soviet SS-N-6 sea-launched ballistic missile that incorporates technology from that system.⁹ With a range of 2,500-3,500 km, depending on the weight of its warhead (500-1,000 kilograms), the missile could reach all of East Asia, including important American bases on Guam and Okinawa. While some experts claim the Musudan is also a strategic deception since the system has not yet been flight tested, it seems more likely that it is a work in progress. Indeed, there have been reports that the missile may have already been deployed.¹⁰ Moreover, during the 2013 crisis on the peninsula, media reports indicated that the Musudan had been spotted in the field, possibly preparing for a flight test although such a test never took place.¹¹

Figure 10: Musudan missiles seen in military parades in Pyongyang.

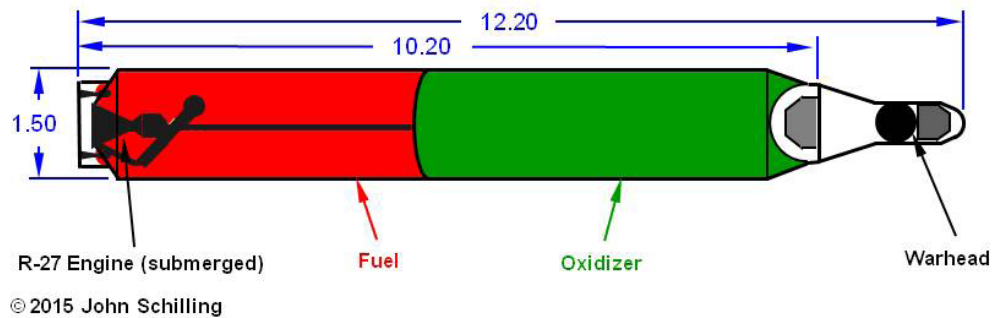


Photo: Korean Central News Agency.

⁹ 150 SS-N-6 missiles remain unaccounted for from the old Soviet inventory and Russian engineers who designed the weapon are known to have worked in North Korea.

¹⁰ Small nuclear powers have in the past deployed nuclear-capable missiles with very limited flight testing. This practice is especially common during the early stages of a country's missile program, when the deployment of nuclear-capable ballistic missiles serves as more of a political tool rather than a tactical military asset. According to some experts, Israel is said to have deployed and armed the Jericho-I missile during the 1973 Yom Kippur War before the system was fully operational possibly to induce action from the United States or to send a signal to Egypt and Syria. Early deployment is also often pursued by countries with financial limitations and time constraints. Pakistan's Ghauri-I missile, for example, has only been tested around ten times since 1998 and continues to suffer from reliability issues.

¹¹ See Kim Eun-jung, "N. Korea loads two medium-range missiles on mobile launchers," *Yonhap*, April 5, 2013, <http://english.yonhapnews.co.kr/national/2013/04/05/59/0301000000AEN20130405004351315F.html>.

Figure 11: Musudan external configuration.

- New solid-fuel missiles:** The Toksa SRBM could serve as a test bed for the development of longer-range, solid-fuel missiles, possibly to replace the Scud, that would have distinct advantages—greater mobility and the ability to launch within minutes—over Pyongyang’s current liquid-fueled inventory. North Korea already has extensive experience producing small solid-fuel rockets. Moreover, in mid-2014, it conducted a series of tests of an extended-range Toksa able to fly 160-200 km. However, it is unclear whether those tests reflect the use of a higher-energy solid propellant, a lightening of the missile’s payload or flying the weapon at minimum energy trajectories. Cooperation with Iran, which has already developed such missiles, may represent a more promising alternative path for North Korea.
- Sea-launched land-attack missiles:** Commercial satellite imagery, ROK official statements and other press reports indicate that Pyongyang may be developing a capability to launch ballistic or cruise missiles from surface or cargo ships and from submarines.¹² In the near term, Pyongyang might be able to develop the ability to launch existing short-range cruise or ballistic missiles from sea-based platforms. However, development and deployment of longer-range weapons, particularly submarine-launched ballistic missiles may still be years away. Sea-based land-attack missiles would increase the survivability of North Korea’s nuclear forces, expand its threat to South Korea, Japan and US bases in East Asia and complicate missile defense planning since a mobile platform would be able to attack targets from any direction.

¹² See Joseph S. Bermudez Jr., “The North Korean Navy Acquires a New Submarine,” *38 North*, October 19, 2014, <http://38north.org/2014/10/jbermudez101914/>; and Joseph S. Bermudez Jr., “North Korea: Test Stand for Vertical Launch of Sea-Based Ballistic Missiles Spotted,” *38 North*, October 28, 2014, <http://38north.org/2014/10/jbermudez102814/>.

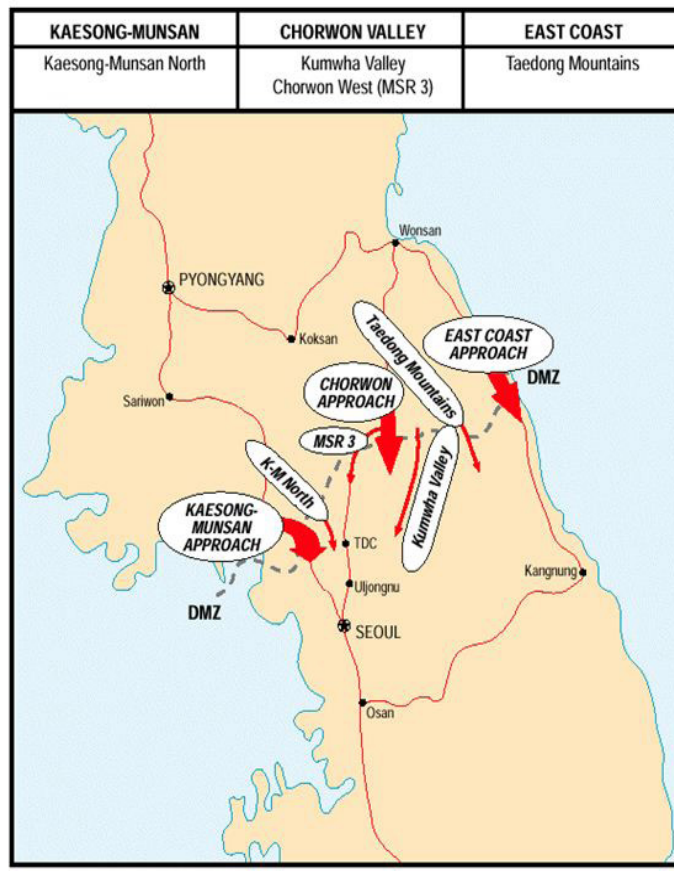
Figure 12: The new Sinpo-class submarine with an opening in the conning tower that may house 1-2 small vertical launch tubes.



Note: image rotated. Image © 2014 DigitalGlobe, Inc. Annotations by 38 North. All rights reserved.

- **Unconventional delivery options:** North Korea could attempt to deliver nuclear weapons covertly. Doing so, however, would have significant drawbacks, particularly the requirement for a pre-delegation of authority to use the weapon down to the small unit level that would be contrary to the expected preferences of an authoritarian North Korean regime. Two possibilities could be:
 1. The placement of nuclear devices on the Korean peninsula in narrow invasion routes leading into the North in order to block and stun invading forces. In the short term, this approach seems unrealistic since the number of devices needed to accomplish this objective could exceed the North's current small arsenal; and

Figure 13: Avenues of approach across the DMZ.



Avenues of Approach

North Korea Country Handbook, Defense Intelligence Agency.

2. The covert delivery of a nuclear weapon by container ship is also possible given the North’s history of using merchant vessels to deploy special operations forces around the world dating back to the 1970s. However, this option also seems implausible because of concerns over command and control as well as the North’s lack of commercial interaction with most potential target countries and the dangers of discovery beforehand.

Figure 14: North Korean bulk carrier ship *Chong Chon Gang* (9000 GRT).



Photo: Maritime Traffic.

Future Developments: Significant Hurdles Must Be Overcome

Delivery systems that appear to be under development are an important indicator of North Korea's objectives for the future of its force. If the North continues to move down this road, it will likely focus on the following improvements.

- **Increase range, accuracy and reliability:** North Korea's nuclear delivery systems suffer from limitations in all three areas. While its current systems are capable of reaching most regional targets, improvements in range would allow the North to reach new ones outside the immediate theater, such as Guam, Okinawa, Hawaii or the West Coast of the United States. Better accuracy would open up the possibility of attacking a larger target set beyond soft targets such as cities or large military bases. Improving reliability would provide greater confidence that the missiles would reach and destroy their targets.

In this context, testing—ground, but especially flight testing—will play a critical role, particularly if the North is seeking to deploy more sophisticated delivery systems using high-performance engines and high-speed reentry vehicles. Indeed, testing missiles equipped with these technologies will require establishing a limited infrastructure, such as including downrange ships to monitor data, that may prove challenging.

- **Increase survivability:** Given the limited size of Pyongyang's nuclear arsenal, increasing survivability is essential to withstanding preemptive strikes and to providing significant retaliatory responses. The North's current delivery systems—largely focused on mobile liquid-fueled Nodong MRBMs—would prove difficult to destroy in a preemptive strike. Nevertheless, Pyongyang could take a number of steps to improve survivability, including: 1) basing any Taepodong ICBMs in hardened silos rather than on an above-

ground launch pad;¹³ 2) deploying solid-fueled missiles that allow full off-road mobility and the ability to launch with a few minutes' notice; and 3) basing on ships or submarines that are more difficult to track.

- **Diversify delivery systems:** Diversification of different basing modes—the underlying principle of the US strategic triad of air, land and sea-based weapons—would complicate any effort to launch a preemptive strike, since destroying systems in a short time frame would prove extremely difficult. Second, diversification of different delivery systems could provide greater flexibility/options for the use of nuclear weapons whether on the battlefield, in the theater or directly against the United States.
- **Achieve greater self-sufficiency:** While Pyongyang has built a strong indigenous capability to deploy missiles, largely based on Russian technology and assistance, it has not yet proven itself able to replicate advanced components acquired from abroad, such as Russian high-energy propellant engines, or to move beyond these technologies. In contrast, Iran, Pakistan and other countries with active missile programs have developed more advanced designs, including long-range solid-fueled rockets.

The challenges Pyongyang faces in developing new delivery systems over the next five years and beyond are likely to be greater than those encountered in its nuclear program, where basic designs and production infrastructure are already largely in place. These challenges could result in slower than anticipated progress or even the cancellation of weapons systems under development.

Particularly important will be North Korea's ability to overcome technological and engineering hurdles that more advanced industrialized countries would find daunting. In this context, since the North is not self-sufficient in missile production, the level of foreign assistance could be a critical factor determining how much progress Pyongyang is able to make in critical technologies such as high-performance liquid-fuel engines, solid-fuel rocket motors, high-speed heat shields and reentry vehicles, guidance electronics, sophisticated machine tools and high-strength, lightweight materials. Experienced engineers may also help the DPRK surmount technical hurdles. While Pyongyang has been successful in securing foreign assistance in the past, whether that can continue remains unclear.

Despite all these potential hurdles, it is worth noting that North Korea may have a far less demanding definition of “success” in the development of new missiles than countries like the United States, whose systems are extensively tested before becoming operational to ensure a high degree of reliability. Other small, emerging nuclear powers have had the same view of new missile delivery systems, deploying them with few flight tests or even though they have

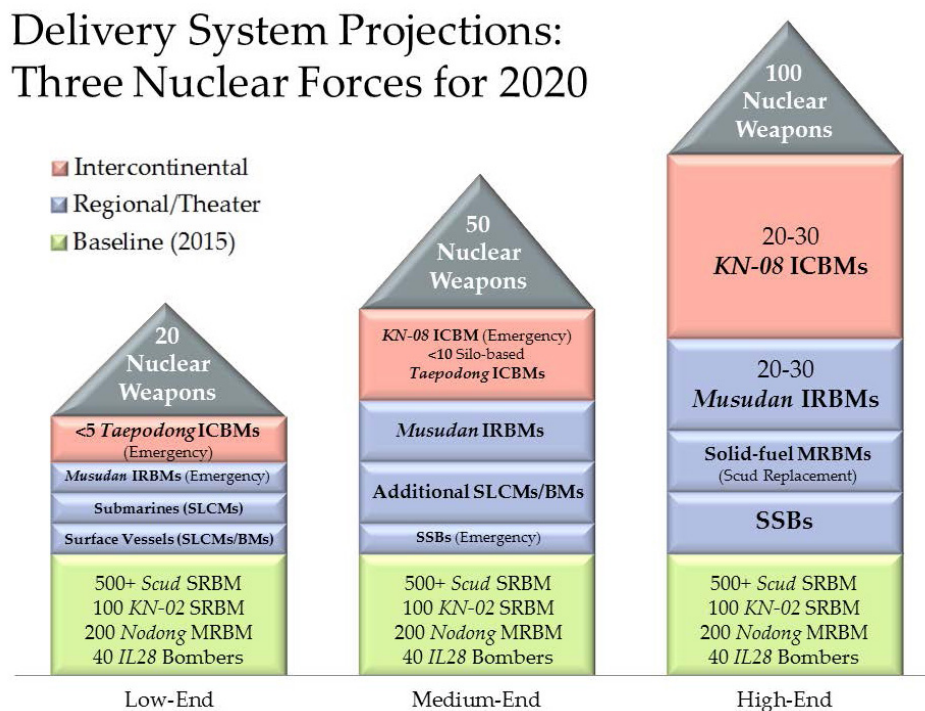
¹³ North Korea has deployed anti-aircraft missiles and radars in small hardened silos since the 1970s. Moreover, Pyongyang has also explored the possibility of basing ballistic missiles in a similar manner since the early 1990s and its scientific literature suggests the North understands key engineering challenges posed by this technology. Speculation has focused on the possibility of silo-basing near the Chinese border for a number of reasons. First, the DPRK military may believe this area is more secure than any other in the North since the US and its allies never reached this area during the Korean War. Second, there may be a view that since this area is close to the Chinese border, the US and South Korea would be reluctant to conduct operations there for fear of dragging the Chinese into a conflict. Finally, the North has already located a number of important defense production facilities in this region, particularly in the northern area.

experienced technical problems. This practice highlights another important consideration for North Korea (and these other countries), namely that deployments of new delivery systems, even if not fully tested, can have an important political purpose in sending deterrence signals to potential adversaries.

Bounding the Problem: Three Scenarios for 2020

In view of the uncertainties in predicting the future of North Korea’s delivery systems, projecting low-end, medium and high-end scenarios—taking into consideration the current baseline force, possible key technical objectives and critical determining factors—will provide an illustrative band of possibilities within which a future DPRK nuclear delivery force is more likely to fall.

Figure 15: Delivery System Projections: Three Nuclear Forces for 2020.



Scenario 1: Minimal Modernization

Pyongyang is only able to make marginal improvements; its deterrent remains almost entirely focused on effectively threatening neighbors while posing a symbolic threat to the United States. This scenario assumes that:

- North Korea’s test program remains extremely limited. Testing is confined to existing medium- or shorter-range missiles and some limited testing of subsystems such as rocket engines. There are no further launches of SLVs and no tests of new intermediate- and intercontinental-range mobile missiles or key technologies such as reentry vehicles.

- North Korea’s ability to access foreign technologies and assistance is significantly constrained. Sanctions and export controls become increasingly effective. Moreover, the North is unable to secure help from foreign scientists and cooperation with other countries—such as Iran—does not yield benefits.
- Pyongyang’s level of political and economic commitment could remain high but it may not be able to overcome the limitations imposed on its program by technical and other realities. Alternatively, the level of commitment may lessen because of economic hardships, a decision by Pyongyang that the existing mix of delivery systems is sufficient for its purposes or a changing external security environment that diminishes the need for continued development.

Nevertheless, North Korea may seek to make minimal improvements to the baseline force including two possible new developments:

- North Korea could deploy short-range sea-launched ballistic and cruise missiles. This threat could include merchant ships carrying either type of weapon or the first operational submarine-launched cruise missile.¹⁴ Given the technological challenges in developing such a capability, these weapons would be based on existing North Korean systems, such as the 160 km KN-01 naval cruise missile or the KN-02 SRBM.
- The road-mobile Musudan IRBM could be deployed in an “emergency operational status.” Despite the lack of full-scale flight tests, the North has already conducted extensive development activities for this missile that might enable such a deployment over the next five years if not sooner. Indeed, the reported Musudan deployments in early 2013 as part of escalating tensions on the peninsula may mean that missile has already achieved an emergency status.

Scenario 2: Steady Modernization

North Korea moves forward slowly with the development of new delivery systems able to reach targets in Northeast Asia and the United States, essentially continuing down its current path. This scenario assumes that:

- Pyongyang tests long-range SLVs, at its current pace of about two to three launches every three years. These launches possibly include a new rocket that might be used to test more advanced propulsion and other technologies. The KN-08 ICBM is also flight tested and may serve the same purpose, along with the development of more advanced reentry vehicles. Theater-range testing would include one or two launches of the new road-mobile Musudan IRBM as well as further development of solid-fuel engine technology.

¹⁴ The United States and the Soviet Union explored the possibility of ballistic missile basing on merchant ships during the early years of the Cold War. Iran has demonstrated this capability and North Korea is believed to have studied this option in the past. Recent commercial satellite imagery, ROK government statements and press reports seem to confirm an active effort by the North in this area although that is certainly no guarantee that the program will produce operational results.

- North Korea's ability to acquire foreign technology is slowed by sanctions and export controls but Pyongyang's efforts to secure technology and engineering assistance abroad are still moderately successful. In that context, continued cooperation with Iran yields benefits for its program, particularly solid-fuel technology that could form a foundation for developing systems with longer ranges than the Toksa SRBM in the future.
- Pyongyang's level of political and economic commitment to its WMD and missile programs continues, made possible in part by ongoing steady improvements in the civilian economic sector achieved through gradual reform and interactions with China, Russia and other countries.

As a result, the regional threat becomes even greater than in the first scenario and an operational intercontinental threat begins to emerge. In the theater, in addition to possibly deploying more land-attack cruise missiles on submarines and surface ships as well as ballistic missiles on surface vessels, Pyongyang may develop an emergency operational capability to launch short-range ballistic missiles from submarines. On land, the Musudan IRBM becomes operational after flight testing. An enhanced range KN-02 solid-fueled short-range missile intended to supplement the 300 km Scud might also become operational. In addition, Pyongyang may decide to deploy countermeasures to cope with evolving theater missile defenses deployed by the United States, South Korea and Japan, most of which focus on intercepting missiles inside the atmosphere. This will require emplacing rocket-powered darts as decoys¹⁵ on missiles such as the Nodong and flight testing to ensure the system works.

On the intercontinental level, Pyongyang might consider limited permanent deployments of the Taepodong in hardened silos. Initial flight testing of the KN-08 may allow the North to field that system in an emergency operational status intended mainly for political demonstrations (reliability would be limited to 30-50 percent). The North might also use SLV launches, particularly of a new larger rocket, to further develop advanced technologies that could have applications in military systems.

Scenario 3: Maximum Modernization

North Korea accelerates the deployment of theater and intercontinental delivery systems and begins to explore fielding even more advanced weapons. This scenario is based on the following assumptions:

- Pyongyang pursues an aggressive flight test schedule of three to four launches per year of long-range rockets that yields important technical advances in deploying new systems.
- North Korea is successful in securing hardware and assistance overseas to reinforce its stepped-up flight test program. Cooperative programs with Iran yield important benefits and the North is able to secure additional assistance from foreign governments or individual experts.

¹⁵ The much simpler balloon or chaff-type countermeasures often suggested for countering anti-ICBM missile defenses would be inadequate for these shorter-ranged systems as they would be rapidly decelerated by the atmosphere during the engagement phase.

- Pyongyang's political and economic commitment to these programs increases, possibly as a result of an increased security requirement to enhance the credibility of its deterrent and/or the availability of greater resources due to successful efforts to develop its economy.

In this scenario, a growing theater and intercontinental threat emerges more rapidly. In the theater, the Musudan IRBM achieves an initial operating capability and deployments of missiles increase by 2020. A solid-fuel missile with a range of 300 km intended to replace the Scud becomes operational. Pyongyang might also deploy its first operational sea-launched ballistic missile submarine armed with weapons based on the Nodong MRBM or Musudan IRBM.¹⁶ On the intercontinental level, the KN-08 ICBM reaches an initial operational capability with growing numbers deployed by 2020, though it will probably be limited by the availability of critical components, particularly engines.

Also under this scenario, Pyongyang's missile development program could accelerate with previously over-the-horizon programs becoming more visible by 2020. These programs could include: 1) a second-generation KN-08 ICBM with greater range, utilizing new high-energy engines that could reach targets anywhere in the United States rather than being limited to the West Coast; 2) more sophisticated guidance systems that would substantially increase accuracy; 3) a solid-propellant replacement for the Nodong MRBM; and 4) additional ballistic missile submarines.

A Final Word

Pyongyang's program for developing new nuclear delivery systems, while ambitious, could easily experience difficulties in the future. Much will depend on the critical factors mentioned earlier, particularly its ability to overcome technological and engineering hurdles that, in turn, may depend a great deal on its ability to acquire technology and assistance abroad. Given these potential difficulties, the level of the regime's political/economic commitment to the program will be critical as well. All of these factors are likely to play a much bigger role in the future of North Korea's missile program than in the future of its already proven nuclear weapons program. Moreover, they could result in not just slower progress, but also in the cancellation of new systems under development.

Indeed, when Pyongyang's program is compared to those of countries like Iran and Pakistan, the lack of progress over the past few decades is striking. Both countries relied on North Korean assistance in the 1990s to develop the mainstay of their arsenals—Iran's Shahab missile and Pakistan's Ghauri missiles—that were derived from North Korea's liquid-fueled Nodong. However, both have since made efforts to diversify their programs by pursuing medium- and intermediate-range solid-fueled missiles. Iran's Sejil, a solid-fueled two-stage missile first tested in 2008, is estimated to be in the final stages of development and is believed by some observers to be a replacement for the Shahab that will be more survivable and transportable. Similarly, Pakistan already fields limited numbers of the solid-fueled Shaheen-I and has been developing a longer-range variant, the Shaheen-II, which was test fired in 2004. In comparison, North Korea's

¹⁶ Such a development would probably require foreign assistance from countries or individuals with experience in building ballistic missile submarines.

experience with solid rocket propellants is much more limited, with the overwhelming majority of its arsenal still based on old Soviet technologies and—with the exception of the KN-02—mostly liquid-fueled.

While failure of Pyongyang's development program would severely limit its ability to further develop a direct threat to the United States beyond probably a handful of ICBMs based on old Soviet technology, its existing inventory of approximately 1,000 missiles has sufficient reliability and range to cover most important targets in Northeast Asia. Moreover, the number of systems likely exceeds even the worst-case estimates for North Korea's nuclear inventory by 2020. In short, North Korea has already achieved a level of delivery system development that will allow it to establish itself as a small nuclear power in the coming years.

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US-Korea Institute at SAIS
Johns Hopkins University
1717 Massachusetts Avenue NW, 6th Fl
Washington, DC 20036
www.uskoreainstitute.org