Korean Missile Forces

By Anthony H. Cordesman
With the assistance of Charles Ayers and Aaron Lin

Working Draft: November 7, 2016
Please provide comments to acordesman@gmail.com

Cover: Missile Defense Agency via Flickr
<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overview of DPRK Missile Developments</td>
<td>3</td>
</tr>
<tr>
<td>How Capable Are the DPRK’s Missiles?</td>
<td>4</td>
</tr>
<tr>
<td>Uncertainties</td>
<td>6</td>
</tr>
<tr>
<td>Figure IV.1: DPRK Ballistic Missile Arsenal</td>
<td>8</td>
</tr>
<tr>
<td>Figure IV.2: ROK Ministry of National Defense Estimates of DPRK Missile Range</td>
<td>9</td>
</tr>
<tr>
<td>Figure IV.3: Japanese Ministry of Defense Estimates of DPRK Missile Range</td>
<td>10</td>
</tr>
<tr>
<td>DPRK Missile Programs</td>
<td>10</td>
</tr>
<tr>
<td>The Hwasong and Toksa Programs</td>
<td>12</td>
</tr>
<tr>
<td>The Nodong</td>
<td>13</td>
</tr>
<tr>
<td>Taepodong-1</td>
<td>13</td>
</tr>
<tr>
<td>Taepodong-2</td>
<td>14</td>
</tr>
<tr>
<td>Recent Taepodong launches</td>
<td>15</td>
</tr>
<tr>
<td>The Taepodong’s Potential Re-Entry Capabilities</td>
<td>16</td>
</tr>
<tr>
<td>US, ROK, Japanese, and UN Responses to DPRK Launches</td>
<td>17</td>
</tr>
<tr>
<td>The Musudan</td>
<td>18</td>
</tr>
<tr>
<td>The KN-08/Hwaseong-13</td>
<td>19</td>
</tr>
<tr>
<td>Submarine Launched Ballistic Missile (SLBM) Program</td>
<td>21</td>
</tr>
<tr>
<td>Figure IV.4: KN-08 ICBM Related Testing</td>
<td>21</td>
</tr>
<tr>
<td>Figure IV.5: US Estimates of Primary North Korean Missiles</td>
<td>24</td>
</tr>
<tr>
<td>Figure IV.6: Estimates of DPRK Hwasong and Nodong Missile Range – Northeast Asia</td>
<td>25</td>
</tr>
<tr>
<td>DPRK Missile Facilities</td>
<td>26</td>
</tr>
<tr>
<td>Figure IV.8: Possible Locations of DPRK Nuclear Warhead and Missile Facilities</td>
<td>28</td>
</tr>
<tr>
<td>DPRK Air Defense and Counter-Space Capabilities</td>
<td>29</td>
</tr>
<tr>
<td>ROK Missile Development</td>
<td>29</td>
</tr>
<tr>
<td>The Early Program – The NHK Program</td>
<td>29</td>
</tr>
<tr>
<td>The 2001 MTCR and the Hyunmu-3 Cruise Missile</td>
<td>30</td>
</tr>
<tr>
<td>Further Revisions to the ROK’s Missile Limitation Agreement</td>
<td>32</td>
</tr>
<tr>
<td>ROK Missile Defense and Space</td>
<td>32</td>
</tr>
<tr>
<td>Missile Defense - The Korean Air and Missile Defense (KAMD) System</td>
<td>32</td>
</tr>
<tr>
<td>Missile Defense - THAAD</td>
<td>34</td>
</tr>
<tr>
<td>Space</td>
<td>35</td>
</tr>
<tr>
<td>Conclusions</td>
<td>35</td>
</tr>
</tbody>
</table>
The two Koreas have made very different political and military decisions in creating their missile forces. The Democratic People’s Republic of Korea (DPRK) has placed far more emphasis on missile forces, although recent developments in the Republic of Korea (ROK) indicate that this may be changing. Long-range artillery, rockets, and missiles help the DPRK threaten and deter South Korea and the United States, and help compensate for the weaknesses in DPRK airpower. They also provide a potential means to deliver the DPRK’s nuclear weapons and other weapons of mass destruction.

**Overview of DPRK Missile Developments**

The DPRK has given high priority to the development of ballistic missiles for a wide range of reasons. They include political and diplomatic considerations, earning foreign currency, and enhancing DPRK military capabilities on both a regional basis and in an effort to shape the Korean military balance in its favor.

According to a US Forces Korea (USFK) report in 2010,¹

> [T]he North Korean regime continues its efforts to develop nuclear weapons and ballistic missile programs both as a means to ensure the regime’s survival and to manipulate the international community. The regime’s potential export of weapons of mass destruction material and technology poses a regional and global threat…North Korea views its ballistic missile programs as a source of prestige, a strategic deterrent, a means of exerting regional influence, and a source of hard currency. North Korea continues to build and test missiles of increasing range, lethality and accuracy, thereby bolstering its inventory of missiles available for internal use or external sale. With as many as 800 missiles in its active inventory, it seems as though North Korea intends to increase its offensive capabilities. Missile sales further constitute a vital source of hard currency for the North Korean regime facilitating its continued irresponsible behavior and repression of its own people.

At the same time, missile tests and deployments are an expensive effort for the DPRK due to its limited technology and economic base. For example, the ROK Ministry of Unification estimated that the DPRK’s two missile launches in 2012 cost it a total of $1.3 billion – with the rockets themselves costing $600 million, launch site development costing $400 million, and other related facilities costing $300 million.² These funds could have bought 4.6 million tons of corn, enough to feed the DPRK for four or five years.³ These costs can only have increased with the corresponding rise in advanced missile tests under Kim Jung Un.

**Arsenal and Capabilities**

Even so, the DPRK now has hundreds of ballistic missiles, along with a significant infrastructure and institutional arrangement to sustain its missile development program. As of May 2012, the DPRK had at least nine different types of guided ballistic missiles available or in development, with some offered for export to other countries, and some open source material reports that the DPRK has operationally deployed 800-1000 missiles.⁴ The specifics of each missile will be discussed later in this chapter, but DPRK’s capabilities may be summarized as follows.

DPRK missile development accelerated at a remarkable pace after the short-range *Hwasong*-5 (a DPRK version of the Soviet *Scud*-B) was put into serial production in 1987. During a five-year period (1987–1992), the country began developing the *Hwasong*-6 (a DPRK version of the Soviet *Scud*-C), the medium-range *Nodong*, the long-range *Taepodong*-1 and *Taepodong*-2, and the *Musudan* (a road-mobile version of the Soviet R-27/SS-N-6 *Serb* submarine-launched ballistic missile).⁵
North Korea has successfully flight tested the *Hwasong*-5/6 and the *Nodong*; however, the *Taepodong*-1 was only partially successful in a 1998 test and a variant of the *Taepodong*-2 was tested successfully in December 2012 and February 2016 as a space launch vehicle (*Unha*-3). Figure IV.1 provides a chart assessing the key characteristics of the DPRK’s various missiles.

Sources vary, but estimates by the NTI indicate that the DPRK possesses around 600 scud variants *Hwasong*-5/6s (*Scud*-B, -C, and -D) that can strike the ROK – though according to one 2006 source, only 100-150 of these were deployed and the rest were exported – and 200 *Nodong* missiles (with up to 50 corresponding TELs) that can strike as far as Japan. Long-range missiles, like the *Taepodong*-1/2, with the potential to hit the continental US and other international targets, are still under development.

It is possible that the DPRK possesses 20-30 *Taepodong*-I missiles and perhaps 5 *Taepodong*-IIs. All of these missiles, except the *Scuds*, could potentially be equipped with nuclear or chemical capabilities, though sources are far from agreement on this issue. One often-cited source also reports that up to 50 *Musudan* missiles are deployed (with 50 TELs), and that the KN-02 is already in use. The NTI notes that, in total, the DPRK has less than 50 *Taepodong* and *Musudan*.

**How Capable Are the DPRK’s Missiles?**

Markus Schiller conducted an extensive 2009 study of DPRK missile developments and estimated that the DPRK holds fewer missiles, and with lower capacities, than is usually assumed. While the DPRK has space launch vehicles and boosters that might launch a small warhead as far as the US, he concludes that an actual ICBM with re-entry capability is unlikely, as is the actual full development and deployment of the KN-08.

1. The Scud B is probably available in large numbers (perhaps hundreds), since the R-17 had a very high production rate and was produced for three decades, if not longer, and many decommissioned or mothballed R-17s existed in post-Soviet Russia. The system is combat proven. Its nominal range is 300 km with a 1-ton warhead. Its real accuracy is probably around 1 km (CEP). Launch procedures are complex, and only few well-trained crews are expected.

2. The Scud C is probably available in smaller numbers (perhaps 100). The system is likely combat proven. Its range is about 500 km with a 0.7-ton warhead. Its accuracy is worse than that of the Scud B. Launch procedures are analogous to those for the Scud B, and only few well-trained crews are expected.

3. The Scud D is probably available in small numbers (perhaps a few dozen). Its range is about 700 km with a 0.5-ton warhead. Its accuracy is worse than that of Scud C. Launch procedures are analogous to those for the Scud B, and only few well-trained crews are expected.

4. The Nodong is limited to a small number of a few dozen at best. Its range is about 900 km with a one-ton warhead. Its accuracy is worse than that of the Scud B. Launch procedures are comparable with those for the Scud B, with additional time-consuming fueling procedures once the missile is in vertical position.

5. Other Taepodong I prototypes are unlikely to exist.

6. One or two more Taepodong II/Unha-2/-3 might exist. Launch procedures are lengthy and easily visible.

7. If available at all, the Musudan is only available in small numbers.

8. The situation of the KN-02 is hard to judge. It might be available in sufficient numbers. Its accuracy might be high. Its range with a 0.5-ton warhead is most likely limited to 70 km, but might reach 120 km, if the newer version of SS-21 found its way to North Korea.

The DPRK would face several important capacity constraints even if it had an operational deployment of 800-1000 missiles.
1. Only a small number of launch crews can be well trained. Even assuming that the production quality of North Korean–produced missiles is high, or that North Korea’s missiles are all of Soviet design and production, the lack of crew training will result in moderate results at best, with handling failures and low accuracy.

2. If missiles are produced in North Korea, they are not of excellent reliability and accuracy because of the lack of firing table creation and lot acceptance tests.

3. The number of imported and well-tested Soviet missiles is limited and might be only a fraction of the total missile force.

It is clear from many sources, however, that the DPRK’s missile forces do continue to improve. The former commander of USFK, Burwell B. Bell testified before the House Armed Services Committee in March 2007 that “North Korea is developing a new solid-propellant short-range ballistic missile… [I]n March 2006, North Korea successfully test-fired the missile. Once operational, the missile can be deployed more flexibly and rapidly than the existing system and North Korea will be able to launch the missile in a much shorter preparation period.” The short-range missile referred to appears to be the Toksa.

The DPRK is also making efforts to improve existing ballistic missiles such as the Hwasong and Nodong, including an attempt to extend their ranges. See Figures IV.1 to IV.3 for more detailed comparisons of the missiles, their capabilities, and their likely ranges.

Most analysts believe that the DPRK is now nearly self-sufficient in ballistic missile production but still relies upon some advanced foreign technologies and components, particularly for guidance systems. The country has an extensive machine tool sector; thus, the DPRK is probably self-sufficient in the fabrication of airframes, tanks, tubing, and other basic components. However, the DPRK’s rapid strides in the development of its ballistic missiles with only a limited number of test launches could mean that the country imported various materials and technologies from outside.

There has been a much more focused DPRK effort to develop and test ballistic missile system (including ICBMs) since the ascension of Kim Jung-Un. The 2015 DoD report on North Korea notes that:

North Korea has an ambitious ballistic missile development program in addition to its deployed mobile theater ballistic missiles. Since early 2012, North Korea has made efforts to raise the public profile of its ballistic missile command, now called the Strategic Rocket Forces. In 2014, Kim Jong Un personally oversaw several ballistic missile launch exercises, and North Korea launched an unprecedented number of ballistic missiles. The State media covered the usually secretive events, including reporting on two launch cycles in the same week. Kim’s public emphasis of the missile force continued into 2015, when he appeared at what North Korea portrayed as the test launch of a submarine-launched ballistic missile (SLBM). In late November 2015, the ROK’s Yonhap news agency reported that North Korea appeared to conduct an SLBM test but it ended in failure with no indication that the missile successfully ejected from the vessel.

North Korea is committed to developing a long-range, nuclear-armed missile that is capable of posing a direct threat to the United States. Pyongyang displayed the KN08 ICBM, which it refers to as Hwasong-13, on six road-mobile transporter-erector-launchers (TEL) during military parades in 2012 and 2013. If successfully designed and developed, the KN08 likely would be capable of reaching much of the continental United States, assuming the missiles displayed are generally representative of missiles that will be fielded. However, ICBMs are extremely complex systems that require multiple flight tests to identify and correct design or manufacturing defects. Without flight tests, the KN08’s current reliability as a weapon system would be low. In October 2015, North Korea paraded four missiles on KN08 TELs. These missiles are noticeably different from those previously displayed on these TELs.

Officials in the Russian government have admitted that Russian missile experts and nuclear scientists were in North Korea in the 1990s providing support, but the officials claimed that these
scientists and experts returned to Russia by 1998. During this time period, DPRK missile experts were also in Iran, where they reportedly showed skills and knowledge that some sources report were “very unimpressive.”

**Uncertainties**

There are as many uncertainties in predicting the future nature of the DPRK’s missile programs as there are in making predictions about its nuclear program. The DPRK’s ambitious missile programs are still largely in development, and their capabilities are impossible to predict because there have not been enough tests of the DPRK’s longer-range missiles to provide a clear picture of their performance.

These uncertainties, along with the fact that the DPRK’s missile testing involves firing the missiles over the ocean – as opposed to firing them towards an independently verifiable target – make it impossible to estimate the reliability and operational accuracy of its missiles, or whether the DPRK has anything approaching some form of terminal guidance technology.

Nevertheless, DPRK advancements in missile technology coupled with its nuclear ambitions have caused considerable concern among ROK and Western sources. Former US Secretary of Defense Robert M. Gates warned in January 2010:

> With the DPRK’s continuing development of nuclear weapons and their development of intercontinental ballistic missiles, North Korea is becoming a direct threat to the United States, and we have to take that into account... I think that North Korea will have developed an intercontinental ballistic missile (within five years)... Not that they will have huge numbers or anything like that, but they will have—I believe they will have a very limited capability.

It is unclear whether the DPRK could make such a large ballistic missile program effective with so few test launches. This has led some experts to believe that the DPRK imported materials, technologies, and designs. While most analysts concur that the DPRK has reverse-engineered Soviet ballistic missiles, Markus Schiller of RAND argues that the DPRK’s ballistic missile program is too sophisticated and has been tested too few times – with too low of a failure rate for so few tests – to be indigenous. He believes that instead, North Korea either received missiles directly from the USSR/Russia or had an arrangement for licensed production. Schiller proposes that the DPRK has been conducting missile tests with Soviet/Russian missiles to appear highly capable, but has probably not tested indigenously produced or designed missiles.

After several years of more advanced DPRK missile testing and development, researchers still have to speculate about the long-term viability of the DPRK missile program. One 2015 report offers three potential scenarios for North Korean capabilities in 2020:

- **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.

North Korea also appears to be gradually developing the capability to launch ballistic missiles from a submarine. North Korea does have an old Cold War era Golf-II class Soviet ballistic missile submarine. 38 North analyzed imagery of a new submarine that appeared at the Sinpo naval yard, which some speculated to be a Golf class submarine. 38 North believes that this is not a Golf class, noting that it was too small to be a Golf class.23

Yonhap cited sources within the ROK Ministry of Defense that said North Korea could complete tests in one to two years.24 This tracks with imagery that shows a test stand that appears to be designed to test a vertical launch tube system for submarines and surface combatants. However, this information says little about North Korean efforts to develop a sea/submarine launched ballistic missile. No tests of a missile that could be fired from a naval platform have taken place.
### Figure IV.1: DPRK Ballistic Missile Arsenal

<table>
<thead>
<tr>
<th>Classification</th>
<th>Range (km)</th>
<th>Payload (kg)</th>
<th>Operational Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hwasong-5 [SRBM]</td>
<td>300</td>
<td>300-320</td>
<td>300</td>
</tr>
<tr>
<td>Hwasong-6 [SRBM]</td>
<td>500</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Nodong 1 [MRBM]</td>
<td>1300</td>
<td>1300-1500</td>
<td>1300</td>
</tr>
<tr>
<td>Musudan (BM-25) [IRBM]</td>
<td>3000</td>
<td>3200-4000</td>
<td>2500-4000</td>
</tr>
<tr>
<td>Taepodong-1 [IRBM]</td>
<td>2500</td>
<td>2500-5500</td>
<td>2000</td>
</tr>
<tr>
<td>Taepodong-2 [ICBM]</td>
<td>10000</td>
<td>6000-9000</td>
<td>4000-8000</td>
</tr>
<tr>
<td>KN-O8</td>
<td>5000-6000</td>
<td>2,500-6,000</td>
<td>700</td>
</tr>
<tr>
<td>Toksa (KN-02) [SRBM]</td>
<td>--</td>
<td>--</td>
<td>120-160</td>
</tr>
</tbody>
</table>

Note: “ROK” represents ROK Ministry of National Defense data; “NTI” represents Nuclear Threat Initiative data; “MT.Com” represents data from MissileThreat.com.

Tactical Missiles (with a range less than 300 km) are under the Artillery Training Guidance Bureau, while Strategic Missiles (more than 300 km) are under the Strategic Rocket Forces Command.

Figure IV.2: ROK Ministry of National Defense Estimates of DPRK Missile Range

Figure IV.3: Japanese Ministry of Defense Estimates of DPRK Missile Range


DPRK Missile Programs

There are extensive reports available on some DPRK missiles, but much less is known about others – in particular, the DPRK’s potential ICBMs.

The Hwasong and Toksa Programs

The DPRK possesses a large SRBM stockpile primarily based on different versions of the Russian Scud missile that can easily reach targets within the ROK. They are domestically produced, have a maximum range of approximately 300-500 km, and can carry a 1-ton warhead.\(^2\)\(^5\) Figures IV.2, IV.3, IV.5, and IV.6 show the capabilities of these missiles.

The DPRK seems to have indigenously reverse-engineered and improved the Soviet Scud-B, perhaps receiving the missile as early as 1972, produced the DPRK-version with USSR assistance or even under license in DPRK factories, or acquired different missile production technologies from several different foreign sources, incorporating them into its indigenous missile program. The DPRK’s version is reported to have a slightly improved range and a slightly increased diameter, as well as use a different rocket fuel. At the very least, it appears that the DPRK had significant help from several foreign sources, including Egypt, China (People’s Republic of China or PRC), Russia, and Iran.\(^2\)\(^6\)
The first North Korean “indigenously modified Scud” was reportedly first tested in April 1982. The first confirmed flight tests of Scud-B (Soviet R-17) versions were in April and September 1984. Successful flight tests of the Scud-B (Hwasong-5) and Scud-C (Hwasong-6) – with a smaller payload (approximately 700 kg) and a longer range (500 km) – were conducted in May 1986 and July 1986 respectively, though it would appear that the first credible report of a successful Hwasong-6 flight test was in June 1990.27 Both were subsequently deployed by 1988.

The DPRK made its first sale to Iran of the Hwasong-5 during this same period. They signed a $500 million agreement in 1987 that reportedly included 90-100 Hwasong missiles and other military hardware exports to Iran (were the missiles were subsequently renamed Shehab-1). Furthermore, a 1985 agreement between the two countries led to DPRK assistance with the construction of a Hwasong-5 production plant in Iran that reportedly became operational in 1988. The DPRK is also reported to have provided assistance to Egypt that led to the establishment of a Scud-B production plant in 1987 and a Scud-C plant in 1990.28

A drawing found on a North Korean freighter in 1999 depicts an enlarged Scud, similar to a Scud-D, and also known as the Scud-ER and Hwasong-7. This missile has a range of approximately 700 km with what appears to be the same engine as the Scud-B and -C. Similar to the Nodong, the warhead is separable. The missile is reported to have been available in the DPRK since 2000.29

Some estimates indicate that the DPRK’s SRBMs include some 600–800 regular and extended-range Scud missiles. According to additional estimates, Pyongyang may deploy these missiles in two belts, with 22–28 bases in the forward area and 12–15 in the rear area. The first is 50–90 km north of the DMZ, and the second 90–120 km north. A third belt may exist more than 175 km from the border.30

Their warheads are probably equipped with high-explosive munitions, though it is also possible they have been fitted with chemical and biological weapons – though most likely not nuclear, as the relative crudeness of the Scud design makes it unlikely that the DPRK would equip it with a nuclear warhead.31

The DPRK has recently been seeking ways to improve its Scud arsenal and has worked on developing new short-range missile platforms. A May 2009 CRS report stated that in 2006 the DPRK tested newer versions of “solid-fuel Scuds, which can be fired quickly, in contrast to liquid-fuel missiles.”32 Based on interviews with ROK officials, the International Crisis Group reported that in 2008:

North Korea also unveiled a new solid-fuelled short-range tactical missile, the “Toksa” (Viper) or KN-02, but it is unclear whether it has been deployed. It is a North Korean version of the Soviet/Russian Tochka (SS-21 Scarab) but has a range of only about 120km. However, it is much more accurate than the North’s other missiles and could strike the Seoul-Incheon metropolitan area and possibly US military bases in P’yŏngt’aek, south of Seoul.33

Initial production of the Toksa/KN-02, which employs technology very different from that of the Scud, likely began in 2006. They were displayed during a military parade in April 2007 and probably entered service in 2008.34 An ROK military source reported that “A North Korean military unit on drill test-fired two shots of short-range missiles, presumed to be KN-02 missiles, into the East Sea” in mid-March, 2013.35

On September 5, 2016, during the G20 summit in neighboring China, the DPRK tested three new ballistic missiles that turned out to be Extended Range Scud Missiles. This was the first time this
variety of missile had been seen or tested. The ER Scuds were fired in the direction of Japan and flew around 1,000 km before landing in the ocean. Jeffrey Lewis notes:

The estimates indicated that North Korea had already-flight tested the ER Scud and assessed its range as between 700 and 1000 km. By contrast, Scud B and Scud C missiles have a range of 300 km and 500 km, respectively.

The missiles fired on Monday appear to be consistent with these descriptions. Estimates of the missile, based on models created by Nathaniel Taylor of the Center for Nonproliferation Studies, suggest it is approximately 1 m in diameter, making it wider than a Scud (.8 m) but narrower than a Nodong (1.3 m). It may also make use of a lighter-weight aluminum airframe, compared to the Scud’s steel airframe.

An additional proliferation concern exists, relating to long-standing ties between Iran and North Korea. The images appear to show a separating warhead that had previously only been seen in Iran several years earlier on a Shahab-3, an Iranian variant of the North Korean Nodong. A separating warhead would pose additional challenges for missile defense systems such as the Terminal High Altitude Area Defense (THAAD) system, which has been envisioned by the United States as integral to deterring North Korean missiles.

**The Nodong**

The DPRK is thought to have started development of a single-stage medium-range missile derived from the Soviet Scud, called the Nodong (also known as the Rodong, Scud-D, Scud Mod-D, Nodong-A, and Nodong-1), in the 1990s. It appears the Nodong was first developed and successfully flight tested in 1993 with an initial production of 18 missiles; the flight tests reportedly included Iranian and Pakistani observers.

Pakistani officials also viewed the Nodong in 1992, while Iranian officials were also present at the 1998 Taepodong-1 test. Much of the information about the missile stems from a comparison with the Ghauri-II/Hatf-V missile of Pakistan and the Shahab-3 of Iran, which all seem to be related missile programs – and results from tests of these missiles appear to have been shared with the DPRK.

The Nodongs shown at an October 2010 parade in Pyongyang appeared to be slightly different than the Pakistani Ghauri and Iranian Shahab-3, looking more like the Iranian Ghadr-1. However, the Nodongs in the 2010 parade were clearly mock-ups, not real. The actual Nodong missile configuration is unknown, at least in open source material, and as such there are no available reliable technical statements beyond those analyzing the Pakistani and Iranian versions of the missile.

It is reported that Soviet/Russian engineers assisted in development of the missile and that Iran pledged $500 million to jointly develop missile capabilities. There are reports that Iran received 15-20 Nodongs, though both the DPRK and Iran deny this. It also seems that Iraq made a $10 million down payment on Nodong missiles in 2003 (before the US invasion), though the missiles were never delivered and the DPRK refused to provide a refund.

There also is some evidence that 12-25 Nodong missiles were sold to Pakistan in the late 1990s in return for uranium enrichment technology/materials, though Pakistan claims to have developed the Ghauri missile indigenously and denies it imported any Nodongs.

The Nodong is a liquid-fuel propellant single-stage ballistic missile, assessed to have a range of about 1,300-1,600 km with a 1,000 kg payload – within reach of almost all of Japan (see Figures IV.2, IV.3, IV.5, and IV.6). Nodong missiles are road-mobile (able to be fired from a Transporter Erector Launcher, or TEL) and liquid-fueled, and are generally stored underground.
and transported to sites that are little more than concrete slabs for launch. This makes it difficult to detect signs of preparation for a launch.\textsuperscript{45}

The Nodong’s accuracy is low for a modern missile. It cannot be used to attack point targets with conventional warheads and would only be effective against large, soft targets like cities, airports, or harbors. It is uncertain what its single-round reliability is, and this would present problems in arming it with a nuclear warhead.\textsuperscript{46}

Some experts feel that DPRK nuclear weapons would likely be launched from the Nodong missile division headquarters in Yongnim-up, Yongnim-kun, Chagang Province. Some reports indicate there are three Nodong missile regiments in the division: The first is headquartered in Sino-ri, Unjon-kun, North Pyongan Province (near the west coast, about 100 km from the Chinese border); the second is headquartered in Yongjo-ri, Kimhyongjik-kun, Yanggang Province (in the center of the country, about 20 km from the Chinese border); the third is located along with the Nodong missile division in Yongnim-up (in the center of the country about 45–50 km from Kanggye City, and about 50–60 km from Huichon City).\textsuperscript{37}

Approximately 175-200 Nodong missiles are said to be deployed, but the program is still developmental and requires large numbers of additional, full-range tests to become a mature program. The Japanese Defense White Paper believes tests are limited to a possible launch into the Japan Sea in late May 1993, a mix of Scud and Nodong launches on July 5, 2006, and a mix of launches that might have involved some Nodongs from the Kittareryong district of the DPRK on July 4, 2009.\textsuperscript{48}

A Nodong was successfully used in the failed Taepodong-1 1998 test.\textsuperscript{49} No unclassified source, however, provides a clear picture of exactly what happened during these tests or how far the DPRK has progressed in bringing the system to the final development stage.

In March 2014, the DPRK launched two Nodong into the Sea of Japan, in the first mid-range North Korean missile test in five years.\textsuperscript{50} This was during a period from February 21 and March 16 when the DPRK “conducted its largest, most diverse, and prolonged missile firing exercises” involving other short-range missile systems.\textsuperscript{51}

\textbf{The Taepodong Program}

The DPRK initiated the development of two ballistic missiles known to the West as Taepodong-1 (also known as the Scud Mod-E, Scud-X, Moksong-1, Paektusan-1, and Pekdosan-1) and Taepodong-2 (also called the Moksong-2 and Paektusan-2) in the late 1980s and early 1990s, respectively. The Taepodongs are not production missiles and have never been successfully tested as a weapons platform – both have only been tested as space launchers, not as ballistic missiles.\textsuperscript{52}

\textbf{Taepodong-1}

The Taepodong-1 was the DPRK’s first multi-stage missile, proving that the DPRK had key ICBM development and deployment technologies. The missile has an estimated range of approximately 1,800-2,000 km, and is assumed to be a two- or three-stage, liquid fuel propellant ballistic missile with a Nodong used as its first stage and a Scud (Hwasong-5 or -6) as its second stage. The space launch vehicle (SLV) adds a solid third stage instead of a re-entry vehicle. The Taepodong-1 has been launched only as an SLV once in August 1998, but it was unsuccessful in delivering a satellite into orbit as a result of failure in its third stage (see Figure IV.7).\textsuperscript{53}
Following the test, the Taepodong-1 program was apparently ended, indicating it may have been a transitory program for the development of the longer-range Taepodong-2.\textsuperscript{54} The Taepodong-2, was developed between 1987 and 1992, and is a two-\textsuperscript{55} or three-stage (the SLV version, the Unha)\textsuperscript{56} missile with a new booster resembling the Chinese CSS-2 and CSS-3 first stage and a Nodong as its second stage.\textsuperscript{57}

The missile has more advanced technology and has a much greater range than previous DPRK missiles. It is currently North Korea’s only system capable of being a true ICBM. Range and payload estimates vary, and while most estimates indicate that the missile has limited accuracy, it is thought to be targeted at major US population centers in both Alaska and Hawaii – perhaps even as far as California.\textsuperscript{58}

A 2009 CRS report stated, “The two-stage variant is assessed by some to have a range potential of as much as 3,750 km with a 700 to 1,000 kg payload and, if a third stage were added, some believe that range could be extended to 4,000 to 4,300 km. Some analysts further believe that the Taepodong-2 could deliver a 700 to 1000 kg payload as far as 6700 km.”\textsuperscript{59}

\textit{Taepodong-2}

David Wright of the Union of Concerned Scientists has calculated that the Taepodong-2 ballistic missile could deliver a 500 kg payload as far as 9,000 km. This would put San Francisco and all US cities along the Pacific coast to the north within range.\textsuperscript{60} While this would be a significant increase in range over the DPRK’s current missiles, it does not represent, as Wright states, “a true intercontinental nuclear delivery capability since developing a first generation warhead and heat shield with a mass of 500 kg or less is likely to be a significant challenge for North Korea.”\textsuperscript{61}

The NTI reports that estimates of range are generally from 6,000-15,000 km, with a two-stage version capable of 7,000-7,500 km and a three-stage variant capable of 10,000-10,500 km.\textsuperscript{62} The abilities of the Taepodong-1 and Taepodong-2 can be seen in Figures IV.2, IV.3 and IV.5.

Like the Taepodong-1, the Taepodong-2 has never been launched with an active warhead, and it is not clear whether its missile engines have been used as an SLV. The Japanese Defense White Paper of 2010 reported that one failed launch occurred in July 2006 (crashing after forty seconds of flight).

Victor Cha of CSIS notes that this missile was one of seven missiles fired at the time, headed on an eastward trajectory – and some of the missile parts landed only 250 km (155 miles) from Vladivostok. Three of the other six missiles also landed in Russian waters, close to Nakhodka. After the launch, the head of Russia’s Strategic Rocket forces criticized the DPRK for testing missiles that did not have any mechanisms for automatic self-destruction in case they travelled off-course. Russia, though only 150 km (90 miles) from the test site, received little advance notice of the testing from the DPRK.\textsuperscript{63}

The DPRK undertook a second launch in April 2009 that most likely involved a variant of the Taepodong-2, the Unha-2 SLV, at a range over 3,000 km (see Figure IV.7).\textsuperscript{64} Prior to the launch, the DPRK announced the test in advance, even informing the International Civil Aviation and International Maritime Organizations of its intentions, providing coordinates of expected stage falling areas.\textsuperscript{65}

The DPRK hailed the 2009 test as a major success – even bragging that the supposed satellite payload was now broadcasting patriotic music from space – but military and private experts said that the launch had failed due to either an unsuccessful separation of the second and third stages.
or because the third stage did not fire successfully, citing detailed tracking data that showed the missile and payload had fallen into the sea.\(^{66}\)

**Recent Taepodong launches**

The DPRK announced on March 16, 2012 that it planned to undertake an “earth observation satellite” launch in April; within hours, China’s vice foreign minister “summoned” the DPRK’s Chinese ambassador to express Chinese “concerns and worries.” Other Chinese attempts to dissuade the DPRK from undertaking a space launch failed,\(^{67}\) and on April 13, 2012, coinciding with huge celebrations of the 100\(^{th}\) anniversary of Kim Il-sung, the DPRK conducted a satellite launch of the Gwangmyongsong-3 using a variant of the Taepodong-2, the Unha-3 SLV. It appeared to have a slightly different third stage than the 2009 launch. The missile flew for over a minute before breaking into several pieces, with the first stage falling into the sea 102.5 miles west of Seoul and the remaining two stages failing.\(^ {68}\)

Several days after the launch, China supported a UN Security Council presidential statement condemning the launch as a violation of previous Security Council resolutions and supporting further Security Council measures in the case of any further DPRK provocations. This is in contrast to China’s reaction to the 2009 SLV launch, when it emphasized the distinctions between a missile and a satellite and insisted that the DPRK had a right to the peaceful use of outer space.

Chinese leaders were in particular angry that the DPRK gave months of advance warning regarding the launch to the US, but had neglected to inform China. The PRC further supported the Security Council’s moves to freeze the assets of several DPRK firms involved in financing nuclear and missile programs, while also initiating preemptive measures to warn the DPRK not to try another missile test.\(^ {69}\)

A further test was successfully undertaken on December 12, 2012, delivering the Gwangmyongsong-3 satellite into orbit. Preparations were visible in late November, and in early December the DPRK announced that it would launch a satellite mid-month, later announcing this would occur between December 10 and December 22.

While previous launch preparations had taken about eight weeks, the December 2012 launch took approximately 40 days to prepare. The rocket had three load-bearing stages, and wreckage from the first stage was recovered by the ROK Navy – including parts of the power plant, a propellant tank, and a second, smaller, and badly damaged propellant tank.\(^ {70}\) Although the DPRK claims otherwise, it also appears that the satellite is “tumbling in orbit” and thus is most likely dead.\(^ {71}\)

Some ROK officials believe that for this launch, the DPRK may have used foreign scientists to assist in fixing some of the problems experienced in previous long-range missile tests, such as weak engine thrust. The DPRK may have used smuggled technology and/or rogue scientists from former Soviet republics like Ukraine. Iranian observers were invited to the launch.\(^ {72}\)

On February 7, 2016, a month after its fourth nuclear test, the DPRK conducted another long range ballistic missile test with the Unha-3 (the satellite launch version of the Taepodong-2) under the auspices of launching a satellite. The launch successfully placed an “earth observation satellite” into orbit, and marked an important progression in the DPRK’s efforts to develop a functional ICBM.\(^ {73}\)
The Taepodong’s Potential Re-Entry Capabilities

Some experts assess that the Taepodong missile could be used to deliver WMDs with only minor modifications to withstand the heat of re-entry.\(^7\) In support of this claim, there is a long-standing US National Intelligence Estimate that the DPRK could successfully test an ICBM by 2015.\(^7\) It should also be remembered that the DPRK has had re-entry technology for its other ballistic missiles for over 30 years.\(^7\) Of course, how accurate such a missile would be is an entirely different matter.

Jane’s Intelligence Review estimates that the Taepodong-2/Unha-3 would not be well suited to weapons conversion, and more development would be necessary before the Unha SLV could be turned into a viable weapon system.\(^7\) The IISS also reported in 2011 that the DPRK would have to undertake “an extensive flight-test program that includes at least a dozen, if not two dozen, launches and extends over three to five years” – and such testing would be observable.\(^7\) Similarly, a RAND report in 2012 asserted that the Unha-3/Taepodong-2 would be incapable of carrying a nuclear warhead at an intercontinental range; if the DPRK wants an ICBM, “they have to develop a new rocket, using different technology. This would take a long time, require extensive work, and cost a lot of money.”\(^7\)

The long preparation time necessary prior to a launch – at least several days – would provide significant advance warning, and the DPRK likely does not have the capability to use underground silos, which would then be vulnerable to surveillance and attack. In addition, a launched SLV would only be able to carry one re-entry vehicle, and the required long burn time and the delayed deployment of potential countermeasures would allow the US or another country under attack to target and engage missile defense systems in order to shoot down the missile.\(^8\)

Michael Ellerman, a senior fellow at the IISS, noted that given the trajectory of ballistic missile development in other countries, space launches do not and cannot play a decisive role in the development of long-range missiles. Furthermore, it is plausible that the DPRK’s missile launches actually were legitimately satellite launches, as claimed by the DPRK.

The trajectory of the rocket and actual placement of the satellite in orbit, along with the prelaunch notification to international safety organizations, points to the DPRK actually attempting to conduct satellite launches. The 1998 Taepodong-1’s trajectory was also consistent with this conclusion, as were those of the 2009 Unha-2 and April 2012 Unha-3 launches.\(^8\)

Ellerman acknowledged that satellite launches and ICBMs are similar in many regards – powerful rocket engines, payload separation mechanisms, inertial navigation and guidance units, and lightweight and strong airframes. However, there are also important differences between the two systems. First, a ballistic missile needs to have re-entry capabilities that protect the payload from heat and structural stress, which require special materials to be used in the missile – and which need to be tested and validated under realistic conditions.\(^8\)

Secondly, operationally, space launches are prepared over a period of days or weeks, waiting for ideal weather and checking and verifying subsystems and components. The process can be delayed and restarted. However, ballistic missiles must be able to reliably be used in a variety of less-than-ideal circumstances, with very little warning or preparation. This requires a much more rigorous validation scheme and extensive testing than has taken place during DPRK SLV launches.\(^8\)

While testing SLVs does assist in developing experience and data that could help in ICBM development, Ellerman believes that this information is of only limited use. Many of the key
requirements of a ballistic missile cannot be tested during satellite launches, and many tests would have to be undertaken before a missile could be confidently given combat-ready status. Often, in fact, ballistic missiles have been converted into SLVs (by the USSR, China, and the US), not the other way around.\(^4\)

At the same time, the DPRK could in theory use the *Unha*-3 as the basis for a missile, though an ICBM based on the *Unha*-3 would weigh over 90 tons, thus too large and unwieldy to be deployed on a mobile launch platform. The DPRK would have difficulties concealing a silo launch site, and due to the DPRK’s geography, any silo would be close enough to the coastline that advanced military powers – like the US – could destroy them preemptively. Therefore, according to Ellerman, it is more likely that the DPRK would design a new missile entirely – such as the mock-ups of the KN-08 displayed during a military parade in April 2012 – than use an SLV as an ICBM. If the KN-08 used more energetic propellants, it could have an intercontinental range; but, without testing, it is unknown if that is even a possibility.\(^5\)

**US, ROK, Japanese, and UN Responses to DPRK Launches**

The DPRK’s missile programs have led to an almost inevitable military reaction: A mix of missile defense and ROK offensive missile programs. In December 2012, Japan, the US, and South Korea all mobilized ballistic missile defense (BMD) capabilities to both guard against the potential DPRK threat and display a show of force prior to the DPRK’s launch of a space vehicle. Jane’s Intelligence Review reported that,\(^6\)

> Japan has both land- and sea-based defences and is continuing to develop its BMD capabilities. The Japan Maritime Self Defense Force has four Kongo-class destroyers, each equipped with the Aegis Ballistic Missile Defence System. The US-developed system includes the SPY-1 search radar with an estimated range of 1,000 km, and the SM-3 Block 1A mid-course interceptor. This provides upper tier BMD coverage for the whole of Japan, designed to intercept a ballistic missile after the boost phase and before re-entry. Three Kongo-class destroyers – the Kongo, Myoko, and Chokai – were deployed in the East China Sea around Okinawa and the Sea of Japan ahead of December’s launch. Providing lower tier, point defence are 16 Patriot batteries, which are equipped with PAC-3 interceptors with a range of 15 km that are capable of engaging short- and medium-range missiles. Detection capability is provided by four new J/FPS-5 Early Warning 3D AESA Radars, as well as seven older FPS-3 sites that have been upgraded for the BMD role.

The ROK has less of a BMD capacity than Japan. While South Korea does have three KDX-III destroyers with the Aegis System, and that are able to detect and track missiles, the ships only have SM-2 anti-missile missiles, and can only intercept low-altitude threats. The ROK also has 48 land-based Patriot systems with PAC-2 missiles on land, but an October 2012 ROK study found that the missile has an interception rate of less than 40% against short- and medium-range ballistic missiles (PAC-3s have a 92% success rate). The ROK’s strongest missile defense assets are two Israeli-supplied Green Pine radars, allowing the ROK to detect and track incoming missiles. These will likely be an important part of any future ROK missile defense network.\(^7\)

The ROK reportedly deployed two of its KDX-III Aegis destroyers to track the December 2012 launch, but it remains dependent on the US for more effective missile defense abilities. The US deployed a Ticonderoga-class cruiser (the USS Shiloh) and three Burke-class destroyers (the USS Fitzgerald, McCain, and Benfold) off the Korean Peninsula in response to the DPRK’s launch plans. All of these US ships have the Aegis Combat System and SM-2 and/or SM-3 interceptor missiles. Overall, the US has a TPY-2 radar deployed in northern Japan, the Army’s Air Defense Artillery regiments have four PAC-3 batteries in the ROK and 12 in Japan, and the 7th Fleet has nine Aegis-equipped vessels based near Japan.\(^8\)
The UN also reacted at the diplomatic level. In response to the December 2012 test, UN Security Council Resolution 2087 was passed on January 22, 2013, adding six North Korean entities to the sanctions list – and further upsetting the DPRK, leading to further regional tensions.

It is probable that the DPRK tested critical technologies during the recent launches, such as increasing the size of propulsion, separation of the multi-staged propulsion devices, and altitude control. The improvements made to the Taepodong-2 apparent in the 2009 and 2012 tests show that the DPRK likely has the ability to improve upon current programs as well as build a new generation of ballistic missiles capable of reaching targets in the continental US.

A 2016 launch provoked an equally pointed reaction, with multiple countries releasing condemnations for the provocative test. The ROK and United States also moved closer towards the deployment of the THAAD anti-missile system in the ROK, with South Korea agreeing to the move by July. Moreover, the launch, and the nuclear test that proceeded it, led to the drafting and passage of UN Security Council Resolution 2270, which subjected North Korea to the most punitive economic sanctions ever placed upon it.

The Musudan

There are reports that the DPRK has developed a more accurate, longer-range intermediate ballistic missile called the Musudan (also known as the Nodong-B, BM-25, Taepodong-X, and Mirim). The single-stage Musudan appears to be based on the design of the Soviet R-27/SS-N-6 missile, an intermediate-range, liquid propellant, submarine-launched ballistic missile deployed by Russia in the 1960s.

It appears that development began in the early 1990s. According to the NTI, in 1992, a large contract between Korea Yon’gwang Trading Company and V.P. Makeyev Engineering Design Office of Miass, Russia was signed. The agreement stated that Russian engineers would go to the DPRK and assist in the development of the Zyb Space Launch Vehicle (SLV). Zyb is a term used by V.P. Makeyev for the R-027/SS-N-6. Later that year a number of Russian scientists and missile specialists were arrested while attempting to travel to Pyongyang. There are reports that many scientists and missile engineers were already working in the DPRK.

Reportedly, prototypes were developed in 2000 and it was first deployed as early as 2003 – though the ROK lists the Musudan as being deployed in 2007, when it was first displayed during a military parade. However, the October 2010 parade was the first time the missile was shown to Western audiences.

The range of the missile is disputed – Israeli sources identified North Korean SS-N-6-based missiles in Iran with a range of 2500 km, and American sources have reported a range of 3200 km with a payload of 500 kg. Other sources claim a maximum range of 4000 km. Assuming a range of 3200 km, the Musudan could hit any target in East Asia (including US bases in Guam and Okinawa) and Hawaii.

Some sources claim that Iran conducted surrogate flight tests of the Musudan in 2006 and 2007. It was reported in 2005 that the DPRK had sold 18 Musudan assembly kits to Iran. There is also limited evidence suggesting that North Korea tested the Musudan as part of its July 2006 missile tests. Furthermore, the Musudan was reportedly used as the Unha-2 SLV’s second stage, or could be used in future Taepodong-2 or -3 versions. While the Unha-2 failed in April 2009, the failure occurred after the effective firing of the second stage, indicating that the stage that potentially contained the Musudan was successful.
Although reports indicate that the design of such a missile would be borrowed from a Russian submarine-launched missile, North Korea probably intends to transport and fire the missile using wheeled transport erector launchers (TEL) units or surface ship-based launchers.\(^9\) While it is uncertain whether it is operational, ROK intelligence sources believe the *Musudan* missile division has three regiments and is headquartered in Yangdok-kun, South Pyongan Province, about 80 km east of Pyongyang.\(^10\)

The DPRK has made its own claims. On June 22, 2016, after five failed launches over the past two months, the DPRK declared that it had successfully tested the *Musudan*. The missile was launched from Wonsan, and after reaching an altitude of 878 miles, landed in the ocean some 250 miles away. While this was far less than the system’s estimated range, North Korean sources claimed that the missile had been launched at a sharp angle to confirm that it could reach some 2000 miles without actually traveling that length.

Unlike with the DPRK’s previous attempts, US and ROK authorities did not label the test a failure, and experts noted that the launch carried all the hallmarks of a success. The test elicited condemnation from Japanese, South Korean and US officials, who labeled it a violation of UN resolutions and a threat to regional stability. With the *Musudan* successfully tested, the DPRK can directly threaten US forces in Guam, assumed to be a key staging point for US forces responding to conflict on the Korean Peninsula.\(^101\)

### The KN-08/Hwaseong-13

Mock-ups of the KN-08, also known as the DPRK’s road-mobile ICBM, were presented in April 2012 at a parade honoring Kim Il-sung’s 100\(^{th}\) birthday. As only mock-ups have been seen, there are no photos of the real missile or any clear evidence that one even exists – at least not in open source material. The missile was displayed on Chinese TELs that were too large for the KN-08 missile. If the missile was actually developed and produced, it would offer the DPRK a longer range than that of the *Nodong* (maximum 5,000 km), giving it a truly intercontinental reach.\(^102\)

There were reports that the DPRK tested an engine for the long-range KN-08 on February 11, 2013, one day before its third nuclear test. One ROK government source stated, “It appears that North Korea conducted the engine test aimed at extending the range of the KN-08 missile to over 5,000 kilometers.” If the North judged the test successful, it could start operationally deploying the rockets.\(^103\)

In 2012, Markus Schiller and Robert H. Schmucker issued a detailed analysis that concluded that KN-08 mock-ups,\(^104\)

…were intended to create the impression of an ICBM that is based on SS-N-6 technology, even though the designs looks more like a high-end solid-fueled ICBM…A KN-08 design based on Nodong technology has limited range and performance. A KN-08 design based on SS-N-6 technology offers impressive range and performance but creates massive operation problems, and production is extremely challenging. Considering the presented KN-08 design, none of the two options makes much sense from a missile engineer’s perspective.

Although many analysts have dismissed the KN-08 mock-ups as simple mock-ups, Jeffrey Lewis and John Schilling offered an alternative analysis in 2013. They asserted that such mock-ups are important parts of missile development programs, as demonstrated by mock-ups of previous ballistic programs like the MX program that led to the Peacekeeper missile. To further support their claim, they pointed out that small design differences in initial KN-08 mock-ups, key indicators that had led to the conclusion that the KN-08 would not go beyond the mock-up stage,
eventually disappeared and the design improved. The KN-08 weld and rivet arrangements also matched those found in North Korea’s successful Unha-3 launch. Lewis and Schilling directly respond to Schiller and Schmucker’s assessment:  

We believe the missile mockups that North Korea displayed in 2012 and 2013 are consistent with an ongoing development program for a missile with limited intercontinental capability using only existing North Korean technology. There are a number of plausible configurations of missile engines that North Korea might use to cobble together a missile that would look like the KN-08.  

One of us—John Schilling—has written a lengthy technical analysis in *Science and Global Security* that considered six different ways that North Korea could assemble components and technologies it possesses into a missile that matches the appearance of the parade mock-ups. Not all of these solutions are elegant.  

For all we know, Werner von Braun is rolling in his grave. But elegant or not, these options are good enough to produce missiles with theoretical ranges from 5,500 kilometers to over 11,000 kilometers…North Korea is parading mockups through the streets of Pyongyang because, like every other country, it built mockups first.  

Satellite imagery from 2014 shows what appears to be continued test of the first stage of the KN-08:  

Moreover, North Korea displayed a newly modified KN-08 model in a 2015 military parade. Reports indicated that, “the missile (had) been shortened and simplified, with two stages instead of three and a blunt warhead replacing the narrow triconic design”, indicating that the “structural design had been substantially improved”. While these changes could produce a more reliable model, they may also delay the KN-08’s transition from development to entry into active service. At the same time, some observers believe that the “smaller and blunter warhead shape” might lend legitimacy to the DPRK’s claims that they have successfully miniaturized their nuclear warheads.
Submarine Launched Ballistic Missile (SLBM) Program

North Korea appears to be in the early stages of developing a submarine launched ballistic missile. A series of events have made this development a point of concern, though little is known about the program. North Korea is clearly still several years away from obtaining any sort of SLBM capability. Developing this SLBM capability into a “second-strike capability,” which is possible
with an SLBM, will also require North Korea to expand and develop effective SSBNs and conduct extensive sea trials.

If the DPRK does obtain an SSBN capability at some point in the future, however, it would allow North Korea to better protect its missile arsenal, and presumably its nuclear arsenal as well. It would also make a surprise launch much easier and give the DPRK a potential second-strike capability as well as complicate missile defense.

There are some indicators of a DPRK SSBN program. In July 2014, satellite imagery reveals a new North Korean submarine at the Sinpo South Shipyard. A South Korean government source reported to Yonhap that the new submarine was based off of reverse engineered Soviet-era Golf-class ballistic missile submarines.

North Korea obtained a number of decommissioned Golf class submarines from Russia, ostensibly to be reduced to scrap metal. It is likely that these submarines were thoroughly studied before they were scrapped. 38 North challenged the conclusion that the new sub was a Golf class derivative, arguing that the submarine was “significantly smaller and bear a close resemblance to the former Yugoslav Sava and Heroj class patrol submarines, neither of which carried ballistic submarines.”

A test stand was also constructed at the same shipyard that appeared to be “the right size and design to be used for the research, development, and testing of the process of ejecting a missile out of a launch tube as well as evaluating its compatibility with submarines and surface combatants as well as the missiles themselves.” It is not yet known what type of missile would be used if North Korea successfully developed the capability to launch a missile in this fashion. The stand is about 12 meters high.

In August 2014, a missile launch tube was reportedly spotted on a North Korean submarine. The missile tube “may be for a missile large enough to carry a nuclear warhead.” This raises the issue of what missile launch technology the DPRK would use. SLBMs are typically launched using a “cold-launch” system, in which the missile is first ejected out of a submarine and above the surface of the water using high-pressure gas. The missile’s rocket engines are ignited once the missile has breached the water’s surface. In order to develop a “cold-launch” system,

A Jane’s analysis points to other developments that could help North Korea to develop this technology:

1. Golf class ballistic missile submarine: The missile launch tubes of these old Soviet submarines would be of particular interest, which used a cold-launch system. One of the submarines also contained an R-27 SLBM, which aided the development of the BM25 Musudan land-mobile ballistic missile. It is not known whether the BM25 will eventually be used as an SLBM, as the BM25 has not yet been test fired. This raises serious questions about the reliability of the missile.

2. Pon’gae 5/KN-06: This North Korean developed surface-to-air (SAM) system that may use a cold launch tube similar in size to the tubes used by the Chinese HQ-16A SAM. The HQ-16A is a medium range SAM.

3. Pon-gae 6: This North Korean developed SAM system is larger than the Pon’gae 5 and is similar to the larger Chinese HQ-9 or Russian S-300 SAM systems. The HQ-9 is base off the S-300, both of which are long range SAMs that utilize cold-launch systems to launch their missiles

Of the above foreign systems mentioned, only the Golf class is known to have been sold to North Korea. The S-300, HQ-9, and HQ-16A are not known to have been sold to North Korea.
The DPRK has made some public reports that such a program is underway. In November 2014, North Korea reported it tested an ejection launcher for an SLBM at the shipyard.\textsuperscript{112} Carried out onboard a land-based vertical launch tube, the latest tests suggested the initial stage of firing a missile out of a submarine launch tube and signified the shift towards underwater missile strike potential for a future nuclear-tipped missile.

Earlier, the US intelligence agencies reportedly observed ‘two or three’ such trials last month at a facility claimed to be a major development centre for the North Korea’s SLBM programme, in line with South Korea’s intelligence over the North’s missile development, Yonhap reported.

The new missile is believed to be either a new anti-ship cruise missile boasting a range of 130km or a new short-range ballistic missile with 240km range.

The DPRK later released photographs showing what was claimed to be a SLBM launch from a submarine on May 10, 2015. However, experts eventually determined that the pictures had been falsified, with the missile actually being launched from a submerged barge.

North Korean efforts to produce a solid fueled missile (easier to store and ideal for use on submarines) did, however, lead to the test of a solid-fueled rocket motor in March 2016, and on April 23, 2016 the DPRK launched a solid-fueled missile. While the April launch badly undershot its intended range, experts still considered it a significant progression in the DPRK’s SLBM efforts.\textsuperscript{113}

Finally, on August 24, 2016 the DPRK successfully tested a two-stage SLBM that flew roughly 500 km.\textsuperscript{114} The tested missile has been dubbed the KN-11 and unlike many of the DPRK’s missiles is solid-fueled.\textsuperscript{115} The tested missile breached Japan’s air defense identification zone (ADIZ)—marking the first time this happened—before landing in the ocean. The range of the missile remains uncertain as it was tested on a lofted trajectory. However, the Union of Concerned Scientists was able to estimate the KN-11’s maximum range to be 1,250 km after ascertaining the flight apogee during the test.\textsuperscript{116}

The successful test of a SLBM is troubling South Korea after the deployment of a U.S. supplied Terminal High Altitude Area Defense (THAAD) battery. Jeffrey Lewis notes, “THAAD has a forward-looking radar with a 120-degree field of view. In the case of a single THAAD battery, North Korea’s submarines would not have to travel very far out to sea to attack the THAAD system from behind the field of view of its radar.”\textsuperscript{117} Consequently, having SLBM capabilities offers the DPRK a reliable way to mitigate THAAD deployment.
### Figure IV.5: US Estimates of Primary North Korean Missiles

<table>
<thead>
<tr>
<th>System</th>
<th># of Launchers</th>
<th>Estimated Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toksa</td>
<td></td>
<td>75 miles</td>
</tr>
<tr>
<td>SCUD-B</td>
<td>Fewer than 100</td>
<td>185 miles</td>
</tr>
<tr>
<td>SCUD-C</td>
<td></td>
<td>310 miles</td>
</tr>
<tr>
<td>SCUD-ER</td>
<td></td>
<td>435-625 miles</td>
</tr>
<tr>
<td>No Dong</td>
<td>Fewer than 50</td>
<td>800 miles</td>
</tr>
<tr>
<td>IRBM</td>
<td>Fewer than 50</td>
<td>2,000+ miles</td>
</tr>
<tr>
<td>TD-2</td>
<td>Unknown*</td>
<td>3,400+ miles**</td>
</tr>
<tr>
<td>SLBM</td>
<td>At least 1</td>
<td>Unknown</td>
</tr>
<tr>
<td>KN08</td>
<td>At least 6</td>
<td>3,400+ miles**</td>
</tr>
</tbody>
</table>

**Note:** North Korea has produced its own version of the SCUD B, and the SCUD C, an extended-range version of the SCUD B. North Korea will continue using and improving the TD-2, which has only been used in a space-launch role, but could reach the United States with a nuclear payload if developed as an ICBM. North Korea is also developing the KN08 road-mobile ICBM and has paraded six launchers for the system. The KN08, an IRBM, and an SLBM have not been flight-tested and their current reliability as weapon systems would be low.

* Launches of the TD-2 have been observed from both east and west coast launch facilities.

** ICBM is defined as a ballistic missile (land-based) capable of a range in excess of 5,500 kilometers (or 3,418 miles).

Figure IV.6: Estimates of DPRK Hwasong and Nodong Missile Range – Northeast Asia

Note: Distances are approximate.
DPRK Missile Facilities

Only limited data is available on DPRK missile production and launch facilities, but some key information is available. It is believed that the DPRK produces and/or stores chemicals, chemical precursors, and chemical agents in 12 factories and six major storage depots. The No. 125 Factory, the so-called Pyongyang Pig Factory in northwestern Pyongyang, reportedly produces Hwasong, Nodong, and surface-to-ship cruise missiles. Officials from Middle Eastern countries have reportedly visited the factory, but the extent of their tours is unknown. Additionally, Mangyongdae Electric Machinery Factory is another reported missile production facility located in the same general area of Pyongyang as the No. 125 Factory.

The No. 7 Factory, located about five miles from the Electric Machinery Factory, is responsible for the production and testing of missile prototypes prior to the initiation of production at other plants. This facility is probably the same facility known as the “San’um-dong Factory” or “San’um-dong Missile Research Center.” The facility is under the Second Natural Science Academy, the research organization in charge of all weapons development in North Korea, working on missile design and development as well as the production of prototypes.

The Academy probably draws upon human resources from other scientific institutions under the Academy of Sciences, but the extent of any such collaboration is unknown. The DPRK is also reported to have integrated their educational institutions into their missile programs. According to DPRK defectors, the Korea National Defense College in Kanggye, Chagang Province, has a “Rocket Engine Department,” and the college provides instruction on the “production, operation procedures, and launching of missiles.” North Korea’s top universities such as Kim Il Sung University, the Pyongsong College of Science, and Kim Chaek University of Technology also have programs in engineering and science that could be applied to rocket and missile development.

The DPRK possesses a number of missile bases and launch facilities (see Figure IV.8). The Missile Division under the Ministry of the People’s Armed Forces commands at least 18 ballistic missile bases in the country, such as the Chiha-ri Missile Base in Kangwon Province and the Mayang Island Missile Base. Many of these bases likely have several alternative launch pads near the missile storage site, which in effect increases the number of locations from which they can launch missiles using mobile TELs.

The DPRK had previously used a small, old launch facility in the northeastern part of the country near Musudan-ri for its launches, called the Tonghae Satellite Launching Ground. However, the DPRK began construction on a new facility close – Sohae, in Tongchang-ri – to the Chinese border in 2001, which was completed by January 2011.

In contrast to the older Tonghae facility which has limited capabilities, the new installation in Sohae includes a movable launch pad with gantry, a missile assembly building, oxidizer and fuel storage, and a 10-story tall tower capable of supporting the DPRK’s largest ballistic missiles and SLVs. The height of the launch tower is unnecessary for any of the DPRK’s Unha/Taepodong missiles or SLVs, which could indicate that the DPRK is looking to develop larger and more modern launch vehicles.

The facility incorporates R&D and support facilities, while Saneum-dong Weapons Research Lab and Yongbyon Nuclear Complex are both less than 50 miles away. Furthermore, the Sohae site can launch toward the South, reducing missile flight time to the ROK and Japan. The site is also
obscured from direct sea or air observation. It was first used in April 2012 to launch the *Unha-3* rocket; the December 2012 *Unha-3* launch was also successfully conducted at this facility.\(^{128}\)

The Sohae site has seen significant construction activity in 2014 including new road access, rail access, unidentified domed structures, and the heightening of the rocket gantry.\(^{129}\) The heightened gantry, which would be required for launches of larger rockets, also came with a new roof and new swing arms that were attached to the gantry tower. Fuel tanks near the launch pad were also moved. By the end of September 2014, the temporary shelters that were used to support the construction unit had been removed, suggesting that the construction project and upgrades at the Sohae site had been completed.\(^{130}\)

A new Musudan-ri facility is also being developed, bigger than the Sohae facility, which should be operational by 2016-17.\(^{131}\)

A test stand near the Sinpo South Shipyard appears to be appropriate for testing missile ejection systems for SLBMs.\(^{132}\) Reports indicate that North Korea has tested such an ejection system, though it is unclear whether a missile was actually launched.
Figure IV.8: Possible Locations of DPRK Nuclear Warhead and Missile Facilities

Note: Locations are approximate.
**DPRK Air Defense and Counter-Space Capabilities**

The DPRK’s satellite program has been discussed previously in this chapter. As for air defense, North Korea is said to have one of the densest air defense networks in the world, but its equipment is primarily Soviet-designed missiles and radars – either made in the USSR or licensed and produced in the DPRK – developed in the 1950s-1970s.

The US has been working for decades to develop ways to defeat such weapons, using radar jamming, anti-radar missiles, and stealth technology; the B-2 and F-22 were designed specifically to evade this type of defense, and B-52s could take out the DPRK’s air defense system by firing AGM-86 cruise missiles from beyond the range of DPRK defenses. The DPRK’s inventory includes the SA-2 *Guideline*, SA-6 *Gainful*, SA-3 *Goa*, SA-13 *Gopher*, SA-16 *Gimlet*, SA-4 *Ganef*, SA-5 *Gammon*, and the SA-17 *Gadfly*.\(^{133}\)

DIA Director Ronald L. Burgess, Jr. provided the following overview of DPRK counter-space preparations in testimony before the Senate: \(^{134}\)

> North Korea has mounted Soviet-made jamming devices on vehicles near the North-South demarcation line that can disturb Global Positioning System (GPS) signals within a 50-100 kilometer (km) radius and is reported to be developing an indigenous GPS jammer with an extended range of more than 100 km.

**ROK Missile Development**

For the last thirty years, the United States has discouraged South Korea from developing long-range ballistic and cruise missiles. In a 1979 memorandum of understanding with the United States, reiterated in 1990, South Korea voluntarily pledged not to develop ballistic missiles with ranges exceeding 180 kilometers in return for technical assistance from the US. However, Seoul has sought to raise that limit since late 1995, resulting in several revisions of the ROK-US agreement.\(^{135}\)

Recently, however, the ROK has deployed a series of cruise missiles, the maximum range of which is 1,500 km – capable of reaching as far as Beijing and Tokyo. In addition to this cruise missile program, the ROK has successfully launched a series of communication satellites in the last decade. While it does not possess a known ballistic missile program, it clearly possesses the know-how to produce a ballistic missile.

**The Early Program – The NHK Program**

South Korea has made some attempts to develop and expand its offensive ballistic missile capabilities since the 1970s in spite of US pressure. In December 1971, ROK President Park Chung Hee issued a directive to develop a short-range ballistic missile aimed at countering the ballistic missile threat from North Korea. In 1975 the ROK successfully reverse-engineered the US *Nike Hercules* surface-to-air missile (SAM) system, which could also be used in a surface-to-surface capacity.\(^{136}\)

This system was named the NHK-1 (also known as the *Paekkom-1*, *Baekgom-1* and *Hyunmu-1*), and had a range of only 150 km (93 miles).\(^{137}\) Development of the NHK-1 continued into the late 1970s with a successful test in September 1978.\(^{138}\) The US, however, feared that the ROK’s actions could trigger a missile arms race on the Korean Peninsula and in greater East Asia, and became increasingly cautious about the impact of the ROK missile program.\(^{139}\)
As a result of pressure from the US, the ROK agreed in 1979 to restrict the range of its missiles to 180 kilometers, and their payload to a maximum of 500 kg, in return for US technical support for ROK missile systems. In 1983, the ROK developed the NHK-2, incorporating improved technology and a range of 180 km (112 miles), which could be easily extended to 250 km (155 miles) – but at the cost of breaking the 1979 agreement.

In 2006 it was reported that the ROK would keep the NHK-2 missile in service until 2010. It is not clear whether the missile has actually been decommissioned.

**The 2001 MTCR and the Hyunmu-3 Cruise Missile**

The DPRK’s growing missile capabilities led the ROK to change its policies as well as seek improve missile defenses. In 1995, Seoul responded to the advances in DPRK missile capabilities by notifying Washington in 1995 that it wished to adjust the restrictions agreed to in 1979. After five years of consultations, the US backed the ROK’s joining of the Missile Technology Control Regime (MTCR) in March 2001, a regime that superseded the 1979 US agreement.

The MTCR seeks to limit the risks of proliferation of weapons of mass destruction by controlling exports of goods and technologies that could make a contribution to delivery systems for such weapons (other than manned aircraft). In this context, the regime limits the range of rockets and UAVs with a payload over 500 kg to 300 km. The MTCR does not, however, restrict the development of missiles as long as the warhead does not weigh more than 500 kg.

As a result, the ROK began focusing on the development of cruise missiles such as the Hyunmu-3 series, capable of delivering payloads below 500 kg to targets deep within the DPRK and beyond. Developed indigenously in the ROK, the Hyunmu-3 system is reportedly similar to the US Tomahawk in structure and guidance technology but with a shorter range. It uses an inertial navigation system and technology that matches map images in its computer memory to the features on the ground below it, giving the missile the ability to hit within three meters of its target.

The Hyunmu-3A deployed in 2006 with a range of 500 km and is capable of striking Pyongyang – but not the DPRK’s long-range missile sites, including the Musudan-ri site in North Hamgyeong Province, which were located more than 300 km from Seoul. In early 2009, however, the ROK deployed the Hyunmu-3B, an improvement of the 3A model, which has a range of 1,000 km, capable of reaching as far as Beijing and Tokyo as well as hitting key targets throughout the DPRK.

The most advanced missile in the ROK arsenal in 2016 was the Hyunmu-3C, which has supposedly entered into the production phase in 2010. In July 2010, it was reported that the ROK had begun manufacturing the Hyunmu-3C with a range of up to 1,500 km (937 miles), capable of reaching parts of China, Japan, and Russia. If these reports are true, the successful indigenous development of a long-range cruise missile would put the ROK in the company of only the US, Russia, and Israel as countries that have developed cruise missiles with ranges of more than 1,500 km.

Shin In-kyun, a military expert who headed the Korea Defense Network, told The Korea Herald that the missile with a 450 kg warhead “measures 6 meters in length and 53–60 centimeters in diameter and weighs 1.5 tons. It can hit targets in all nuclear facilities and major missile bases in the DPRK with high precision (a margin of error of less than 2 meters).”
The development of the long range, highly accurate *Hyunmu*-3 is likely to have a mixed impact on the force balance on the Peninsula. According to Oliver Bloom of CSIS: 153

The South Korean cruise missile development certainly won’t fundamentally alter the military balance on the Korean Peninsula, nor will it give the South Koreans an incentive to launch a preventive strike (especially given the number of North Korean missiles and chemical weapons aimed at Seoul), but the new missile certainly may give South Korea another tool in its box in handling North Korean contingencies. If the situation on the peninsula deteriorated to open conflict, South Korea would have an independent means of accurately striking distant North Korean targets without risking aircraft. What’s more, the accurate cruise missiles would give South Korea a means to preempt an imminent North Korean attack, were such a thing to develop.

The ROK has also made advances in artillery rockets. From 2002-2004, the ROK purchased 110 US Army Tactical Missile Systems (ATACMS). 154 In 2002, the ROK Army purchased 111 ATACMS Block I and 110 ATACMS Block IA missiles, which were deployed in 2004. The Bock 1 unguided missile contains 950 M74 anti-personnel/anti-materiel (APAM) submunitions with a range of 128 kilometers (80 mi). The Block 1A missile uses GPS/INS guidance, carries 275 M74 submunitions and has a 165 kilometers (103 mi) range. An affiliated company of the Hanwha Group of Korea produces munitions for the missile systems under license from Lockheed Martin. 155

According to an article in Wikipedia, 156

The U.S. has ended the ATACMS program and in 2007, the Army terminated the ATACMS program due to cost, ending the ability to replenish stocks. To sustain the remaining inventory, the ATACMS Service Life Extension Program (SLEP) was launched, which refurbishes or replaces propulsion and navigation systems, replaces cluster munition warheads with the unitary blast fragmentation warhead, and adds a proximity fuze option to obtain area effects; deliveries are projected to start in 2018. The ATACMS SLEP is a bridging initiative to provide time to complete analysis and development of a successor capability to the aging ATACMS stockpile, which could be ready around 2022. [12]

In March 2016, Lockheed Martin, Boeing, and Raytheon announced they would offer a missile to meet the U.S. Army's Long-Range Precision Fires (LRPF) requirement to replace the ATACMS. The missile will use advanced propulsion to fly faster and further, out to 500 kilometers (310 mi)(Limited by the Intermediate-Range Nuclear Forces Treaty), [13] while also being thinner and sleeker, increasing loadout to two per pod, doubling the number able to be carried by M270 MLRS and M142 HIMARS launchers. One contractor is to be down-selected in 2018-19 to begin production in 2021-22. [14][15]

It is unclear how the ROK has modified and upgraded its systems. Global Security, however, reports that 157

In June 2003, Hanwha obtained the license to locally produce the 227mm MLRS as part of the second stage MLRS procurement program. Hanwha produced and delivered MLRS rockets worth KRW600 billion each year to the ROK Army. Over 4,000 missiles had been ordered for the year 2005. The launchers were ready for the new 300 km-range ATACMS missile directly purchased from the US. The new extended-range MLRS systems have taken over the roles of USFK MLRS currently assigned for counter-battery missions.

South Korea deployed its first missiles with a maximum range of 300 km, which the Army will bought for 400 billion won (about $307 million) from a U.S. defense firm, in 2004. The two governments signed a contract in 2002 under which the Korean Army purchased the Army Tactical Missile System (ATACMS) Block IA. Lockheed Martin supplied the systems. The contract included 29 multiple launch rocket systems and 111 surface-to-surface missiles, each with a warhead fitted with 300 anti-personnel and anti-material bomblets. South Korea was the first foreign buyer of the latest Lockheed missile systems. With a maximum range of 300 km, the missile is capable of hitting most positions in North Korea. The missiles are capable of engaging targets at ranges well beyond the capability of existing land-launched canons and rockets in South Korea. The missile is so powerful that each unit can destroy everything in an area as wide as three to four
soccer stadiums at once. A Korean company affiliated with the Hanwha Group produces munitions for the missile systems under a license from Lockheed.

**Further Revisions to the ROK’s Missile Limitation Agreement**

The US and the ROK agreed on an increase to the range limits on ROK ballistic missiles in October 2012, due to the increased provocations of the DPRK and the deteriorating security situation on the peninsula. The negotiations were initiated in September 2010, in the wake of the Cheonan and Yeonpyeong Island incidents, to allow the ROK enhanced deterrence capabilities against the DPRK.\(^\text{158}\)

According to the new agreement, the ROK can deploy ballistic missiles with a payload of up to 500 kg and range of up to 800 km (500 miles), which is enough to reach any target in the DPRK from the ROK’s central region, is out of firing distance of the DPRK’s long-range artilleries and KN-02 ballistic missile, while simultaneously does not overly threaten China or Japan. However, some areas of China and Japan will be in reach of the ROK’s new extended missile range.\(^\text{159}\)

At shorter ranges, the ROK can also put up to two ton warheads on ballistic missiles. Previously, the ROK was unable to deploy ballistic missiles with a payload of 500 kg beyond a range of 300 km, a flight ceiling of 48 kilometers or 160,000 feet.\(^\text{160}\)

The new agreement also gives the ROK the option to use drones that can carry up to 2.5 tons of weapons and other equipment; prior to the revised agreement, the ROK could not deploy drones carrying more than half a ton of equipment and weapons. The ROK began using low-flying reconnaissance drones in 2002.\(^\text{161}\)

There were no changes to the maximum load weight restrictions for cruise missiles and drones flying less than 300km, or those that carry less than 500kg. Also, there remain no restrictions on research and development of missiles and UAVs that go beyond the scope of the current missile guidelines.\(^\text{162}\)

Two days after the ROK announced the new missile deal, the DPRK said it had missiles that could hit US bases in “Japan, Guam and the US mainland.”\(^\text{163}\)

The ROK demonstrated its readiness to increase its missile capabilities with a test launch of a new ballistic missile on April 4, 2014. A defense ministry reported that the new design had a range of 310 miles, and that the ROK would try to expand this effective range to the 500 mile limit set by its agreement with the US.\(^\text{164}\)

**ROK Missile Defense and Space**

South Korea has steadily increased its missile defenses and space systems to better defend against potential DPRK attacks.

**Missile Defense - The Korean Air and Missile Defense (KAMD) System**

In 2011, it was reported that ROK was reacting to the DPRK’s missile tests and programs by rushing to improve its ballistic missile defenses (BMDs) and create a new force to detect and intercept DPRK ballistic missiles, focusing on a low-tier system. According to *Defense News*, this capability was planned to cost a total of 300 billion won ($214 million):\(^\text{165}\)

Seoul plans to buy new radars which can detect objects up to 1,000 kilometers (600 miles) away for the new system, which will put the North’s missiles under close watch around the clock, they said…North Korea has
short-range Scuds and Rodongs with a range of 1,300 kilometers, while actively developing longer-range Taepodong missiles that could reach the United States.

…South Korea in 2007 launched its first Aegis destroyer, which was finally deployed for operational use in December 2008… The King Sejong, the $1 billion, 7,600-ton KDX-III destroyer, adopts the US-built Aegis system that allows a ship to combat multiple surface, underwater and aerial threats… South Korea plans to deploy a second Aegis destroyer and a third for operational use in 2010 and 2012, according to its navy.

After the December 2012 DPRK missile test and the February 2013 nuclear test -- and after the October 2012 revision of the missile guidelines discussed previously -- the ROK further accelerated its BMD efforts. It then decided not to join the US multi-layered antimissile program, but rather to build a Korean Air and Missile Defense (KAMD) as a low-layer defense system more appropriate for the situation on the Korean peninsula. This system was designed to destroy attacking missiles either using Aegis systems on destroyers or Patriot systems on land.\(^{166}\)

The ROK spent $909 million buying 48 Patriot Advanced Capability 2 (PAC-2) systems from Germany in 2008, but the interception success rate of this system is below 40%. To achieve an interception rate of above 70%, the ROK is quickly moving to acquire PAC-3 systems.\(^{167}\) An ROK analysis of the KAMD by Park Chang-kwoun of the Korea Institute for Defense Analyses stated,\(^{168}\)

> During their Foreign and Defense Ministers’ Meeting held on June 14th [2012] in Washington, D.C., the ROK and the U.S. agreed to explore ways to strengthen “comprehensive and combined missile defenses” in response to North Korea’s growing missile capabilities. The two nations aim to strengthen their combined response capabilities against the North Korean missile threat through effective interworking system between the Korean Air and Missile Defense (KAMD) and the missile defense system of the United States Forces Korea (USFK). Establishing the ROK-U.S. combined missile defense system against the North Korean missile threat is an imperative measure to guarantee the security and reinforce the deterrence capability of the ROK.

…KAMD is designed to be a Korea-specific missile defense system that only intends to intercept incoming hostile missiles at the low-altitude (10-30km) for the purpose of local defense.

The U.S., on the other hand, is developing a comprehensive missile defense system that includes high-altitude missile defense in an integrated manner with its European allies and Japan. As an ally of the U.S., South Korea also seeks to join and cooperate with the U.S.-led regional missile defense system.

…The development of the KAMD would be achieved in a gradual manner, considering the limited defense budget and technological capabilities of South Korea. The U.S. is committing an astronomical amount of budget to the tune of 1.5 trillion dollars into building its missile defense system for the next decade—yet, there have been reports that there still remain a number of technical challenges. In fact, South Korea has only limited defense budget that can be devoted to the establishment of the missile defense system.

…South Korea is planning to launch its Air and Missile Defense cell (AMD-cell), a missile defense command-and-control center, by the end of this year and to deploy its own missile defense system based on surveillance platforms such as Green Pine Radars and SPY-1D in Aegis Combat System and interception platforms such as PAC-2 Gem and SM-2 Block III. The Green Pine Radars, ballistic missile early warning radars, will be acquired from Israel by the end of this year. In addition, South Korea’s indigenous antiaircraft missile, the Cheolmae-II will be added to the ballistic missile interception system.

If defense budget permits in the future, South Korea would be able to further strengthen interception capabilities of the KAMD by acquiring the PAC-3 and the SM-6, which is currently under development. Moreover, the ROK will begin a task of improving the Cheolmae-II. Since key components of the current KAMD interception system— the PAC-2, the SM-2, and the Cheolmae-II— were not originally developed as ballistic missile interception systems and have fragmentation warheads, the KAMD has a certain limitation in performing ballistic missile interception. Consequently, acquisition of new interception systems including the PAC-3 and the SM-6 is expected to bolster South Korea’s ballistic missile interception capabilities.

Meanwhile, the USFK operates a Theater Missile Operations cell (TMO-cell) and has ballistic missile interception systems including the PAC-2 and the PAC-3 deployed in its major military bases. These systems
allow the USFK to be able to respond to North Korean ballistic missile threats from the early stages backed by various satellite systems of the U.S. forces. Currently, the missile defense system of the USFK is designed for effective defense of the U.S. military installations. In case of contingency, however, the missile defense capabilities of the U.S. forces would be further improved if U.S. Aegis destroyers are deployed to South Korea's coastal areas and complement the current missile defense system.

The ROK has, however, had to steadily broaden and adapt its planning to take account of increases in the DPRK threat. For example, it has been reported that the ROK has looked into buying Israel’s Iron Dome to protect the approximately 11 million people who live in Seoul, only 35 miles from the DMZ. According to such reports, South Korea first offered to buy Iron Dome in January 2012 if Israel bought South Korean fighter jets in return – but Israel instead decided to buy from Italy. In November 2012, the ROK offered South Korean ships, potentially to hold Israel’s advanced missile systems, but no deal was announced.  

Iron Dome may not be ideal for the ROK. The DPRK has such an extensive artillery and short-range rocket arsenal – the DPRK could fire 500,000 artillery rounds on Seoul in the first hour of a conflict in addition to longer-range missiles, that it would take far too many Iron Dome batteries to protect Seoul sufficiently, unless the system was focused on just a few high-value targets. Each Iron Dome battery built to shoot down missiles costs approximately $50 million, and the interceptor rockets cost $50,000-$80,000 each.

**Missile Defense - THAAD**

The most important development in ROK planning has been adding the Terminal High Altitude Area Defense (THAAD) to its missile defense program. THAAD potentially offers a critical improvement to the ROK’s missile defenses by adding a wide area capability to endo-atmospheric intercepts covering the gaps between the narrow area coverage of the PAK and the exoatmospheric capability of AEGIS-Standard as well as advanced radar and battle management capabilities.

In 2014, USFK commander General Curtis Scaparrotti suggested that the ROK deploy a THAAD battery in country as a counter to North Korean missiles. The THAAD system, developed by the United States, “is a transportable system to intercept ballistic missiles inside or outside the atmosphere during their final, or terminal, phase of flight”. It is “able to intercept incoming missiles both inside and just outside of the Earth’s atmosphere at a range of 200 kilometers.”

THAAD’s “ability to intercept both inside and outside the atmosphere makes (it) an important part of layered missile defense concepts, falling in between the exclusively exo-atmospheric Aegis interceptors and the exclusively endo-atmospheric Patriot interceptors.” This helps explain why the U.S. and ROK increasingly examined the deployment of THAAD, particularly after the DPRK’s 2016 nuclear and missile tests.

On July 8 2016, negotiators from both countries agreed to placing the system in South Korea, drawing pointed criticism from the DPRK, China and Russia. China and Russia are worried that the system’s powerful radar will be used to detect missile launches and tests far within their own borders. It was announced that THAAD’s deployment site would be Seongju, a county located in the southwest, with activation scheduled for 2017. While the location was identified as being relatively remote and capable of covering some 2/3 of the country, the decision to place THAAD in Seongju provoked protests by many of the nearby residents. In addition, there remains some concern as to the effectiveness of the THAAD system as a deterrent to North Korean missiles. One potential problem is the system’s cost: “a single THAAD unit of six mobile launchers, 49
interceptors, fire control and communications, and the AN/TPY-2 radar runs $1.6 billion.\textsuperscript{175} Other concerns have been raised about the system’s functionality, complexity, and relative newness.\textsuperscript{176}

\textbf{Space}

The ROK has improved potential ballistic missile capabilities through its successful and expanding space program. Seoul began development of its own space program in the 1990s, including the development of a space-launch vehicle (SLV). After numerous delays, the ROK launched the two-stage Korea Space Launch Vehicle-1 (KSLV-1) rocket on August 25, 2009. The launch was intended to place an earth and atmospheric monitoring satellite – the \textit{Science and Technology Satellite} 2 (STSTAT-2) – into orbit, but after a successful launch, the satellite failed to successfully re-enter the atmosphere.\textsuperscript{177}

The partial success of this launch raised concerns that South Korea had sufficient technology for a long-range ballistic missile system that could deliver WMD payloads, especially given that the US and ROK were discussing changing the missile limitation guidelines that would allow missiles with a range of no more than 800 km, as previously discussed.\textsuperscript{178}

Following the December 2012 successful DPRK satellite launch, the ROK successfully launched a KSLV-1 rocket and put a satellite into space on January 30, 2013. The launch took place from Naro Space Center, and the rocket had been designed in partnership with the Khrunichev State Space Science and Production Center of Russia. The ROK has already begun work on an entirely domestically developed system with a projected 75 ton rocket engine, to be produced by 2021.\textsuperscript{179}

The implications of this launch are varied. While it proves that the ROK could successfully deploy ballistic missiles, perhaps acting as a deterrent to the North, the DPRK could also use the ROK’s new capabilities to justify its own program. Because the two launches were so similar, the DPRK will use the ROK’s launch as an excuse to ignore any UN sanctions, potentially claiming unfair treatment despite the two countries’ similar stated intentions of peaceful space exploration. Given the ROK’s successful January 2013 launch, it is possible that the ROK could work to couple their space program with a ballistic missile program to counter the DPRK threat apparent in its 

\textit{Nodong}, 

\textit{Musudan}, and 

\textit{Taepodong} missile programs.\textsuperscript{180}

\textbf{Conclusions}

It is important to stress that advanced forms of conventionally armed ballistic and cruise missiles can be used to threaten or attack targets and do so with strategic effect. It is unclear how accurate the DPRK’s missiles are, and it seems doubtful that Pyongyang now has a real-world terminal guidance capability to use conventionally armed ballistic and cruise missiles effectively against critical point targets. As long as the DPRK does not have such “smart” warheads, conventionally armed missiles are largely terror weapons. Once the DPRK does have this capability, however, they potentially could have “weapons of mass effectiveness,” able to destroy high-value and critical infrastructure targets with conventional warheads.

The US does have conventionally armed, precision-guided, deep-strike SRBMs, however, and both the US and the ROK have strike aircraft and precision-guided air-to-surface weapons that targeting patterns in the Balkans conflict and both Gulf Wars show can hit critical infrastructure targets with strategic effect. This could lead to new patterns of escalation where the US and ROK use precision guided air-to-surface, surface-to-surface, and cruise missiles to destroy critical DPRK targets, or threaten to use such weapons to deter Pyongyang.
The US also can deliver precision strike weapons with “stealth” strike aircraft and bombers, and Japan and the ROK are likely to acquire strike aircraft with some “stealth” capability. Alternatively, the US and ROK might threaten or initiate the use of precision-guided air-to-surface, surface-to-surface, and cruise missiles to destroy critical DPRK targets or to halt a DPRK conventional attack.

Still, conventional missile programs are only part of a far wider range of important issues in assessing the overall impact of the Korean balance. They cannot be separated from all of the uncertainties surrounding the DPRK’s chemical, biological, radiological and nuclear weapons programs – the CBRN or weapons of mass destruction (WMD) threat. The interactions between the various elements of this complex mix of known and unknown programs may be summarized as follows:

1. The DPRK has implosion fission weapons. The numbers, weapons yields, and ability to create reliable bombs and missile warheads are uncertain, but it seems likely it either has warheads or is rapidly moving toward acquiring them. It almost certainly has programs to develop boosted and thermonuclear weapons, but their status is unknown.

2. The ROK had a covert nuclear weapons program that it halted after quiet negotiations with the US. This, along with its extensive civilian nuclear power industry, gives the ROK a significant nuclear breakout capability if it should reverse its decisions.

3. Japan is unlikely to have nuclear weapons programs but has all of the technology and material necessary to rapidly acquire them and develop boosted and thermonuclear weapons.

4. The US and China have nuclear-armed aircraft and ICBMs, IRBMs, MRBMs, and SRBMs with boosted and thermonuclear weapons. The DPRK may have long-range tactical and theater missiles with implosion nuclear weapons.

5. The DPRK is a major chemical weapons state, and probably has advanced chemical warheads and bombs. China may have stocks of chemical weapons. There is no way to estimate the size, type, and lethality/effectiveness of their relative stockpiles, or doctrine and plans for using them. It should be noted, however, that relatively crude mustard gas weapons played a decisive role in area denial and disruption of Iranian forces in the final phase of the Iran-Iraq War in 1988, and that stocks of persistent nerve gas and so-called 4th generation chemical weapons are possible. Although Seoul neither confirms nor denies the existence of a CW program, the ROK is suspected to have a chemical weapons program and may have covert stocks of chemical weapons.

6. The DPRK is strongly suspected to have a biological weapons program and may have stocks of such weapons. These could range from basic weapons types to genetically modified types. China’s program is not discussed in unclassified official statements. The ROK may have a program. It should be noted that China, Japan, the DPRK, the ROK, and the US all have advanced civil biological, food processing, chemical processing, and pharmaceutical facilities that can be adapted to both chemical and biological weapons development and production. All have significant capability for genetic engineering of biological weapons. All would have to develop advanced biological weapons for test purposes to conduct an effective biological defense program.

7. No public details are available on the efforts of any power to develop small or specialized chemical, biological, radiological, or nuclear weapons for covert delivery or potential transfer to non-state actors and third-party countries.

8. China and the DPRK have large numbers of conventionally armed long-range missiles capable of hitting targets in the ROK. The nature of their conventional warheads is not clear, and this is critical since unity conventional warheads have limited lethality and terminal guidance is needed to provide the accuracy necessary to strike at high-value, rather than broad-area targets. China and the DPRK may have, and are certainly developing, ballistic and cruise missiles with some form of terminal guidance.
9. The US has large numbers of precision-guided long-range cruise missiles for air and sea launch and precision-guided long-range multiple rocket launchers. The ROK is also developing an advanced cruise missile program of its own. US stealth aircraft can deliver precision-guided weapons at standoff ranges from most Chinese and DPRK surface-to-air missiles with the exception of the S300/S400 series. China is developing long-range anti-ship ballistic missiles that can strike large surface ships like US carriers at long distances. These potentially are “weapons of mass effectiveness” that can be used in devastating strikes against critical facilities and infrastructure without the use of WMD warheads.

10. The US, Japan, and the ROK have some ballistic missile defense capability and are working together to develop wide-area theater ballistic missile defense systems. China has the Russian S300/S400 series of advanced surface-to-air missile defenses and is almost certainly seeking more advanced missile defense capabilities. The DPRK lacks such capabilities but is almost certainly seeking them. The balance of air and missile defense capabilities plays a critical role in limiting the offensive capabilities of the opposite side and reducing the risk in using one’s own missiles. This makes air and missile defenses the equivalent of a major offensive weapon.

11. China, the US, the ROK, and possibly the DPRK all have advanced cyber warfare capabilities. China has some anti-satellite capability and possibly some form of EMP weapon. These, too, are potential “weapons of mass effectiveness” that can be used in devastating strikes against critical facilities and infrastructure without the use of WMD warheads.

Current assessments of the Korean balance tend to focus on the nuclear elements of the DPRK’s WMD and missile programs, but this previous list shows that such programs are only part of a far more complex and rapidly evolving mix of current and potential capabilities to deliver weapons of both “mass destruction” and “mass effectiveness.”

The threat that such weapons may be used also cannot be limited to the Korean Peninsula. It already extends to Japan and the US bases there, as well as potentially to Alaska and the Pacific coast of the US. Potential US reactions again raise the issue of what China’s response would be and whether a crisis could escalate to the point where the US-Chinese strategic and nuclear balance became relevant – a threat that could force Japan to make hard choices of its own.

The range of uncertainties affecting DPRK capabilities also raises two key issues for DPRK and Korean Peninsula arms control:

1. One is the so-called Nth weapon paradox. It may be possible to reduce a nation’s nuclear weapons, but it is probably impossible to be certain it does not retain at least a few. The problem for arms control is that the smaller the stockpile, the more it has to be used in ways that threaten absolutely critical targets like major population centers rather than a given military target. Arms reductions can easily escalate targeting.

2. The second is the “diversion effect”: the risk that nuclear controls can drive states even more toward advanced biological and chemical weapons. Advances in biotechnology have made control regimes virtually impossible, as well as vastly increased the potential lethality of biological weapons to levels beyond that of even boosted and thermonuclear weapons.

As the next chapter shows, the nuclear threat is only part of the WMD capabilities affecting the Korean balance. The DPRK has long been a chemical weapons power. It is believed to have active biological weapons programs, and it clearly has long-range missile programs that can target Japan and anywhere in the ROK. These can potentially be armed with a range of CBRN warheads, but no meaningful unclassified evidence exists of the range of such warheads or their lethality. The same is true of DPRK bombs and rocket warheads. This means that CBRN escalation could occur at a wide range of unpredictable levels, including asymmetric, covert, and terrorist attacks. Moreover, the DPRK is already acquiring missile engines and boosters that will give it ICBM capabilities to attack targets in the US.
4 However, Schiller notes that in his research he has been unable to find the original source of these claims and doubts their authenticity; Markus Schiller, *Characterizing the North Korean Nuclear Missile Threat*, RAND, 2012, iii, xv, 38.
6 Ibid.
9 However, Schiller notes that in his research he has been unable to find the original source of these claims and doubts their authenticity; Markus Schiller, *Characterizing the North Korean Nuclear Missile Threat*, RAND, 2012, iii, xv, 38.
12 Ibid.
30 Bermudez, “Going Ballistic.”
32 Niksch, *North Korea’s Nuclear Weapons Development and Diplomacy*.
37 Ibid.
Korean Missiles Forces

Ibid.

NTI, “North Korea Missile Capabilities,” May 1, 2010.

Ibid.


NTI, “North Korea Missile Capabilities,” May 1, 2010.

Pinkston, The North Korean Ballistic Missile Program, 47.


Internal government memorandum made available to International Crisis Group, North Korea’s Nuclear and Missile Programs, 13.


Ibid.


HS Jane’s, Jane's Sentinel Security Assessment - China And Northeast Asia: North Korea,” IHS Jane’s, April 13, 2016.


Ibid.

NTI, “North Korea Missile Capabilities,” May 1, 2010.

Victor Cha, The Impossible State, 363.


NTI, “North Korea Missile Capabilities,” May 1, 2010.


Bonnie S Glaser and Brittany Billingsley, Reordering Chinese Priorities on the Korean Peninsula, 10.


Bonnie S Glaser and Brittany Billingsley, Reordering Chinese Priorities on the Korean Peninsula, 11.


Emma Chanlett-Avery and Ian E Rinehart, North Korea: U.S. Relations, Nuclear Diplomacy, and Internal Situation, 16.


Pinkston, The North Korean Ballistic Missile Program, 45.

Ibid.


Ibid.

Ibid.

Ibid.

Ibid.

Ibid.

Ibid.

Ibid.

Ibid.

Ibid.

Ibid.

Ibid.

Ibid.

Ibid.

Ibid.


“North Korea’s Sohae Satellite Launching Station: Major Upgrade Program Completed; Facility Operational Again,” 38 North, October 1, 2014, http://38north.org/2014/10/sohae100114/.


Bermudez, “North Korea: Test Stand for Vertical Launch of Sea-Based Ballistic Missiles Spotted.”


Bermudez, “A History of Ballistic Missile Development in the DPRK.”


Ibid.

Ibid.

Ibid.

“Ibid.

Ibid.

Ibid.

Ibid.

“Ibid.


Korean Missiles Forces

149 Ibid.
153 Bloom, “South Korea Develops New Long-range Cruise Missile.”
160 Ibid.
161 Ibid.
164 “South Korea extending ballistic missile range to counter North's threat”, Reuters, April 4, 2014.
171 Kevin Baron, “Why doesn’t Seoul have Iron Dome?” Foreign Policy – The E-Ring, April 9, 2013.


Ibid.