

Flashback to the Past: North Korea's "New" Extended-Range Scud

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Summary

At 12:14 p.m. on September 5, 2016, North Korea launched three missiles within one minute of each other from a highway south of Pyongyang. All three launches were successful; the missiles reportedly each covered a distance of 1,000 km and landed about 240 km west of Okushirito Island, part of the Japanese prefecture of Hokkaido.

The tests marked the first public demonstration of this missile, but the weapon itself is not new. Rumors surfaced more than 15 years ago that North Korea possessed this missile, and strong indications exist that it was part of a massive transfer of Soviet technology and know-how to the DPRK in the 1990s.

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Figure 1. The missile launches of September 5, 2016.

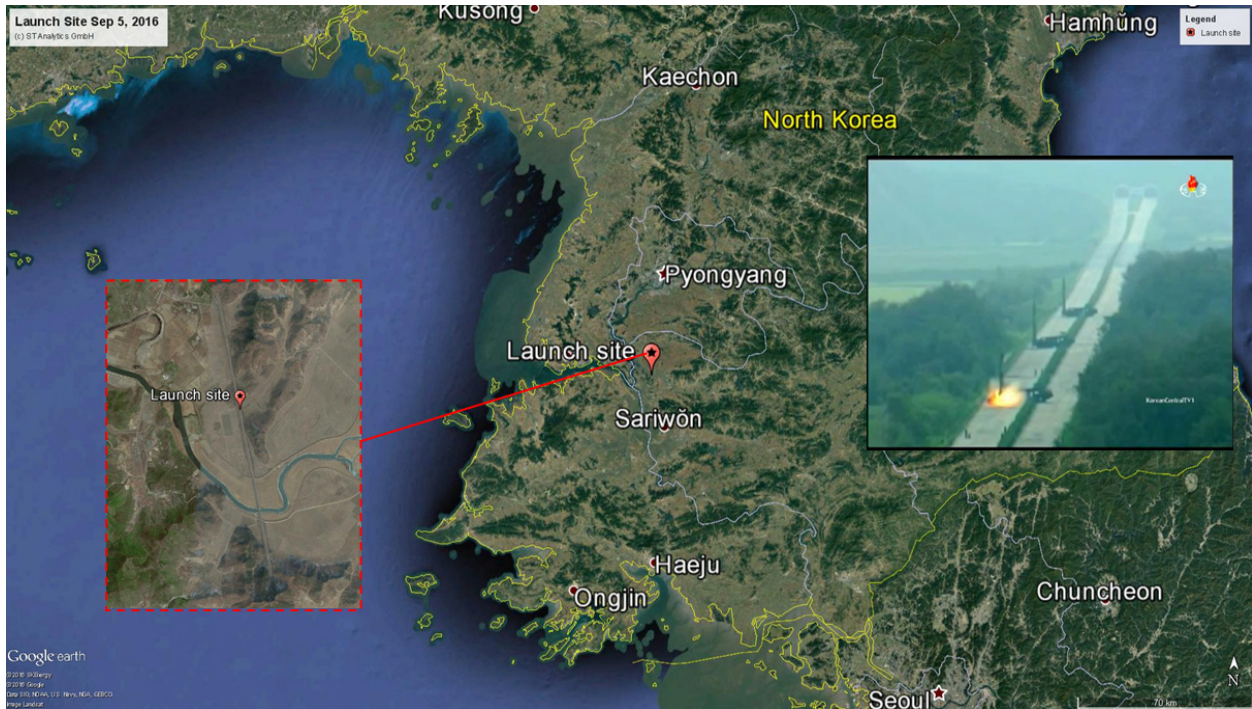


(Photo: KCNA)

Technical Analysis

KCNA published footage of the September 5 missile tests, showing three missiles lifting off in rapid succession from three transporter-erector-launchers (TELs) with less than a minute between the first and second launch and only a few seconds between the second and third.

Figure 2. Launch site.



The launch video was recorded from a distance, making the three TELs and the tunnel entrances look closer together than they actually were.

All three missiles were of the same type, now referred to as “Scud-ER” (for Extended Range) by some experts. The TELs that launched them are based on the Belarusian MAZ 543 chassis, which features four axles. They appear to be the kind generally used for Scud-B and Scud-C launches, with just a few minor modifications for the erector mechanism to hold the “new,” longer missile.³

Measuring North Korean missile dimensions using the available low-quality photos and videos is always difficult, especially with regard to the length of internal propellant tanks. However, an iterative combined process of reconstruction and measurement allows for a consistent picture of the missile that is in line with the measured dimensions. The margin of error for these calculations is below 5 percent.

³ Only the length of the erector assembly required modification; the standard assembly is wide enough to hold a missile that is 1 m in diameter.

Figure 3. The missile.

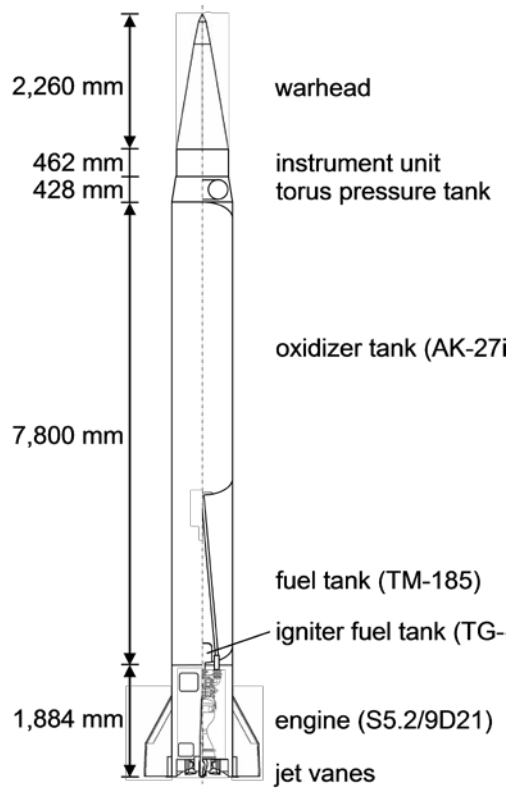


(Image: Schmucker Technologie)

The missile has a diameter slightly over 1 m and a total length of around 12.8 m. Its launch mass is 9.23 metric tons. Its launch acceleration of 1.4 g is low for a ballistic missile of its size, indicating the use of an existing engine not specifically designed for this rocket.⁴ Analysis shows that the low acceleration is precisely what one would expect from a missile of that size and weight equipped with a nominal S5.2/9D21 engine from the R-17/Scud-B missile. Its reported range of 1,000 km is thus only possible with a lightweight aluminum tank structure and some modifications of the rocket's pressure system, including a torus-shaped pressure tank located at the top. The rocket provides the maximum performance that a single Scud-B engine can achieve in a missile.

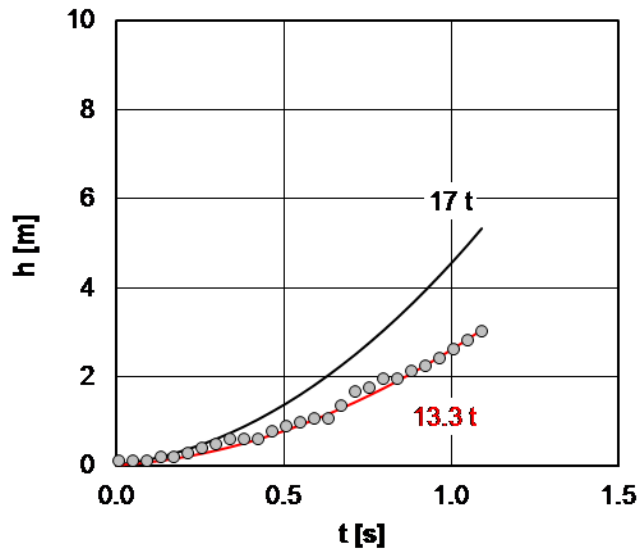
⁴ For an optimum standard launch acceleration of 1.8 g, an engine with 17-metric-ton thrust would have been expected, comparable to the old Soviet S5.1 engine, or to one chamber of the Soviet S2.1150 engine cluster for the Burya booster.

Figure 4. Dimensions and configuration.



The missile's total length is estimated as 12,834 mm, with a small margin of error. (Image: Schmucker Technologie)

Figure 5. Acceleration.

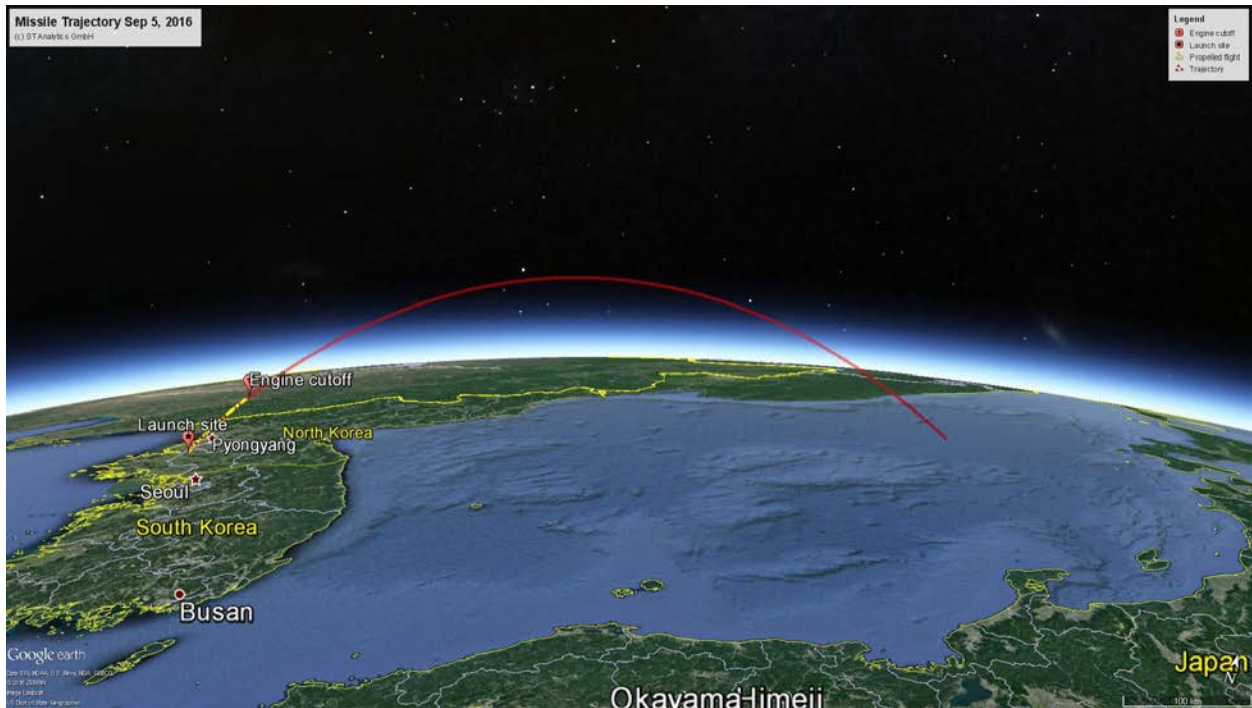


The measured acceleration matches that of a standard 13.3-metric-ton Scud-B engine for the reconstructed missile. (Image: ST Analytics)

The guidance system is housed inside the cylindrical section below the warhead,⁵ and the whole guidance and control system matches that of the original Scud-B. The burn time is 127.8 seconds, reflecting the limits of the original control system; the original Scud-B jet vanes also can operate for more than 120 seconds. A warhead weighing approximately 500 kg would separate after engine cutoff.

The launch preparation time, however, is longer than for the Scud-B; the recently tested missile probably cannot be transported in fueled condition due to its aluminum tank structure, requiring it to be fueled just before launch. Available footage indicates that the missile uses kerosene and another liquid propellant called inhibited red fuming nitric acid (IRFNA), the same propellants used for Scud missiles as well as the larger Nodong missile.

Figure 6. Scud-ER Missile Trajectory from September 5, 2016 tests.



The missile's peak altitude is only around 200 km, and its flight time is 9 minutes. The boost phase is marked yellow.

⁵ Since the days of the Iraqi program, it is widely known that the rearrangement of the Scud guidance instruments as seen in the Al-Hussein (short) allows for a shorter instrument unit than seen with the original Scud-B. However, the instruments in the shortened unit can only be accessed from top, thus complicating launch operations.

A New Design?

For decades, North Korea relied on so-called Scud technology for its missiles. The Scud-B, the Scud-C, the Nodong, the elusive Scud-D, the Taepodong-1 satellite launcher and the Unha satellite launchers all used this proven Soviet technology type. It is clear by now that North Korea received massive support from Soviet/Russian entities in the late 1980s and early 1990s, when Scud technology became the backbone of the North Korean rocket programs. This explains North Korea's focus on these technologies, as well as its quick row of successes over these years.⁶

The first launch attempts for the solid-fueled KN-11 submarine-launched ballistic missile in 2015 and the liquid-fueled Musudan in 2016 seemed to represent a shift toward different technologies,⁷ away from the Scud-focused designs that appeared in the 1990s.

This is still true because the “new” Scud missile is not a new missile. Around 2000, rumors circulated that North Korea had made more missiles available for export than just the Scud-B, the Scud-C and the Nodong—the only missiles it was known to have launched, if only a few times.⁸ One of these mysterious other missiles was said to be a wrung-out Scud with a diameter of 1.025 m, a total length of more than 12 m and a launch mass of 9.3 metric tons. According to rumors, the weapon had a range of 1,000 km with a 500-kg warhead. The data indicated a very ambitious design beyond North Korea's proven capabilities, but because the missile was never seen and no indications emerged of development work, observers dismissed reports of the weapon as part of a North Korean disinformation campaign.

At the same time, another Scud version that was designated the Scud-D was allegedly transferred to Syria, where one was fired in September 2000 over a distance of roughly 700 km. No photos of this missile have surfaced, but analysts generally assumed it was another conventional modification of the R-17/Scud-B family; with a diameter of 0.88 m and a length greater than 12 m. Such a weapon could carry a 500-kg warhead farther than 700 km. Considering Iraq's effort to extend the range of its Scud arsenal in the late 1980s, this modification seemed to reflect a logical design path.

Yet the rumored Scud-D has remained elusive. Syria reportedly launched more of these missiles from 2005 and onward, but the details were not consistent with the Scud-D as it was depicted in literature.⁹ Only three launches of the Scud-D were ever reported from North Korea (in 2006 and

⁶ This hypothesis is still disputed by some experts, but shall not be discussed here. The authors are currently preparing an essay that focuses solely on this issue.

⁷ The Musudan seems to be based on technology from the Soviet R-27/SS-N-6 submarine missile (which is far superior to Scud technology), while the KN-11 shows clear parallels to Chinese design approaches. The R-27 was also developed at the Soviet Makeyev Design Bureau, just like the Scud-B and the Scud-C.

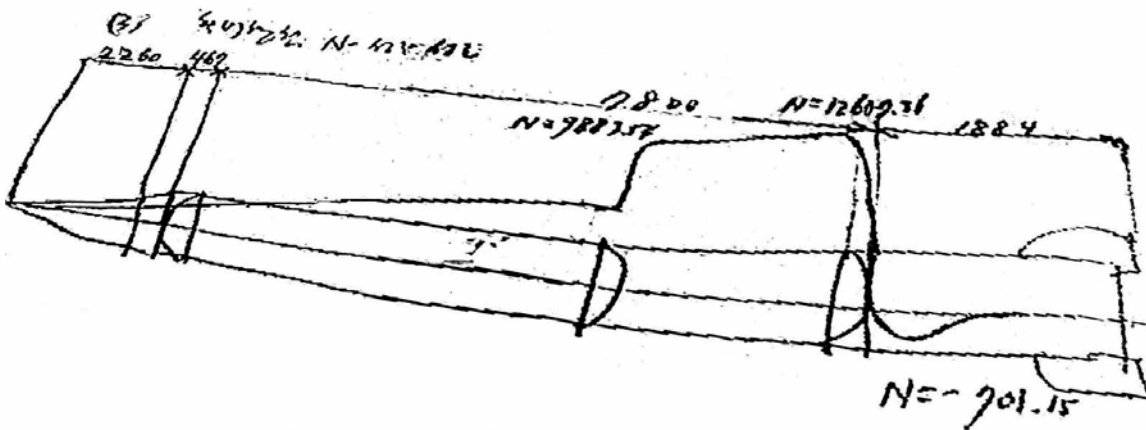
⁸ These tests were surprisingly successful, given that no development work was observed.

⁹ The Syrian launches also did not appear consistent with characteristics of the “new” North Korean missile from

2009), but their range was little more than 400 km—far short of the Scud-D’s estimated range—and no photos were ever published. It remains unknown if this Scud-D actually exists, if the “new” North Korean 1-m Scud version actually is the Scud-D that also found its way to Syria, or if a 0.88-m Scud-D was ever launched in North Korea.

Clues to these questions might be hidden in a group of mysterious drawings found by Indian port authorities on the North Korean freighter *Kuwolsan* harbored in Kandla in 1999. Certain details did not add up when analysts initially interpreted the drawings as diagrams of the Scud-D missile, but another look reveals striking similarities with the “new” 1-m diameter Scud.

Figure 7. *Kuwolsan* drawing.



This drawing, found in 1999 aboard the North Korean freighter *Kuwolsan*, shows a missile with segments that are a perfect match in length for the “new” 1-m Scud missile. Just one short additional segment between tanks and the warhead seems to be missing here. (Image: Schmucker Technologie)

Numbers written alongside the missile sketch are a near-perfect match for the “new” missile’s estimated dimensions. The diagram depicts an engine compartment that is 1,884 mm in length,¹⁰ with tanks that add up to 7,800 mm in length. The 2,260 mm separable warhead is shorter than that of a Scud-B, and looks a little smaller in diameter than the rest of the missile. There is a 462 mm section between the warhead and the tanks. This makes the total length 12,406 mm, somewhat short of the measured 12.8 m. However, clearly visible in photos of the “new” missile is a section between the warhead and the tank consisting of two parts, one of them cylindrical and with the smaller warhead diameter, the other conical, and both around 45 cm long.

This leads to an interesting hypothesis for this missile’s origins. It seems that the “new” Scud was already available around 2000, with detailed designs floating around. As for the other North Korean missiles of that era, no development program was ever observed in North Korea.

September 5.

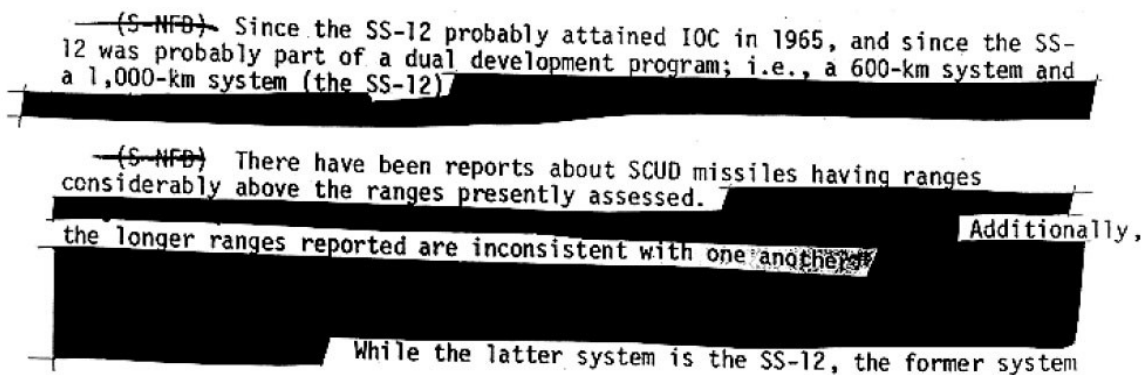
¹⁰ This length is identical to the engine compartment of the Scud-B and the Scud-C.

According to our research, it is clear that the Scud-B and Scud-C were both transferred to North Korea from the Soviet Union in the late 1980s and early 1990s, and there are strong indications that the same had happened with the Nodong. There was also a strong connection to the Makeyev Design Bureau, with the observed designs originating from Makeyev, and with several reports stating that engineers or designers from Makeyev tried to travel (or successfully traveled, depending on the report) to North Korea around 1992.

This raises the question of whether there also is a Soviet equivalent to the “new” Scud missile. And it seems that there is one, again linked to the Makeyev Design Bureau.

As others have explained,¹¹ Makeyev started a performance improvement program for the Scud-B in 1963, in cooperation with the Machine Plant No. 235 in Votkinsk. It seems that the Scud-C was not the only result of this cooperation. At the same time, there was a request from the Red Army for a missile capable of hurling a 500 kg warhead up to roughly 1,000 km.¹² The Intermediate-Range Nuclear Forces Treaty later referred to the missile that fulfilled this requirement as the OTR-22, and its Soviet system name was Temp-S, system GRAU number 9K76.

Figure 8: Excerpt from 1974 DIA report.



(Image: US Defense Intelligence Agency/National Security Archive)

¹¹ M. Schiller, “Characterizing the North Korean Nuclear Missile Threat,” Technical Report TR-1268, RAND Corporation, Santa Monica, September 2012. 25 and 80. http://www.rand.org/pubs/technical_reports/TR1268.html. R. H. Schmucker, M. Schiller, “Raketenbedrohung 2.0 – Technische und politische Grundlagen” [Missile Threat 2.0 – Technical and Political Basics], E.S. Mittler & Sohn, Hamburg, Bonn, April 2015. 298.

¹² In the West, there was some confusion at that time about this missile, which was deployed from 1967 onward. At that time, it was referred to as the SS-12, but the designation later shifted to SS-22, or Scaleboard.

A declassified DIA report from 1974 mentions Scud missile versions being developed for “ranges considerably above the ranges presently assessed,” and “the longer ranges reported are inconsistent with one another.”¹³ One of these advanced Scuds was the Scud-C. Another version could have been the “new” North Korean Scud, developed as a rival system for the 1,000 km requirement, combining the improved Scud-C design with the newly mastered aluminum airframe technology.¹⁴ Except for the fins, the “new” missile’s dimensions nearly matched those of the OTR-22 (which had grid fins that were folded closely to the missile body during transport). The “new” missile would probably even fit into the oddly shaped transport container of the old Soviet Temp-S system, and the Temp-S warhead has about the same diameter as the “new” missile’s body.

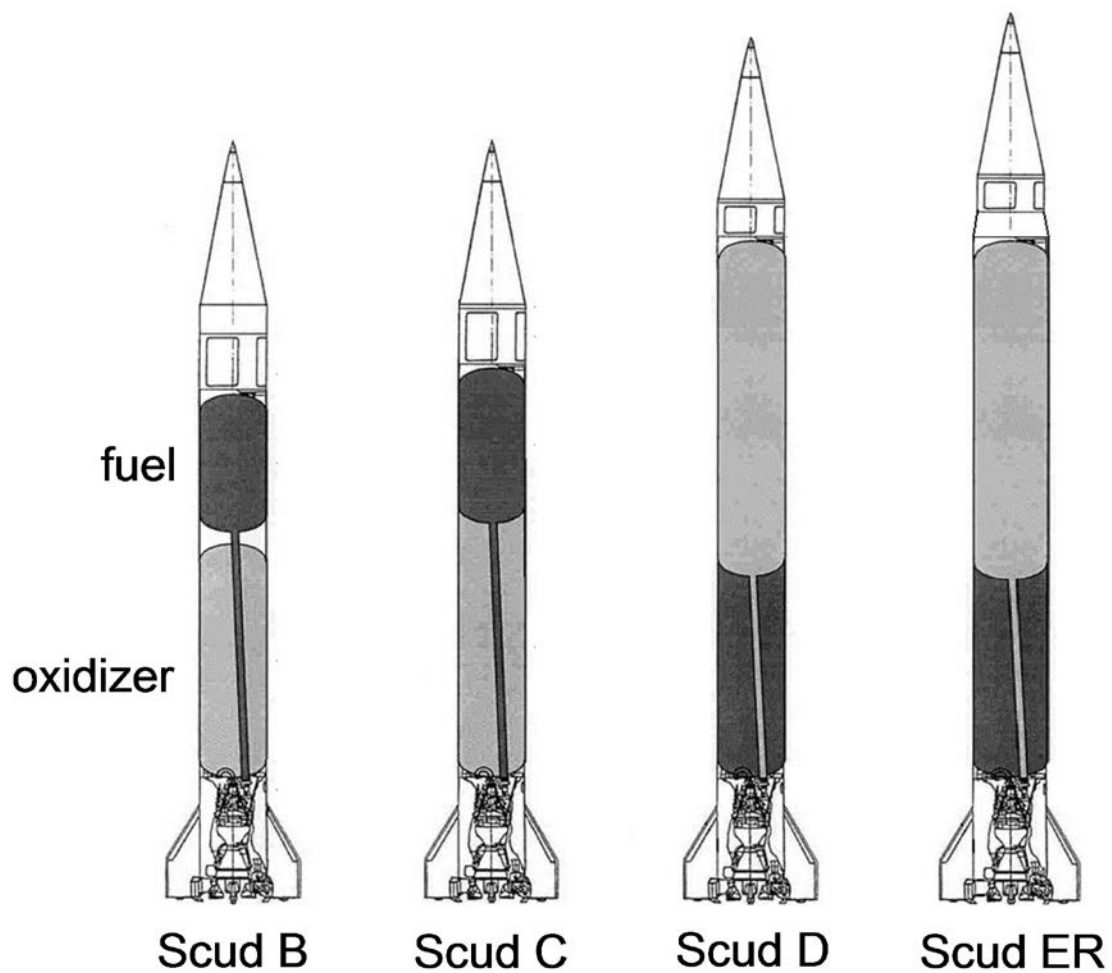
If you look at the Scud-B, Scud-C, Scud-D and Scud-ER, the path is sensible, smart, and logical. It seems as if a single design team took a stepwise approach by increasing the basic Scud’s range to 500 km, 700 km and 1,000 km, at the same time reducing the warhead weight while pursuing new design solutions only where necessary. This path resembles the development of many other Soviet rocket lines, including the R-1/R-2/R-5 line, the R-12/R-14/R-16 line and the famous R-7/Soyuz line.

This does not necessarily mean that the “new” missile is actually an old Soviet missile, but this hypothesis is consistent with every other missile activity that has been observed in North Korea in the past 30 years. Even if the Scud-ER was based on a Russian design and modified by domestic engineering, this missile is not new. As previously mentioned, the very Russian design was already present in North Korea in the 1990s, when massive technology transfers from Russia had started what is now known as the ever increasing North Korean missile threat.

¹³ “The National Security Archive”, The George Washington University, Website, 2016.
<http://nsarchive.gwu.edu/NSAEBB/NSAEBB39/document1.pdf>.

¹⁴ At this time, it was common for the various Soviet design bureaus to compete in developing missiles for given requirements, or even to develop missiles on their own to be prepared for future requirements, all to gain the favor of the Soviet Politburo.

Figure 9. Evolving Scud Configurations.



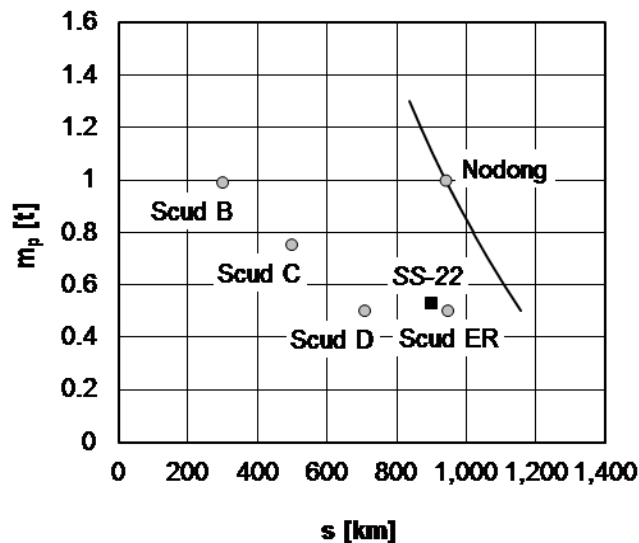
The Scud-ER is a logical step along the known line of Scud missiles. The short instrument section was introduced with the Scud-D, and the propellant tanks were swapped. (Image: Schmucker Technologie)

Table 1. Scud data (nominal and reconstructed).

Design Characteristics	Scud-B	Scud-C	Scud-D	'New' Scud
Launch Mass m_0 [kg]	5,860	6,100	7,200	9,230
Length l_r [m]	10.944 (nuc.) 11.164 (con.)	10.944	12.4	12.834
Diameter d_r [m]	0.88			1.025
Max. Diameter [m]	1.810			1.955
Oxidizer	Inhibited red fuming nitric acid IRFNA (AK-27i)			
Fuel	Kerosene (TM-185) and igniter fuel (TG-02)			
Thrust (sea level) F_{sl} [kN]*	130.53			
Thrust (vacuum) F_{vac} [kN]*	144.22			
Mass Flow m [kg/s]	57.83			
Propellant Mass m_{pr} [kg]	3,771	4,335	5,480	7,730
Net Mass m_{net} [kg]	1,087	1,000	1,200	970
Pressure Gas Mass [kg]	15	15	20	30
Payload Mass m_p [kg]	987 (nuc.) 989 (con.)	750	500	500
Burn Time t_b [s]	61.96	72	90	127.8
Range s [km]	300	500	700+	1,000

* Without jet vane losses

Figure 10. Range and payload graph.



The performance graph illustrates the development path of the Scud family. It also highlights that the Nodong and the “new” Scud were quite close to the SS-22 in range, but with severe operational drawbacks that may have precluded their acceptance for deployment by the Soviet Politburo. Due to its high net mass, the Nodong does not show impressive performance gains with lighter warheads. (Image: Schmucker Technologie)

Conclusion

It seems strange that North Korea would develop just another missile with a range of around 1,000 km. The Nodong already covers this distance with a 1 t warhead, and more than that with a 500 kg warhead. There is some belief that the Scud-ER may have been a cheaper alternative to produce or perhaps a backup to the Nodong, however, every development program requires time and money, tying up precious resources and personnel for a significant amount of time. Redundant access to an already accessible strike range is a luxury that North Korea would seem not to be able to afford.

Some sources indicate that this missile already was available in North Korea in the late 1990s, when the country had just received massive transfers of Soviet/Russian technology. It seems plausible that the “new” missile was part of this deal and only has been revealed now at a time when North Korea wants to show to the world that it is not a missile ‘paper tiger,’ but a nation that can surprise anyone anytime with its quickly evolving capabilities on the missile sector.

It is unknown how many of these missiles are actually in North Korean hands, but seeing large numbers in the future would be a surprise. Because the area within range of the country’s missiles has not expanded and the “new” missile requires significant time to fuel at the launch site, the North Korean missile threat remains fundamentally unchanged. It cannot be ruled out, though, that additional Soviet-era missile designs still unknown to the West could become the basis for more North Korean missiles in the near future.