28 October 2015

Getting Better

The New KN-08 Design

Markus Schiller[1]
Robert H. Schmucker[2]

On 10 October 2015, to honor the 70th anniversary of its ruling Workers' Party, North Korea paraded four never before seen missiles through the streets of Pyongyang. According to a plaque mounted at one of the vehicles, these missiles are named Hwasong-13, as were the ICBMs that were unveiled three years earlier at a parade in April 2012. It is therefore assumed that the new missile is the updated design of the old Hwasong-13, also referred to as the KN-08. While a much better design approach than the old KN-08, the new version still shows some strange features, some of them only required for submarine missiles.



Figure 1: The New KN-08/Hwasong-13 Design

Differences to the Old Design

At a close look, it seems easier to mention the few commonalities of the old and the new design due to the many changes that were incorporated.

[1] Dr.-Ing. Markus Schiller, *ST Analytics GmbH*, 80331 Munich, Germany, schiller@st-analytics.de
[2] Prof. Dr.-Ing. habil. Robert H. Schmucker, *Technische Universität München*, 85748 Garching, Germany

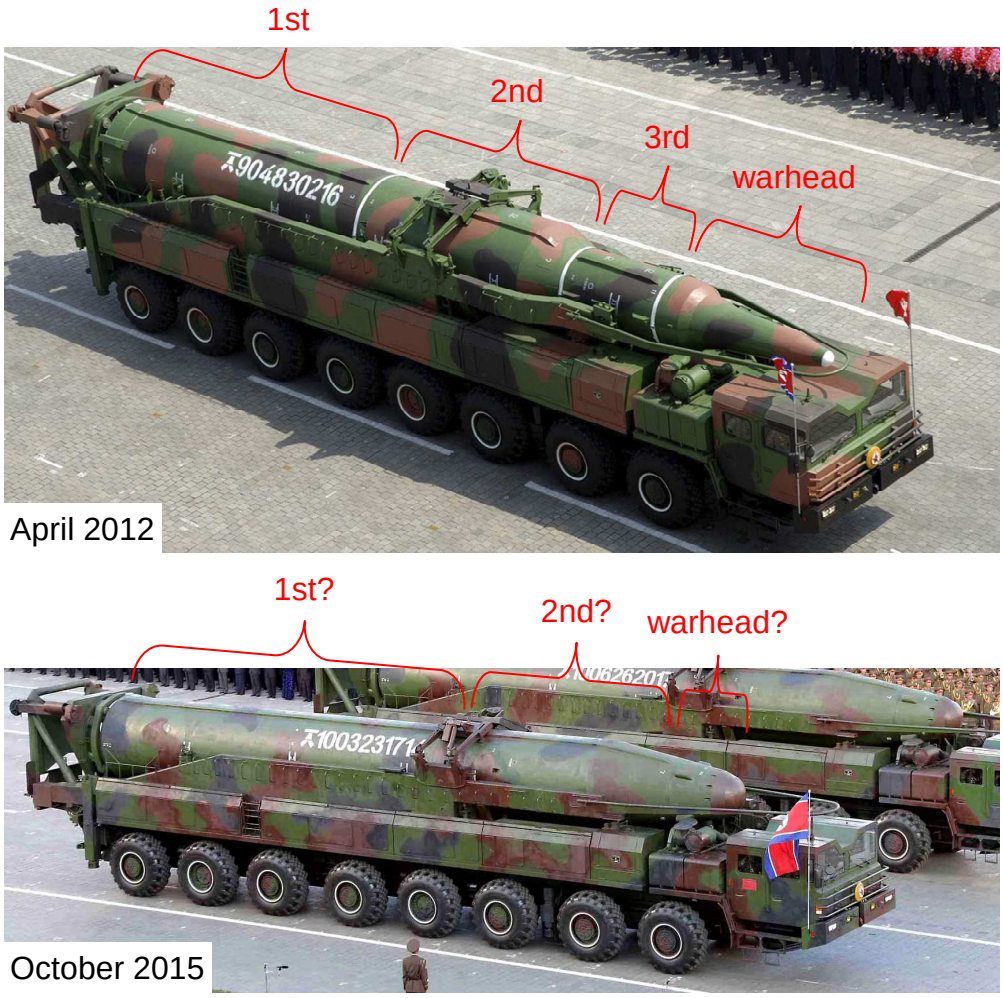


Figure 2: Old and New KN-08 Design

Due to the poor quality of available photos, it is hard to clearly identify the number of stages. There are some indications, though, that there is a separation plane located at the holding mechanism. Assuming this is true, the most important differences are:

- 2 stage design instead of 3 stages
- larger first stage
- different second stage
- different warhead and/or post boost system
- reduced total length

The main diameter seems to be the same as the old design, meaning around 2 m.

Table 1: Old and New KN-08 Design

Design Characteristics	Old	New
Stages	3	2
Stage Diameters	~ 2 m, ~ 2 m, ~ 1.3 m	~ 2 m, ~ 2 m
Total Length	~ 19 m	~ 17 m
Cable Duct/Raceway	only at tanks	from base to top
Stage Separation Rockets	chaotic locations	sensible locations
Visible Warhead Length	long	short
Front Shape	conical warhead	blunt
Mock-up Quality	very poor (2012) poor (2013)	average (2015)

The whole design looks much more mature than the old version, and the overall quality of the mock-ups is much better.[3] Details like the skirt at the missile's base, or the number 7 painted on a hatch at the front end of the second stage indicate some consistency between the old and the new design. Some other common details were reworked, like the pits on the second stage that indicated internal pre-acceleration rockets – they were rotated by 180° to now serve as retro rockets.[4]



Figure 3: Internal Rockets at Old and New Design's 2nd Stage

Moving from a 3 stage design to a 2 stage design is an interesting step. If ever, a change in stage numbers is done the other way by adding an additional stage if performance deficits become obvious. Adding an additional stage can add performance (payload/range) to many missile designs, while reducing the number from 3 to 2 usually results in reduced performance. This could indicate that the old design was not carefully planned and developed, and that a serious analysis showed that two stages are the better option.

[3] Usually, all missiles shown on parades are mock-ups. See http://en.asaninst.org/contents/assessment-of-north-koreas-latest-icbm-mock-up/ .

[4] Pre-acceleration rockets accelerate the liquid-fueled upper stage at separation to have the propellants settling down to the tank bottom, thus avoiding gas bubbles to be sucked into the propellant feed system, which in turn may destroy the turbo pump. Retro rockets pull the stage away from the next stage (or warhead) at burnout, thus allowing clean separation and precise injection into the ballistic trajectory.

Observed Details

A number of observed details on the new KN-08 design are worth some comments.

- Red Plaque at Driver's Cabin

The red plaque at the driver's cabin reads "Hwasong-13 launcher overseen by the great leader Comrade Secretary Kim Jong Il and revered top commander in chief Kim Jong Un." Perhaps this is meant to show that the Hwasong-13/KN-08 program was already initiated by Kim Jong Il, and Kim Jong Un is well aware of the program's status and progress.



Figure 4: Plaque at TEL Driver's Cabin

- Stage lengths and total length

The new design's first stage clearly is longer than the old one. The second stage also seems a little bigger than the old design. The stage size ratio now looks quite sensible, especially for a two stage liquid-fueled missile. Due to the lack of both a third stage and a long warhead design, the new design is much shorter than the old design, which already seemed way too small for its TEL in regard to length as well as weight.

- Mock-up quality

There should be no doubt that the presented missiles are mock-ups, and not real and operational missiles. No country is known to show functional missile systems on its parades, and North Korea will not do otherwise. There also are some minor details that make it obvious that these "missiles" are not the real thing. However, the quality of these mock-ups increased a lot compared to the old designs shown in 2012 and 2013.

- Propellants

There are yellowish propellant caps visible at the side of the missiles. For Soviet missiles (including missiles in Iran or North Korea), fuel is coded yellow while oxidizer is red, thus indicating that the fuel tank on both stages of the new KN-08 design is located at the

bottom. The precise position of these filling and/or drain valves is also interesting. They are not located on the top of the horizontal missile, thus indicating that the missile is not being fueled in a horizontal position, as is for example the R-17/Scud B. But if this missile is being fueled in a vertical position, it either has to be fueled before it is placed on the TEL, thus not allowing temperature sensitive propellant combinations that are usually used for submarine-launched ballistic missiles – or it has to be fueled at the launch site, making the weapon system a sitting duck for perhaps an hour or more right before launch. The fuel hatch position at the first stage also indicates that the engine is not submerged in the fuel tank, thus contradicting the impression made by the cable duct (or raceway) that runs all along to the very back of the missile.



Figure 5: Fuel Fill and/or Drain Valves

- Warhead

The new warhead design is the most interesting detail of the presented missiles.



Figure 6: Details of 2nd Stage and Warhead

There are four little boxes mounted around the likely warhead unit, looking like some kind of propulsion system. The quality of the available footage and photos is too low to identify the orientation of these assumed propulsion units, but considering the previously identified retro rockets that pull the 2nd stage away from the warhead unit (Figure 3), another set of rockets accelerating the warhead away from the upper 2nd stage makes no sense. Therefore, there is a good chance that these boxes are intended to look like a post boost system. This is further backed by the 2013 KN-08 design that featured fuel filling and drain valves between 3rd stage and warhead (Figure 7), which clearly indicated a separate post boost system. In this case, the dents along the new design's brown nose cap are simply intended to allow access to screws that hold the cap in place. With a length of only little more than 0.7 m and a base diameter of perhaps 0.7 m, the brown nose cap alone is too small to for any noteworthy warhead. Due to aerodynamic stability, the warhead's center of gravity has to be located quite far at the front, thus severely limiting the possible size of any warhead charge. This again implies that a reentry vehicle could be mounted instead of the brown nose cap – there is enough empty space left at the truss structure to hold a cone with about 2 m total length and 0.7 m base diameter, which pretty well matches the size and shape of the old KN-08's warhead cone design.



Figure 7: Evolution of the Implied KN-08 Post Boost System Design

There is, of course, another option, one that was already identified by other analysts.[5] The whole missile design slightly reminds of the Soviet R-29 Submarine Launched Ballistic Missile (SLBM) family. These missiles featured highly complex warhead designs with reentry vehicles mounted backwards on a post boost propulsion unit, and extending down into the upper stage propellant tank.

New Design, R-29, and SLBM Characteristics

This brings up the theory that the new design was derived from the R-29 SLBM, perhaps even using some of the R-29's technology. However, this is quite unlikely for several reasons.

[5] *Analysis: Redesigned KN-08 missile unveiled in military parade*, S. LaFoy, NK News.org, October 16, 2015 http://www.nknews.org/2015/10/analysis-redesigned-kn-08-missile-unveiled-in-military-parade/



Figure 8: New KN-08 and Soviet R-29 SLBM

On first look, there actually seem to be some parallels between the R-29 and the new KN-08. However, a closer look reveals that while the basic design might have been inspired by the R-29, there are several clear differences in shape and details. There also are some technical points that prohibit the use of R-29 technology, ranging from obvious problems with using the R-29's propellant combination for a road-mobile missile up to the numerous highly complex design solutions that had to be used on the R-29 to reduce its size. The R-29 had to fit into a submarine launch tube, while the KN-08 does not have any size restrictions, so there is no need to increase risk and complexity by applying these design solutions to the KN-08!

Thoughts on the Design Change

In spite of total lack of evidence,[6] the old KN-08 design was considered quite advanced, if not close to operational, by some analysts once it was paraded through Pyongyang for a second time in July 2013.

Assuming that this advanced status was true, it seems very strange indeed that the old design was replaced by a new design without ever having left the ground – until today, there has not been a single test flight of the KN-08, old or new.

There also is the chance that the old KN-08 never was a serious design concept, and that

[6] *A Dog And Pony Show*, M. Schiller, R. H. Schmucker, April 18, 2012
http://lewis.armscontrolwonk.com/files/2012/04/KN-08_Analysis_Schiller_Schmucker.pdf
The Assumed KN-08 Technology, M. Schiller, R. H. Schmucker, April 26, 2012
http://lewis.armscontrolwonk.com/files/2012/05/Addendum_KN-08_Analysis_Schiller_Schmucker.pdf
Assessment of North Korea's Latest ICBM Mock-Up, M. Schiller, R. H. Schmucker, J. J. Kim, January 14, 2014
http://en.asaninst.org/contents/assessment-of-north-koreas-latest-icbm-mock-up/

the old mock-ups were hastily put together without much thought, just to have something that could be paraded at Kim Il Sung's 100th birthday on 15 April 2012.

We always leaned toward the latter hypothesis, especially in the light of the big picture that resulted from combining observations, known limitations, and past experiences in the fields of technology, policy, and economics.[7] Strategic nuclear capability seems to be something that North Korea wants to have, but the objective is already sufficiently met once its enemies believe that North Korea might have that capability.

Conclusion

The new design is far more advanced than the old KN-08. There might be ambitious goals set by the North Korean leadership, demanding a functional road-mobile ICBM without having a clue of the efforts required for such a program. Kim Jong Un might even have commanded to set up some sort of program that perhaps enjoys highest priority, but the actual progress of this program has to be seen. Even though North Korean engineers certainly are just as smart as anywhere else, North Korea still is a poor country lacking a strong high-tech industry and an educated workforce. The global sanctions do not make that situation easier. However, developing a missile of the presented size – and deploying this missile as part of an operational weapon system – is a tremendous task that requires massive efforts. Only very few countries are capable of doing that, and even less have mastered this task to this day.

The KN-08 program should be closely followed and monitored, as should be any other rocket related program in North Korea, but no big leaps are to be expected in the coming years. The KN-08 missile is not yet a threat, and it has to be seen when – or if at all – it will be one. There are no miracles, not even in North Korea.

[7] For further reading, see

Characterizing the North Korean Nuclear Missile Threat, M. Schiller. RAND Corporation, Santa Monica, CA, 2012. ISBN 9780833076212 http://www.rand.org/pubs/technical_reports/TR1268

Raketenbedrohung 2.0 – Technische und politische Grundlagen [Missile Threat 2.0 – Technical and Political Basics], R. H. Schmucker, M. Schiller. E.S. Mittler & Sohn, Hamburg, Bonn, April 2015. ISBN 9783813209563