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The Hwasong 15 – A Threat to the US Mainland

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North Korea's Hwasong 15 ICBM – A Threat to the US Mainland

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North Korea Launches a new ICBM the Hwasong 15

In the early morning of November 29, 2017 at 02 47 local time (06 17 PM GMT) North Korea launched a new ballistic missile the Hwasong 15. The missile was launched from Pyongsong in South Pongyan province about 30 Km north of Pyongyang.

After a flight time of 53 minutes and 49 seconds and reaching an altitude of 4475 Km, the missile landed about 250 Km west of Aomori (northern part of Japan's main island of Honshu) demonstrating a range of 950 Km.

The missile was reported to be broader and longer than the Hwasong 14. Analysts tracking North Korea's missile and nuclear weapon development suggested that this two-stage missile could comfortably reach the US mainland with a reasonably sized nuclear warhead.

They also stated that it was powered by a newly developed two engine booster stage that could be gimballed for control purposes. The burn time for the first stage is reported to have been 128 seconds while that of the second stage was 161 seconds.[2]

After three Hwasong 12 launches in May, August and September and two Hwasong 14 launches in July 2017 the November test of a new ICBM provides further evidence of North Korea's intentions to be able to quickly achieve an "assured retaliation" capability against the US and its allies.

As a part of its ongoing research on North Korea's nuclear and missile programmes, the International Strategic & Studies Programme (ISSSP) at the National Institute of Advanced Studies (NIAS) has been making a series of assessments that cover the Hwasong 12 IRBM launches of May, August and September of 2017 as well as the July 4 and July 28 launches of the Hwasong 14 ICBM. The connections between North Korea's nuclear weapon tests and the missile programme are also covered in these studies.

This report provides a critical evaluation of the Hwasong 15 launch of November 29, 2017. It draws upon our earlier work covering the different launches of the Hwasong 12 and Hwasong 14. As in the other studies it uses measurements on images of the Hwasong 15 missile put out by North Korea to size the missile. It then uses this data along with the NIAS developed Quo Vadis trajectory software to match the reported performance of the missile with various

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[2] Ankit Panda, "The Hwasong 15: The Anatomy of North Korea's new ICBM", The Diplomat, December 06 2017, at https://thediplomat.com/2017/12/the-hwasong-15-the-anatomy-of-north-koreas-new-icbm/

missile parameters through an iterated trial and error process. The results of this matching exercise are then used to evaluate the range of the missile with different payload masses and different directions of launch. Based on the results of these analyses the ability of the Hwasong 15 to reach different parts of the US mainland are critically evaluated. The implications of this test on the US North Korea dynamic are also touched upon briefly.

Figure 1 provides a visual overview of these long-range North Korean missiles launched in 2017.[3]

Figure 1

Image Analysis

Table 1 provides the L/D ratio measured on the Hwasong 15.[4] For comparison the ratios for the Hwasong 12 and the Hwasong 14 are also presented. Since the missiles appear to be carrying different kinds of warheads the ratio of the missile length without the warhead to the diameter has been used as a more appropriate measure to make comparisons.

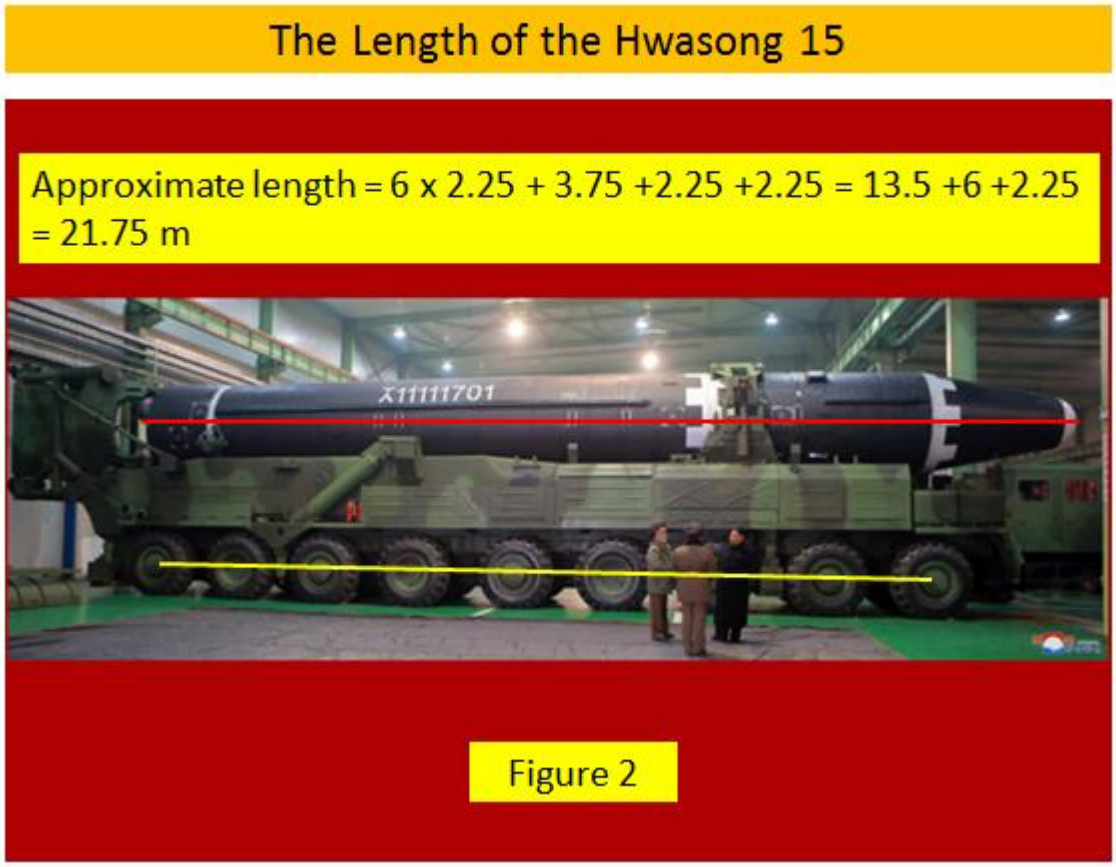
Table 1

Missile	L/D Ratio	Stage Length / D Ratio
Hwasong 12	9.80	7.61
Hwasong 14	10	6.61
Hwasong 15	9.17	7.74

[3] This image was one of several released by North Korea after the launch.
[4] L/D is the Length to Diameter ratio

As we can see from the Table when the warhead lengths are taken out the Hwasong 12 and the Hwasong 15 with ratios of 7.61 and 7.74 appear to be quite similar. The Hwasong 14 with a ratio of 6.61 appears to be different. In an earlier assessment of the Hwasong 14, NIAS had estimated the diameter of the Hwasong 14 as about 2 m. Reports put out in the public domain state that the Hwasong 15 is both broader and longer than the Hwasong 14.[5] From this we can infer that the diameter of the Hwasong 15 is greater than 2 m.

There are also some images of the Hwasong 15 mounted on its new 18 wheeled TEL being transported prior to the launch. **Figure 2** provides one of these images. From a study of the different TEL images the tire diameter appears to be about 1.5 m and the wheel base about 2.25 metres.[6]



The approximate length of the missile based on this is about 21.75 m which translates into a diameter of 2.37 m for the Hwasong 15. **This diameter is very close to the 2.4 diameter of the booster stage of the Unha 3 Satellite Launch Vehicle (SLV)**. Though the engine used for the Hwasong 15 is quite different from that of the Unha 3 booster it is likely that the same manufacturing infrastructure has also been used for the Hwasong 15 booster stage.

[5] See Reference 1

[6] The original MAZ 543 TEL from the Soviet Union also had a tire with a diameter of 1.5 m and a wheel base of 2.2 m. North Korea seems to have used this a basis for their new TEL designs. The wheel base is the distance between the centers of two adjacent wheels.

Most analysts reporting on the Hwasong 15 do not provide detailed information on the length or the diameter of the Hwasong 15. One analyst does connect the Hwasong 15 with the Unha 3 and goes on to derive some parameters of the missile based on this link.[7]

Using the diameter of 2.4 m as the basis the overall length of the Hwasong 15 works out to be **22 m**. This is not inconsistent with the TEL derived measurement of 21.75 m. The lengths of the different components of the missile including the warhead and the stages are provided in **Table 2** below.

Table 2

Missile Component	Length (m)
Warhead	3.4 m
Stage 2	4.2 m
Stage 1 tankage	11.9 m
Stage 1 engine	2.5 m
Overall Length	22 m

Estimation of Missile Parameters for Baseline Configuration

These lengths were used as the basis for estimating the propellant and inert masses of the two stages of the Hwasong 15 missile. These missile parameters are needed for establishing an initial configuration for running the ISSSP developed Quo Vadis software package used in reconstructing the trajectory. The propellant and inert masses needed for the trajectory reconstruction were derived from the ISSSP's reconstruction of the Unha 3 launch of 2016. [8] **Table 3** provides the details of these estimates.

Table 3

Hwasong 15 Stage 1	
Propellant Mass	52000 Kg
Inert Mass	9900 Kg
Stage 1 Mass	61900 Kg
Hwasong 15 Stage 2	
Propellant Mass	7500 Kg
Inert Mass	2000 Kg
Stage 2 Mass	9500 Kg
Lift Off Mass without Payload	71400 Kg

[7] See Norbert Brugge, "North Korea's ultimate nuclear ICBM Hwasong 15 (HS-15)" posted on 07-12-2017 at http://www.b14643.de/Spacerockets/Specials/Hwasong-15/index.htm

[8] [8] The Unha 3 launcher parameters that provide a good fit with the realized trajectory and orbit are available in S.Chandrashekar, N. Ramani & Arun Viswanathan, "An Analysis of North Korea's February 2016 Successful Space Launch", available at http://isssp.in/wp-content/uploads/2016/04/North-Korean-Feb-2016-Successful-Space-Launch.pdf

These estimates of propellant and inert masses along with typical thrust and specific impulse values were used in a Hwasong 15 trajectory reconstruction exercise using the Quo Vadis software. The purpose of this exercise was to match the trajectory results with what has been reported in various open sources on the observed performance of the Hwasong 15. Apart from the range, altitude and time of flight of the missile these also included matching the burn times of the first and second stages that had also been reported.[9] The results of this matching exercise are presented in **Table 4**.

Table 4

Performance Parameter	Reported Value	Trajectory Value
Range (Km)	950 Km	954 Km
Altitude (Km)	4475 Km	4467 Km
Time of Flight (seconds)[10]	3229 seconds	3427 seconds
Burn Time stg 1 (seconds)	128 seconds	132 seconds
Burn Time stg 2 (seconds)	161 seconds	163 seconds
Launch site	Pyongsong	Pyongsong
Payload (Kg)	NA	150 Kg
Pitch (degrees)	NA	89.76 degrees
Azimuth (degrees)	NA	55 degrees
Impact Point	250 Km west of Amori	41.3 N 136.80 E

From the trajectory reconstruction exercise, it appears that a Hwasong 15 with a payload of 150 Kg launched at a pitch angle of 89.76 ° and an azimuth of 55° provides a reasonable match with the observed performance of the missile.

The missile parameters that provide this match are in **Table 5**.

[9] See Reference 1

[10] One plausible explanation for the difference of about 200 seconds between the reconstructed trajectory time of flight and the reported flight time could be because it may be difficult to track the missile at altitudes below 10 Km.

Table 5

First Stage Parameters	Values
Propellant Mass Stage 1 (Kg)	52000
Inert Mass Stage 1 (Kg)	9000
Stage Mass (Kg)	61000
Fuel Fraction	0.85
Thrust Sea Level (Newtons)	950000
ISP Sea Level (seconds)	246
Burn time Computed (seconds)	132
Area of Cross Section (m^2)	4.52
Second Stage Parameters	
Propellant Mass Stage 2 (Kg)	7600
Inert Mass Stage 2 (Kg)	1100
Stage Mass (Kg)	8700
Fuel Fraction	0.87
Thrust (Newtons)	135000
ISP Vacuum (seconds)	295
Burn time Computed (seconds)	163
Area of Cross Section (m^2)	4.52
Payload Mass Kg	150
Lift Off Weight (Kg)	**70750**

As we can from the Table the parameters appear to be those of an advanced missile.

Findings

The Hwasong 15 appears to be a high-performance missile with a Lift Off Weight (LOW) of 71 Tonnes.

The first stage carries about 52 Tonnes of propellant with an inert mass of 9 Tonnes. The stage has a thrust of around 95 Tonnes with a sea level specific impulse of about 246 seconds.

The second stage carries about 7600 Kg of propellant with an inert mass of 1100 Kg. It has a thrust of about 13.5 tonnes and a specific impulse of 295 seconds.

It appears from this trajectory reconstruction exercise that the missile only carried a Re-entry Vehicle shell without any active warhead components.

Can the Hwasong 15 Reach the US mainland with a Nuclear Payload?

Using this configuration of the Hwasong 15 we then estimated the range of the missile launched towards the US mainland with different payload masses in different azimuth directions. The results are presented in **Table 6.**

Table 6

Payload (Kg)	Azimuth (Degrees)	Range (Km)	Coverage
600 Kg	90 °	10106 Km	Maximum Range trajectory with suitable azimuths can cover the east Australian coast and parts of the North Island in New Zealand.
600 Kg	40 °	9324 Km	Reaches San Francisco – just short of LA
500 Kg	10 - 40 °	9460 – 10634 Km	All of the west coast up to San Diego can be reached. Alburqueque, Omaha, and Minneapolis are within range. 800 Km short of Chicago – ~1600 Km short of Washington, ~1400 Km short of New York
400 Kg	10 – 40 °	10810 – 12918 Km	All of the west coast up to Central America within reach. Most of central USA and the southern states can also be targeted. Can hit Chicago and just reach New York on the East Coast.
300 Kg	10 – 40 °	13173 – 19302 Km	All of mainland USA up to Florida and large parts of South America can be reached

With a payload of 500 to 600 Kg the Hwasong 15 can reach a large part of the US west coast and many cities in the western and central part of the continental USA. Chicago, New York and Washington DC are however out of reach. If the warhead weight is closer to 400 Kg the Hwasong 15 can reach both Chicago and New York. Any payload between 300 to 400 Kg would threaten almost the whole of the US.

North Korea has so far conducted six nuclear weapon tests including one thermo-nuclear and possibly one boosted fission test. Based on this testing history, it is quite likely that they can build a Re-entry Vehicle with a nuclear weapon that would have a mass of 500 to 600 Kg.

In an earlier analysis ISSSP had provided an overview of the threats posed by both the Hwasong 12 IRBM and the Hwasong 14 ICBM.[11]

While the Hwasong 12 was mainly directed at North Korea's neighbourhood especially the US base at Guam, the Hwasong 14 was directed at the USA.

As per that assessment for the Hwasong 14 to threaten the US mainland the warhead weight had to be about 200 to 250 Kg.

With only six nuclear weapon tests behind it many analysts doubted North Korea's ability to field a miniaturized nuclear warhead. The November 2017 test of the Hwasong 15 is a clear signal to the US that North Korea can reach the US mainland with a nuclear warhead that it can easily build and readily mount on the Hwasong 15.

Implications

As we had mentioned in our earlier assessments, North Korea is sending clear and strong signals to the US and its allies that it has in place "an assured nuclear retaliation capability" that it will use if threatened.

Launches from different sites across the country, missile launches in the night and short launch preparation times suggest that North Korea can deploy a very robust mobile missile force. The launches of the Hwasong 12, Hwasong 14 and the Hwasong 15 make it clear that the US mainland and the territories of all its allies in the Asia Pacific region are within the range of North Korea's nuclear tipped missiles. The signals also indicate that North Korea's ability to strike back after any pre-emptive attack are robust. Any attempt to take them out are likely to be counter productive.

North Korea's actions confirm that Kim Jong Un is no irrational madman but a coldly rational player who wants to make sure that he and his regime survive at all costs. One would expect him to continue missile testing as North Korea moves towards operational deployment.

Like all the tests carried out so far, these tests will be designed to communicate clear capabilities to the adversary. Further nuclear weapon tests can also be expected as North Korea signals to the world that it can indeed miniaturize a nuclear warhead that can reach the US mounted on an indigenously made ICBM. All these tests will be carefully tailored to ensure that they pose no overt threat to the US or its allies in the region.

[11] S.Chandrashekar, Rajaram Nagappa and N.Ramani, "David versus Goliath – US irrationality and nuclear war in the Korean peninsula", http://isssp.in/wp-content/uploads/2017/09/David-versus-Goliath_US-irrationality-and-nuclear-war-in-the-Korean-Peninsula.pdf

At some stage when Kim feels that he has done enough to communicate "Assured Retaliation" he may be willing to negotiate a deal. This could be as early as 2018 or later depending on the progress of his testing and capability build up programme.

The actions of the new entrant into the nuclear club may also have a cascading effect on the behaviour of US allies in the region. Japan and South Korea are directly affected countries. In the context of President Trump's US first policy their belief in the US resolve to come to their aid during a crisis could weaken further because of the North Korean threat. The two Koreas may talk directly to each other to resolve their differences. Japan may also take steps to strengthen its own capabilities to defend against a North Korean nuclear threat. China in cooperation with Russia will also use these developments to weaken the US relationships with its allies and strengthen its position.

North Korean capabilities can also lead to a further weakening of the current non-proliferation regime through horizontal transfer of key technologies to other countries. Iran Pakistan and North Korea have been partners in the nuclear and missile domains for decades. A sanctioned North Korea could leverage its technological capabilities into helping them achieve their goals – weaponization for Iran and miniaturization for Pakistan. If Iran in turn goes nuclear it will have a domino effect on the middle east with major consequences.

The spill over effects of these tangled relationships are also likely to affect other countries in the Asia Pacific in varying ways. Most countries who are either neutral or pro US are likely to move away from their current positions and hedge their bets vis a vis China.

For the US the only viable alternative short of war with its consequent risks, is to demonstrate resolve and unity with its friends and allies. It needs to make clear that in case of any transgressions by North Korea that threaten their sovereign interests they will respond militarily. Scaling down the rhetoric and moving towards the reality of a nuclearized Korean peninsula appears to be the only way forward.

The North Korean leader has so far been circumspect in the actual testing of the missiles. Kim's rhetoric though belligerent at times has remained largely neutral. In contrast the responses by President Trump have been particularly bellicose and personally directed towards the North Korean leader. These increasingly personalized exchanges largely initiated by the US President, appear to pose the greatest risk towards the emergence of a stable deterrence posture by the two major protagonists.

For the first time since the end of the Cold War the US is being directly threatened by a country other than Russia. Much of the theory, practice and norms of behaviour on nuclear deterrence and stability were formulated and used during the Cold War period. Though China's emergence as well the entry of India and Pakistan into the nuclear club has complicated this situation somewhat, Cold War concepts and notions continue to dominate strategic thinking. North Korea's transformation in 2017 into a full fledged nuclear weapon state may call for a major rethinking on the theories and practice of war, deterrence and stability.

2018 promises to be a most interesting year for the Asia Pacific region as the US North Korea dynamic plays out amongst an increasingly hostile relationship between the US and the China Russia combine.