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S. Chandrashekar, Rajaram Nagappa
and N. Ramani

International Strategic and Security Studies Programme
National Institute of Advanced Studies | Bangalore | INDIA

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S.Chandrashekar, Rajaram Nagappa, N. Ramani[1]

On August 28 2017 North Korea launched a second Hwasong 12 Intermediate Range Ballistic Missile (IRBM) from close to the Sunan Airport in Pyongyang. Unlike the lofted trajectory of the first flight, the trajectory of the second flight was a standard one taking it over Japan before impacting in the Pacific Ocean.

According to agencies tracking the missile, the Hwasong 12 reached an altitude of 550 Km had a flight time of about 15 minutes (900 seconds) and achieved a range of 2700 Km. The reports also stated that the missile overflew Cape Erimo in Hokkaido Japan about 9 minutes (540 seconds) after liftoff. Residents of the area were also warned about possible debris and asked to take protective action. Some reports also suggested that three different objects splashed down in the Pacific Ocean though they do not provide any information on when they separated.

Videos and images released by North Korea after launch confirmed that what had been launched was indeed the same Hwasong 12 IRBM that had been flight tested for the first time in May 2017.

The Hwasong 12 pedigree

The International Strategic & Security Studies Programme (ISSSP) of the National Institute of Advanced Studies (NIAS) had carried out a detailed assessment of the first flight of the Hwasong 12 missile. This was based on measurements on the images of the missile and the reconstruction of the trajectory based on information provided by the tracking agencies. As per this assessment:

- the Hwasong 12 is a two stage missile with a length of 23.5 m, a diameter of 2.4 m and a liftoff mass of about 75 tonnes;
- it uses Kerosene and AK 27 (a mixture of Red Fuming Nitric Acid and Nitrogen Tetroxide) as fuel and oxidizer;
- The predicted range of the Hwasong 12 missile with a warhead weighing 650 Kg launched due east with an azimuth of 90 degrees will be 4385 Km.

A critical evaluation of the August 28 2017 flight

Using its earlier assessment of the Hwasong 12 missile as a baseline, the ISSSP decided to make a critical evaluation of the August 28 2017 launch. The method adopted was to use the Quo Vadis trajectory software developed by NIAS to reconstruct the trajectory of the missile. The results of this reconstruction exercise are then used to draw inferences about the possible rationale behind North Korea's August 28 launch of the Hwasong 12.

[1] All the authors are with the International Strategic & Security Studies Programme, National Institute of Advanced Studies Bangalore, India. For correspondence please contact E-Mail: chandrashekar.schandra@gmail.com

One of the major differences between the May and August flights was in the range of the missile. The inference from the May 2017 flight was that if the Hwasong 12 is launched on a maximum range trajectory it would have a range of about 4400 Km. The reported range of the August 2017 flight is only 2700 Km. This range along with the altitude (550 Km) and time of flight (900 seconds) parameters that are also reported by tracking agencies is not consistent with either a lofted or a shallow trajectory. This would imply that the missile did fly on a maximum range trajectory. One possible explanation for the reduced range of the second flight can be that the propellant loaded into the second stage had been reduced substantially. While such an option is certainly feasible there is no technical or strategic logic for North Korea to test such a configuration. A more likely and plausible reason for the reduction in range would have been an increase in the payload weight.

A number of trajectory simulations were carried out using Quo Vadis software. Through an iterative trial and error process we were able to match the range, altitude as well as the flight time of the missile with the values reported by the missile tracking agencies. By choosing an azimuth of 69 degrees we were also able to reconstruct the time of 9 minutes when the missile is reported to have flown over Cape Erimo in the Japanese island of Hokkaido. The final results of this simulated trajectory and the associated missile parameters are provided in **Table 1.**

As we can see from Table 1 a Hwasong 12 missile with a payload weight of 3200 Kg provides a realistic fit with the observed values of 2700 Km range, 550 Km altitude and 900 seconds of flight time. The time of flight over Cape Erimo is also consistent with the reported data. It is clear from this analysis that North Korea had put a very heavy payload mass on this test of its Hwasong 12 missile.

The rationale for a heavier payload

One possible explanation for the heavy payload for the August 28 lunch can be that North Korea wanted to test a possible third stage warhead combination in order to increase the range of the missile. Since there is no evidence from the tracking data that a third stage was fired this does not seem to be a plausible explanation. This is also not very consistent with the observed trajectory which suggests a standard coast to maximum altitude after the burnout of the second stage.

The other possibility is that the missile launch was intended to test out the requirements for a MIRV capability. This would require a heavy Post Boost Vehicle (PBV) to be mounted on top of the second stage to house the warheads. The larger diameter of about 2.4 m would permit the easy mounting of the warheads around the periphery of the PBV. This would also provide the volume and the mass needed to house propellant and oxidizer tanks as well as other guidance and navigation equipment that would be needed.

One of the puzzles around the May 20017 launch of the Hwasong 12 was the purpose behind its extended range of about 4400 Km. Why would North Korea need such a missile to target Guam when it had already demonstrated the range needed through its Musudan flights?

The simple answer to this appears to be that such a larger missile is needed in order to mount a PBV (along with associated MIRVs) on the Hwasong 12. Guam a US base will be heavily defended with BMD

systems. In order for the North Korean nuclear threat to be credible against such capabilities it may be necessary for North Korea not only to develop MIRVs but also to signal to the US that it can readily do so.

Table 1

First Stage Parameters	Values
Propellant Mass Stage 1 (kg)	32250
Inert Mass Stage 1 (kg)	6140
Stage Mass	38390
Fuel Fraction	0.84
Thrust Sea Level (Newtons)	1260000
ISP Sea Level (seconds)	228
Burn time Computed (seconds)	57.23
Area of Cross Section (m^2)	4.52
Second Stage Parameter	
Propellant Mass Stage 2 (kg)	31700
Inert Mass Stage 2 (kg)	4635
Stage Mass	36335
Fuel Fraction	0.87
Thrust (Newtons)	1386000
ISP Vacuum (seconds)	260
Burn time Computed (seconds)	58.31
Area of Cross Section (m^2)	4.52
Payload Mass Kg	**3200**
Lift Off Weight (Kg)	77925
Missile Trajectory Parameters	
Azimuth (degrees)	69
Range (Km)	2716
Altitude (Km)	544
Time of Flight (seconds)	911
Impact Latitude Longitude	42.26 N 157.88 E

The reports of three separate objects impacting in the Pacific Ocean are not inconsistent with the demonstration of MIRV development. If and when some more data is available on this aspect a more informed judgment may be possible. In the absence of such information we cannot rule out the possibility that the August 28 missile launch was a MIRV test. Though this particular trajectory took the missile over Japan a very similar trajectory flown in a south eastern direction can target Guam.

While the very large payload capability demonstrated in the August 28 flight suggests that North Korea is signaling its possible development of an MIRV capability whether it can quickly mount a number of independent reentry vehicles on the Hwasong 12 is still open to doubt. What is not in doubt is that it can put a highly maneuverable warhead on missiles. This by itself would be sufficient to complicate BMD

defenses. The signal that North Korea is sending out through its August 28 launch is its intention of deploying an MIRV system to counter any BMD system that its adversaries may have in place.

North Korea's Strategy

The continued nuclear weapon testing that is going on in parallel with the missile tests also provide credible indications to North Korea's adversaries that it is well on its way to miniaturize its warheads and that its threats should therefore be taken seriously. The miniaturization drive is also consistent with the MIRV initiative.

North Korean behavior and signaling therefore appears to be completely rational and consistent with strategies aimed at deterring the US and its allies from intervention in North Korean affairs. It is also making a statement that even with the introduction of BMD systems into its neighbourhood, it has the technical wherewithal to counter them and will do so in order to ensure that its threats remain credible. MIRV is the logical counter to the deployment of BMD systems. North Korea's actions appear to be entirely consistent with this rationale.