Analysis of Pakistani Ghauri Missile Test of 28 November 2012

Pakistan launched a Ghauri missile on 28 November 2012. The Inter Services Public Relations (ISPR) claimed the flight as successful. The ISPR press release is shown in Annexure-1. The flight pictures accompanying the press report are reproduced as figure 1 below.

Figure 1: Ghauri flight of 28/11/2012

The two pictures indicate normal take off and normal flight. The flight seems to have developed problems at a later stage. This is based on the Pakistani media report that large fragments of the missile fell in and around the village of Dadu in Sind Province. The internet edition of the Dawn[1] quoting a military spokesman stated that "*the metallic objects found in a remote area of Dadu were part of the motor body which separated from the missile as planned and within the safety corridor"* (emphasis added)

The report goes on to state "*Splinters of the missile fell on several villages and the biggest fragment, according to media reports, weighed about 187kg. No loss of life or property was reported"* and that "*The disclosure of the debris does raise doubts about the success of the missile test"* (emphasis added)

[1] http://dawn.com/2012/12/01/mysterious-objects-were-parts-of-hatf-missile-ispr/ accessed 18 December 2012

However the ISPR spokesman claimed *"The test conducted on Wednesday was a success. The missile remained within the designated flight path and corridor".* (emphasis added)[2]

The media speculation of the event was that the flight was a failure. One report stated that this was the third failure of the Ghauri missile[3]. The previous two failures included the very first launch in 1998 and a subsequent one which came to public light because of Iranian diplomatic protest of missile parts falling in its territory. The media report also stated that one of the recovered pieces of debris carried the marking 'Flight Control Computer'.

Discussion

1. Missiles are equipped with destruct system which is activated if the missile trajectory is deviating from the planned/predicted course and poses safety concerns to life and property lying in the flight path of the missile. This is especially true for missiles during the developmental phase. Preference is to do the developmental flights over the sea to minimize the hazard resulting from flight related contingency and falling debris during developmental flights. However, in the absence of a launching platform on the coast or in the absence of land/ship based down range stations one may be forced to launch such missiles overland and accept the risk of missile malfunction once in a while.
2. Bulk of the missile failures can be related either to propulsion system or control system. The missile is most vulnerable to failure during its thrusting phase. The thrusting phase of the Ghauri can be expected to be about 100 seconds. In case of a malfunction, the destruct system ruptures the propellant tanks or the plumbing feeding propellants to the combustion chamber.
3. A propulsion related failure will essentially be explosive and as hypergolic propellants are involved will result in a huge fireball. **As the debris has been located near Sind, at a considerable distance from the launch site, the failure is not related to propulsion**.
4. The pictures of the damaged debris also do not show an explosion related signature.
5. Ghauri employs jet vane control system, which is active only during the thrusting phase of the main stage. For the same reason as point 3 above, it can be assumed that the control system has steered the missile within the prescribed range safety corridor.
6. The Mashood Test Firing Range is located at Tilla Jogian ($32^0$52'06.16"N, $73^0$26'25.79"E) is the probable launching site for the missile. From the reported

[2] The ISPR press report can be seen in Annexure - II
[3] Usman Ansari, *Pakistani Ballistic Missile Test Failed,* Defense News, posted on 03 December 2012, http://mobile.defensenews.com/article/312030008

debris location, it would appear that the missile was launched in a Southwesterly direction to impact in the Arabian Sea. The Arabian Sea coast is 1063 km from the Mashood Test firing range and the missile was planned to impact in the sea off the Sonmiani test range. This compares with our computed range capability[4] of the Ghauri missile which is 953 km with a payload of 1000 kg for 135^0 launch. The distance to the coast is within the ball-park figure of payload and vehicle parameter uncertainties.

Dadu village ($28^0$13'09.20N, $70^0$53'36.84"E) is located 863 km from the Mashood Test Firing Range. The missile track is shown in figure 2.

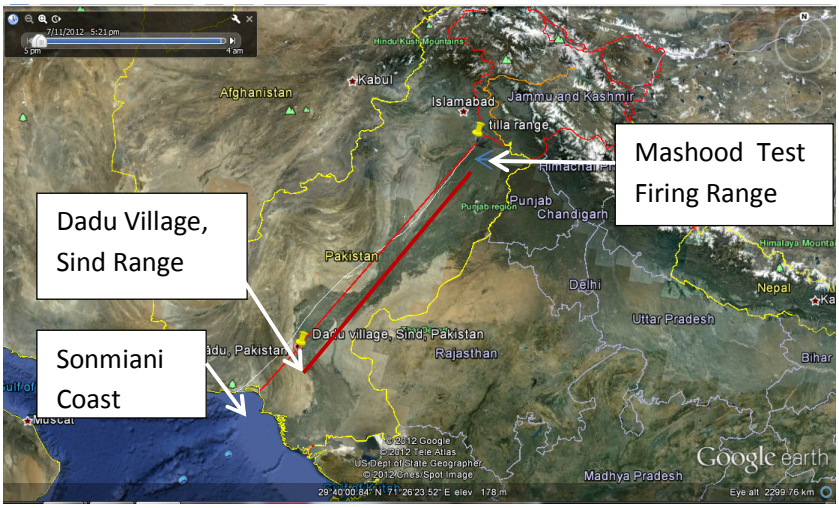


Figure 2: Ghauri missile ground trace

7. As per our calculation, the range (ground trace) at missile burnout is 61.3 km and the altitude is 59.5 km. As the debris is much further downrange we can positively rule out failure during the thrusting phase. .
8. The newspaper Dawn also carried two pictures[5] of missile pieces that were recovered from the scene. The pictures along with the newspaper caption are reproduced below:

[4] S. Chandrashekar, Rajaram Nagappa, Lalitha Sundaresan, N. Ramani and Manabrata Guha: *Missile Developments in India's Neighborhood,* Chapter in *India's National Security—Annual Review 2010*, Ed. Satish Kumar, Routledge, New Delhi 2011, pp 333-354.

[5] **'Mysterious metal objects' in Dadu fell from Hatf V missile: ISPR—** DAWN.COM, 30 November 2012, http://dawn.com/2012/11/30/mysterious-metal-objects-in-dadu-fell-from-hatf-v-missile-ispr/ accessed on 18 December 2012

Photos show the metal pieces, now said to be parts of the Hatf-V Ghauri's motor, which fell on some villages in Sind province's Dadu district on Wednesday night.—Dawn Photo

9. The following details can be made out from the images[6]:
   Left hand image: The details are shown in figure 3.
   - The centre line of the dish carries the marking **'3-E-RPT-9'**. It is perhaps a hardware identification number. The expansion for RPT could not be made out.
   - The section is part of a bulk head structure
   - The dish is severed (caused either on impact or by flexible linear shaped charge used in destruction and stage separation systems)
   - Some parts of the dish are heat affected, but the overall damage signature is not due to flame cutting.

   Right hand image: The details are shown in figure 4.

   - This appears to be the part of actuator mounting setup
   - The elbow pipe seen could be the housing for one of the jet vanes

[6] Personal communication with former Scientists of Liquid Propulsion Systems Centre, Indian Space Research Organisation.

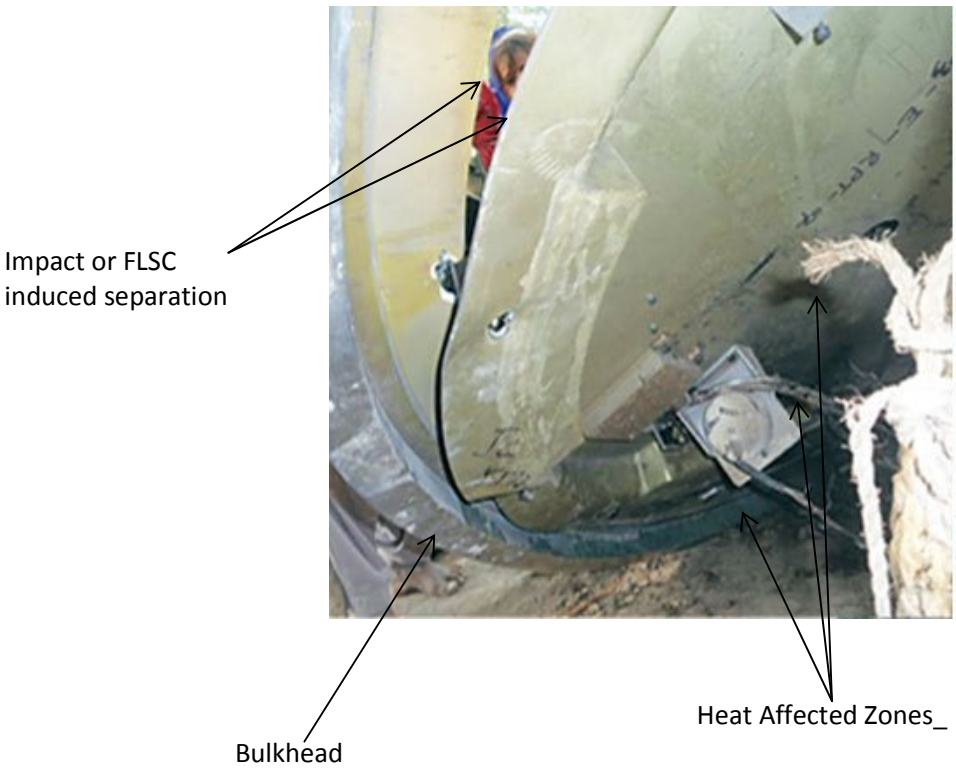


Figure 3: Bulkhead debris

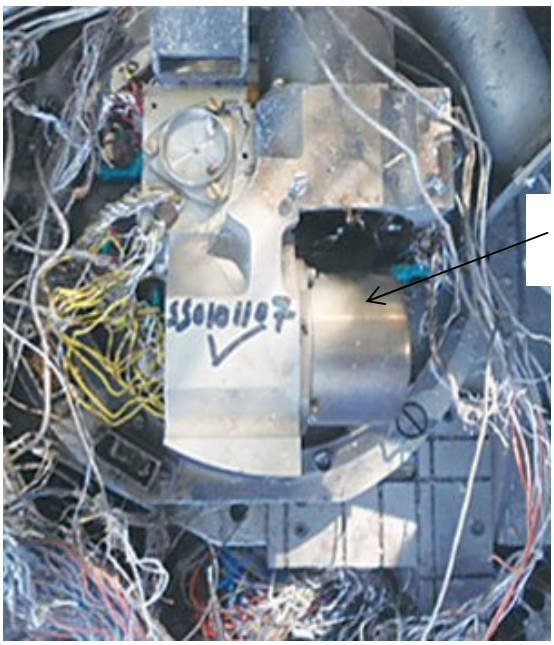
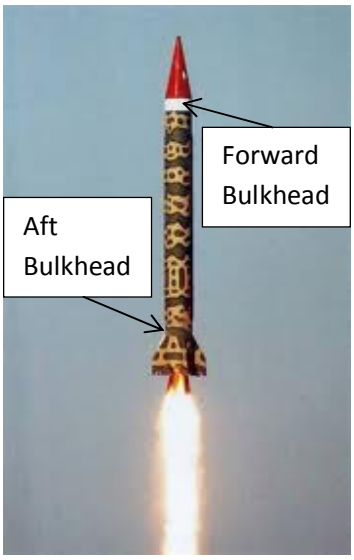


Figure 4: Actuator bay



10. Flexible linear shaped charge (FLSC) induced separations tend to be clean and normally do not leave signatures of heat affected zone. The Ghauri missile will have a bulkhead at the fore-end corresponding reentry vehicle/motor joint or at the aft-end corresponding to the motor/fin shroud joint. If the reentry vehicle is separated from the main vehicle, the forward bulkhead will be separated using FLSC. **It makes sense to do this operation immediately after burnout, rather than at the fag end of the mission** (i.e. near the debris location point)**.**

11. The aft-end bulkhead need not be separated by design as it serves no purpose to do so.

12. From the analysis presented under point 9, it can be concluded that the debris is from the aft bulkhead area of the missile.

13. As there is no reason to separate this joint from the missile, the damage is not due to FLSC but severance has occurred due to impact with the ground.
14. It is possible that some gas leakage has occurred during the thrusting phase of the motor and cause local heating and heat affected zone. This could have weakened the structure. The structure could have failed during the reentry phase due to adverse imposed structural loads.
15. In such an event, the flight of the rest of the vehicle may be unsteady, but could continue. The achieved range however, will be shorter than the missile capability and could have landed in the shallow waters near the coast.
16. As Somniani is a protected area, the impact of the rest of the missile may go unreported in the press. This would result in the success rate of the Ghauri system at 70%.

Conclusion

The overall Ghauri flight mission of 28 November 2012 should be treated as failure contrary to the claims made by the Inter Services Public Relations.

This failure also opens up questions of reliability of the missile as 3 failures have been recorded out of ten flights.

As Ghauri missiles may have been assembled in Pakistan in limited numbers, the missile is not likely to be a permanent part of the Pakistan ballistic missile system. The operational details and procedures for a liquid fuelled system coupled with a success rate not

commensurate with reliability requirements are other negative factors. Ghauri will therefore be used for training purposes and temporarily deployed for long range penetration. It would be safe to conjecture that the missile will be phased out once Shaheen-2 is operationalized in Pakistan.

Annexure-1

Press Release

No PR260/2012-ISPR Dated: November 28, 2012
Rawalpindi - November 28, 2012:

Pakistan today successfully conducted the training launch of Medium Range Ballistic Missile Hatf V (Ghauri). The launch was conducted by a Strategic Missile Group of the Army Strategic Force Command on the culmination of a field training exercise that was aimed at testing the operational readiness of the Army Strategic Force Command. Ghauri ballistic missile is a liquid fuel missile which can carry both conventional and nuclear warheads over a distance of 1300 kms.

The test monitoring of the launch was conducted at the National Command Centre through the medium of National Command Authority's fully automated Strategic Command and Control Support System (SCCSS). It may be recalled that the SCCSS enables robust Command and Control capability of all strategic assets with round the clock situational awareness in a digitized network centric environment to decision makers at the National Command Centre (NCC). The test consolidates and strengthens Pakistan's deterrence capability, and national security.

The President and Prime Minister congratulated all ranks of the Army Strategic Force Command on the excellent standard achieved during training which was reflected in the proficient handling of the weapon system in the field and the accuracy of the training launch.

Annexure-2

DAWN.COM
NEWSPAPER

'Mysterious objects' were parts of Hatf missile: ISPR

From the Newspaper | Our Staff Reporter | 1st December, 2012

ISLAMABAD, Nov 30: The mysterious wreckage that fell on some villages in Dadu district of Sindh on Wednesday night belonged to Hatf-V (Ghauri) missile, tested by the Army's Strategic Force Command at the conclusion of its field exercises.

"The metallic objects found in a remote area of Dadu were part of the motor body which separated from the missile as planned and within the safety corridor," a military spokesman said.

The army's strategic command had been closely following the missile after the test-fire through the newly commissioned automated Strategic Command and Control Support System.

After media reports about the landing of mysterious objects on some villages in Dadu district, local troops took possession of the pieces of the engine and other metallic objects.

The armed forces routinely test missiles but it is for the first time that such an incident has happened.

Splinters of the missile fell on several villages and the biggest fragment, according to media reports, weighed about 187kg. No loss of life or property was reported.

The disclosure that the debris was that of Hatf-V has raised doubts about the success of the missile test.

However, ISPR insists that the test was successful.

"The test conducted on Wednesday was a success. The missile remained within the designated flight path and corridor," the spokesman said.

"It was ensured that human life or property will not be at risk," he said.