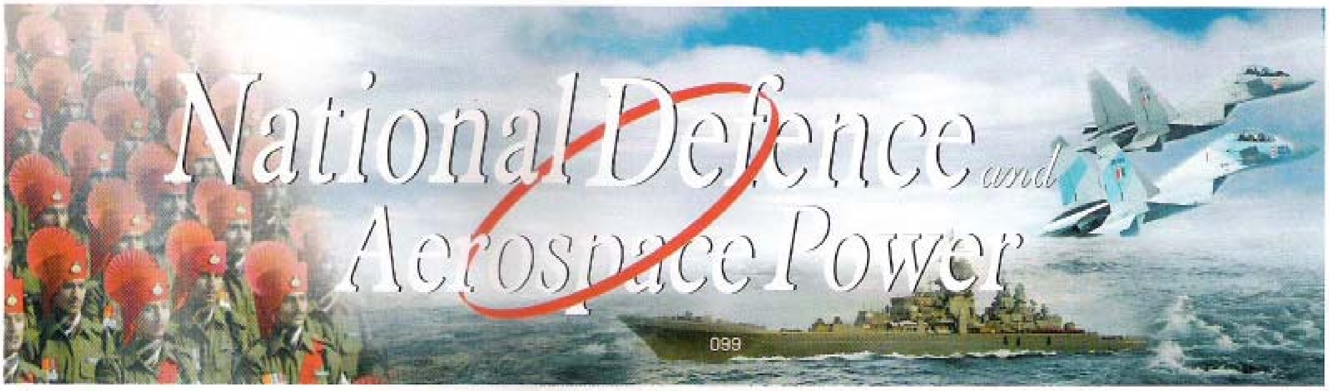

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INDIAN BMD: POINTERS AND FUTURE

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Recently, DRDO successfully tested the indigenous Ballistic Missile Defence (BMD)system for the seventh time. This is a remarkable achievement considering that only five countries have demonstrated this capability. The last test was significant from the previous tests, as two targets were engaged simultaneously, though one was a simulation. Nevertheless, we have to look at what DRDO has actually demonstrated and what remains to be proved and improved.

In all the tests, Prithvi missile was used as the attacker missile which simulated the trajectory of a 600 km range missile. It was reported that, in the last test, the apogee of the attacker Prithvi, was increased to 110 km from its normal apogee of 40 km.[1] This missile has an actual range of 350 km. Despite the fact that Prithvi's trajectory was altered to simulate a missile with a longer range, it does not mimic a longer range missile as claimed, because of two reasons. Firstly, the re-entry velocity of Prithvi is very low. Though DRDO claims to have increased the re-entry velocity by adding additional boosters, it is not clear whether it attained the required velocity to mimic a longer range missile. Recent reports in the media mentioned the interceptor (AAD) speed as Mach 4.5 and the closing speed, before interception, as 2 km/sec.[2] The specified interceptor speed should be the average value, because observation of the test video shows that the interceptor is at its coast phase at the time of impact, during which the speed would be slightly lower than the average speed. So, even assuming the interceptor speed to be half of the given closing speed, the velocity of the target would be approximately Mach 3, which is still low compared to the re-entry velocity of a 500km range missile with a ballistic coefficient of 1000 lbs/ft^2, which would be around Mach 6.[3] Moreover, the ballistic coefficient of Prithvi could be lower than the above considered value due to the larger surface area of the re-entry body unlike that of a separating warhead.

Out of the eight tests conducted so far only two were exo-atmospheric, the rest were endo-atmospheric. In none of the tests both the interceptors were fired simultaneously to evaluate the overall system performance. Only in the last test, two attacker missiles were simultaneously engaged, though one was an electronic simulation.

Secondly, the warhead does not separate from the body of the missile, which makes it a large target for both ground based radar and the radio frequency seeker to acquire and track. In the Pakistani M-9, M-11 and other Chinese missiles with ranges upto 2000 km the warhead separate from the missile body. According to Jane's Strategic Weapons System, the warhead of the M-9 and M-11 separates either after burnout or before re-entry.[4] So, in a real scenario the system has to confront a target with much higher re-entry velocity and small radar cross section. The performance of the BMD system under these conditions have not been proven so far. But the unfortunate fact is that India, at present, does not have any other missile without these drawbacks in this range that could be used as a target.

A 2000 km range ballistic missile, launched in the usual minimum energy trajectory, will have a re-entry velocity of around 4 km/sec[5] even at an altitude of 15 km, which means that the velocity is more than Mach 10. As discussed above the system has not been tested against a target with such velocity. Hence the capability of the system to perform under this condition is yet to be proved. Since the AAD missile has the required speed (Mach 4.5) to intercept a re-entry vehicle re-entering at a velocity of a 2000 km range missile, the primary objective of the test would be to evaluate the performance of the various guidance systems (command guidance, onboard INS and the radio seeker) and the control systems, against a ballistic target (separating warheads) re-entering at an actual velocity of missiles with the specified range.

Out of the eight tests conducted so far only two were exo-atmospheric, the rest were endo-atmospheric. In none of the tests both the interceptors were fired simultaneously to evaluate the overall system performance. Only in the last test, two attacker missiles were simultaneously engaged, though one was an electronic simulation. The electronically simulated target had a range of 1500 km and was successfully intercepted by an electronically simulated interceptor at an altitude of 120 km.[6]Dr.AvinashChander, Chief Controller (Missile and Strategic Systems), DRDO cited range limitations and geometry for not using an actual missile with a 2000 km range.[7] This is an acceptable reason, but at the same time, claiming that the last test has fully proved the robustness of the system cannot be accepted, unless tested under a realistic scenario. Moreover, the type of the electronically simulated interceptor is not known. Dr.AjaiShukla, in his article has mentioned that the simulated interceptor is an AAD,[8] but AAD is designed only to engage targets at an altitude of 30 km, but the reported electronic interception altitude was 120 km. Thus, the electronically simulated interceptor could be the Prithvi Defence Vehicle (PDV), which is said to be the deployment variant of the BMD system. The PDV will be a two stage solid fuelled missile capable of intercepting targets at an altitude of 150 km while the earlier variant, the PAD, can only engage targets at altitude of 80 km. More of the exo-atmospheric interception test should also be done to validate the overall performance of the system, as an effective upper layer defence would reduce the burden for the lower tire. Exo-atmospheric interception is more challenging than endo because the velocity of the re-entry body suffers a sharp decline from an altitude of 20 km[9] due to a denser atmosphere which increases the drag co-efficient per unit area considered, thereby reducing the ballistic co-efficient. Additionally, the sensors will have to encounter and discriminate decoys (if employed by the attacker) and missile debris at exo- atmospheric altitudes.

The current interceptor uses a radar seeker for terminal guidance. The next test will reportedly include a dual seeker (both radar and an electro-optical seeker) for terminal guidance.[10] An optical seeker will have better target acquisition capability, particularly, for low tier defence as the re-entry vehicle will be clearly visible as it would get heated due to friction while travelling down the atmosphere. This would enhance the probability of interception.

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The main components of the Indian BMD system are the Long Range Tracking Radar (LRTR), Fire Control Radar (FCR), and the two interceptors- Advanced Air Defence (AAD) for endo-atmosphere and the PDV for exo-atmosphere. Except the interceptors, all the other components are developed with foreign assistance. However, the radar seeker for the interceptors was developed with Russian assistance.[11] The Long Range Tracking Radar (LRTR) for example, is a modified version of the Israeli Green Pine radar in which the range has been increased to 6oo km. The Green Pine radar can track a target travelling at a maximum speed of 3 km/s[12] (Mach 10), the same data is not known for its modified version (Sword Fish). If the value is same, the radar cannot track an IRBM with a 2000km which normally has a re-entry velocity of 4 km /sec. The fire control radar which provides command guidance for the interceptor is based on the Thales Multi-function Fire Control radar. DRDO needs to build capability to develop core technologies for these crucial components in the future. Having the capability to build core technologies would enable perfecting, upgrading and enhancing and building future systems.

DRDO has announced major changes to the interceptor and the target missile in the next test. New exo-atmospheric interceptor, as discussed earlier will have a dual terminal sensor and can climb to an altitude of 150 km. The target missile would also be a new missile- a boosted (to increase terminal velocity) two stage version of the Dhanush missile. It will also feature a new pulse motor, which will provide surges of propulsion during missiles later stage, increasing its manoeuvrability when very close to the target. This attacker missile would be launched from a ship positioned 300- 350 km from the interceptor location reaching an apogee of 150km. With these improvements, which according to the DRDO chief, the target missile would mimic the actualterminal conditions of a 1500km class ballistic missile. Along with this, six more electronic interception would also be attempted, both endo and exo-atmosphere.[13] A test conducted under these conditions would comparatively pose a tough challenge to the BMD system.

Looking at the Future

1. The Prithvi variants have to be replaced with **solid fuelled** SRBMs with separating **warheads with higher re-entry velocity.** This will have two benefits; firstly, it would make it available for testing the real effectiveness of the BMD system. Secondly, it would provide a more reliable and survivable nuclear delivery vehicle, that would have shorter launch preparation time and better mobility. Prithvi is reported to have a launch preparation time of two hours and also needs more than ten support vehicles which will make it easy for the enemy to detect and target.[14]

2. At present, endo-atmospheric interception have taken place within 15 km altitude. The interception altitude should be increased giving the system more time allowing for kill assessment and to fire another round, if needed. A faster processors and better algorithm might be needed to perform this in real time. A high altitude interception would also be the best protection if the system is deployed to protect soft targets such as population centres.

3. New long range wideband X-band radar have to be developed. For terminal Ballistic missile defence systems the decoy-warhead discrimination is not needed much as the light weight decoys would slow down and burn during re-entry. However, it would be more efficient in discriminating the warhead from any missile debris, particularly, for short range missiles with apogee within the atmosphere. One other use for high frequency radar would be to see through the nuclear cloud created by a masking high altitude atmospheric nuclear explosion, the enemy might employ to aid the penetration of the forth coming strikes, which even S-band radar can perform. However, to increase the probability of intercept, long range X-band radar netted to the other sensors and systems in the BMD architecture will enable the discrimination of warheads from decoys and other missile debris and track the actual warhead from the mid-course phase itself, providing longer reaction time for the terminal defences i.e this would relieve time pressure for the terminal defence systems by allowing it to be prepared to engage the target much earlier. For enhancing the robustness of the system, the midcourse tracking system should be independent of the terminal defence sensor systems. This would also be a stepping stone for building a mid-course interception system for future. An effective mid-course defence system would reduce the burden for the low tire systems providing a better defence.

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To perfect, improve and fine-tune the system to defend against potential ballistic missile threats, information on the enemy ballistic missile signatures will be enormously helpful. Enemy ballistic missile tests have to be monitored electronically by using long range wideband high frequency radars and other space based radar and optical sensors which will provide us with a library of signatures of the enemy ballistic missiles. For example,the wideband signal returns can be used to obtain a wide variety of target details by using various methods of analysis. Micro-Doppler method can also be employed by using time-frequency analysis to obtain target details like the shape of the target which can also be used for real time Decoy-Warhead discrimination by using the data in the algorithm of the Fire Control System.

4. Defence against ballistic missile is not only intercepting the missiles after it is launched but also could be destroyed on the ground during launch preparation, once it is detected. India has highly accurate supersonic cruise missiles that could be used to destroy the launcher before the hostile missile takes off. India has acquired the Israeli Phalcon AWACS system, and is in the process of testing the indigenous AWACS system. India also has radar and optical imaging satellites for surveillance. These additional resources should be harnessed to enhance the ability to defend against missiles. These AWACS and satellites can be integrated with a broader missile defence architecture which includes the accurate missile to enable this option. This would be more practical during crisis situations than at normal times, where it would be difficult to ascertain the target of the missile being prepared for launch. The complexity in doing this would be command and control issues. Defence against ballistic missiles has to be an integrated efforts done using multiple methods and at various levels.

It would be a wiser choice for the government to decide against deploying this system in the present condition. Instead, DRDO shall be directed to improve the system and test it under realistic conditions. Multiple tests have to be done putting the system under various stressful scenarios, at various weather conditions and operating it for longer duration before deployment. The accuracy of the Patriot system, for example was found to be reducing when operated for longer duration. During the first Gulf War, on February 25, a Patriot battery, charged with protecting Dhahran Air Base, had been running for 100 hours consecutively, it failed to detect the incoming Iraqi Scud.[15] The system should also be tested under a clustered air environment to check its ability to discriminate the actual target from other objects in its view. There are bitter incidents of friendly fire during the Gulf War where the Patriots shot allied aircrafts killing three pilots. The reason was that the Patriot's radar was stumped by the cluttered air picture in theatre.[16]The BMD system should not be operated in isolation, it has to be netted with other sensors to have a better situational awareness to avoid friendly fire.

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Parallel development of the next phase of the BMD system would help in perfecting the Phase I systems from the experience gained. Once the reliability of the Phase I system is proved after repeated testing under realistic conditions, which should be monitored and certified by an independent and competent body, after which it can be put before the government to decide on deploying the system. Looking long term, government should initiate policies that would enable the creation of better industrial infrastructure for DRDO, enabling it in developing core technologies that could cater for the future technological needs of the country.

Notes

[1]http://ajaishukla.blogspot.in/2012/12/anti-ballistic-missile-defence-star.html

[2]ibid

[3] Herbert Lin, "Rationalized Speed/ altitude Thresholds for ABM Testing",*Science and Global Security*, Volume 2, 1990, pp 91, Figure 2.

[4]Duncan Lennox, *Jane's Strategic Weapons Systems, Issue 55,2011*

[5]n 3

[6]http://www.thehindu.com/todays-paper/tp-national/interceptors-success-real-and-simulated/article4128758.ece

[7]http://www.thehindu.com/sci-tech/technology/real-time-trial-of-interceptor-and-simulated-missiles/article4122348.ece

[8]n1

[9]n3

[10]http://ajaishukla.blogspot.in/2012/12/prithvi-defence-vehicle-test-enemy.html

[11]http://www.globalsecurity.org/wmd/world/india/bmd.htm

[12]http://www.radartutorial.eu/19.kartei/karte405.en.html

[13]n.10

[14]n.4

[15]Victoria Samson, American Missile Defence: A Guide to the Issue, Chapter 6, Praeger, California, 2010, pp.100

[16]Ibid pp.105

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