Evolution of India's Ballistic Missile Defence Program: Prospects and Challenges

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Abstract

India has made significant strides in acquiring, testing, and deploying Ballistic Missile Defence (BMD) systems. This strategic endeavour, prompted by the ballistic missile threat posed by neighbouring countries, has culminated in a double-layered BMD shield, which, coupled with other defence assets, safeguards Indian airspace. India's BMD program has showcased technological advancements and self-reliance and ambitions to develop laser-based interception technology, albeit over an extended timeline. The program's prospects are promising, offering India strategic autonomy, flexibility in countering diverse missile threats, and potential collaboration with partner nations. Resource allocation and technological adaptation are crucial concerns, necessitating careful planning, coordination, and integration within the existing military infrastructure.

Introduction

Ballistic Missile Defence (BMD) capabilities are essential in modern warfare as they can destroy/intercept incoming hostile aerial targets, like drones, fighter jets, and ballistic and cruise missiles (which can carry conventional and potentially, nuclear warheads). Ballistic missiles can deliver tons of conventional and non-conventional warheads directly to the enemy territory, at high

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speeds and within minutes. Therefore, having such missiles and their countermeasures in the national defence arsenal forms an important part of deterrence. While nuclear weapons and their delivery platforms serve the purpose of deterrence, BMD capabilities serve the purpose of self-defence and maintaining a balance of power. BMD systems are thus, essential to defend the national territory and important locations from incoming enemy aerial attacks.

India's journey in aerospace started with the establishment of the Indian Space Research Organisation in 1969, through which Indians gained experience in rocket development and satellite launches. This helped India develop its own launch vehicles and rocket engine technologies. It was followed by a successful nuclear test in 1974, followed by another test in 1998, that helped India develop nuclear weapons.

It was against this backdrop that India decided to pursue an indigenous missile development program which was officially announced in the year 1983.[1] Through this program, India successfully developed and deployed various cruise missiles, ballistic missiles and defensive weapons like Surface-to-Air Missiles (SAM).

Fast forward to more than a decade later, India's strategic rivals, China and Pakistan had developed their own nuclear and missile programs. Thus, it became imperative for India to now develop its own BMD capabilities to safeguard its territory against potential incoming enemy missiles and other aerial threats.

In the year 2000, the then Indian government under Prime Minister Atal Bihari Vajpayee, sanctioned the development of India's BMD program.[2] In 2002, the United States (US) put diplomatic pressure on Israel which prevented the latter from selling its Arrow air-defence missile system to India. The American officials argued that the sale was violative of the Missile Technology Control Regime (MTCR) guidelines.[3]

This boosted the political resolve in India to develop a fully indigenous BMD capability. By 2009 India had developed its short-range air-defence missile system that was named Akash, deployed by the Indian Air Force.

Introduced in light of the ballistic missile threat from Pakistan and the People's Republic of China (PRC), India's BMD was planned as a double layered system consisting of land and sea-based interceptor missiles: the first layer named 'Prithvi Air Defence' (PAD) and the second layer named 'Advanced Air Defence' (AAD). The PAD is used for high-altitude interception and the AAD takes care of low-altitude interceptions. Both layers are supported by a range of tracking stations, radars, command and control posts etc. As on date only five countries have such BMD systems: US, Russia, China, Israel and India. India has achieved a good amount of self-reliance in BMD by developing and testing missiles like the Prithvi, Akash, Long Range SAM, Quick Reaction-SAM (QR SAM) and Medium Range-SAM (MR SAM) among others. These interceptor missiles, their related infrastructure and other assets form the basis of India's BMD program. India has also established a nuclear triad: land, air and sea based nuclear weapon delivery capabilities.

Thus, the acquisition of a well-developed BMD system complements the nuclear triad and has established India as a force to be reckoned with globally.

Capabilities and Current Status of India's BMD Program

India's BMD shield is basically a two-layered system that takes care of incoming hostile enemy aerial targets from a range of around 30 km till around 5,000 km. In case of incoming ballistic missiles, this activity of interception can be conducted in any one of the three stages of the enemy missile's launch trajectory:

- In the 'boost phase', when the hostile missile is climbing up in the atmosphere.
- In the ballistic or 'mid-course' phase, during the main flight path of the missile.
- In the 'terminal phase', when the hostile missile has re-entered the earth's atmosphere, and is closing in on its targets.

India has the BMD systems needed to destroy incoming hostile missiles in the mid-course and the terminal phase. Indian scientists are working to further develop these systems to destroy the hostile missiles during the boost phase itself that requires long-range interception, tracking and sophisticated advanced

warning capabilities The land-based BMD systems have been fully developed locally and tested multiple times over the last 20 years. The sea-based system testing happened in Apr 2023, with all parameters successfully met.[4] The double layered BMD shield is elaborated as under:

- **The First Layer.** The first layer of the Indian BMD shield is the land based Prithvi Air Defence System. This system is developed to destroy incoming enemy missiles at high altitude ranges. Various publicly available sources mention that the altitudinal range is around 50 to 80 km. India has plans to extend the PAD capabilities beyond 180 km altitude. This will be a significant boost for India to help it counter potential incoming missiles from the Chinese mainland. This system can destroy enemy missiles outside the earth's atmosphere, which is known as an 'exo-atmospheric kill'.

- **The Second Layer.** The second layer of the Indian BMD system is the AAD, developed for lower altitude interception: up to 15 to 50 km. The AAD can intercept enemy missiles within the earth's atmosphere, which is known as an 'endo-atmospheric kill'. Since this second phase is under further development, not many details are available about it in the open domain. India is now working to make the PAD as well as the AAD capable of endo-atmospheric and exo-atmospheric kills. The latest development in the Phase 2 BMD was the successful test of a sea-launched interceptor missile, conducted by the Indian Navy and the Defence Research and Development Organisation (DRDO), on 23 Apr 2023. With this test, India has once again become a part of an elite group that has sea-based BMD capabilities.

Achieving Comprehensive Ballistic Missile Defence

Both these layers are complemented by other systems like ships, sensors, aircrafts, radars, tracking stations, and satellite support. Thus, this forms a complex web of hundreds of systems, which are a part of the bigger web called 'BMD shield' that protects the Indian airspace.

As far as tracking of targets is concerned, India has a range of different ships, aircrafts, satellites and tracking stations, providing timely information about hostile activities to the command-and-

control centres. India also has a dedicated missile tracking ship named INS Dhruv developed by the DRDO.[5] It is jointly operated by the Indian Navy, the National Technical Research Organisation and the DRDO. As of date only five countries have such ships: US, Russia, France, China and India.

India also uses the Swordfish radar to track aerial targets, direct the line of fire and guide support the interceptor missiles. In 2017, an upgraded version of this radar, named as Super Swordfish, was developed, and put to use.[6] This radar can track targets up to a range of 1,500 km. The interceptor missiles also have their own inertial navigation systems.

As per the author's analysis, India's BMD system is fully integrated. It was officially ready to deploy as of 2020 and concerned agencies have started further developments on the second layer of the BMD. However, the armed forces and other agencies are waiting for the union government to issue official orders to deploy the PAD system since 2020.[7] Reports say that once the government approves, it will take around three to four years to fully deploy the system, which will then have to be tested as a single comprehensive unit.[8]

Scientists are also working towards making interceptors used in both layers operate on solid fuels. This is because chemicals in the liquid fuels corrode the fuel storage tanks easily. Therefore, most of the missiles are not kept in a 'ready-to-fire' mode. Also, it takes a minimum of three to four hours to fill the liquid fuel in the missile,[9] a hardly acceptable scenario wherein precious time will be lost in case of an emergency. The capability to have the entire missile run on solid fuels has been achieved for the first layer of the BMD, wherein a modified version of the PAD has been created, which is named as the Prithvi Defence Vehicle (PDV). This missile has a three-stage engine, working on solid fuels, and has been successfully tested. The PDV will be capable of destroying missiles beyond 180 km altitude. These initiatives have got more credibility after India successfully conducted its maiden anti-satellite test, in 2019.

An advanced version of the PDV, named as PDV Mark 2, is also ready for production. As niche technologies, it may take around 20 years to be developed, tested and implemented. To complement the BMD program, India has other capable systems like Akash,

SPYDER, MR-SAM, QR-SAM etc. These have been successfully tested multiple times and have been deployed across India.

Media reports indicated in Jul 2023 that the Ministry of Defence is at an advanced stage of clearing a proposal regarding a three-layered BMD system.[10] This long-range SAM system is expected to have a range of 400 km. The project will be totally indigenous and is expected to cost around USD 2.5 bn. Presumably, this project is being created in a way that the new systems will be in the class of the S-400 missile defence systems. Since the PRC has also procured these missiles, India would want to negate China's edge, by relying on not just the S-400, but also alternative options. The Indian Air Force is reportedly the lead agency for this project, as it has been insisting on promoting indigenisation in this domain.[11]

Prospects for India's BMD Program

Such an extensive and full-fledged BMD program has many prospects for further growth and development:

- **Strategic Autonomy.**

  - India has been investing in developing advanced technologies for its BMD program, including interceptor missiles, radar systems, and command and control infrastructure. These have been made indigenously for the most part, thereby making India capable and self-reliant technologically. Continued testing and validation are then essential to improve the reliability and effectiveness of the BMD system.

  - Prospects here include successful testing of the interceptors under different scenarios, leading to a higher confidence level in the system's performance. The technological advancements could further lead to improved interception capabilities and enhanced performance of the BMD system. It will also help increase the range, accuracy and other parameters thus including a wider geographical area. This in itself has its own consequences for the regional and global balance of power.

- From a geopolitical perspective, this BMD initiative also indirectly benefits from India's close cooperation with foreign countries like the US and Israel, and from it being a part of globally influential bodies like the MTCR, which gives the country access to high-end technology.

- **Flexibility.**

  - India's BMD program aims to establish a multi-layered defence by integrating different types of interceptors and systems. This provides increased flexibility in countering various types of ballistic missiles. India has also engaged in defence cooperation with various countries, which could potentially lead to knowledge-sharing, joint development, and collaborative research in the field of BMD.

  - India can also look forward to helping its immediate neighbours by using its BMD capabilities to safeguard their airspaces, as these nations do not have the resources to pursue their own BMD programs. Further, India can look forward to exporting some of its BMD components like interceptors, radars, and short and medium range SAM systems to friendly foreign countries.

- **Strategic Deterrence.** A robust BMD program can enhance strategic deterrence by demonstrating the country's ability to defend against potential missile threats. This could influence adversaries' perceptions of India's defence capabilities and potentially impact their strategic calculations.

Challenges to India's BMD Program

The Indian BMD program does face some challenges, internally as well as externally, which impact its planning, deployment and usage:

- **Pakistan**

  - India had been preparing for a two-front war scenario for many years because it faces a ballistic missile threat, directly from both Pakistan and the PRC. While Pakistan's missile and nuclear program is India-centric, India has developed its nuclear, missiles and BMD capabilities keeping in mind the Chinese threat.

- On the level of scale, Pakistan has a range of tactical missiles like Hatf-1 and ballistic missiles like Ghaznavi, Babur, Abdali, Shaheen, Nasr etc. These missiles can strike up to a range of 3,000 km, a range that covers the entire Indian territory.[12] Pakistan is now working to develop the Multiple Independently Targetable Re-entry Vehicle (MIRV) technology,[13] which enables a single ballistic missile to release multiple warheads on the enemy, simultaneously. Accordingly, this requires the defending entity to fire at least two interceptor missiles, separately, for every warhead released by the incoming hostile missile. Media reports in 2017 indicated that Pakistan has already developed and tested the MIRV technology on its newly developed Ababeel ballistic missile.[14]

- **China**. A bigger concern than Pakistan is the PRC which is known to have a well-developed nuclear program, ballistic missile program and a fully deployed BMD system. It is also known that Pakistan and the PRC have good collaborations and share military technologies with each other, since India is the common adversary for both. The PRC seeks to compete with the US, in almost every domain, at the global level, and has developed its armed forces and arsenal accordingly. Its ballistic missiles have a range of more than 12,000 km and the PRC also possesses anti-satellite capabilities.[15] Having a strong economy and a huge manufacturing base enables the Chinese to stay ahead of India in all domains, quantitatively as well as qualitatively. In the MIRV domain, the PRC has capabilities comparable to those of US and Russia. A major concern for India here is that the PRC may proliferate these technologies to rogue states like Pakistan thereby negating India's conventional advantage over Pakistan.

- **Cost and Resources**. Overcoming technical challenges related to sensors, interceptors, command and control systems, and integration can be daunting. This exercise is also financially demanding. Securing adequate funding and allocating resources for research, development, testing, and deployment has always been a significant challenge in India, where most of the annual defence budget is spent on revenue expenditure. India may have to hunt for export markets for

some of its air-defence systems to cover the production costs, which will inevitably put India in conflict with existing market players, such as the Patriot, Terminal High Altitude Area Defence and Iron Dome. Thus, India will have to balance its security and geopolitical interests accordingly.

- **Adaptation and Evolution**. Ensuring that the various components of the BMD system can work together seamlessly and coordinate with the existing defence infrastructure can be complex. India will have to eliminate the duplication and mixture of assets and follow standardised methods and protocols. The human error factor must also be considered while training the concerned staff. With the dawn of technologies like quantum computing and artificial intelligence, integrating them in the national security infrastructure will be a bigger challenge for India. Integrating the BMD capabilities with the existing military infrastructure requires careful planning to ensure smooth coordination and functioning during real-world scenarios. Also, as missile technology evolves, potential adversaries may develop more advanced and unpredictable missiles. India's BMD program must stay ahead of these developments to remain effective. Rigorous testing and validation of BMD systems are thus crucial to ensure their reliability.

Conclusion

In its entirety, BMD is a very nuanced subject. Most of the data on this topic is classified. Therefore, all capabilities of such systems, available in the public domain are just projections, as countries do not share the actual capabilities of such sensitive technologies, and therefore all analysis is speculative.

However, the capability of a nation to possess these systems and demonstrate its abilities through continuous testing is necessary to have an edge over its adversaries. What is now needed for countries like India is to keep evolving their BMD systems qualitatively by heavily investing in research and development. By producing a sufficient number of these systems, economies of scale can be achieved in the long run, thus bringing down development costs.

In conclusion, India's evolving BMD program underscores the significance of continuous research and development to maintain a technological edge in contemporary warfare. While specific capabilities remain classified, India's commitment to enhancing its BMD systems contributes to self-reliance in its national defence as well as regional security and reinforces its position as a formidable force in the international arena.

Endnotes

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