OPERATIONALISATION OF INDIA'S BALLISTIC MISSILE DEFENCE

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By

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ISBN : 978-93-84492-38-0
Price in India : ₹ 100 /-

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Printed in India

Printed by
Xtreme Office Aids Pvt. Ltd.
Basement Bhanot Building (Below Syndicate Bank)
Nangal Raya Commercial Complex, N.D-110046
Ph.: +91-9811707220
E-mail: xtremeofficeaids@gmail.com
Website: www.xtremeonline.in

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Abstract

A fully effective Ballistic Missile Defence is a complex system incorporating state-of-the-art technologies. The United States has been working on Ballistic Missile Defence since 1946. The Soviet Union began development of a BMD System somewhere in 1955 but it was only in 1964 when Soviet "Galosh" anti-ballistic missile (ABM) system got detected. The initial system was based on nuclear-tipped missiles. Subsequently, as part of the ABM Treaty agreement in 1972, these systems were dismantled in 1975. However, the research continued in the field of BMD, particularly in replacing the nuclear warheads with hit-to-kill or kinetic energy interceptors. In spite of so much of expertise achieved by the US, over a period of ten years from 1999 to 2009, its combination of the land-based (PAC-3 and THAAD), the sea-based (SM-3) and silo-based (NMD) Anti-ballistic missile "hit-to-kill" systems achieved a total of 43 successes out of 53 attempts - an 81 percent record. India having commenced its quest for BMD somewhere in 1999, surprisingly the success rates of its test flights both in case of Prithvi Air Defence missile (3 out of 4) and Advanced Air Defence missile (5 out of 6) have been very encouraging - 75 to 84 percent but all these tests are known to have been conducted under laboratory conditions. DRDO is working to enhance the present altitude of these missiles from 80 to 150 km. Knowing fully well that Pakistan has declared its intent to use its tactical nuclear weapons to offset India's conventional superiority, it should be operationally

expedient for the DRDO to deploy one to two BMD systems by maximum 2020. The BMD should not be conceived as an alternative to our strategic nuclear deterrent but should rather complement it by strengthening the "No First Use" doctrine and ensuring survivability of the second-strike retaliatory capability. Accordingly, employment of BMD systems should be amalgamated into our Nuclear Doctrine.

Introduction

The first ballistic missile, viz., V-2 (The "V" stood for *Vergeltungswaffe* meaning vengeance weapon) was launched by Germany against England on 8 September 1944. Since then there has been considerable debate over the feasibility of protecting a nation against ballistic missile attack. The United States has been developing ballistic missile defences (BMD) to defend against enemy's missiles since the late 1940s. In the late 1960s and early 1970s, the United States had deployed a limited nuclear- tipped BMD System to protect a portion of its U.S. land-based nuclear intercontinental ballistic missile (ICBM) force, with a view to preserve its strategic deterrent against a Soviet nuclear attack on the United States homeland.[1] The Soviet Union began development of a BMD System somewhere in 1955 but it was only in 1964 when Soviet "Galosh" anti-ballistic missile (ABM) system got detected and subsequently disclosed to the world by the

> **IN THE LATE 1960s & EARLY 1970s, THE UNITED STATES HAD DEPLOYED A LIMITED NUCLEAR-TIPPED BMD SYSTEM TO PROTECT A PORTION OF ITS U.S. LAND-BASED NUCLEAR ICBM FORCE.... THE SOVIET UNION BEGAN DEVELOPMENT OF A BMD SYSTEM SOMEWHERE IN 1955 BUT IT WAS ONLY IN 1964 WHEN SOVIET "GALOSH" ABM SYSTEM GOT DETECTED.**

US Secretary Robert McNamara in 1966. It was to be deployed around Moscow and was a ground-based system utilizing nuclear warheads as the kill mechanism.[2] Subsequently, as part of the ABM Treaty agreement in 1972, both the countries agreed not to develop, test, or deploy sea-based, air-based, space-based, or mobile land-based ABM systems. However, the research continued in the field of BMD, particularly in replacing the nuclear warheads with hit-to-kill or kinetic energy interceptors. Finally in 2002, President Bush withdrew from the 1972 ABM Treaty and committed the United States to deploy an initial national missile defense (NMD) capability in 2004.[3] In the following decade, considerable advancements have taken place in the field of BMD systems.

India has been working since 1999 on a two-tiered BMD system. India's Defence Research and Development Organization (DRDO) had earlier stated that by 2012 or 2013, the first phase of the BMD shield would be ready to protect New Delhi from hostile missiles with a 2000 km range. It also boasted that by 2016, the second phase would be operational with the capability to kill hostile missiles with 5000 km range.[4] With no BMD System in sight, the nation's Ministry of Defence has reportedly directed the DRDO to urgently submit a final induction strategy and timelines for the BMD System.

With a view to arrive at a path for speedy operationalisation of India's BMD System, it is intended to study and analyse the subject under the following heads:-

1. A Brief Overview of the Evolution of BMD Systems.
2. Ballistic Missile Threat and Challenges Involved to Counter It.
3. Primary Missile Defence Systems of the USA.
4. Strategic Necessity for India's BMD System.
5. Path to Operationalisation for India's BMD System.

A Brief Overview of the Evolution of BMD Systems

The United States' efforts at BMD began in 1946 under Project *"Defender".* Major milestones achieved for test, development and deployment of BMD systems are summarised as:-

1957- U.S. Army NIKE / Zeus ABM programme began.It was an expansion of NIKE anti-aircraft missile through the utilization of a nuclear warhead.

1959 - A major milestone in the history of anti-missile technology: A ballistic missile is intercepted for the first time - A modified Hawk anti-aircraft missile was able to shoot down an "Honest John" tactical ballistic missile.

1962 - FIRST ICBM "INTERCEPT" BY THE NIKE / ZEUS MISSILE WAS ACHIEVED - A MINUTEMAN ICBM WAS INTERCEPTED, BASED ON THE MISS-DISTANCE REQUIRED FOR A KILL, USING A NUCLEAR WARHEAD

1962 - First ICBM "intercept" by the NIKE / Zeus missile was achieved - A Minuteman ICBM was intercepted, based on the miss-distance required for a kill, using a nuclear warhead. Despite this successful NIKE / Zeus intercept, it did not lead to system deployment because of: Questionable discrimination capability; Concerns regarding the nuclear warhead detonation effects; and high costs of the system.

1963 - NIKE X was launched, which was a layered system with the Spartan Missile (an extended-range NIKE / Zeus) for intercepts in space (prior to re-entry) and the Sprint Missile (a shorter-range, high-acceleration missile) for atmospheric intercepts. Both systems used nuclear warheads for the target kill. Low-altitude intercepts of the Sprint required that the radars be hardened against the detonation of its own nuclear warheads.

1966- Fielding of an ABM system around Moscow by Soviet Union- known as "Galosh" - had been under development since 1955. China achieved ICBM capability.

1967- The US decided to deploy the "Sentinel System" - a layered system based on the Sprint and Spartan missiles - against China. It was a limited defence system not aimed at the Soviet Union as it could not handle multiple reentry vehicles.

1969- President Nixon announced the decision to deploy anti-missile systems called "SafeGuard" around two Minuteman sites to handle the developing Chinese threat. It was same as the "Sentinel System", but was intended to guard missile sites rather than cities.

1969 - PRESIDENT NIXON ANNOUNCED THE DECISION TO DEPLOY ANTI-MISSILE SYSTEMS CALLED "SAFEGUARD" AROUND TWO MINUTEMAN SITES TO HANDLE THE DEVELOPING CHINESE THREAT.

1970 - "SafeGuard" deployment began in Grand Forks, North Dakota, around the Minuteman silos.

1972- With the signing of ABM Treaty, the "SafeGuard" Deployment was halted, although it kept going for four more years.

1973- 1983: In 1974, the ABM Treaty was amended so that each side would have only one site (Moscow and Grand Forks, N.D.) Research and developmental tests continued.

1984- 1993: The Strategic Defense Initiative Organisation (SDIO) was established. In 1985, a Titan Rocket was destroyed by an infrared, advanced chemical laser. In 1987, a layered defence system was planned, with space-based boost-intercept, and ground-based, mid-course and terminal phases, and with space and ground-based sensors. The US continued to pursue the full range of R&D options. In 1991, the first operational military engagement between ballistic missiles and BMDs; Patriot missiles were used against Iraqi Scuds during the Gulf War. In 1993, the Strategic Defence Initiative was ended by President Clinton and the programme office was renamed the Ballistic Missile Defense Organization and focus shifted to defend against a few, relatively-unsophisticated, long-range missiles, launched from “rogue nations”, with a secondary role against an inadvertent launch of a Russian missile.

1994 - 2001: In 1996, the National Missile Defense (NMD) programme officially began. It was to be a ground-based system, utilizing “hit-to-kill” targeting as the kill mechanism. Its eventual location was to be Alaska, in order to protect all 50 states; using space-based sensors and ground-based radars. The R&D undertaken would be compatible with the ABM Treaty, with intention to modify the treaty, if and when deployment began. Same year, the first multinational, ABM programme was established - known as Medium Extended Air Defense System (MEADS) - to protect manoeuvring forces of the US, Italy and Germany, as well as fixed installations, against tactical ballistic missiles, cruise missiles and all types of aircraft. Design and development of the NMD was to be completed by 2003. In 1999, the NMD Act was passed by Congress and was signed by President Clinton. Between 1999 and 2001, four integrated flight tests of the NMD System were conducted, out of which two achieved successful intercepts while two were failures. Technology had yet to be proven hence President Clinton decided not to authorize deployment of the NMD System. The R&D programme was to remain on track.

September 2001 Onwards: The BMD Organization was renamed as Missile Defence Agency (MDA) to provide it greater prestige. Three successful intercepts in a row were achieved by the NMD System. In 2002, Bush Administration officially withdrew from the ABM Treaty. In 2004, ABM missiles began entering Fort Greely, Alaska silos. In 2005, NATO officially adopted the U.S. /German/ Italian MEADS for Theatre Missile Defense. In 2006, Standard Missile 2 (SM-2) achieved intercept of long-range ballistic missile in terminal phase; prior intercepts had been boost or mid-course. The US had deployed 10 interceptors at Fort Greely, Alaska and Vandenberg Air Force Base, California. In 2008, President Bush received agreement from Czech Republic and Poland to deploy BMD sites (missiles and radars) in Eastern Europe for defence against Iranian launches. Russia strongly objected. In 2009, Japan purchased sea-based SM-3 and ground based THAAD for defence against North Korean launchers.

On 11 January 2010, the PRC announced that it had successfully tested a “ground-based, mid-course missile interception technology”.[5]

Ballistic Missile Threat and Challenges Involved to Counter It.

The trajectory, a ballistic missile follows to deliver its warhead on the target comprises of three phases:

- **The Boost Phase.** When the missile is launched, it is initially in its boost phase, in which large rockets lift the warhead on its way to the target. Since they are burning, they produce a very large heat signature, which can easily be seen and tracked. The initial powered phase can last from a few seconds to several minutes, depending upon the range to be achieved and the weight of the warhead. The initial thrust is provided by a single or multi-stage

A BALLISTIC MISSILE CAN BE INTERCEPTED DURING THE BOOST PHASE, MID-COURSE PHASE OR TERMINAL PHASE. CHALLENGES OF INTERCEPTION INVOLVED IN EACH PHASE ARE DIFFERENT.

rocket. In this phase, the missile is highly vulnerable, as it is large and “soft’, and moves relatively slowly as it accelerates up to full speed.

- **The Free-Flight Phase.** After the rocket burns out, the warhead goes through an extended exoatmospheric mid-course phase or a free flight phase as it simply follows a ballistic trajectory - unless it is intentionally programmed to perform manoeuvres. The highest point attained by an ICBM is around 1200 km.

- **The Terminal Phase or Reentry Phase.** Where the warhead reenters the earth’s atmosphere to hit the target area. This phase lasts from 60 to 90 seconds of the flight.[6]

Challenges of Interception. A ballistic missile can be intercepted during the Boost phase, mid-course phase or terminal phase. Challenges of interception involved in each phase are different:

- **Boost Phase Intercept**. It is easiest from the point of detection, tracking and kinematic perspective - the exhaust plume can be seen from orbit and hundreds of kilometres away in the air as also missile has all its stages intact, presenting a large radar signature. However, because of the short duration of this phase, interceptor has to be located nearby to kill the target quickly. Further, since no advance warning may be available about the launch, there would be very little time to discriminate whether this target is an ICBM carrying a nuclear warhead or is a non-threatening launch carrying a satellite into the space. Thus sensors are required for discriminating this. A major advantage in hitting the target during this phase is that the target would find it difficult to develop counter measures, such as decoys to lure the kill mechanism away.

- **Mid-Course Phase Intercept.** The mid-course phase (lasting up to 20 minutes) is most attractive for interception of a warhead, because it is in "free-fall", allowing for long time periods of analysis and human decision-making prior to committing an intercept. However, in this phase, it is also most easy to use a decoy to simulate the reentry vehicle or warhead because in the absence of atmospheric resistance, decoys such as aluminum chaffs or other light-weight objects follow the same trajectory characteristics as a heavy reentry vehicle. Therefore this phase becomes most difficult from the perspective of discrimination between the real warhead and decoys, which could be released. More sophisticated the decoying capability employed by a missile, the more challenging the intercept becomes in this phase. Even though the missile speed is comparatively low as it flies across the top of the ballistic arc, kinematically interception is challenging in terms of altitude.

- **Terminal Phase Intercept.** In this phase, the dense, pointed reentry vehicle will move rapidly through the atmosphere, while the decoys being the lighter objects will slow down. From a discrimination perspective, the use of atmosphere is very attractive but from a timing perspective, it is extremely challenging to wait for the sorting to take place and then commit interceptors to kill the reentry vehicle, prior to its rapid approach toward its target. Further during reentry, the heat generated due to atmospheric friction is so high that the discrimination between the reentry vehicle and debris becomes extremely

THE US MDA HAS SPENT APPROXIMATELY $ 100 BILLION ON MISSILE DEFENCE SINCE 2002 AND ITS BMD PROGRAMME HAS AN ANNUAL COST OF $8 - $10 BILLION.

difficult.[7] It may be seen that each of these phases has significant advantages and disadvantages for an ABM system.

Primary Missile Defence Systems of the USA

The United States Missile Defense Agency (MDA) has been developing a number of systems that would provide multiple opportunities to counter limited ballistic missile attacks. Reportedly, these systems are designed and deployed to shield against ballistic missile attacks of rogue nations like North Korea and Iran and would not be effective against the sophisticated ballistic missiles of Russia and even China. The US MDA has spent approximately $ 100 billion on missile defence since 2002 and its BMD programme has an annual cost of $8 - $10 billion.[8] The US has deployed a global array of networked ground, sea, and space-based sensors for target detection and tracking, an extensive number of ground- and sea-based hit-to-kill and blast fragmentation warhead interceptors, and a global network of command, control and battle management capabilities to link the sensors with the interceptors. The United States' BMD System, which comprehensively covers interception of ballistic missile in all the phases is diagrammatically shown as Figure 1 in the Appendix. There are four primary BMD programmes:-

- **Ground-Based Midcourse Defense (GMD).** This is the most complex and costly portion of the U.S. missile defense system. Since 2004, the US has deployed 30 Ground-based Interceptors - 26 located at Fort Greely, Alaska and four at Vandenberg Air Force Base, California - with plans to increase it to 44. The GMD System is designed to destroy a limited attack in space from intermediate- and long-range ballistic missiles aimed at the United States. In a June 2014 test, an interceptor launched from Vandenberg Air Force Base destroyed a target missile launched from the Marshall Islands, marking the first successful hit (out of four tries) since 2008. But according to experts, the technology is still unreliable and would need further testing.

- **<u>Aegis BMD</u>.** It has been considered as the most reliable component of the U.S. missile defense. Traditionally sea-based, this system is designed to intercept short- and medium-range ballistic missiles. Under current plans, the BMD- capable Navy Aegis warships are scheduled to increase from 33 at the end of Financial Year 2016 to 49 at the end of Financial Year 2021. As of June 2014, the Pentagon had disclosed that the system had 28 successful intercepts out of 34 tests. Aegis BMD ships and Aegis Ashore (land-based) capabilities in Romania (and Poland in 2018) contribute to NATO's territorial defence mission.[9]

- **<u>Terminal High Altitude Area Defense (THAAD)</u>.** THAAD is a highly mobile, rapidly deployable, truck-mounted system designed to shoot down short- and medium-range ballistic missiles during their terminal phase of flight. THAAD was initially proposed in 1987 and its first flight test occurred in April 1995. It had a poor test record, until the first successful intercept in 1999. In recent years, THAAD's test record has improved considerably. According to MDA news release of 30 July 2017, 11th Air Defense Artillery Brigade from Fort Bliss, Texas carried out successful interception of a medium-range target ballistic missile with THAAD Weapon system and this was reportedly the 15th successful intercept in 15 tests for the THAAD Weapon system.[10] The United State has fielded four THAAD batteries, delivered a fifth battery for field testing, and has two more batteries in various stages of production. One U.S. THAAD battery is deployed in Guam and others are planned for South Korea and the Middle east.[11]

- **<u>Patriot Advanced Capability-3 (PAC-3).</u>** PAC-3 is the successor to the systems, which were deployed in the Persian Gulf War and is the most mature element of the BMD System. Rapidly deployable, the system is vehicle mounted and employs sensors to track and intercept incoming missiles in their terminal phase, at lower altitudes than THAAD systems. The PAC-3 was used in combat in Iraq in 2003 with mixed success. PAC-3 batteries have been deployed in several nations including South Korea, Afghanistan and Turkey among others.[12] Patriot works in concert with THAAD to provide an integrated and overlapping defence against missiles in their final phase of flight.

Strategic Necessity for India's BMD System

Parallel to the United States, Russia has been creating its own equivalents of the U.S. missile defence systems THAAD and GMD, which are likely to be provided to the Russian Armed Forces in the very near future. According to Pavel Sozinov, general constructor of the concern Almaz-Antei, Russian System called CMD is equipped with GBI missiles and it has the capability to intercept not only medium range ballistic missiles butsome warheads of ICBMs also.

A series of tests have already been performed and Russian Defence Ministry has demanded a considerably higher interception effectiveness than that of the Americans.[13] In case of China, subsequent to its anti-satellite test in 2007, in which it destroyed its weather satellite with a kinetic kill vehicle, it had

INDIA FINDS ITSELF IN A UNIQUE SECURITY DILEMMA - CONFRONTED BY TWO NUCLEAR NEIGHBOURS: CHINA WITH AN INVENTORY OF ABOUT 270 NUCLEAR WEAPONS AND HUNDREDS OF SOPHISTICATED BALLISTIC MISSILES; AND PAKISTAN WITH AN ARSENAL OF AROUND 140 NUCLEAR WEAPONS, WHICH IS RAPIDLY GROWING (AS AGAINST INDIA'S 130 NUCLEAR WEAPONS).

reportedly conducted three "land-based mid-course missile interception tests" in 2010, 2013 and 2014. According to the U.S. intelligence, the first anti-ballistic missile test in 2010 had used a SC-19 missile (the same, which was used in its anti-satellite test of 2007) to successfully intercept a CSS-X-11 medium- range ballistic missile.[14] The endeavour to remain ahead in competitive weapon technologies is governed by a country's security policies as also it is an important factor of deterrence. Thus in view of BMD development by the US, Russia, China and even Israel, pursuit of BMD programme by India is a logical extension of its security needs.

India finds itself in a unique security dilemma - confronted by two nuclear neighbours: China with an inventory of about 270 nuclear weapons and hundreds of sophisticated ballistic missiles; and Pakistan with an arsenal of around 140 nuclear weapons, which is rapidly growing (as against India's 130 nuclear weapons).[15] Further, Pakistan has developed new nuclear capable, short-range nuclear ballistic missile, the HATF- IX (also referred to as Nasr). Not only it has declared the possession of tactical nuclear weapons but conveyed in various forums or through writings about its intended first use in the battlefield to offset India's conventional superiority.[16] In case of tactical nuclear weapons, the launch authority will invariably be delegated to field commanders. An accidental launch or an inadvertent launch based on strategic miscalculations by Pakistan should be considered by India as a realistic threat assessment. The governance in Pakistan remains in a state of flux, oscillating between civil and military rule. Any disorder arising out of politico-military tussle or socio-economic instability may give it a cause to launch nuclear strike against India to divert focus from domestic problems. With the proliferation of terrorist organizations in Pakistan, supported by its own military or ISI, the probability of nuclear weapons falling into the hands of terrorist organization or even to Jihadi or radical elements within the Army cannot be ruled out. Between 2007 and 2012 terrorists carried out six attacks against Pakistan's sensitive military installations, some of which are believed to house nuclear components, and the terrorists demonstrated an ability to penetrate progressively deeper.[17] There is another possibility of ballistic missiles falling into the hands of terrorist groups. Even missiles with non-nuclear payloads could be a major threat to India's security and economy. An example already exists wherein Iran's elite Revolutionary Guard had supplied the Islamic militant group Hamas with the technology to develop 75 km range Fajr-5 missiles, which the latter had fired at Tel Aviv, Israel.[18]

CURRENTLY, IT MAY NOT BE TECHNOLOGICALLY FEASIBLE FOR INDIA TO DEVELOP AND FIELD A BMD SYSTEM TO COUNTER BALLISTIC MISSILES OF CHINA BUT A LIMITED BMD SYSTEM IS ESSENTIAL AGAINST PAKISTAN.

While India has in place its declared Nuclear Doctrine to counter nuclear threat by other nations, irrespective of it to be delivered by ballistic missiles or any other means. But challenge lies in countering ballistic missile attacks by non-state actors or even an accidental launch as described above. Problem becomes more complex when ballistic missile carries a conventional payload. Options available to handle such situations are either to harden all vulnerable assets like population centres, command and control centres and other facilities, which may be cost- prohibitive or alternatively to go for a selective or limited BMD System.

Currently, it may not be technologically feasible for India to develop and field a BMD System to counter ballistic missiles of China but a limited BMD System is essential against Pakistan as it would offer following advantages:-

- In the event of an accidental or an inadvertent launch, BMD capability will allow space and time for India to evaluate Pakistan's intent and may also provide an opportunity to resolve and reconcile, rather than escalate.[19]

- The deterrence effect of BMD is also applicable when non-state actors target state actors, for example, if Pakistan based non-state actors or rogue elements from Pakistan's armed forces target India with nuclear weapons, New Delhi - considering that such an attack is most likely to be very limited - will be able to neutralize it and get a breathing space and time to comprehend the situation before launching an appropriate response.[20]

- BMD system strengthens public and government confidence in own deterrence capability while at the same time making an adversary aware that a nuclear first strike may not yield the intended results.

- BMD system increases stability and gives India the choice of keeping its nuclear weapons at lower state of readiness - perhaps even demated - sanguine in the belief that its second-strike capability will remain intact to retaliate.[21]

Path to Operationalisation for India's BMD System

India's BMD programme is structured as a two-layered missile defence system - Prithvi Air Defence (PAD) for interception in the upper atmosphere and the Advanced Air Defence (AAD) missile for interception at low altitude.

- **PAD.** Developed to intercept incoming exo-atmospheric ballistic missiles, the PAD is a two-stage missile with a maximum interception altitude of 80 km. Called the *Pradyumna,* PAD has the capability to engage the 300 to 2,000 km class of ballistic missiles at speeds of 5 Mach. Guidance is provided by an inertial navigation system with mid-course updates from the Long-Range Tracking Radar (LRTR) and active radar homing in the terminal phase. *Swordfish* is an Indian LRTR specifically developed as a part of its ballistic missile defence programme. This indigenously developed radar is an acknowledged derivative of the Israeli EL/M-2080, *Green Pine* long-range radar, a critical component of Israel's Arrow Missile Defence System. However, it differs from the Israeli system as it employs Indian transmit-receive modules, signal processing computers and power supply. It is also more powerful than the *Green Pine System* and was developed to meet India's specific BMD needs. It is used to track and provide fire control to interceptor missiles. Currently, *Swordfish* LRTR has a range of 600 to 800 km and can spot objects two inches in diameter. India is upgrading this radar to increase its range to 1500 km. This will be used along with upgraded variants of the PAD / AAD missiles.[22]

- **Testing of PAD**. The first PAD exercise was conducted in November 2006, in which a PAD missile successfully intercepted a modified Prithvi-II at an altitude of 50 km. The Prithvi-II missile was modified successfully to mimic the trajectory of M-11 missile. On 6 March 2009, DRDO carried out a second successful test of the PAD interceptor missile. The target used was ship-launched *Dhanush* missile, which followed the trajectory of a missile with a range of 1500 km. The target was tracked by *Swordfish* LRTR radar and destroyed by the PAD at 75 km altitude.[23]

  A new exo-atmospheric interceptor missile named the Prithvi Defence Vehicle (PDV) having a range of 50-150 km is slated to replace the existing PAD / *Pradyumna.* Among other features, this new two-stage, solid-fueled PDV interceptor is fitted with an Imaging Infrared (IIR) seeker, developed by DRDO to distinguish between incoming warheads and decoys. The PDV was first tested in April 2014. The missile interceptor had a "near miss" at an altitude of 120 km.[24] However, on 12 February 2017, PDV was able to successfully destroy a ballistic missile target launched from over 2000 km at an altitude of 97 km.[25]

- **AAD**. The AAD system is a single-stage, solid-fuel missile named Ashvin, designed to intercept incoming endo-atmospheric ballistic missiles at an altitude of 20-40 km. The interceptor is 7.5 m tall, weighs around 1.2 tonnes and has a diameter of less than 0.5 m.Guidance is similar to that of PAD with an inertial navigation system, mid-course updates from ground-based radar and active radar homing in the terminal phase.[26]

A FULL-FLEDGED BMD WILL BE A "LAYERED" SYSTEM - TARGETING THE BALLISTIC MISSILES IN THEIR BOOST, MID-COURSE AND TERMINAL PHASES - GUIDED AND TRACKED BY A VARIETY OF GROUND, SEA AND SPACE-BASED SENSORS AND CONTROLLED BY A COMPUTERIZED COMMAND & CONTROL SYSTEM. OUR PRESENT BMD CAPABILITY IS LIMITED TO A TWO-LAYERED SHIELD - CAPABLE OF PROTECTING AGAINST BALLISTIC MISSILES THAT ARE INSIDE (ENDO) AS WELL AS OUTSIDE (EXO) THE EARTH'S ATMOSPHERE UP TO A MAXIMUM HEIGHT OF 80 KM.

- **Testing of AAD**.

On 6 December 2007, the AAD successfully intercepted a modified Prithvi-II missile at an altitude of 15 km. On 15 March 2010, AAD interceptor missile test from the Odisha Coast was aborted as the target, a Prithvi missile fired, had deviated from its path and plunged into the sea. On 26 July 2010, the AAD was successfully test-fired from the Integrated Test Range (ITR) at Wheeler Island. Again on 6 March 2011 and 10 February 2012, AAD missiles were able to successfully intercept the targets.[27] On 1 March 2016, AAD missile was able to destroy the target missile, meeting all the mission objectives successfully, according to DRDO.[28]

- **Phase 2 Missile Defence System.** This will be based on the AD-1 and AD-2 interceptor missiles. Phase 2 interceptors will be hypersonic with speeds of Mach 6 to 7 hence they will take lesser times to intercept. These interceptors will be capable of intercepting missiles, with ranges greater than 5,000 km, which follow a distinctly different trajectory than a missile with a range of 2000 km or less. During their final phase, ICBMs rush towards their targets at speeds twice to that of IRBMs.[29]

- **Desirable Configuration for India's BMD.** A fully effective BMD is a complex system incorporating state-of-the-art technologies. The United States has been working on BMD since 1946. The initial system was based on nuclear-tipped missiles and was dismantled in 1975. The subsequent system was based on hit-to-kill or kinetic energy interceptors. In spite of so much of expertise, over a period of ten years from 1999 to 2009, the combination of the land-based (PAC-3 and THAAD), the sea-based (SM-3) and silo-based (NMD) Anti-ballistic missile "hit-to-kill" systems achieved a total of 43 successes out of 53 attempts - an 81 percent record.[30] These limited BMD systems are deployed by the US to provide a shield against a threatened or actual launch by rogue states like North Korea or Iran and are considered to be ineffective against high-volume and sophisticated attacks from either Russia or China.[31]

> **AVINASH CHANDER, FORMER DRDO CHIEF OPINED "THIS INTERCEPTOR MISSILE DEFENCE SYSTEM GIVES US MULTI-LAYERED CAPABILITY, BOTH FOR MEDIUM AND SHORT RANGE MISSILES. FOR INDIA, THIS MEANS PROTECTION PRIMARILY ON THE WESTERN FRONT, THAT IS AGAINST PAKISTAN….. THIS HELPS INDIA CREATE A CREDIBLE DEFENCE SYSTEM AGAINST ROGUE ATTACKS.**

In spite of the fact that India is a very late starter in the field of BMD, the success rates of its test flights both in case of PAD (3 out of 4) and AAD (5 out of 6) have been very encouraging - 75 to 84 percent but all these tests are known to have been conducted in a pre-arranged manner or so-called under laboratory conditions. Further, our missiles are primitive compared to the sophisticated missile interceptors of the US. Though a full-fledged BMD will be a "layered" system - targeting the ballistic missiles in their boost, mid-course and terminal phases - guided and tracked by a variety of ground, sea and space-based sensors and controlled by a computerized command and control system. Our present BMD capability is limited to a two-layered shield - capable of protecting against ballistic missiles that are inside (endo) as well as outside (exo) the earth's atmosphere up to a maximum height of 80 km (now being extended up to 150 km). It has the ability to intercept short and medium range ballistic missiles only. It may be pertinent to consider that the U.S. Patriot Missile batteries, originally designed to intercept Soviet intermediate-range ballistic missiles in Western Europe, were proved ineffective against

Scuds, which were of outdated technology, during the first Gulf war in 1990-91.[32]

Some of the strategic thinkers are of the opinion that the Indian BMD System should be employed to provide protection to nuclear assets, command and control centres and the political leadership so as to ensure survivability of the second-strike retaliatory capability and thereby strengthen India's stance of 'No First Use'. However, technologically Indian BMD System may not be in a position to undertake such an extensive task. Subsequent to India's latest successful test launch of PDV on 12 February 2017, Avinash Chander, former DRDO Chief opined "This interceptor missile defence system gives us multi-layered capability, both for medium and short range missiles. For India, this means protection primarily on the Western front, that is against Pakistan….. This helps India create a credible defence system against rogue attacks."[33]

The DRDO has already missed its date of 2012 for planned deployment of the first phase of BMD System. In view of the Pakistan's declared intention to use tactical nuclear weapons, the operationalisation for India's BMD System needs to be expedited. Initially, the system may not be perfect. But realistically, no defensive system can be full proof or 100 percent effective. However, by employing multiple missile interceptors guided by hi-tech sensors, it should be adequate to serve the purpose by destroying the majority of short and medium range ballistic missiles thereby saving a very significant number of lives as also allowing time to the political leadership to decide upon the magnitude of

COMPARISON WITH THE UNITED STATES HAS NO RATIONALE. INDIA COULD LAUNCH ITS MARS ORBITER MISSION (MOM) SPACECRAFT AT ONE TENTH THE COST OF NASA'S MAVEN (MARS ATMOSPHERE AND VOLATILE EVOLUTION MISSION): $74 MILLION VS. $671 MILLION.

retaliatory second-strike. In fact, the first choice for a Theatre Missile Defence System is for the defence of troops, command centres and even population centres; as being followed by the United States and NATO.[34]Reportedly, India is contemplating to deploy its initial BMD system in the Western Sector of Rajasthan.[35]

However, the Research & Development and testing should continue to enhance the capability of our BMD system to counter the evolving future missile threats. This will involve integration of multiple sensors, combining of various interceptors, and the ability to discriminate between warheads and decoys and ultimately a computerized command and control system. The software and communication challenges of this system are massive - linking in real time the many distributed sensors, the command and control systems, the interceptors and their guidance systems. According to an estimate, the software for this system will require more than 1.2 million lines of code.[36]

Conclusion

The opponents of BMD argue that the system being very costly it will result in to massive defence spending, which India cannot afford and may cite the example of the United States for having spent about $35 billion for a single site of its BMD and plans to spend $ 10 billion every year.[37] Comparison with the United States has no rationale. India could launch its Mars Orbiter Mission (MOM) Spacecraft at one tenth the cost of NASA's MAVEN (Mars Atmosphere and Volatile Evolution Mission): $74 million vs. $671 million.[38] The important aspect to be seen is that any delay in developing BMD will result in a technology gap, which would be difficult to cover, leaving an emerging power like India at a long-term disadvantage.

Development of a sophisticated military technology usually takes 15 to 20 years before it can be fully fielded, even for a country like the US. Thus having started the BMD programme in late 1990s, it should be reasonable if the DRDO can deploy one to two BMD systems by 2020. The BMD should not be conceived as an alternative to our strategic nuclear deterrent but should rather complement it by strengthening the NFU doctrine and ensuring survivability of the second-strike retaliatory capability. Accordingly, employment of BMD systems should be amalgamated into our Nuclear Doctrine

The current BMD systems do not have the ability to intercept cruise missiles or counter multiple independently targeted Re-entry vehicles (MIRVs). The future Research & Development in missile defence should accept this as a challenge to counter.

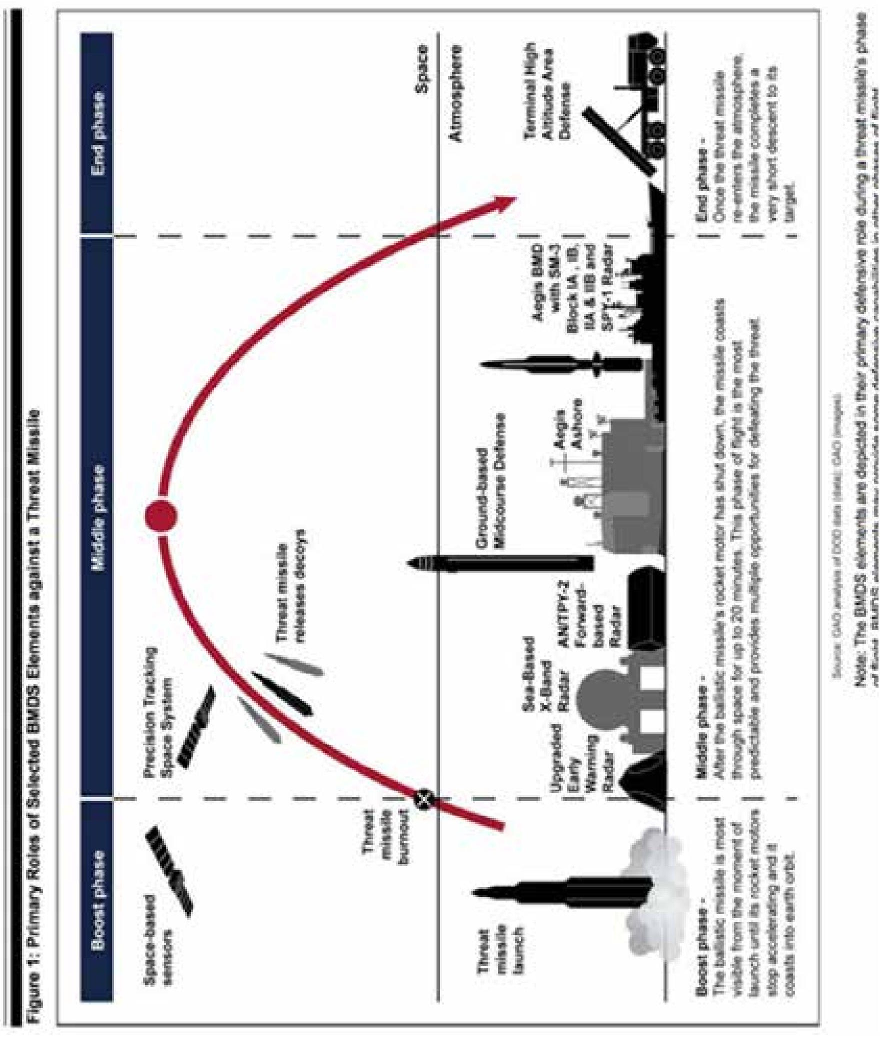

Figure 1: Primary Roles of Selected BMDS Elements against a Threat Missile

India Successfully Tests Prithvi Defense Vehicle (PDV)
on 12 Feb 2017, A New Missile Killer System.

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