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IADWS: INDIA'S INDIGENOUS QUEST FOR STRATEGIC SUPREMACY

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(Image Source: PIB/Ministry of Defense**)**

Introduction

The present era of advancements in technology coupled with unprecedented geopolitical tensions that are dynamic and complex do come with challenges that are new to the world as well. The aerial threat has evolved from localized gun and observer networks into automated, geographically distributed, multi-domain architectures that includes radars, airborne attacks, cyber and electronic warfare, missiles and so on, marking a sharp acceleration in their intensity and complexity. The need for a multilayered networked air defence solution becomes a paramount necessity so as to equip the armed forces with equally strong counter to such threats. The Integrated Air Defence Weapon System (IADWS) is a layered, networked suite of sensors, guns, surface-to-air missiles, interceptors, DEWs, command and control nodes. Included are the systems designed to detect, track, identify and counter the airborne threats ranging in altitude, speed and intensity. It is one such development that stands as a testament to India's growing defense prowess. With rise in development of unmanned aerial vehicles (UAVs), cruise missiles, and swarming drones as evident in ongoing wars IADWS emerges not just as a technological achievement but as a strategic necessity. Developed by the Defence Research and Development Organisation (DRDO), it is a

However, the Kargil War (1999) highlighted gaps in high-altitude surveillance and rapid response, accelerating the shift toward integrated systems.

India’s Air defence legacy: The BMD

India's air defense traces its roots back to World War II, where the Royal Indian Air Force (RIAF) participated[1] and was exposed to early radar and anti-aircraft systems. Post independence in 1947, the Indian Air Force (IAF) was lagging behind in the same as it inherited limited capabilities most being primarily of British origin anti-aircraft guns and radar networks that were not very advanced.[2] The 1962 Sino-Indian War and 1965 Indo-Pakistani War exposed vulnerabilities and capacity gaps,[3] which prompted the imports of Soviet systems.

It was in 1970s that the Indian Air Force was inducted with the soviet made *S-125 Neva/Pechora* which is an MR-SAM[i] designed to counter low to medium altitude threats using *5V24* missiles which had a range[ii] of about 25km and altitude ceiling[iii] of about 18km thus making it effective against threats from aircrafts, helicopters and even cruise missiles.[4] The 1980s and 1990s saw further Soviet acquisitions, including the S-200 with an impressive 150 - 300 km range and 300m to 40 km altitude, that could dominate the high altitude intercepts up to Mach 4[5] and the OSA-AK that provided agile, all-weather low-altitude coverage for troops on the move had compact 2 - 15 km range and 25m to 12 km altitude horizons.[6]

However, these systems suffered from various shortcomings. The S-125's limited mobility on trailers[7] resulting in prolonged setup and relocation times, and its single-channel guidance restricted multi target engagement,[8] rendering it ineffective against hypersonic, ballistic, or mixed aerial threats, with ranges capped at 3.5-35 km and altitudes up to 18 km, leaving gaps against standoff attacks. The S-200, optimized for high-altitude that intercepts up to 300 km, falls behind in mobility along with with extended setup/teardown periods, vulnerability to electronic warfare (EW) jamming, and poor performance against low-altitude, maneuvering, or stealthy targets below 0.3 km, compounded by finite stockpiles and toxic fuel hazards that prioritize sustainability over operational flexibility. Meanwhile, the Osa-AKM's radar emissions exposed its positions making it susceptible to SEAD.

When deployed without integration, these systems amplify gaps in layered defense. Isolated operations lead to coverage blind spots, saturation vulnerabilities from drone swarms or precision strikes, and reduced effectiveness against diverse threats like 5th-generation fighters. Lacking data fusion, networking, or passive modes, they invite SEAD exploitation as mentioned earlier and economic burdens from complex upgrades. These systems exemplified critical limitations that underscored the vulnerabilities in non-integrated air defense architectures. Their deficiencies prompted the shift to IADWS

[i] **M**edium **R**ange – **S**urface to **A**ir **M**issile system
[ii] Range – Maximum distance a missile can travel horizontally
[iii] Altitude ceiling – Maximum vertical height a missile can reach

frameworks, emphasizing seamless sensor command integration, mobility, faster deployability and adaptability for comprehensive threat neutralization.

In the year 2000, the then Hon'ble Prime Minister Atal Bihari Vajpayee, sanctioned the development of India's BMD[iv] program[9] which was an initiative to develop and deploy a multi layered ballistic missile defence system to protect India from ballistic missile attacks.[10] It was to be a two layered defence system with a capability to intercept land and sea based missiles.[11] It operates in two phases, with an extended third one to be used against Hypersonic and other such advanced threats.

A pivotal development was the 1998 collaboration with Israel, which facilitated the acquisition of the EL/M-2080 Green Pine radar technology, adapted into India's Swordfish Long-Range Tracking Radar (LRTR).[12] Developed by the Defence Research and Development Organisation (DRDO) and Bharat Electronics Limited (BEL), the Swordfish, an L-band active electronically scanned array (AESA) radar, has a detection range of 600–800 km with a potential to be extended to 1500km and is capable of tracking objects with a 0.25 m² radar cross section at 1,000 km.[13] Featuring Indian-designed transmit/receive modules, signal processing, and power systems, it supports rapid beam steering, multi-target tracking of up to 200 targets at Mach 12, and robust anti-jamming capabilities.[14] Swordfish integrates with interceptors like the Prithvi Air Defence (PAD) for exo-atmospheric intercepts at 80 km and the Advanced Air Defence (AAD) for endo-atmospheric engagements at 30 km.[15]

India's air defense capabilities with indigenous developments gained significant momentum in the 2000s. The Akash Surface-to-Air Missile (SAM) system, developed by the Defence Research and Development Organisation (DRDO) in the 2000s, marked a milestone in India's self-reliance. This medium-range system, with a 30 km range,[16] employs the Rajendra phased-array radar to track and engage multiple targets, [17]including aircraft and unmanned aerial vehicles (UAVs), with high precision. Its ability to counter low-altitude threats and integrate with command networks made it a cornerstone of India's air defense.

[iv] BMD – **B**allistic **M**issile **D**efence system

India's multi-layered defense network also includes very long-range tracking radars (VLRTR)[18] and the Medium-Range Surface-to-Air Missile (MR-SAM) system, co-developed with Israel in 2010,[19] which employs AESA radars to track low-flying threats like cruise missiles and drones. Indigenous efforts, such as the Uttam AESA radar[20] for fighter jets and the Virupaksha radar[21] for Su-30MKI upgrades underscore India's drive toward self-reliance.

The 2010s marked further advancements through strategic collaborations and system integrations. The Indo-Israeli Barak-8 (MR-SAM),[22] enhanced India's naval and land-based defenses with a 70–100 km range and a multi-function AESA radar,[23] capable of intercepting low-flying threats like cruise missiles and drones. Its versatility across platforms strengthened India's coastal and battlefield air defense.

In 2011, the upgraded Super Swordfish/LRTR-II extended its range to 1,500 km,[24] enhancing its ability to counter intermediate-range ballistic missiles (IRBMs) and intercontinental ballistic missiles (ICBMs).

Concurrently, India began inducting the Russian S-400 Triumf system, a long-range platform with a 400 km reach and the 91N6E radar, enabling simultaneous engagement of 36 targets, including hypersonic threats at Mach > 5.[25] The decade also saw upgrades to legacy systems, integrating them into the Integrated Air Command and Control System (IACCS) for networked operations. This facilitated real-time data sharing and coordination across radar, missile, and command units, enhancing situational awareness.

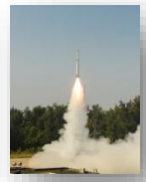
By 2025, India's air defense has evolved into a sophisticated, multi-tiered framework under Mission Sudarshan Chakra, an AI-integrated nationwide shield. The Integrated Air Defence Weapon System (IADWS), tested in 2025, integrates BMD, SAMs, directed energy weapons (DEWs), and AI-driven command-and-control to counter drone swarms and hypersonics. Emphasizing sensor fusion, AI for predictive analytics, and quantum computing for threat modeling, India's air defense aligns with global trends in network-centric warfare.

From BMD to IADWS

The table gives a brief overlook of all the phases under India's BMD program

Phase 1: To intercept and counter short range threats (~2000km)
 *Prithvi Air Defence* (PAD) / *Pradyumna* Interceptor - A two stage solid propellant missile for High altitude threats (50 to 80km) using *gimbaled thrust vectoring*[v] for precision. (**Image source:** GlobalSecurity.org)
 *Advanced Air Defence* (AAD)/ *Ashwin* Interceptors – A single stage missile for lower altitude threats (up to 30km) (**Image source:** GlobalSecurity)
 *Swordfish Long Range Tracking Radar* – The AESA[vi] radar with a detection range of about 600 to 800km with a capacity to detect small objects as well. (**Image source:** Indian Defence News/defence update)
Phase 2: Against Intermediate range threats (~5000km)
AD-1(handling 5000km range threats) and *AD-2*(handling 3000 to 5500km range threats) Interceptors which are two stage missiles that use solid propellants. (**Image source**: PIB) *Prithvi Defence Vehicle (PDV) Mk1 and Mk2(capable of ASAT[vii])* - Exo atmospheric interceptors reaching 120km altitude. Swordfish enhanced to 1500km scan integrated with VLRTR[viii]

[v] exhaust nozzle of the rocket can be swiveled from side to side
[vi] **A**ctive **E**lectronically **S**canned **A**rray
[vii] **A**nti **SAT**ellite
[viii] **V**ery **L**ong-Range **T**racking **R**adar

(**Image source:** ResearchGate)    
Phase 3: *Sudarshana Chakra* – Nationwide AI Integrated Shield
• Expands BMD to a *Rastriya Suraksha Kavach* covering important cities, cites, assets, hospitals, religious sites etc. • BMD to be integrated with S-400, Kusha - LRSAM[ix], Akash-NG[x], MRSAM, along with Laser Based Weapons. (**Image source:** Defence News India, Swarajya, SP's Land Forces, Mint) • Akashteer AI system to fuse threats from multiple domains (land, sea, air, cyber) and Quantum Computing as a predictive measure against hypersonic threats. • Counter strikes through Pralay SSM[xi], BrahMos and loitering munitions.

(**Table:** The Indian BMD Program)

(**Source:** Indian Defence Research Wing and Author Compilation)

A potential deal to aquire the *Arrow 2* intercepting missiles to be inducted in BMD, capable of intercepting short and medium altitude ballistic missiles with Israel was vetoed by USA

[ix] **L**ong **R**ange **S**urface to **A**ir **M**issile

[x] NG - **N**ew **G**eneration

[xi] **S**urface to **S**urface **M**issiles

in 2002 citing MTCR[xii] violations.[26] As a counter to this the DRDO accelerated the already sanctioned BMD program achieving various milestones.

What is in an IADWS?

The evolution of India's BMD program aimed at countering the aerial threats to what now includes the IADWS has been a remarkable one. The adaptation of advanced technologies to enhance the counter capabilities is clearly seen in recent developments that have taken in the same. The IADWS uses combination of various advanced set of equipment such as Radars, Missiles, and Laser weapons of high energy, Command Control Centers, which are used for detecting, tracking, intercepting and destroying threats. The Indian IADWS consists of three layers which work under a centralized command and control.[27] A matter of pride is that all these are *indigenously* developed by DRDO[xiii],RCI[xiv] and CHESS[xv].

- Radar and Sensor Network

  Used for scanning the airspace using the EM[xvi] waves. It includes AABSR[xvii] and AABMR[xviii] possessing *search on move* and *track on move* capabilities.[28] Radar signals hit the object in the sky and are then bounced off producing "*echoes"* which are then analysed to determine information related to the threats such as its range, speed, altitude and trajectory.[29]
- Centralised Command and Control Center (C2C2)

  The *Heart of IADWS* that uses real time radar and sensor data to analyse potential threats and to assign suitable weapons for the same. It is extremely effective in automating the battle management cycle starting from detection till engagement.[30]
- Outer Layer - QRSAM[xix]

[xii] **M**issile **T**echnology **C**ontrol **R**egime
[xiii] **D**efence **R**esearch **D**evelopment **O**rganisation
[xiv] **R**esearch **C**enter **I**marat
[xv] **C**enter for **H**igh **E**nergy **S**ystems and **S**ciences
[xvi] **E**lectro **M**agnetic
[xvii] **A**ctive **A**rray **B**attery **S**urveillance **R**adar
[xviii] **A**ctive **A**rray **B**attery **M**ultifunction **R**adar
[xix] **Q**uick **R**eaction **S**urface to **A**ir **M**issiles

(Image source: BDL India)

Designed and Engineered keeping in mind the short range defence (5 to 30 km).[31] Running on solid fuel, they use active radar homing.[32] They track and intercept fast moving threats like jets or cruise missiles. The launchers are highly mobile with radars providing 360 degree coverage.[33]

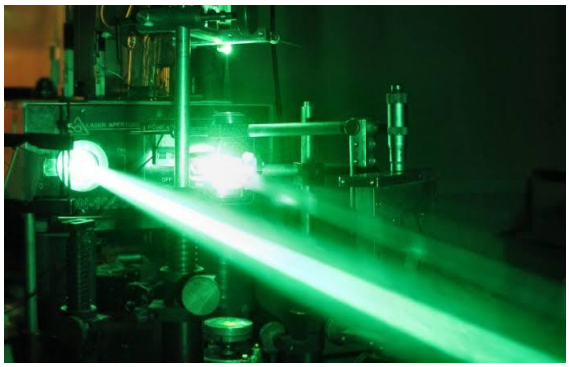
- Middle Layer - VSHORADS[xx]

(**Image source:** Defence News India)

A 4.0[xxi] technically advanced MANPAD[xxii] being capable of meeting the needs of all the arms of the defence forces.[34] These are suitable for short hops. Propelled by a dual thrust solid motor,[35] it targets low altitude aerial threats within a range of 6km.[36]

- Inner Layer - Laser Based DEW[xxiii]

[xx] **V**ery **SHO**rt **R**ange **A**ir **D**efence **S**ystems
[xxi] 4th Generation
[xxii] **MAN P**ortable **A**ir **D**efence **S**ystem
[xxiii] **D**irected **E**nergy **W**eapons



(Image for representation only)

(**Image source:** Unmanned airspace)

A high powered laser based weapon used to disable threats at close range and comes with unlimited ammo for efficient and effective neutralization of munitions that shoots to destroy any incoming threats immediately by travelling at speed of light.[37] They cause structural damage to critical components of the threats by focusing and rapidly depositing energy on them leading to a thermal or electrical destruction.[38]

Why IADWS?

Air defense systems like IADWS are pivotal for aerial dominance shapes outcomes in hybrid warfare. For India, tensions along its borders underscore the need for robust defenses against adversaries' aerial incursions and surveillance. Their missile arsenal and proxy drone attacks can be countered effectively by layered shields. The IADWS bolsters our capability in defence, reducing vulnerability and enabling offensive maneuvers. Globally, the ongoing conflicts have spotlighted air defenses, be it the systems like Patriot[xxiv] and S- 300[xxv] which effectively thwarted missiles, or the Iron Dome[xxvi] countering the Hamas rockets. These systems mirror the capability of IADWS's in countering aerial threats.

Economically speaking, the global air defense system market size is estimated at USD 48.32 billion in 2025 and is predicted to reach around USD 78.23 billion by 2034, growing at CAGR of 5.5% from 2025 to 2034 while the Asia Pacific air defense system market

[xxiv] A long range air defence system developed by USA
[xxv] A Russian made Surface to Air Missile system
[xxvi] An Israeli mobile all weather air defence system

size is has crossed the USD 16 billion mark in 2025 and is expanding at a CAGR of 5.65% for the same forecast period.[39] Economically, indigenous development saves forex reserves, foster jobs and aligns with India's defense export goals.

India's development of the Integrated Air Defence Weapon System (IADWS) carries profound geopolitical implications, enhancing its strategic autonomy especially amidst the escalating tensions with adverse neighbors like Pakistan, which has been repeatedly accused with illegal surveillance and in effectively countering its aerial threats as seen during Op Sindoor. By achieving self-reliance through DRDO under Atmanirbhar Bharat, India reduces vulnerability to external dependencies, such as the 2002 U.S. veto on Israel's Arrow-2, and positions itself as an efficient contender in hybrid warfare scenarios. This multilayered shield detects, deters and destroys aerial incursions, enabling offensive maneuvers and asserting dominance especially in the volatile Indo-Pacific.

Where do we stand globally?

The table below provides a comparison of selected aerial defence systems across the globe.

Parameter	United States	China	France	Israel	India
Primary Short Range Systems	**Iron Dome**[40] (range: 4 to 70 km,[41] Anti rocket/ artillery), **Avenger**[42] (MANPADS with Stinger missiles, range: 8 km, C-RAM[xxvii])	**HQ-10**[43] (naval/short Range - 9 km),	**VL MICA**[44] (vehicle launched, range - 20 km, anti-air/drone), **Crotale NG**[45] (range - 15 km)	**Iron Dome**[46] (range – 4 to 70 km, high intercept rate against short range threats), **Iron Beam**[47] (laser, operational 2025, range - up to 10 km)	**QRSAM** (quick reaction, range - 30 km) **VSHORAD** (man-portable, range - 6 km), **SPYDER**[48] (short range variant, range - 15 km)
Primary Medium Range Systems	**Patriot PAC-3**[49] (range – 20 to160 km,	**HQ-16**[50] (range- 40 to 70 km,	**SAMP/T with Aster 15/30**[51] (range- 25 to120 km,	**David's Sling**[52] (range - 40 to 300 km,	**Akash** (range: 25-30 km, indigenous SAM), **Barak-8**

Parameter	United States	China	France	Israel	India
	anti - air/ballistic)	naval/land based, anti-air)	anti-air/cruise missile)	anti-cruise/ballistic missiles)	(range - 70 to100 km, joint venture with Israel)
Primary Long-Range Systems	**THAAD**[53] (range: 200 km, high-altitude ballistic),	**HQ-9B**[54] (range: 200-300 km, anti-air/ballistic)	**SAMP/T with Aster 30 Block 1NT**[55] (extended range: 150+ km, anti-ballistic up to 600 km threats)	**Arrow 3** (exo-atmospheric, range: 2,400 km, anti-ballistic)	**S-400** Triumf (range: 400 km, multi-target engagement)
Ballistic Missile Defense Systems	**Ground Based Midcourse Defense**[56] (anti-ICBM)	**HQ-19** (anti-ballistic) **HQ-29**	**SAMP/T Aster 30 Block 1** (short range, ballistic defense)	**Arrow 2/3**[57] (two-layer, endo/exo-atmospheric intercepts)	**Phase-II BMD** (**Prithvi/Advanced Air Defence** interceptors, range - 5,000 km coverage), **Project Kusha** (developing 150 to 400 km interceptors)
Key Capabilities	Multi-layered integration with NORAD, high-altitude intercepts, naval/air integration, effective against ICBMs and hypersonics	Networked with radars, anti-satellite potential, large-scale deployment; improving overseas basing	Rapid deployment, networked radar, anti-UAV/cruise; NATO interoperable	High success rate, laser tech for cost-effective intercepts, real-time adaptation	Indigenous multi-layered network (IADWS tested Aug 2025), swarm drone defense; integrated with S-400 for long-range

Parameter	United States	China	France	Israel	India
Challenges	High costs of interceptors, complex logistics for THAAD/Aegis global deployments,[58] vulnerability to hypersonic saturation attacks	Limited transparency in testing, reliance on reverse-engineered tech,[59] challenges in countering advanced stealth.	Limited scalability for large-scale conflicts, high maintenance costs for SAMP/T, gaps in countering hypersonic weapons	Limited coverage area (small nation), high operational tempo strains resources, laser systems untested in large-scale conflicts.	Integration delays with S-400 and indigenous systems, limited production capacity for Akash/QRSAM, vulnerability to swarm drone saturation

Challenges

India faces multidimensional threats. Failure to address these will have severe consequences as there shall be a compromise in the security domain due to voids present. Below given are such threats that need to be focused on the earliest.

- Evolving Threats like that of Hypersonic missiles (Mach >5), drone swarms, and low-observable stealth aircraft evade legacy radars
- Geographical and Operational Constraints due to Vast land and coastal borders that create coverage gaps, especially in difficult terrains like those of mountainous Ladakh, dense urban areas and marshy lands.
- Ineffective Legacy systems those lack seamless fusion with modern ones, leading to delays in responses.
- Cyber and EW Vulnerabilities which are results of jamming and spoofing technologies deployed by the adversaries advancing in the field at a faster pace
- Resource Limitations i.e., Budget constraints and squadron shortages (as seen in case of IAF having 31 operational ones out of the required 42[60]) that hinders full modernization to name a few.

Along with these challenges there are several gaps that exists such as,

- Coverage and Range: With Limited nationwide BMD focusing mainly on metropolitan areas, leave rural and other vital assets exposed. There is a dominance of Short-range systems thus creating gaps in long-range interception that are still in developmental stages (> 400 km)
- Technological Lags such as that of inferior hypersonic countermeasures in comparison to other counterparts in the market, heavy dependence on imported technologies for drone swarm detection[61] which comes with security concerns as well.
- There exist supply chain risks that are associated with ongoing conflicts in countries that are major exporters of technologies like that of S-400 (Russia-Ukraine war).
- Shortage of manpower that persists as a result of skill gaps in operating AI-integrated systems.

In order to deal with above mentioned challenges and gaps Indian government has taken some active measures such as,

- Indigenous R&D under the Atmanirbhar Bharat initiative such as DRDO's Project Kusha (350 km LRSAM) and XRSAM (extreme long-range)[62] while Akash-NG and QRSAM are being developed to address short medium range related gaps.
- Mission Sudarshan Chakra which is to be an AI-driven integration of all systems for nationwide shield, including DEWs for unlimited engagements.
- Acquisitions and Upgrades such as procurement of Akash launchers and missiles,[63] upgrading S-400 with indigenous components.
- Collaborations with nations with developed and advanced technologies in the filed such as U.S. (iCET[64] for co-development in DEWs and AI integration), Israel (to enhance Barak-8), etc…
- Budget and Policy: Investing multi billions[65] for gap-filling and to boost Make in India i.e., local manufacturing (e.g., BrahMos production).
- Training and Exercises: simulations such as that of Akashteer[66] for multi-domain fusion and active research in quantum technologies for predictive analytics.

Conclusion

The Indigenous Integrated Air Defence Weapon System provides resilience, it symbolizes strategic autonomy, deterring aggression in an era highly prone to instabilities caused by multitude of factors. It epitomizes India's defense evolution, from historical vulnerabilities to futuristic capabilities. With its successful 2025 tests,[67] IADWS not only strengthens national security but also positions India as a global player in defence innovations. As geopolitical instabilities and complexities continue to surge, such systems are indispensable. The Indian air defence capabilities displayed during recent *Operation Sindoor* shows how crucial it is for us to be well equipped to counter aerial threats while also delivering a befitting counter so as to assert our dominance in both defence as well as technology domain in our aspirations to become a Global military power advocating peace through position of strength.

DISCLAIMER

The paper is author's individual scholastic articulation and does not necessarily reflect the views of CENJOWS. The author certifies that the article is original in content, unpublished and it has not been submitted for publication/ web upload elsewhere and that the facts and figures quoted are duly referenced, as needed and are believed to be correct.

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