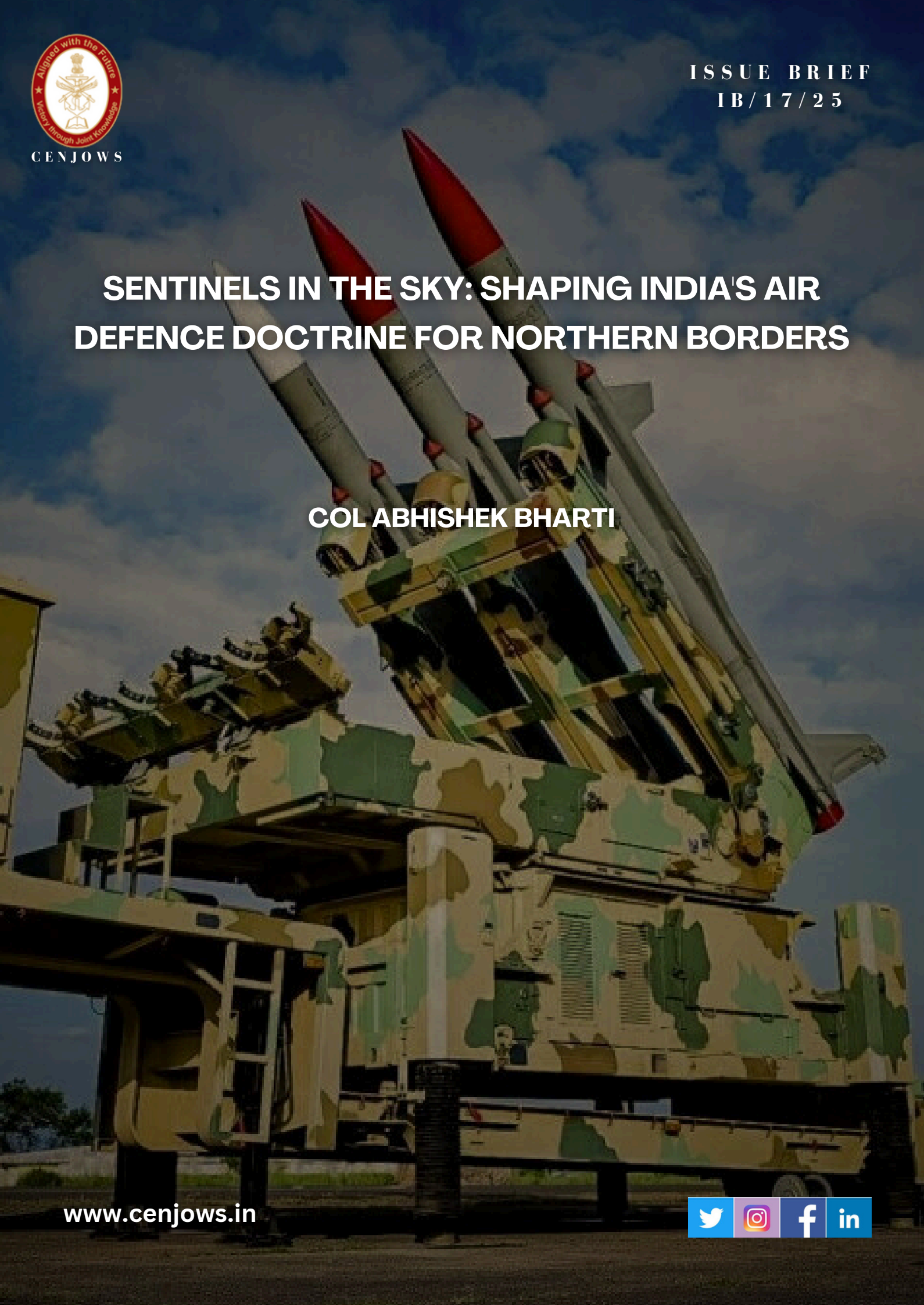
CENJOWS

ISSUE BRIEF
IB/17/25

SENTINELS IN THE SKY: SHAPING INDIA'S AIR DEFENCE DOCTRINE FOR NORTHERN BORDERS

COL ABHISHEK BHARTI



www.cenjows.in

CENTRE FOR JOINT WARFARE STUDIES

CENJOWS

Sentinels in the Sky: Shaping India's Air Defence Doctrine for Northern Borders

Col Abhishek Bharti is an Army Air Defence officer. He is currently serving as a Directing Staff at Defence Services Staff College, Wellington.

Abstract

India's high-altitude frontier with China demands an air defence doctrine that is both technologically modern and terrain-responsive. With the convergence of aerial threats - drones, loitering munitions, cruise missiles, and hypersonic glide vehicles - the conventional paradigms of air defence face doctrinal obsolescence. This article proposes an integrated, multi-layered, and multi-domain integrated air and missile defence framework specifically tailored for mountainous terrain. Drawing from recent global conflicts and indigenous developments, it offers a phased roadmap for capability development, doctrinal evolution, and policy integration. The recommendations aim to enhance deterrence, operational readiness, and national strategic autonomy in the Himalayan battlespace.

Introduction

India's 3488-kilometre-long Himalayan frontier with China spans altitudes from 9,000 to over 18,000 feet - posing logistical, operational, and technical challenges to Air Defence (AD) operations. This diverse altitude gradient, ranging from the arid heights of Eastern Ladakh to the forested slopes of Arunachal Pradesh, demands context-specific capabilities. The Line of Actual Control (LAC) is not just a political boundary; it is a theatre for next-generation aerial conflict shaped by terrain, weather, and technological asymmetry.[1]

Recent incidents - from the 2020 Galwan clash to persistent PLA infrastructure upgrades - have highlighted the increasing role of air and missile power in shaping outcomes, even in remote mountainous regions.[2] Meanwhile, global conflicts in Russia-Ukraine, Nagorno-Karabakh, and West Asia have demonstrated how inexpensive, networked aerial threats can overwhelm even advanced AD systems.[3] In this transformed environment, India's existing AD doctrine - often platform-centric, service-specific, and plains-oriented - needs urgent reimagination.[4]

> *From the ridgeline to the exosphere, AD is no longer vertical; it is volumetric, multidomain, and cognitive.*

This article presents a doctrinal framework that fuses lessons from high-altitude warfare, strategic foresight, and emerging technologies to propose a tailored Integrated Air and Missile Defence (IAMD) architecture for India's Northern Borders. This reimagined approach is not merely about intercepting aerial threats; it is about denying air dominance, enhancing survivability, and preserving the strategic initiative in one of the world's most challenging operating environments.

The Changing Character of Air Threats

The character of aerial threats has undergone a profound metamorphosis in recent years. What once comprised mainly manned aircraft and ballistic missiles has now evolved into a dense spectrum of threats - from stealthy cruise missiles and low-Radar Cross Section (RCS) drones to loitering munitions, Hypersonic Glide Vehicles (HGVs), and autonomous swarms.[5] These threats are not only more numerous but also more elusive, intelligent, and cost-effective. They exploit the gaps in legacy AD systems through speed, stealth, swarm tactics, and electronic deception.[6] Recent conflicts offer sobering illustrations: -

- In Ukraine, swarms of expendable drones and loitering munitions were able to destroy advanced AD systems by saturating their engagement envelopes.[7]
- In Nagorno-Karabakh, a well-coordinated drone-artillery complex devastated traditional Surface to Air Missile (SAM) and radar deployments.[8]
- In Israel, Hamas and Iranian proxies have demonstrated how low-cost rockets and Unmanned Aerial Vehicles (UAVs), launched in waves, can exhaust interceptors and confuse defence radars.[9]

These vignettes underscore the doctrinal imperative for India: any AD system that is not multi-layered, intelligent, and integrated is destined to be outpaced.

The Himalayan region adds further complexity. The terrain compresses radar horizons, reduces reaction time, and limits mobility. In such conditions, threats like terrain-hugging cruise missiles or loitering drones can evade detection until the last moment.[10] Stealth-capable 5th-generation fighters (e.g., J-20 and J-35) employing terrain masking and standoff weapons complicate radar detection and intercept planning.[11] Moreover, the People's Liberation Army's (PLA's) increasing deployment of long-range rocket artillery, UAVs, and theatre-range ballistic and hypersonic missiles across Tibet poses a clear and present danger to India's forward bases, logistics hubs, and command infrastructure.[12] Emerging air threats manifest in multiple dimensions :-

- **Swarm drones** capable of autonomous coordination and saturation.
- **Loitering munitions** acting as persistent airborne assassins with terminal guidance.
- **Stealthy cruise missiles** with low-observable signatures and advanced navigation systems like Terrain Contour Matching (TERCOM) and Digital Scene Matching Area Correlator (DSMAC).
- **HGVs** that manoeuvre at Mach 5+ speeds, complicating intercept solutions.
- **Cyber-electromagnetic attacks** aimed at blinding radars, spoofing Identification Friend or Foe (IFF) systems, or jamming Command and Control (C2) networks.
- **Precision stand-off weapons** launched from outside visual/ radar range, enabled by space-based cueing.

These realities demand a doctrinal shift from merely intercepting targets to proactively denying the adversary aerial dominance. ***The AD doctrine must therefore evolve to become pre-emptive, predictive, and deeply networked*** - where sensors, shooters, and decision-makers operate in unison, irrespective of service or platform. In sum, India's AD posture for the Northern Borders must recognise the changing geometry and speed of air threats. A failure to adapt would render even the most expensive systems obsolete. It is not only the sophistication of the threat that matters, but also its simultaneity, scale, and asymmetry.[13]

The emphasis must shift from platform-centricity to kill web synergy. Doctrinal readiness today will determine tactical survivability tomorrow.

Recalibrating Ad Architecture for Northern Borders

The doctrinal reconfiguration of AD along the Northern Borders must begin with terrain-realistic design and threat-specific solutions. Unlike the plains, where large radar arrays and mobile launcher systems can be freely manoeuvred, mountainous terrain imposes limitations on logistics, field of view, and reaction time. Recalibrating the architecture thus involves prioritising the following shifts: -

- **Sensor Fusion in a Layered Network:** Deploy a mix of Low-Level Light Weight Radars (LLLR), passive Electro-Optical (EO) sensors, aerostat-based radar systems, and stratospheric airships to plug surveillance gaps. Network these into a real-time common operating picture with elevation-aware processing algorithms.[14]
- **Multi-Layered Interceptor Strategy:** Integrate Long-Range SAM (LRSAM), Medium-Range SAM (MRSAM), and Short-Range SAM (SRSAM) like Akash, QRSAM, SPYDER, with Short Range Air Defence (SHORAD) Systems like OSA-AK, Strela 10M, Tunguska and Very Short Range Air Defence (VSHORAD) weapon systems like Schilka, L-70, Zu 23mm, as well as Man Portable Air Defence Systems (MANPADS) like Igla/ Igla-S into an overlapping mesh.[15] Position layered kill zones based on threat approach corridors and terrain bottlenecks.[16]

Layer	Weapon Platforms	Typical Engagement
1 (Innermost)	DEWs, L-70, Zu-23-2B, MANPADS, CIWS	Micro/ Mini-UAVs, Swarm Drones, PGMs, Pop-Up Threats (Helicopters), RAM Projectiles
2	OSA-AK, Strela-10M, Schilka, Tunguska	Low-Altitude Helicopters, UAV Swarms, Loitering Munitions, Cruise Missiles
3	SRSAM (Akash), QRSAM, SPYDER, Fighter Interceptors	Tactical Jets, Standoff Glide Weapons, Larger UAVs/ UCAVs, Medium-Range Cruise Missiles, Anti-Radiation Missiles
4	MRSAM (Barak-8), Fighter Interceptors	Fast-Jets, Heavy UAVs/ UCAVs, Sea-Skimming Missiles, High-End Cruise Missiles, Anti-Radiation Missiles
5	LRSAM (S-400), Fighter Interceptors	Long-Range Bombers, AWACS/ AEW&C, Ballistic & Cruise Missiles
6 (Outermost)	BMD (AD-1/AD-2)	Exo-/Endo-Atmospheric Intercept of SRBMs/ IRBMs

Table 1: Multi-Layer Interception Strategy
(Source: Author's Own Creation)

- **Mobile, Modular, and Air Liftable Systems:** Prioritise deployment of air-transportable and quickly redeployable AD units that can operate on hybrid power. Light trailers, ski-mountable launchers, and all-terrain command posts enhance survivability and flexibility.[17]

- **Intelligent IFF and Blue Force Tracking:** Implement advanced friend-foe detection tools that function reliably under jamming and are compatible across services. IFF misidentification in foggy mountain skies could be fatal.[18]

- **Hardened C2 Infrastructure:** Establish terrain-hardened command centres linked via optical fibre backbone, satellite terminals, and High Frequency (HF)/ Very High Frequency (VHF) redundancies. Artificial Intelligence (AI)-enabled Battle Management Systems (BMS) should process multi-sensor data, prioritise threats, and autonomously allocate shooters.[19]

- **Redundancy and Resilience:** Every radar and launcher should be duplicated, with alternate positions identified. All critical nodes must be Electro Magnetic Pulse (EMP)-hardened and operate with minimal electronic signature to avoid detection.[20]
- **Logistical Preparedness:** Forward area maintenance centres with pre-positioned high-altitude spares, fuel, and armaments are essential. System readiness in minus 30°C cannot depend on just-in-time logistics.

Recalibrating the AD posture is not merely an equipment issue - it is about institutional, procedural, and human readiness to fight a modern air war in a high-altitude theatre.

- **Doctrine for Cross-Domain Synchronisation:** AD must be integrated into broader warfighting across land, air, cyber, and space. For instance, radar data should feed into artillery fire control systems to neutralise detected launch platforms like enemy Multiple Launch Rocket System (MLRS) units.

Platform–Threat Response Matrix

An effective high-altitude AD system requires matching the right platform against the appropriate threat to ensure cost-effectiveness, operational efficiency, and minimised fratricide. This section outlines India's optimal response matrix for contemporary and emerging air threats: -

- **Swarm Drones, Loitering Munitions and First Person View (FPV) Drones**
  - ***Recommended Platforms****:* Bhargavastra (India's first indigenous vehicle-mounted counter-swarm drone system which uses micro-missiles and is currently under development)[21], radar-cued quick-reaction gun systems like the upgraded L-70[22] and ZU-23-2B integrated with electro-optical fire control, anti-drone jammers and spoofers, Defence Research and Development Organisation's (DRDO's) Drone Detect, Deter, and Destroy (D-4) system[23], and Directed Energy Weapons (DEWs) under development such as the Integrated Drone Detection and Interdiction Systems (IDD&IS)[24] and Directionally Unrestricted Ray-Gun Array (DURGA)-II[25].
  - ***Doctrine Note****:* Deploy layered point-defence zones with soft-kill Electronic Warfare (EW) measures (jamming, spoofing) as the outermost layer,

followed by kinetic options. Emphasise radar-EO sensor fusion and short-range intercept redundancy. Jammers, spoofers, and retrofitted anti-aircraft guns with '3P' (Pre-fragmented, Programmable, Proximity-fused) ammunition[26] - currently being explored for indigenous development - offer high return at low cost. Employ Emission Control (EMCON), decoy emitters, and frequent repositioning to defeat loitering munitions.

- **Terrain-Hugging Cruise Missiles**
  - ***Recommended Platforms**:* SRSAM, MRSAM, LRSAM, and low-level surveillance radars integrated with Command and Control (C2) networks such as Akashteer of Indian Army and Integrated Air Command and Control System (IACCS) of Indian Air Force (IAF).[27] Airborne Early Warning & Control (AEW&C), aerostats, and Airborne Warning and Control System (AWACS) platforms are critical enablers for early detection of low-flying cruise missiles, especially in radar shadow zones characteristic of mountainous terrain.
  - ***Doctrine Note**:* Terrain-hugging missiles demand a layered interception grid supported by forward-deployed sensors and pre-designated kill corridors. Effective AD hinges on gap-free low-altitude radar coverage and real-time data fusion across sensor-shooter networks. Fighter aircraft configured for AD patrols and legacy SAM systems serve as cost-effective supplementary interceptors, particularly in terrain-constrained sectors.
- **Tactical and Theatre Ballistic Missiles**
  - ***Recommended Platforms**:* S-400, indigenous Phase-II Ballistic Missile Defence (BMD) system comprising AD-1 and AD-2 interceptors (under development)[28], and MRSAM as an interim solution for limited engagement envelopes.

- ***Doctrine Note**:* Prioritise space-based Intelligence, Surveillance, and Reconnaissance (ISR) and early warning for optimal cueing.[29] Mid-course interception offers the most viable engagement window, especially in high-altitude terrain where terminal response times are compressed. Pre-emptive targeting of Transporter Erector Launchers (TELs) remains a cost-effective strategy to neutralise threats before launch.

- **HGVs**

  - ***Recommended Platforms**:* Under development – space-based Infrared (IR) sensors, exo-atmospheric BMD interceptors, and kinetic kill vehicles. In the interim, passive detection networks and fighter Combat Air Patrols (CAPs) positioned along likely launch corridors provide limited deterrence and early response options.

  - ***Doctrine Note**:* The extreme speed and manoeuvrability of HGVs compress detection-to-intercept timelines, making AI-driven automation and rapid decision-making imperative.[30] A "shoot-at-launch" approach, enabled by persistent ISR and predictive analytics, offers the most viable defence posture. Until dedicated interceptors are operational, deterrence and early warning remain the cornerstone of HGV countermeasures.

- **Rocket, Artillery, and Mortar (RAM) Projectiles**

  - ***Recommended Platforms**:* DRDO's projected Close-In Weapon Systems (CIWS), directed-energy solutions such as anti-rocket lasers (under development), and electronic deception systems for trajectory spoofing.[31]

  - ***Doctrine Note**:* RAM threats demand fully automated point-defence systems with minimal sensor-to-shooter latency. Integration with counter-battery fire control systems is essential for the swift neutralisation of launch sources. Passive defences such as hardened shelters, dispersion, and trench networks continue to offer cost-effective mitigation against saturation fire.

- **Cyber-Electronic Threats to AD Systems:**
  - ***Recommended Platforms**:* EMP-shielded C2 nodes, hardened fibre-optic communications, quantum-resilient encryption, and rapid reboot systems.[32]
  - ***Doctrine Note**:* Layered cyber defences and cyber-wargaming drills must become standard. Software resilience and redundant communications are cost-saving essentials.
- **Stand-Off Precision Guided Munitions (PGMs)**
  - ***Recommended Platforms**:* DEWs under development, including IDD&IS and DURGA-II[33], supported by terrain-aware camouflage, decoy systems, and multispectral signature suppression techniques such as camouflage nets and thermal masking.
  - ***Doctrine Note**:* Mobility, EW, Global positioning System (GPS) denial, and deception remain central to defeating PGMs. Passive defences - particularly camouflage, spoofing, and terrain masking - offer highly cost-effective protection against precision strikes, especially in high-altitude and open-terrain environments.
- **Stealth-Capable 5th/6th Generation Fighters**
  - ***Recommended Platforms**:* S-400's multi-band radar suite, VHF/ Ultra High Frequency (UHF) radars[34], Infrared Search and Track (IRST) systems on Su-30MKI[35] and Rafale, AEW&C platforms like Netra and PHALCON, passive EO and electromagnetic detection networks, and future counter-stealth configurations of India's AMCA.[36] Quantum sensing radars (in future, for detection of low-RCS platforms under heavy EW).
  - ***Doctrine Note**:* Counter-stealth operations require multi-static radar networks, passive detection, and real-time fusion. Quantum radars, leveraging quantum entanglement or photon timing, offer a future-proof solution for overcoming stealth.[37]

- **Advanced Attack Helicopters**

  - ***Recommended Platforms**:* MANPADS such as Igla and the forthcoming VSHORAD system[38], legacy gun systems like L-70, ZU, Schilka, Tunguska, OSA-AK, and QRSAM (Under development)[39]. For early detection, low-level radars like Bharani, airborne sensors including Netra AEW&C, PHALCON AWACS, and tethered aerostats are critical to counter terrain-masked approaches.[40] CAPs by fighters further extend engagement options.

  - ***Doctrine Note**:* Rotary threats demand multi-layered vertical coverage. Deploy VSHORAD assets in air ambush role at terrain choke points, empower decentralised fire units, and integrate aerial and ground-based sensors to monitor low-level ingress routes. Detection architecture must account for Nap-of-the-Earth (NOE) flight profiles.

This platform-threat pairing serves as the doctrinal fulcrum around which India's IAMD must revolve. Prioritisation for ***threat-agnostic architecture but threat-specific solutions*** will enhance both operational effectiveness and resource optimisation. Aligning specific countermeasures to each threat as above ensures that the IAMD doctrine is not generic, but tailored to real-world challenges in the Northern theatre.

Indigenisation And Capability Gaps

While India has made significant strides in indigenous AD systems, capability asymmetries persist, especially in areas critical for high-altitude, high-velocity engagements. A credible Northern AD doctrine must integrate India's self-reliance objectives with realistic assessments of current limitations. India's indigenous contributions include systems like: -

- **Akash and Akash-NG**[41]: SRSAM suitable for mountainous terrain with recent mobility upgrades.
- **QRSAM**: Fast-reaction systems tailored for the protection of mobile tactical units and high-value assets.
- **Akashteer and IACCS**: C2 networks integrating multi-service AD radars for real-time threat tracking.
- **Anti-Drone Systems**: Bhargavastra, DRDO's D-4 and Netra EW suite, IDD&IS (Mk-I/ II), alongside private-sector soft-kill technologies.

Despite these achievements, significant capability gaps remain: -

- Absence of a credible **counter-hypersonic interceptor** or dedicated **exo-atmospheric kill vehicle**.
- Limited deployment of **Over-the-Horizon (OTH) radars** essential for long-range detection in mountainous regions.
- Lack of **terrain-adaptive passive surveillance systems** (e.g. multi-static radars, EO/ IR arrays, and acoustic sensors).
- Shortfalls in **high-altitude-tested CIWS and point-defence systems** for RAM threats.
- Underdeveloped **DEWs** for cost-effective anti-drone operations.
- Inadequate **EMP protection and cyber hardening** in existing radar and launcher networks.

Bridging these gaps requires: -

- Fast-tracking projects like **BMD Phase-II** and **DURGA-II** through enhanced funding and industry–military collaboration.
- Deepening **public–private partnerships under Innovations for Defence Excellence (iDEX) and Make-I/II** categories to incubate indigenous AD technology.[42]
- Encouraging participation of academia in AI, sensor fusion, and advanced materials relevant to AD.[43]

Indigenisation must be driven by both strategic autonomy and terrain-specific necessity.

- Field testing all new systems rigorously under **high-altitude, low-oxygen, sub-zero temperature conditions** to ensure reliability.[44] India's Northern AD doctrine cannot rely on off-the-shelf imports alone. Instead, it must shape requirements that stimulate innovation within India's defence Research and Development (R&D) and manufacturing ecosystem.

Jointness and Inter-Service Integration

Seamless interoperability between the Indian Army and IAF is the sine qua non of effective air and missile defence along the Northern Borders. ***In today's environment, where threats traverse multiple domains and demand instantaneous responses, service-specific silos are not only inefficient but strategically perilous.*** An IAMD construct must prioritise: -

- **Unified C2:** Establishing a Northern Theatre AD Coordination Centre with cross-service operational authority. This node should oversee joint sensor fusion, prioritisation of targets, and real-time shooter allocation. This proposal aligns with India's broader push toward integrated theatre commands, ensuring that AD of the Northern sector is centrally coordinated.
- **C2–Sensor–Shooter Integration:** All radars, airborne surveillance platforms (AWACS, AEW&C, UAVs), and missile/ gun systems - irrespective of service ownership - must feed into a common digital backbone (e.g., Akashteer–IACCS integration). This will ensure no gap in engagement sequencing and eliminate redundancy or fratricide.
- **Joint Rules of Engagement (ROE):** Create doctrinally aligned engagement criteria adaptable to multi-layer threats, including protocols for positive identification, prioritisation of critical assets, and fallback contingencies during electronic disruption.

Doctrinal integration must move from intent to institution.

- **Tri-Service Training and Simulation:** Conduct regular joint IAMD exercises simulating saturation attacks, cyber-electromagnetic interference, and real-time handover between Army and IAF shooters. Shared training curriculum for operators and planners will create a common tactical language and interoperability.[45]
- **Blue Force Tracking and IFF Synergy:** Standardise and modernise IFF systems across services, ensuring fail-proof tracking even under GPS-denied or jammed environments.

The success of the Northern IAMD grid will hinge not on how sophisticated each system is in isolation, but how fluently and rapidly they speak to each other. Without robust jointness, even the best defence architecture will become a disconnected mosaic vulnerable to coordinated aerial assault.

Red Teaming India's AD Posture: A Scenario-Building Exercise

Scenario-building is not mere speculation; it is a strategic tool that enhances military preparedness by identifying vulnerabilities, refining tactical responses, and enabling coordinated joint action.[46] In the context of evolving aerial threats, especially in mountainous regions, this exercise underscores the urgency of transitioning from reactive legacy models to proactive, integrated, and terrain-sensitive AD architectures.

Likely Air Threat Manifestation

➤ Threat Spectrum Across Domains

For the purpose of this analysis, we consider the full range of aerial threats: all variants of fighter aircraft, helicopters, transporters, bombers, UAVs/ Unmanned Combat Aerial Vehicles (UCAVs)/ kamikaze drones, RAM projectiles, PGMs, smart/ glide bombs, cruise missiles, and ballistic missiles.

➤ Adversary Preferences and Strategic Posture

While the use of manned fighter jets and helicopters remains an option for our adversaries along the Northern Borders, the emerging preference leans heavily towards cost-effective, low-risk alternatives such as unmanned platforms, long-range PGMs, and both cruise and ballistic missiles. This inclination is shaped by several factors, including parity with the IAF in these sectors, the challenges posed by mountainous terrain, and the high-risk nature of deploying manned platforms in contested airspace. The future battlefield, therefore, is likely to witness a growing dominance of non-contact warfare over traditional contact engagements.

➤ China's Expanding Arsenal and Strategic Ambitions

China remains the world's largest exporter of drones and possesses the most extensive land-based ballistic missile arsenal.[47] Its inventory of cruise missiles and PGMs is also among the largest globally. With rapidly accelerating production capabilities, it is not only gaining quantitative

superiority but also closing the qualitative gap with Western nations. In some areas, it may soon surpass them.

➤ **Targeting Logic and High-Value Assets**

China's targeting preferences - extrapolated from recent conflicts - point to a focus on degrading adversary warfighting potential through the destruction of high-value assets. Likely targets in the Indian context include: airfields, artillery groupings, AD radars and missile batteries, mechanised formations, communication nodes, command centres, formation headquarters, bridges on critical logistics arteries, troop concentrations, supply depots, fuel storage facilities, and energy infrastructure. In a digitised battlespace where distance offers no sanctuary, even targets in operational and strategic depth are vulnerable to saturation strikes.

➤ **Doctrinal Patterns: Non-Contact and Saturation Warfare**

The likely offensive profile will feature synchronised salvos of drones, PGMs, cruise missiles, and rocket artillery - executed day or night with battlefield transparency enabled by persistent ISR drones. These platforms offer not just reconnaissance but also real-time battle damage assessment and retargeting. Swarm drones may simultaneously saturate the airspace with hundreds of platforms scanning the landscape and designating targets. Each wave will likely exploit real-time vulnerabilities, converting mass into precision. To heighten chaos, cyber and electronic warfare measures will precede and accompany physical strikes - jamming communications, spoofing radars, and paralysing defensive networks.[48]

Strike Simulation: A Plausible Scenario

- **Operational Context**

  To illustrate the critical gaps in the current posture and underscore the urgent need for the transformation, consider a red-team scenario. Imagine a near-future crisis where two friendly nations, referred to as *Nation A* and *Nation B* - "Iron Brothers" in alliance - launch a synchronised multi-domain offensive against their common adversary, *Nation C*. The strike aims to overwhelm Nation C's AD infrastructure using a carefully timed, multi-vector onslaught involving drones, cruise missiles, and

ballistic missiles launched from geographically disparate platforms across land, air, and sea.

➢ **Strike Configuration and Execution**

- *Nation A* activates its naval task force comprising destroyers and submarines positioned in international waters. From these maritime platforms, it launches cruise and ballistic missiles towards a cluster of High-Value Targets (HVTs) deep within Nation C's territory.
- Simultaneously, Nation A's airbases near the border unleash drone swarms and cruise missiles, designed to align their Time-on-Target (ToT) with those launched from the sea.
- *Nation B*, from its inland missile bases and forward-deployed airbases, contributes to the saturation strike with ballistic missiles, drones, and PGMs, coordinated to ensure simultaneous convergence with Nation A's vectors.
- The designated target zone is a densely packed five-kilometre radius encompassing an airfield, formation headquarters, communication nodes, ammunition depots, and logistics hubs - a classic vulnerability cluster in mountainous terrain.

➢ **Synchronisation and Multi-Axis Convergence**

- Advanced planning tools and real-time datalink connectivity between Nation A and Nation B enable precise timing of missile releases. Drones and cruise missiles adjust their speeds and altitudes mid-flight to achieve convergence at the target, while ballistic missiles descend from different vectors with staggered trajectories to dilute interception probability.
- The attack capitalises on the terrain's radar shadow zones, exploiting valleys and ridgelines to conceal inbound threats until the terminal

The convergence of simultaneous multi-vector strikes from land, air, and sea platforms on tightly clustered high-value targets poses a formidable challenge to India's existing AD posture.

phase. Nation C's AD systems, reliant on non-networked radars and manually cued interceptors, are inundated by volume, velocity, and vector complexity.

- **Impact Assessment**

The outcome is strategically decisive. Nation C's obsolete and siloed AD systems are unable to cope with the saturation. Early warning coverage collapses under the clutter. Short-range systems misallocate firepower. C2 nodes are neutralised in the first wave, rendering subsequent responses disjointed. The coordinated saturation results in widespread destruction and strategic paralysis.

- **Red Team Takeaway**

Are We Prepared? This scenario, though hypothetical, is drawn from operational patterns evident in contemporary conflicts. Could such an attack unfold along India's Northern front? The answer demands serious introspection. Our terrain along Northern Borders lends itself to Vulnerable Area (VA)/ Vulnerable Point (VP) clustering. Our adversaries possess the means and doctrine for such saturation attacks. ***This is not a question of if, but when***. ***Are our sensors integrated? Are our shooters responsive? Are our doctrines evolved for convergence and velocity?***

This red-teaming exercise is a clarion call to overhaul India's AD posture - towards a resilient, multi-layered IAMD shield, capable of absorbing and defeating tomorrow's threats.

Space-Based ISR And Early Warning Systems

In the mountainous Northern theatre, where terrain-induced radar shadows and reduced line-of-sight challenge conventional surveillance, space-based assets emerge as indispensable enablers of AD.[49] An IAMD strategy without space-based ISR and early warning is incomplete. To offset terrain masking and enable long-range threat detection, India must develop and integrate the following space-based capabilities: -

- **Dedicated Early-Warning Satellites:** India should fast-track deployment of space-based IR sensors in geostationary and highly elliptical orbits. These can detect

missile launches through thermal signatures during boost phase and offer critical early cueing for ground-based interceptors.

- **High-Resolution Earth Observation Satellites:** Day-night, all-weather imaging from satellites like Radar Imaging Satellite (RISAT), Cartography Satellite (CARTOSAT), and future AI-enhanced constellations can offer persistent surveillance of PLA airfields, missile deployments, and launch activity across the Tibetan Plateau.
- **Tactical Micro-Satellite Swarms:** Miniaturised, Low Earth Orbit (LEO)-based ISR satellites capable of rapid revisit rates can provide dynamic tracking of airborne platforms, UAV traffic, and movement of enemy radar vehicles or mobile SAMs.
- **Satellite-Aided Target Cueing and Battle Damage Assessment (BDA):** Integration of satellite intelligence with IAMD systems will facilitate automated target validation, threat prioritisation, and post-engagement BDA - especially in electronically contested environments.
- **Space-Based Networking Backbone:** For uninterrupted data relay, particularly in EW-contested zones, satellite communication links must serve as hardened redundancies for ground-based C2 systems. These links must be encrypted, resilient to jamming, and integrated with Akashteer/ IACCS frameworks. The increasing weaponisation of space, through Anti-Satellite (ASAT) tests and co-orbital interceptors, poses a direct threat to India's satellite-based ISR and early-warning infrastructure. Protecting these assets is now intrinsic to AD. India must therefore integrate Space Situational Awareness (SSA), satellite hardening, and counter-space deterrence into its IAMD doctrine, ensuring continuity of cueing and communication even under hostile space conditions.

In future conflicts, safeguarding space-based sensors will be as vital as ground-based interceptors.

Operationalising these space-based assets requires doctrinal shifts: -

- Space ISR and missile early-warning must be formally embedded into India's AD planning cycles.
- The Indian Space Research Organisation (ISRO), DRDO, and Defence Space Agency (DSA) must jointly define threat models and develop interoperable systems.

- India should pursue SSA and counter-space capability to protect its orbital assets from enemy ASAT systems.

By elevating 'space' to the status of a full-fledged operational domain, India's Northern IAMD network will gain strategic depth, early cueing advantage, and resilience against terrain limitations. India's crucial Space-Based Surveillance-3 (SBS-3) initiative plans for a modest 52 satellites dedicated to space surveillance.[50] In light of China's SpaceSail (also known as Qianfan or Thousand Sails) program's colossal undertaking of roughly 15,000 LEO satellites, the urgency to expedite and potentially expand SBS-3 becomes even more pronounced.[51] ***The sky may not be the limit - but space certainly is the next frontier of AD.***

Leveraging AI and Automation In Ad Networks

The scale, velocity, and multidimensionality of contemporary aerial threats demand a cognitive leap in C2. AI and machine learning are no longer futuristic enhancements - they are doctrinal necessities for managing high-speed, multi-vector attacks in terrain-constrained high-altitude environments.[52] AI must be embedded across the entire IAMD kill web[53] :-

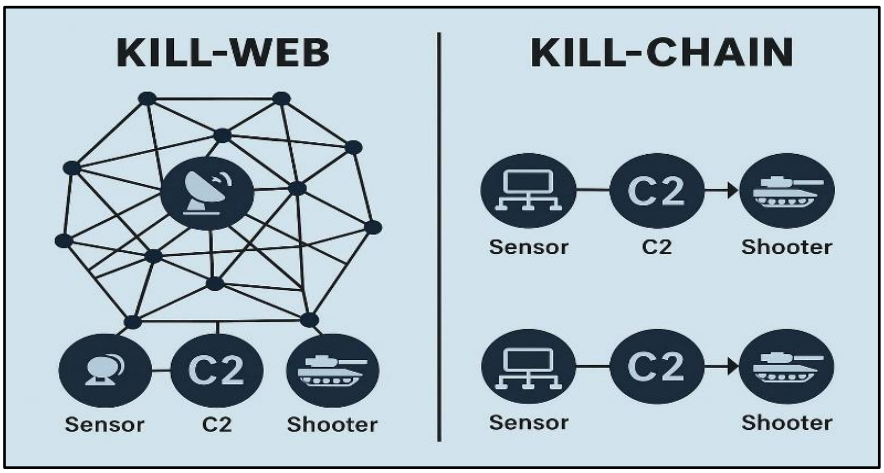


Image 1: Kill Web & Kill Chain Concept

(Source: Author's Own Creation)

- **Sensor Fusion and Threat Classification:** AI algorithms can process multi-modal data from radars, satellites, EO sensors, and acoustic arrays to generate a unified and deconflicted threat picture. Machine learning models can classify targets, differentiate friend from foe, and detect anomalies - especially stealthy or low-RCS threats.[54]

- **Automated BMS:** AI-enabled BMS can autonomously assign engagement priorities, match shooters to targets based on availability and probability of kill, and re-task sensors in real-time based on threat evolution.
- **Predictive Analytics for Threat Anticipation:** AI can detect patterns in enemy force posture, radar signatures, or launch cycles to predict likely strike windows or directions, enabling pre-emptive repositioning of mobile AD assets.[55]
- **Autonomous Counter-UAS Systems:** Drones must be countered by other drones and autonomous systems. India must develop AI-powered drone interceptors, loitering "drone-hunters," and point-defence systems that react with microsecond latency to emerging swarms.[56]
- **Simulated Wargaming and Training:** AI-based simulation engines can replicate enemy tactics, saturation scenarios, and EW attacks to train Indian AD operators in a variety of realistic conflict settings.
- **Cognitive EW and Cyber Resilience:** AI can assist in detecting cyber intrusions, jamming attempts, and electronic deception - dynamically adapting spectrum usage, hardening C2 protocols, or activating decoy nodes.

Doctrinally, this implies a shift from reactive human-in-loop decisions to proactive human-on-loop oversight, especially for time-critical engagements. While ultimate weapon release authority must remain human, the sensor-to-decision pipeline must be accelerated through AI augmentation. For India's Northern theatre, where the time-space envelope is compressed and terrain limits visibility, ***AI offers the only viable pathway to tempo dominance.***

The future of AD will not be manpower-intensive; it will be cognition-intensive.

Wargaming and Scenario-Based Simulation Training

In high-altitude theatres where terrain, weather, and communication delays amplify complexity, the effectiveness of air and missile defence systems hinges as much on operator proficiency as it does on technological sophistication. This makes wargaming and simulation-based training a doctrinal imperative, not a supplementary tool.[57] Modern IAMD wargaming must replicate: -

- **Multi-Vector Saturation Attacks:** Simulations should include drone swarms, cruise missiles, loitering munitions, and EW attacks launched simultaneously to overload defensive layers.
- **Time-Critical Decision Cycles:** High-fidelity digital twins of real-world systems (including radars, missile batteries, and C2 nodes) should be used to train operators in rapid target classification and engagement decisions under time compression.
- **Joint Force Scenarios:** Conduct tri-service wargames with Army, Navy, IAF, and DSA elements to validate interoperability, joint kill chains, and seamless transfer of sensor-to-shooter data.
- **Red Teaming and Adversary Modelling:** Incorporate AI-driven Red Teams simulating PLA's Tactics, Techniques, and Procedures (TTPs), enabling adaptive learning and doctrinal innovation.
- **Cyber-EW Contingency Simulation:** Model disruptions to GPS, IFF, satellite communication, and radar jamming to train forces to fight through degraded environments with alternate protocols.

Additionally, establish a permanent **Mountain AD Combat Lab** under Headquarters Northern Command (Northern Theatre Command in future) to :-

- Capture After-Action Reviews (AARs) from each exercise.
- Update Standard Operating Procedures (SOPs) dynamically.
- Test emerging systems (e.g. DEWs, loitering interceptors).
- Maintain doctrinal currency with real-world threat evolution.

The speed of modern warfare leaves no room for on-the-job learning.

Simulation-based readiness must be institutionalised. By making wargaming the proving ground for doctrine, India can ensure that its Northern air defenders are not just trained, but combat-primed.[58]

STRATEGIC WAY FORWARD

To operationalise the doctrinal transformation of India's Northern IAMD, a phased, institutionalised, and future-ready roadmap is essential. The strategic way forward must include: -

- **Establishment of a Unified C2 Structure:** Create a permanent unified C2 structure of the Indian Army and IAF, responsible for all IAMD operations across the Northern theatre. It should possess operational control over sensors, shooters, and C2 elements of both services.
- **Phased Capability Development:** Prioritise short-term enhancements (e.g. anti-drone systems, EO/ IR radars, QRSAM deployments), mid-term integration of Akashteer with satellite cueing and AI-driven BMS, and long-term investments in hypersonic defence and DEWs.
- **Doctrinal and Training Reforms:** Formalise joint IAMD doctrine, create AI-augmented ROEs, and institutionalise red-teaming, adversary replication, and terrain-specific simulation protocols for operator readiness.
- **Indigenous R&D Acceleration:** Incentivise public-private partnerships under iDEX and SPARK (Support for Prototype and Research Kick-start)[59] to drive innovation in DEWs, advanced sensors, AI software, and exo-atmospheric interceptors. Indigenous solutions must be prioritised for high-altitude certification.
- **Infrastructure and Logistics Modernisation:** Build air-liftable modular launchers, EMP-hardened command centres, weatherproof missile shelters, and mountain-compatible refuelling and rearming facilities across critical AD nodes.
- **Space Integration:** Ensure that ISRO, DRDO, and DSA jointly develop integrated ISR, early-warning satellites, and SSA tools to provide continuous overwatch and rapid cueing. India should plan for a future missile defence architecture, similar in ambition to the proposed 175 billion Dollars United States' 'Golden Dome' concept, capable of countering ballistic, cruise, and hypersonic missile threats across all altitudes.[60]

- **Cyber-EW Synergy:** Harden all IAMD systems against cyber and EW by deploying cognitive EW suites, adaptive spectrum management tools, and offensive EW options.
- **Budgetary and Policy Backing:** Secure dedicated IAMD funding lines in the defence budget, grant fast-track acquisition powers for Northern theatre assets, and ensure oversight at the apex national security level.

This strategic roadmap reflects not just an adaptation to today's threat landscape - but a commitment to future-proofing India's sovereignty. The northern skies demand sentinels who are not just alert, but adaptive, agile, and anticipatory.

CONCLUSION: ADAPT OR PERISH

India's Northern Borders are more than rugged lines on a map - they are future flashpoints where technological superiority and doctrinal agility will decide deterrence and dominance. In this unforgiving battlespace, legacy responses to modern threats invite strategic peril. A credible air and missile defence doctrine for the Himalayas must go beyond layered interceptors. It must embody integration across services, domains, and technologies. It must synchronise space-based cueing with ground-based shooters, AI-powered decision-making with human judgement, and autonomous sensors with simulated readiness. This article has outlined a doctrine that is not merely reactive but anticipatory - driven by cognition, resilience, and terrain realism. The proposed framework is not an end-state but a compass - a guide to navigate the turbulence of emerging threats and technological disruption.

To stand still in doctrine is to fall behind in deterrence. The Deterrence is costly but war is costlier.

The formidable geography of India's Northern Borders presents distinct challenges to AD operations. Consequently, the formulated doctrine must prioritise the synergistic application of air power assets, ground-based systems, and integrated command structures to establish effective control over this strategically significant airspace. ***India must choose agility over inertia, adaptation over legacy, and foresight over familiarity.*** Only then will the northern sky belong to sentinels who are not merely watching - but ready.

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.

End Notes

[1] Government of India, MoD. “Annual Report 2022-23.” Ministry of Defence. New Delhi: Ministry of Defence, 2023. https://mod.gov.in/sites/default/files/DEFENCE%20AR%202022-23%20LOW.pdf.

[2] Choudhury, Diptendu. “Strategic Premises for the Future of India’s Air Power.” orfonline.org. OBSERVER RESEARCH FOUNDATION (ORF), February 24, 2025. https://www.orfonline.org/research/strategic-premises-for-the-future-of-india-s-air-power.

[3] Watling, Dr Jack, Justin Bronk, and Nick Reynolds. “The Russian Air War and Ukrainian Requirements for AD.” rusi.org, November 7, 2022. https://www.rusi.org/explore-our-research/publications/special-resources/russian-air-war-and-ukrainian-requirements-air-defence.

[4] Deshpande, Smruti. “Complex Network of India’s Existing AD Capabilities & the Way Forward.” The Print. theprint, May 2, 2024. https://theprint.in/defence/complex-network-of-indias-existing-air-defence-capabilities-the-way-forward/2065704/.

[5] Watling, Jack. *The Arms of the Future*. Bloomsbury Publishing, 2023.

[6] Antal, John F. *Next War*. Casemate, 2023.

[7] Watling, Dr Jack, Justin Bronk, and Nick Reynolds. “The Russian Air War and Ukrainian Requirements for AD.” rusi.org, November 7, 2022. https://www.rusi.org/explore-our-research/publications/special-resources/russian-air-war-and-ukrainian-requirements-air-defence.

[8] Shaan Shaikh and Wes Rumbaugh, “The Air and Missile War in Nagorno-Karabakh: Lessons for the Future of Strike and Defense,” Center for Strategic and International Studies, December 8, 2020, https://www.csis.org/analysis/air-and-missile-war-nagorno-karabakh-lessons-future-strike-and-defense.

[9] Abhimanya Kulkarni, “Israel’s Iron Dome Failed to Defend Hamas Rocket Barrage. Here’s Why,” NDTV.com, October 12, 2023, https://www.ndtv.com/world-news/israel-hamas-war-explainer-video-why-israels-iron-dome-struggled-to-defend-hamas-rockets-4473267.

[10] Deshpande, Smruti. “Complex Network of India’s Existing AD Capabilities & the Way Forward.” The Print. theprint, May 2, 2024. https://theprint.in/defence/complex-network-of-indias-existing-air-defence-capabilities-the-way-forward/2065704/.

[11] Shubhangi Palve. “China’s Expanding Radar Capabilities Pose Serious Threat to India’s Missile Program; How Can New Delhi Respond?” EURASIAN TIMES, April 8, 2025. https://www.eurasiantimes.com/indias-missile-program-espond/.

[12] George, Justin Paul. “China’s Hypersonic Weapons Aren’t Just Hype. India Should Be Worried.” The Week, December 4, 2021. https://www.theweek.in/news/india/2021/12/03/chinas-hypersonic-weapons-arent-just-hype-india-should-be-worried.html.

[13] Trevithick, Joseph. “Big Emphasis on ‘Spectral Warfare’ in Air Force’s next Generation Air Dominance Plans.” The War Zone, March 27, 2023. https://www.twz.com/big-emphasis-on-spectral-warfare-in-air-forces-next-generation-air-dominance-plans.

[14] Team Bharatshakti. “Akashteer Unveiled: Indian Army’s Game-Changing AD System Takes Flight.” Bharat Shakti, November 12, 2024. https://bharatshakti.in/akashteer-unveiled-indian-armys-game-changing-air-defence-system-takes-flight/.

[15] Deshpande, Smruti. “Complex Network of India’s Existing AD Capabilities & the Way Forward.” The Print. theprint, May 2, 2024. https://theprint.in/defence/complex-network-of-indias-existing-air-defence-capabilities-the-way-forward/2065704/.

[16] PTI. “Army Plans to Boost AD Capabilities with New Guns, Potent Radars.” The Economic Times. Economic Times, February 22, 2025. https://economictimes.indiatimes.com/news/defence/army-plans-to-boost-air-defence-capabilities-with-new-guns-potent-radars/articleshow/118468586.cms?from=mdr.

[17] IMR Reporter. “A Model Integrated AD Command for India.” IMR, June 19, 2020. https://imrmedia.in/a-model-integrated-ad-command-for-india/.

[18] Khera, Kishore. “AD Command -A Bold Test Case.” New Delhi: IDSA, January 27, 2020. https://idsa.in/system/files/issuebrief/ib-air-defence-280120.pdf.

[19] Choudhury, Diptendu. “Strategic Premises for the Future of India’s Air Power.” orfonline.org. OBSERVER RESEARCH FOUNDATION (ORF), February 24, 2025. https://www.orfonline.org/research/strategic-premises-for-the-future-of-india-s-air-power.

[20] Clarke, Richard A, and Robert Knake. *Cyber War: The next Threat to National Security and What to Do about It*. 2025. Reprint, New York: Ecco, 2010.

[21] ET Online. “Bhargavastra: Watch India Test Low-Cost Drone Killer That Destroys Swarms in Seconds.” The Economic Times. Economic Times, May 14, 2025. https://economictimes.indiatimes.com/news/new-updates/bhargavastra-watch-india-test-low-cost-drone-killer-that-destroys-swarms-in-seconds/articleshow/121158690.cms?from=mdr.

[22] Rana, Javaria. “How Upgraded L/70 Guns, or ‘Original Bofors’, Became India’s Frontline Defence against Pakistan UAVs.” ThePrint. theprint, May 14, 2025. https://theprint.in/defence/how-upgraded-l-70-guns-or-original-bofors-became-indias-frontline-defence-against-pakistan-uavs/2625448/.

[23] BEL. “Anti-Drone System - BEL.” BEL, February 20, 2024. https://bel-india.in/product/anti-drone-system/.

[24] Defence New Agency. “Indian Defense Fields Locally Developed IDD&IS Anti-Drone Systems Alon.” Armyrecognition.com, March 21, 2024. https://armyrecognition.com/news/army-news/army-news-2024/indian-defense-fields-locally-developed-idd-is-anti-drone-systems-along-china-border.

[25] Ranjan. “DURGA 2: India’s Direct Energy Weapon to Be Tested Soon.” Indian Defense Analysis, February 20, 2024. https://indiandefenseanalysis.wordpress.com/2024/02/21/durga-2-indias-direct-energy-weapon-to-be-tested-soon/.

[26] Baesystems.com. “FUZE 3P Ammunition,” 2025. https://www.baesystems.com/en/product/fuze-3p-ammunition.

[27] Kumar, Santosh . “Akashteer: The Unseen Force behind India’s New War Capability.” Edited by Ritu Kataria and Kritika Rane. Pib.gov.in, May 16, 2025. https://www.pib.gov.in/FeaturesDeatils.aspx?NoteId=154475&ModuleId=2.

[28] IDRW. “DRDO Initiates Limited Serial Production of Phase-II BMD Interceptor AD-1 Missile for Expanded Trials - Indian Defence Research Wing.” Indian Defence Research Wing, March 19, 2025. https://idrw.org/drdo-initiates-limited-serial-production-of-phase-ii-bmd-interceptor-ad-1-missile-for-expanded-trials/.

[29] Bansal, Shantanu K. “Addressing India’s Space-Based Surveillance and Reconnaissance Needs - IADN.” - IADN, March 13, 2023. https://iadnews.in/addressing-indias-space-based-surveillance-and-reconnaissance-needs/.

[30] Trevithick, Joseph. “Big Emphasis on ‘Spectral Warfare’ in Air Force’s next Generation Air Dominance Plans.” The War Zone, March 27, 2023. https://www.twz.com/big-emphasis-on-spectral-warfare-in-air-forces-next-generation-air-dominance-plans.

[31] Negi, Kuldeep. “IAF to Get High Power Radars, Close-in Weapon Systems as Cabinet Committee on Security Clears Rs 13,000 Crore Deals.” Swarajyamag, February 23, 2024. https://swarajyamag.com/news-brief/iaf-to-get-high-power-radars-close-in-weapon-systems-as-cabinet-committee-on-security-clears-rs-13000-crore-deals.

[32] Clarke, Richard A, and Robert Knake. *Cyber War: The next Threat to National Security and What to Do about It*. 2025. Reprint, New York: Ecco, 2010.

[33] Bureau, The Hindu. “DRDO Tests Directed Energy Weapon System That Can Disable Drones, Missiles.” The Hindu, April 13, 2025. https://www.thehindu.com/news/national/drdo-tests-directed-energy-weapon-system-that-can-disable-drones-missiles/article69446266.ece.

[34] Sain, Manibh. “S-400 Triumf Explained: Full Technical Specifications of the World’s Most Advanced Air Defense System.” StatusNeo - Cloud Native Technology Services & Consulting, May 12, 2025. https://statusneo.com/s-400-triumf-explained-full-technical-specifications-of-the-worlds-most-advanced-air-defense-system/.

[35] Ashish Dangwal. “Boosting Power of Su-30 MKI Fighters, India’s Russian-Origin Sukhoi Jets to Get Indigenous Search & Track System.” EURASIAN TIMES, April 29, 2022. https://www.eurasiantimes.com/boosting-power-of-su-30-mki-fighters-indias-russian-origin-sukhoi-jets/.

[36] Ivezic, Marin. “Quantum Radar: The next Frontier of Stealth Detection and Beyond.” PostQuantum - Quantum Computing, Quantum Security, PQC, February 15, 2023. https://postquantum.com/quantum-sensing/quantum-radar/.

[37] Khosla, Air Marshal Anil. “BIG Test for U.S. F-47 Fighter? Can China’s ‘Anti-Stealth’ Radar ‘Trap’ U.S. 6th-Gen Aircraft as Next-Gen Warfare Heats-Up?” EURASIAN TIMES, April 3, 2025. https://www.eurasiantimes.com/stealth-vs-counter-stealth-the-evolving-battle-in-6th-gen-air-warfare/?amp.

[38] Ministry of Defence. “DRDO Successfully Conducts Successive Flight-Trials of Very Short-Range Air Defence System off the Odisha Coast.” Pib.gov.in, February 1, 2025. https://www.pib.gov.in/PressReleasePage.aspx?PRID=2098784.

[39] “DRDO’s QRSAM Trials to Be Completed by 2026: Indian Army Set to Place Orders - Indian Defence Research Wing.” Indian Defence Research Wing, September 18, 2024. https://idrw.org/drdos-qrsam-trials-to-be-completed-by-2026-indian-army-set-to-place-orders/.

[40] Drdo.gov.in. “Technologies | Defence Research and Development Organisation - DRDO, Ministry of Defence, Government of India,” 2025. https://www.drdo.gov.in/drdo/labs-establishment/technologies/electronics-radar-development-establishment-lrde.

[41] Ministry of Defence. “DRDO Conducts Successful Flight-Test of New Generation AKASH Missile off Odisha Coast.” Pib.gov.in, January 12, 2024. https://www.pib.gov.in/PressReleasePage.aspx?PRID=1995445.

[42] Sreevas Sahasranamam. “Rise of the Defence Innovation Ecosystem in India.” BusinessLine, May 12, 2025. https://www.thehindubusinessline.com/opinion/rise-of-the-defence-innovation-ecosystem-in-india/article69568474.ece.

[43] Ahmed, Shayesta Nishat . “India’s Path to Defence Self-Reliance: Challenges and Progress in the IDEX Initiative.” MP-IDSA, July 19, 2024. https://idsa.demosl-03.rvsolutions.in/publisher/issuebrief/indias-path-to-defence-self-reliance-challenges-and-progress-in-the-idex-initiative-2/.

[44] PTI. “Army Plans to Boost Air Defence Capabilities with New Guns, Potent Radars.” ThePrint. Theprint, February 21, 2025. https://theprint.in/india/army-plans-to-boost-air-defence-capabilities-with-new-guns-potent-radars/2506280/.

[45] Indian air Force. DOCTRINE of the INDIAN AIR FORCE. 1st ed. 2022. Reprint, New Delhi: Indian Air Force, 2022.

[46] Hoffman, Bryce G. *Red Teaming*. Currency, 2017.

[47] Darbey, Abhishek Kumar. “China’s Increasing Global Drone Footprint - MP-IDSA.” MP-IDSA, November 21, 2024. https://www.idsa.in/publisher/comments/chinas-increasing-global-drone-footprint-2.

[48] Clarke, Richard A, and Robert Knake. *Cyber War : The next Threat to National Security and What to Do about It*. 2025. Reprint, New York: Ecco, 2010.

[49] Goswami, Namrata. “China Advances Its Space Capabilities, Enlarging Its Strategic Advantage.” Thediplomat.com. The Diplomat, August 16, 2024. https://thediplomat.com/2024/08/china-advances-its-space-capabilities-enlarging-its-strategic-advantage/.

[50] Gupta, Shishir. “Exclusive: CCS Clears Launch of 52 Surveillance Satellites.” Hindustan Times, October 11, 2024. https://www.hindustantimes.com/india-news/exclusive-ccs-clears-launch-of-52-surveillance-satellites-101728615288379.html.

[51] Curran, Andrew. “China Continues to Build out Its Spacesail Satellite Constellation.” Spaceanddefense.io. SPACE & DEFENSE, March 13, 2025. https://spaceanddefense.io/china-continues-to-build-out-its-spacesail-satellite-constellation/.

[52] Choudhury, Diptendu. “Strategic Premises for the Future of India’s Air Power.” orfonline.org. OBSERVER RESEARCH FOUNDATION (ORF), February 24, 2025. https://www.orfonline.org/research/strategic-premises-for-the-future-of-india-s-air-power.

[53] Alderman, Ray. “How the Kill Web Manipulates Time and Space - Military Embedded Systems.” Militaryembedded.com, March 31, 2020. https://militaryembedded.com/comms/communications/how-the-kill-web-manipulates-time-and-space.

[54] SentinelOne. “AI Threat Detection: Leverage AI to Detect Security Threats.” SentinelOne, April 6, 2025. https://www.sentinelone.com/cybersecurity-101/data-and-ai/ai-threat-detection/.

[55] Ibid.

[56] Souli, Nicolas, Panayiotis Kolios, and Georgios Ellinas. “An Autonomous Counter-Drone System with Jamming and Relative Positioning Capabilities.” *ICC 2022 - IEEE International Conference on Communications*, May 16, 2022, 5110–15. https://doi.org/10.1109/icc45855.2022.9838783.

[57] Antal, John F. *Next War*. Casemate, 2023.

[58] McConnell, Lt. Col. Richard A., and Maj. Thiago Caron da Silva. “Wargaming, the Laboratory of Military Planning.” Edited by Maj. Cleber H. B. Simões and Maj. Roney Magno De Sousa. Army University Press, April 2024. https://www.armyupress.army.mil/journals/military-review/online-exclusive/2024-ole/wargaming-the-laboratory-of-military-planning/.

[59] India, Ministry of Defence. “Innovations for Defence Excellence.” Myscheme.gov.in, 2024. https://www.myscheme.gov.in/schemes/idex.

[60] Martin, Lockheed. “Golden Dome for America Revolutionizing U.S. Homeland Missile Defense.” Lockheed Martin, 2024. https://www.lockheedmartin.com/en-us/capabilities/missile-defense/golden-dome-missile-defense.html.