

Exploring Multi-dimensional Trends for the Indian Air Force

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Air power is a critical aspect of national defence and plays a vital role in safeguarding a country's interests within and beyond its borders. Possessing one of the world's largest and most diverse air forces, India has a significant stake in the evolution of air power and must stay abreast of the latest trends and developments in this field. India has already begun to incorporate these trends into its air force. It is looking towards developing its capabilities in these areas further to maintain its military capabilities and protect its national interests. The Indian Air Force (IAF) has recently revised its doctrine and facets of multi-domain operational trends are expected to be incorporated. This article intends to explore some critical multi-dimensional trends in air power and how they shape the IAF's capabilities and approach to defence. These trends include aspects in the operational, technological and human resource domains and will be evaluated with the lessons learned from recent global conflicts and the technological revolution in the air power domain. In addition, the analyses will examine a few doctrinal issues relevant to the Indian context. Finally, the article will also provide some valuable lessons and recommendations culled from academic research for addressing these multi-dimensional trends.

Keywords: *Indian Air Force, IAF Doctrine, Air to Aerospace Power, Technological Trends*

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INTRODUCTION

The Indian Air Force (IAF) was established in 1932 and has been crucial in several major conflicts and operations. The IAF's primary mission is to secure the Indian airspace and conduct offensive and defensive operations. The IAF's current inventory includes a mix of old and modern aircraft, which presents a challenge for maintaining operational readiness and combat effectiveness. In addition, the IAF has to contend with a complex geopolitical environment, including an adversarial relationship with Pakistan and an increasingly assertive China. In its centennial decade, the IAF, which began its journey as a small flight, is the world's fourth largest air force in size. It is recognised today for its professionalism and work ethics. By virtue of these characteristics, the IAF has been ranked as the third best air force in the world, surpassing China's numerically superior People's Liberation Army Air Force (PLAAF). The ranking released by the agency World Directory of Modern Military Aircraft (WDMMA) in its Global Air Powers Ranking (2023) asserts that the ranking is based on True Value Rating (TvR). 'TvR is a power not simply evaluated based on its total number of aircraft, but rather based on its quality and general inventory mix. Greater emphasis is placed on the categories of special-mission, dedicated bomber force, combat air support, training, force experience, and on-order units.'¹

The Russia–Ukraine conflict has entered its second year and does not appear to be ending soon. However, an analysis of Russia's prolonged special military operations indicates plenty of variables and intangibles taking primacy in warfare. Various phases of operations have generated discussions, debates and analysis about the relevance of different warfighting machines such as tanks, artillery, MANPADS, strategic and tactical para operations, etc. Questions have been raised on the efficacy of air power and the air force in particular. There has been debate on the emergence of unmanned aerial vehicles and the fading away of manned aircraft. Countries are watching the conflict with great interest, and militaries have started revisiting and redefining their doctrines, tactics and procedures. Many who thought that wars were short, swift and agile have begun preparing for long, drawn-out conventional and hybrid wars.

Notwithstanding various divergent views and lessons learned so far, it is evident that the ongoing conflict in Ukraine has encompassed multiple forms of warfare, including the use of different types of weapons, deterrence strategies, information warfare and the exacerbation of polarisation in the global order. It has given new and multiple dimensions to changing geopolitics.

Weapons of all kinds, including legacy equipment and systems, modern precision and sophisticated weapons in all domains, drones, hypersonic, satellite-based communication and cyber impact, have been extensively used. It is hypothesised that no weapon is outdated, and no single weaponry has primacy. Each type of munition, system and machinery will stay relevant in the modern, technologically intensive warfighting scenario. It also reminds us that nations must be self-reliant in all aspects, especially their military arsenal. Self-reliance should not only mean the technology possessed by the country in terms of prototypes but emphasise the mass production and availability of adequate inventory of military equipment.

THREAT AND CHALLENGES FOR THE IAF

With the advent of Rafale planes, Apache helicopters and a broad array of smart or advanced technology, the IAF is on the cusp of becoming a potent air force. The IAF chief, Air Chief Marshal VR Chaudhari emphasised in one of the seminars that ‘the nature of warfare is undergoing fundamental changes due to the emergence of new technology and radically new doctrines over the past few years.’² He asserted, ‘India’s security dynamics involve a variety of threats and obstacles. It will necessitate that India develop multi-domain capabilities and execute all operations simultaneously and in a compressed time frame.’³

The IAF operates in a complex and challenging external environment, which poses numerous threats to its operational capabilities. The IAF’s modernisation efforts and the ongoing investments in its capabilities will help ensure that it remains one of the most potent air forces in the region and can effectively counter any potential threat to India’s security and sovereignty. Therefore, the IAF must continuously upgrade its capabilities and strategies to maintain its readiness and effectiveness in responding to these threats.

One of the primary external threat challenges faced by the IAF is from neighbouring countries, Pakistan and China. Both these countries have invested heavily in their military capabilities, including their air forces. They have also been involved in border disputes with India, which creates a constant state of tension and the potential for conflict. Pakistan has been engaged in a low-intensity conflict with India for several decades, and the IAF has played a critical role in defending India’s borders against Pakistan. In addition, the Pakistani Air Force has been continuously modernising its fleet, including the likely production of a joint venture of fifth-generation fighter aircraft with Turkey. It has also acquired a squadron of combat Unmanned Air Combat

Vehicles 'Akinci' in April 2023.⁴ This poses a significant challenge for the IAF as it must keep pace with these developments to maintain its military advantage by strengthening its arsenal of aircraft, missiles, radars, space assets and network centrality.

Similarly, China's rise as a military superpower has significantly impacted India's security calculus and has been a serious concern. China has developed advanced military technologies, including fifth-generation fighter aircraft, long-range missiles and advanced electronic warfare systems. China has also been investing in infrastructure development in its border regions with India, which could allow it to mobilise its forces quickly in the event of a conflict. It has been rapidly modernising the People's Liberation Army Navy's (PLAN's) capabilities, expanding its military footprint in the Indian Ocean Region (IOR). Since 2009, the PLAN's presence in the Indian Ocean has been gradually increasing. Since 2017, deploying submarines alongside survey and hydrographic ships of the PLAN in the Indian Ocean has become a regular occurrence and continues to grow. The PLAN also has adequate wherewithal to operate its aircraft carrier in the IOR.⁵

Cyber threats are another significant challenge faced by the IAF. The increasing use of technology in modern warfare has made the IAF vulnerable to cyberattacks. These attacks can impact its operational capabilities and information security. As a result, the IAF must continuously enhance its cybersecurity capabilities to mitigate these threats.

THE IAF'S EXISTING RESOURCES

One of the main challenges faced by the IAF is the need for more fighter aircraft. Currently, the IAF has around 30 squadrons of fighter aircraft, significantly lower than the required strength of 42. In addition, the IAF is now operating several legacy fighter aircraft, including the MiG-21 Bisons, nearing the end of their service life. To compensate for the shortage of fighter aircraft, the IAF has implemented several measures, including upgrading the existing aircraft, acquiring new aircraft and increasing the availability of combat-ready aircraft. In addition, a simultaneous indigenous drive is on the fast track to develop the Light Combat Aircraft (LCA) Mk-IA, LCA Mk-II and Advanced Medium Combat Aircraft (AMCA).

Another challenge faced by the IAF is the limited availability of strategic transport planes. The IAF currently operates a fleet of transport planes that include the C-130J, C-17 and IL-76, which are critical for the airlifting of troops, equipment and supplies. However, the IAF's fleet of transport

planes is still limited, and some aircraft are ageing, which can impact their reliability and availability. To address this challenge, the IAF has initiated several programmes, including acquiring new transport planes and upgrading the existing aircraft. As a result, it is anticipated that C-295 aircraft would fill the gap in the mid-segment of the transport fleet. However, owing to the strategic and tactical airlift and rapid mobilisation of man and material, more dedicated aircraft such as the C-17 and C-130 would be required. The IAF has faced a challenge in recent years with the reduced number of force multiplier aircraft of Airborne Warning and Control Systems (AWACS) and Flight Refueler Aircraft (FRA). Reduction in the number of these aircraft affects the on-station availability to carry out the missions effectively. The IAF currently operates a small IL-78 aerial refuelling tanker fleet, the AWACS and the Netra Airborne Early Warning and Control (AEW&C) system. However, the number of these aircraft is significantly lower than what is required to meet the operational needs of the IAF. In addition, the Intelligence, Surveillance, Targeting and Reconnaissance (ISTAR) class of aircraft is yet to be inducted into the service. The IAF has been trying to acquire additional aerial refuelling tankers and AEW&C systems for several years. However, the procurement process has been delayed for various reasons, including prioritisation, bureaucratic and budgetary issues. Force multiplier aircraft are highly specialised and technologically advanced, and their cost is generally significantly higher than other combat aircraft. The indigenous efforts of AEW&C are an ongoing process, and it is expected to take a substantial number of years due to the technical complexities of integrating systems.

Despite these challenges, the IAF remains a potent force. The IAF has a highly skilled and experienced workforce capable of operating in challenging environments. The performance in various international exercises and during Humanitarian Assistance Disaster Relief (HADR) missions demonstrates IAF's excellence. The IAF also has a robust support infrastructure, including maintenance facilities, airfields and communication networks, which enable it to operate effectively in sub-optimal conditions. The IAF demonstrated its combat capability in several wars and conflicts, including the Kargil War in 1999 and the Balakot airstrikes in 2019. The IAF's fighter and transport planes played a critical role in both conflicts, providing air support to ground troops and striking enemy targets deep inside the enemy territory. The IAF's ability to operate in sub-optimal conditions and deliver decisive results in conflicts demonstrates its combat readiness and operational effectiveness.

To counter the above-mentioned external threats and challenges, the IAF must invest in modernising its equipment, training its personnel and enhancing its operational capabilities. The IAF has been taking several measures to strengthen its capabilities, such as acquiring modern fighter aircraft, upgrading its existing fleet and investing in air defence systems. The IAF has also been conducting joint military exercises with friendly foreign countries to enhance its interoperability and sharing best practices. India's two-front military challenge poses significant implications for India's national security. The country has to maintain a constant state of readiness to respond to any potential threats on both fronts apart from a possible collusive threat from its adversaries. It requires a careful balancing of military resources and strategies to ensure that India's national security interests are protected.

REVISED DOCTRINE DEFINES MULTI-DOMAIN TRENDS

The IAF operates under a set of principles and guidelines known as the 'Doctrine of the IAF', which is comprehensive and dynamic. It has evolved over time, reflecting shifts in the strategic environment and technological advancements. Since its initial publication in 1995, the IAF doctrine has undergone four revisions. The most recent revision in 2022 reflects changes in the strategic environment, new threats and the requirement for jointness, integration and transformation from air power to aerospace power force.⁶ Multiple conflicts have put the IAF's doctrine to the test, including the 1999 Kargil War, the 2001 attack on the Indian Parliament resulting in Op Parakram and the 2019 Balakot airstrikes. The IAF's response in these conflicts has demonstrated the effectiveness of its doctrinal tenets and capabilities. The IAF's transformation into an aerospace power is a significant change that reflects warfare's evolving nature and the aerospace domain's significance in contemporary conflicts. The IAF doctrine provides a comprehensive framework for achieving this transformation, and its continued evolution is vital to India's security and strategic interests. In addition, the doctrine describes present and future multi-domain trends for the conduct of aerospace-domain air operations. These multi-domain trends extracted from the doctrine can be broadly categorised as:

- Air to Aerospace Power
- The Atmanirbharta Drive
- Exploring Strategic Partnerships
- Human Resources (HR) Restructuring
- Technological Trends

Air to Aerospace Power

One of the significant, positive and emerging trends of the IAF observed in the past decade has been the efforts to transform from a traditional air power force to a modern, sophisticated aerospace power force. This transformation is based on the doctrine of the IAF, a comprehensive document outlining the air force's vision, mission and strategy. This shift has been driven by the changing geopolitical landscape and the need to address emerging security challenges in the 21st century.

The IAF recognises that the aerospace domain is no longer limited to the atmosphere but extends beyond it. It acknowledges that the aerospace domain is becoming increasingly complex, congested and contested, with multiple actors operating within it. Aerospace powers allow greater flexibility and reach in military operations, enabling forces to project power over greater distances and across multiple domains. The doctrine aims to transform the IAF into a comprehensive aerospace power that can operate seamlessly in all domains of the aerospace environment. The revised doctrine has comprehensively enunciated the need to exploit the space domain for the application of space-related deliverables such as communication, navigation, precision positioning and targeting, Intelligence, Surveillance and Reconnaissance (ISR) data collection for strategic and tactical operations, etc.

The transformation of the air force into an aerospace power has been driven by technological advancements and the recognition of the strategic significance of space. It includes manned and unmanned aircraft, satellites, radars, missiles and other cutting-edge technologies. The air force has invested in cutting-edge technologies to improve its aerospace capabilities. This includes the creation of new space-based platforms, including satellites and space-based sensors, space-transitioned and -controlled weapons, missile defence, etc. The air force has also invested in hypersonic weapons technology, which entails using supersonic aircraft and missiles that can travel faster than Mach 5. This technology is anticipated to substantially improve the air force's capability to quickly and effectively strike targets. In addition, transitioning from air power to aerospace power has necessitated extensive technological and operational changes. For instance, the development of satellites and other space-based technologies has enabled the air force to extend its reach and capabilities beyond the atmosphere of the Earth. Similarly, the air force's ISR and strike operations have been revolutionised using Unmanned Aircraft Systems (UASs) and other unmanned systems.

Based on its application, utilisation and exploitation, the IAF is the most equipped and pragmatic force to become a genuine aerospace power.

It represents a significant evolution in military strategy as it recognises the significance of all three domains and seeks to leverage their unique capabilities to achieve military objectives in a global security environment that is becoming increasingly complex and dynamic. The IAF focuses on capacity building in the four fundamental components of the air operations cycle: detection, identification, interception and destruction.

In March, the Chief of Air Staff while addressing Def Tech 2023 emphasised that ‘...I feel there is a need to develop both offensive and defensive space capabilities to safeguard our asset. We need to capitalize on our initial successes in space and prepare ourselves for the future.’⁷ The IAF’s effort towards the successful transition to aerospace power would require nothing less than a top-down approach and direction under the Whole-of-Government Approach (WoGA). This approach requires a comprehensive process that involves collaboration and coordination with other services, government agencies and international partners. It also requires acknowledging the importance of innovation, research and development to maintain a technological edge and the need for continuous training and education to develop the necessary skills and knowledge. The creation of the Defence Space Agency (DSA) with the IAF as the lead service as a Single Point of Contact (SPOC) is a step in the right direction to make the space domain reachable to the services and the air force in particular for military application within the contours of national policy, security and objectives.

The Atmanirbharta Drive

Another trend shaping Indian air power is the development of the aerospace industry in India. The Indian government has been encouraging the growth of the aerospace industry by promoting public–private partnerships, joint ventures and technology transfer agreements. This has led to the development of indigenous aircraft such as the LCA Tejas and the AMCA. The growth of the aerospace industry in India is expected to reduce the country’s dependence on foreign aircraft and enhance its self-sufficiency in producing military aircraft. India is increasingly focusing on the indigenous development of defence equipment and technology. The government has launched several initiatives to promote indigenous defence manufacturing, including the Make in India campaign. Besides aircraft, the IAF is closely working with Indian Space Research Organisation (ISRO), Hindustan Aeronautics Limited (HAL) and other Defence Public Sector Undertakings (DPSUs). The IAF is also holding the hands of private players in the drive of indigenous development and the required weaponry production. Precision targeting uses advanced targeting

systems to hit targets accurately with minimal collateral damage. The IAF has invested in precision-guided munitions and advanced targeting systems to improve its strike capabilities.

In March 2023, while speaking at Def Tech 2023 on India's aerospace capabilities and technological needs, the IAF chief remarked, 'Weapons of India @100 will look significantly different from weapons of India @75'.⁸ He added, 'Directed energy and hypersonic weapons have already been tested and utilised. DEWs, especially lasers, offer numerous advantages over conventional weapons, including precision engagement, low cost per shot, logistical advantages, and low detectability.'⁹ Moreover, the future conflict would stretch across all physical domains, including land, sea, air, cyber and space, necessitating the usage of weapons from each of them.

The essence of Atmanirbharta is in moving beyond prototypes to expand indigenous design and the development of capabilities using the Indian defence industry, start-ups, Micro, Small and Medium Enterprises (MSMEs) and academics to create a self-sustaining defence Research and Development (R&D) ecosystem. It will ensure that the air force has access to the technology and is not limited to prototype productions alone. To speed up the development of niche technologies, it is important to identify the most critical areas for development, clearly state what is needed and work closely with the industry to create and build the technology. According to experience, the supplied product does not match the actual requirements on the ground. The product, therefore, enters the initial and final operational configuration loop. By the time the product is released for induction, it becomes technologically obsolete. Hence, all parties must collaborate for a tangible outcome well on time.¹⁰

To harness the efforts of indigenisation to meet the needs of the IAF, a Directorate of Indigenisation was raised at the Air Head Quarters. Its primary objective is to coordinate with the various directorates, industry and ministries at the apex level for a successful Atmanirbharta production, maintenance and sustenance effort. An aviation engineer expert says that 'the IAF's efforts for indigenisation is not limited to manufacture, fabrication and reengineering, but indigenisation also encompasses Indigenous Technology Development for repair and overhaul, where the technology has not been available for various reasons.'¹¹

The government has mandated Innovation for Defence Excellence (iDEX) initiatives to create an ecosystem 'to foster innovation and technology development in Defence and Aerospace by engaging Industries including MSMEs, start-ups, individual innovators, R&D institutes & academia'.¹² The

IAF is actively pursuing this route of indigenisation and is holding the hands of small manufacturers. Some of the approved programmes include UAS-based ESM for SIGINT in hilly terrain and high-altitude areas, Expendable Active Decoy, Hand-Held Hard Kill Counter UAS System, etc.¹³

The induction of the LCA (Tejas), the Arudhra and Aslesha Radars, the Astra Air-to-Air Missile, the Akash Surface-to-Air Missile System, the Advanced Light Helicopter and the Light Combat Helicopter demonstrates the IAF's dedication to the Atmanirbharta initiative. In addition, the IAF has established a Make-Project Management Unit (PMU) to synchronise efforts for the Make in India initiative. The Make-PMU functions as an umbrella to ensure the swift completion of projects.¹⁴ Though these small successful projects will add up to the bigger objective of self-reliance, the IAF will have to take a more significant step in this field to stay ahead of the learning and production curve.

Strategic Partnerships through Exercises

Changing geopolitical dynamics has also had a significant impact on Indian air power. Hence, the IAF constantly revisits its strategy, tactics and training, keeping abreast with the latest developments in the air forces worldwide. To invigorate this practice, the IAF is following a 'Beyond the Boundaries' theme in 2023. Under this theme, it aims to engage with other air forces worldwide for mutual professional and diplomatic exchange. In addition, the IAF had decided to conduct about 12 international exercises this year, in both Indian skies and abroad. It also aims to engage with other air forces in both bilateral and multilateral formats.

The rise of China as a military and economic power, along with its increasing assertiveness in the region, has led to a renewed focus on enhancing India's air power capabilities. The IAF has been actively strengthening its operational and strategic partnerships with other countries, such as the United States, Russia, France and Israel, to enhance its capabilities and address shared security concerns. This enables the IAF to build its capabilities to respond to emerging threats and expand its operational reach through forward basing and logistics support. It also enhances its strategic reach and enables it to operate in a wider range of environments.

The IAF has been participating in international exercises for decades to enhance its interoperability and operational capabilities. These exercises allow the IAF to learn new Tactics, Techniques and Procedures (TTPs), test capabilities in realistic scenarios and operate with the latest technology and equipment. It also helps build strategic partnerships with other countries,

which is essential in today's complex security environment. Regularly participating, planning and conducting such exercises have become integral to its training and operational ethos. The multinational exercises provide an opportunity to operate with the latest technology and equipment, which are not always available in India. Such platforms also allow the IAF to demonstrate its capabilities to other countries and foster cooperation. This, in turn, can lead to joint operations, information sharing and collaborative development of new technologies.

HR Restructuring

To maintain the highest level of operational readiness, the IAF must efficiently and effectively manage its human resources (HR). Therefore, restructuring HR within the IAF is crucial to achieving this objective. With the advancement of technology, an HR structure that is more decentralised and adaptable to a rapidly changing environment is the need of the hour. Furthermore, the modern battlefield necessitates a vast array of specialised skills and the IAF must ensure that its personnel possess these skills to carry out its missions. The IAF must therefore establish specialised units and teams with personnel trained in specialised areas such as cyber warfare, intelligence and space operations.

The creation of a new Weapon System (WS) branch is a long-envisaged requirement that will see officers getting commissioned in the next one-year timeframe. However, the scope for refinement in HR restructuring still exists, especially in the backdrop of theaterisation. The armed forces worldwide follow a set pattern of branches in their military. Similarly, the IAF follows a conventional branch structure that is generally system-driven, such as Fighters, Transport, Logistics, Administration, etc. However, with the technological advancement in newer systems, communication, networking, space, cyber, battle management, etc., the operational construct of air forces is changing drastically. Such revolution in the connected and congested battle space has given rise to the need to create new cadres. Some of the new branches or cadres could be battle managers, scholar warriors, space, research and development, etc.

A case in point could be the specialist fleet of Control and Reporting (C&R) operators responsible for the air defence of the country in peacetime and conducting all kinds of operations in wartime. They perform various air operations that are planned, controlled and executed from the ground and air. These battle managers are best poised to understand all kinds of operations undertaken by manned and unmanned aircraft, surface-to-air

guided weapons of all ranges and all kinds of battlefields, including the Tactical Battle Area (TBA). This branch could be brought under the ambit of the operational and combat branch to stay relevant in the evolving and futuristic networked and connected battlespace.

The first batch of Agniveers has already been inducted and it has thrown open new challenges in the training and operational outlook of various trades in the IAF. To make this transformational change a success, the IAF has tweaked its training curriculum and duration, keeping pace with contemporary thought, technique and deliverables in consideration.

Technological Trends

Technology is one of the key multi-dimensional trends shaping Indian air power. Rapid technological advances are transforming the IAF's operations and the capabilities it needs to maintain its combat readiness. In addition, the character of warfare is changing due to the development of new technologies such as Artificial Intelligence (AI), Machine Learning (ML) and cyber capabilities. As a result, the IAF has been actively investing in R&D to enhance its capabilities and modify its operational concepts suitably. To enhance its operational capabilities, the IAF has been investing in new technologies such as Unmanned Aerial Vehicles (UAVs), advanced sensors, precision-guided munitions, hypersonic weapons and directed energy weapons. Integrating advanced technologies with existing platforms and systems enables the IAF to achieve greater situational awareness, better target acquisition and more precise strike capabilities.

The IAF is the first service to formally acknowledge the introduction of these technologies via a top-down strategy. In July 2022, the IAF inaugurated its 'Centre of Excellence (CoE) for Artificial Intelligence' under the 'Unit for Digitisation, Automation, Artificial Intelligence, and Application Networking' (UDAAN). The CoE Centre has commissioned a platform for big data analytics and AI to manage all aspects of analytics, deep learning algorithms, natural language processing, ML and neural networks. The IAF has taken proactive steps to incorporate Industry 4.0 and cloud computing into its military operations. The AI CoE's high-end computing, large-scale data storage and comprehensive AI software suites would substantially enhance the IAF's operational capability. The AI-based applications are being made with the help of experts from within the company and from government agencies, small and medium-sized businesses and elite institutions in the field of AI.¹⁵

The first-ever symposium and exhibition on Artificial Intelligence in Defence (AIDef) were conducted in July 2022, revealing the air force's aim, vision, strategy, readiness and holistic foresight for adopting future technologies. The Defence Minister and the Chief of Air Staff (CAS) were present during the symposium. While the CAS stated that the 'IAF will harness technological advancements by embarking on this path', the Defence Minister stressed that 'India is developing AI-based weapons or systems, keeping in mind the crucial role technology can play in future warfare.'¹⁶ It is projected that the IAF will be able to adopt AI solutions in the two primary categories of data and technology. First, the IAF possesses the necessary hardware for separating or analysing data for input into the decision support system. In addition, the IAF is well-equipped to utilise AI and deep learning techniques. The Software Development Institute (SDI) provides aircraft and airborne systems with airborne applications. The SDI has proactively integrated AI technologies into all broad warfighting operations. Several recent technological advances of significance are discussed in the following sections.

Intelligence, Surveillance and Reconnaissance (ISR)

The IAF has leveraged technological ISR advances by integrating AI. As per the Deputy Chief of Air Staff responsible for the procurement, 'the adoption of these technologies has drastically reduced timelines for intel gathering, asset identification and weapon-to-target mapping, thereby positively impacting war readiness and fighting capability of the force.'¹⁷ A symposium report reveals that the IAF has created and implemented an application that integrates all electronic intelligence gathered by its assets and those of other intelligence agencies into a single structure to produce an exhaustive Electronic Order of Battle (EOB). The IAF is said to have created an image intelligence analysis programme that uses AI on reconnaissance data to identify assets, analyse hostile targets and monitor enemy activities. In addition, the IAF employs a distinct analysis tool for processing and analysing intelligence in preparation for constructing a composite intelligence picture. The Ministry of Electronics and Information Technology (MeitY) is collaborating on developing this application. The application would offer an 'AI-based solution for extracting a summary of intelligence inputs from numerous sources and formats using deep learning techniques'.¹⁸ This programme will considerably improve the intelligence's usability and give relevant, timely inputs to our field commanders.

Campaign Planning and Analysis System (CPAS)

The IAF has created the CPAS to provide campaign planning and debriefing solutions for all aircraft. The IAF operates a fleet that includes various aircraft, each adhering to its own set of standards and mission system, including debriefing tools. Thus, bringing it all together on a single platform is a daunting task. Nonetheless, it is learned that the IAF has fully accomplished this considerable undertaking. The CPAS can simulate a whole military campaign to enhance the planning and decision-making skills of planners and commanders, making it a vital training tool for all levels of combat.¹⁹

Forecasting Operational Stamina

The IAF is working on sophisticated AI and big data analytics programmes to anticipate operational endurance. The AI-powered platform will show operational stamina in real time and predict a practical operational potential based on a set timeframe and the campaign's goals. The initiative aims to provide commanders with a real-time, all-encompassing view of operations, logistics and resource availability. Currently, all IAF operations are planned, coordinated and monitored using 'air-operation systems'. It will provide alternatives for attaining the desired result. The dashboard is accessible to IAF commanders and allows them to monitor all actions in real time. Now, the IAF is incorporating AI into this programme to take it to the next level.²⁰

eMMS/ IMMOLS/e-Office

The IAF has always been the most technology-intensive force. Much before the current self-reliance and automation drive, the IAF has been on the automation drive for over a decade through the help of technology. Several projects have enabled the IAF's material and office administration to be fully automated. The e-MMS, or e-maintenance management system, manages and monitors all IAF asset serviceability and availability. A sophisticated technique is now being developed to use maintenance data to predict the failure rates of essential equipment. Moreover, the IAF administers the Integrated Materials Management Online System (IMMOLS), an e-audit-cleared programme with real-time supply chain management and monitoring capabilities. The programme is being augmented with cutting-edge AI and analytics techniques to forecast the demand for multiple resources intelligently. In addition, e-office technology is fully utilised for paperless office tasks. These advancements in routine jobs have enhanced work productivity as an important trend in the IAF.

AI in Battle Management Systems (BMS)

The BMS is the order of the day in the contested, congested and connected battlefield space. For an effective BMS, the availability of network-centric facilities with robust, fast and jam-resistant systems are the prerequisite. Safeguarding the Indian airspace is the IAF's primary responsibility. It can do this with the help of a fully networked system of sensors called the Integrated Air Command and Control System (IACCS). It is an automated air defence command and control centre for controlling and monitoring air operations by the air force. Information plays a critical role in the network-centric warfare era. It is required to be made available at the appropriate level for executing a series of tactical decisions. Information sharing entails exchanging crucial data via dedicated links between the navy, army and civilian radar networks. The IACCS system receives data from different types of homogeneous/heterogeneous radars (2-D or 3-D), Air Force Movement Liaison Units, including airborne AWACS, etc., generates reports from mobile observation posts and integrates other data elements from other air force airbases or civilian agencies such as the Air Traffic Control services to create a real-time comprehensive Recognised Air Situation Picture (RASP).²¹

The IAF is partnering with Bharat Electronics Limited (BEL), International Institute of Information Technology (IIIT) Hyderabad, Indian Institute of Technology (IIT) Jabalpur and IIT Kharagpur to embed AI systems within the IACCS architecture to develop further and assimilate the latest technology. The application will provide instructions and guidance for interception, voice recognition, multi-sensor integration and estimation of aerial threats. These features would significantly enhance decision-making abilities in time-sensitive domains. The IAF is suitably set to perform its activities efficiently using numerous cutting-edge technology features. The IAF has effectively utilised technology as a force multiplier. Its ongoing programmes must continue to be steered in collaboration with academia and the private industry for optimal benefit.

Software Defined Radio

The increasing use of Network-Centric Warfare (NCW) is the methodology that is required at all levels and by all assets, be it on the ground or air. NCW is a concept of warfare in which all military assets are connected through a network, allowing for real-time communication and coordination. The IAF has been increasingly adopting NCW to enhance its operational capabilities. It has developed its own network-centric capability, the Air Force Network

(AFNet), to strengthen its command-and-control capabilities. Further work on a war footing is going on for the erstwhile Operational Data Link (ODL) to the current Software-Defined Radio (SDR). The SDR is a network-centric capability that allows fighters and other aircraft to safely and securely communicate and share combat images. SDRs shape the radio waveform using secure software that makes hacking and interception difficult, enabling secure audio, data and video transmission. To accomplish this the IAF purchased 400 BNET from Rafael, Israel, and integrated them with its Mirage 2000, Su-30 MKI and MiG-29 fighter fleets. This will guarantee secure communication between fighters and various sensors (surveillance radars and surface missile systems), most notably with AWACS aircraft and IACCS. The initiative is close to becoming operational. The acquisition of additional SDRs to expand the SDR-Net is actively being considered, albeit via an indigenous route.²²

CONCLUSION

The IAF is shaped by several key multi-dimensional trends, including technological advancements, changing geopolitical dynamics, evolving threat perceptions and shifting operational concepts. These trends have led to a renewed focus on enhancing the IAF's capabilities and maintaining combat readiness. The IAF has been actively modernising its aircraft and weapons systems fleet, strengthening its operational and strategic partnerships and adopting innovative operational concepts to address the changing nature of threats. Though low on numbers, the emergence of advanced fighter aircraft, long-range surface to air missiles, airlift capability, etc., has enabled the IAF to enhance its air superiority capabilities. The IAF has also invested in advanced sensor and communication systems including the AEW&C system and satellite-based communication networks to enhance its situational awareness and NCW capabilities. These technological advancements have allowed the IAF to adapt to the changing nature of air warfare and maintain its combat readiness. In addition, the IAF has invested heavily in training and development programmes to ensure that its personnel are equipped with the contemporary and futuristic skills and knowledge required to perform their roles effectively. As a result, the IAF remains a potent force in the region and is well-positioned to continue playing a pivotal role in India's national security. Its revised doctrine has reaffirmed and reassured the safeguarding of national security from all possible domains. The IAF's shift towards multi-domain operations, which involves the integration of air, space and

cyber capabilities to achieve strategic objectives, is driven by the recognition that future conflicts will be fought across multiple domains and the need to maintain a competitive edge in each domain.

NOTES

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