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India's Defence Modernization and the Pursuit of Technological Autarky: Policy Reforms, Persistent Gaps, and Strategic Pathways

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Abstract:

India's defence sector is undergoing a profound strategic transformation driven by the ambition to achieve self-sufficiency (autarky) in arms development, which is a cornerstone of its pursuit of great power status. This imperative is rooted in the doctrine of techno-nationalism and the need to deter ongoing security threats. Historically characterized by deficiencies and heavy reliance on imports, the strategic policy shift toward Atmanirbhar Bharat (Self-reliant India) has led to demonstrable successes. Indigenous defence production achieved a historic high of ₹1.27 lakh crore in 2023-24, and defence exports surged significantly, reaching ₹23,622 crore in 2024-25. Nonetheless, modernization efforts are hindered by critical technological gaps in core areas, such as propulsion and advanced electronics, as well as an insufficient financial commitment to Research and Development (R&D), which currently accounts for around 4% of the defence budget. The continued dependence on external sources for highly technical subsystems creates an "autarky gap". Achieving genuine autonomy requires escalating R&D spending to a recommended 8-10% of the total defence budget, implementing structural R&D reforms (such as creating a Department of Defence Science, Technology, and Innovation-DSTI), and institutionalizing the proactive, in-house design and integrated acquisition model successfully pioneered by the Indian Navy.

Keywords: Atmanirbhar Bharat (Self-reliant India), Defence Modernization, Indigenization.

1. Introduction

The strategic rationale for India's continuous pursuit of autarky in defence equipment and armaments production is founded on the conviction that great powers require robust domestic arms industries [1], [17]. This policy objective, first articulated by Prime Minister Jawaharlal Nehru [19], is crucial for guaranteeing national sovereignty [18]. Reliance on foreign arms producers can potentially undermine a nation's strategic freedom during crises due to supplier restraints or technology holdbacks [3], [22]. The

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need to update military capabilities is further accelerated by contested borders and the emergence of non-traditional threats, including information warfare, cyber warfare, and the weaponization of space [18].

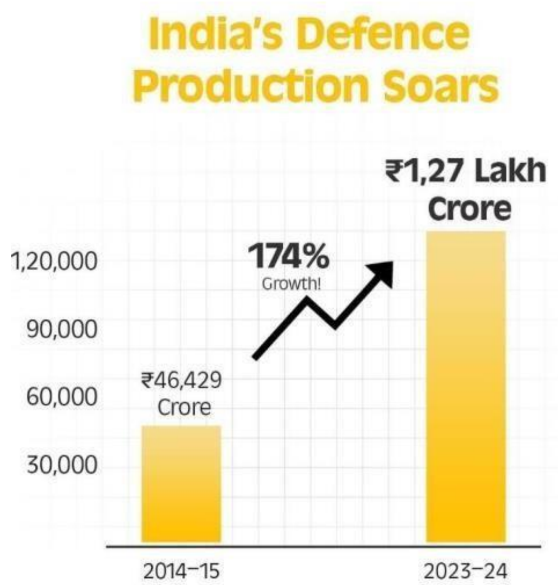

Figure 1 India's Defence Production Growth: 2014-2024

Figure 2 Defence Equipment Flow (Strategic Partnerships)

For most of its history, the Indian defence industrial base has struggled to deliver technologically advanced, domestically developed weaponry [23]. This protracted difficulty is evidenced by a history marked by setbacks, program overreach, and costly delays, resulting in India ranking consistently as one of the world's largest arms buyers [21]. India’s imports predominantly originate from Russia, followed by countries such as France, the United States, and Israel [21] (Fig. 2). The current modernization drive, framed by the

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Atmanirbhar Bharat Abhiyan (self-reliant campaign), represents a coordinated national effort to overturn this dependency by prioritizing indigenous design, development, and manufacturing [8], [9].

2. Problem Statement

India's quest for self-sufficiency in defence manufacturing autarky forms the foundation of its strategic modernization [23]. Despite decades of effort, the country remains critically reliant on imports for key defence technologies, particularly propulsion systems, electronics, and sensors [16] (Fig. 3). The core research problem centres on evaluating India's progress in defence modernization and indigenization, identifying persistent gaps hindering complete self-reliance, and analysing whether current policy reforms are sufficient to achieve genuine technological autonomy [14], [20].

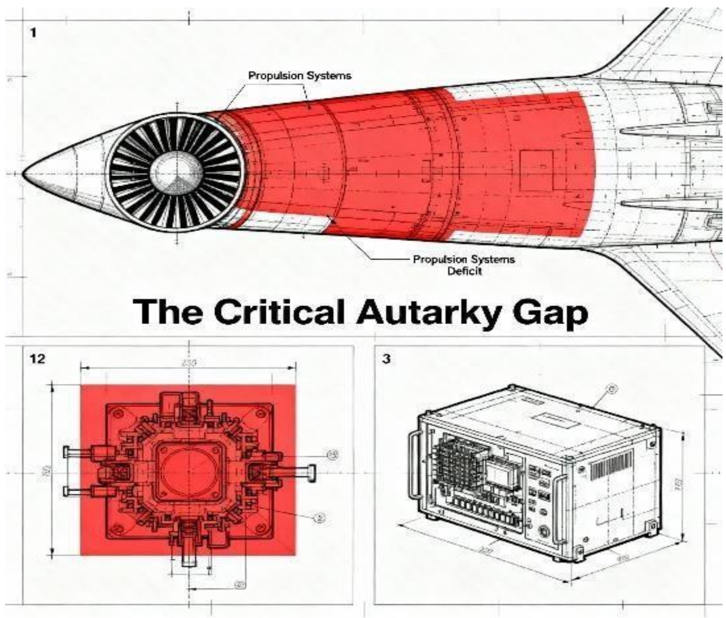

Figure 3 Critical Autarky Gap in Aerospace Propulsion Systems

Figure 4 Defence Production and Exports

3. Research Gaps

Despite ambitious policy shifts, India faces significant structural and technological gaps that limit its trajectory toward self-reliance [23]:

Financial and Institutional Gaps: Inadequate R&D investment remains a critical structural impediment, with India allocating only around 4% of its total defence budget to R&D in recent years [23], significantly lower than major global powers and the recommended 8-10% needed for breakthrough technologies [30] (Fig. 2).

Technological Deficits: Persistent technological shortfalls necessitate reliance on imports for high-value subsystems [16] (Fig. 3). A critical deficit exists in propulsion technology, specifically jet engines, highlighted by the difficulties in the LCA Tejas program [4] (Fig. 3). Dependency is heavy for essential components like advanced sensors, electronics, avionics, and engines [3], [22] (Fig. 3).

Systems Integration Weakness: Indian defence R&D struggles with systems integration-the capability to efficiently coordinate and assemble disparate components into a fully functional weapon system-which limits the ability to effectively absorb foreign technology acquired through licensing or joint ventures [27].

Structural Inefficiencies: The defence industrial base is still largely dominated by protected Defence Public Sector Undertakings (DPSUs) and Ordnance Factories (OFs) [20], creating a monopolistic environment that removes the incentive for competition and efficiency [23]. This has led to frequent project delays and cost overruns, such as the Arjun MBT program, which was reportedly delayed by over three decades and exceeded original cost estimates by 20 times [23].

Emerging Technology Lag: Investment lags in next-generation domains such as artificial intelligence (AI), hypersonic technologies, and cyber security [6], [7].

4. Research Objectives

The objectives of this research are derived directly from the need to address the structural and technological challenges confronting India's defence sector. The objectives are as follows.

a. Aimed at critically evaluating the quantitative trajectory of indigenous defence manufacturing and export expansion catalysed by the Atmanirbhar Bharat and allied self-reliance frameworks.
b. Focused on identifying, classifying, and analysing the enduring technological, infrastructural, and systemic constraints that perpetuate the "autarky gap" within critical defence subsystems and high-value components.
c. Directed toward conducting a comparative assessment of the indigenization paradigms, performance metrics, and institutional models across the Indian Army, Navy, and Air Force, highlighting differential success determinants and operational bottlenecks.
d. Intended to assess quantitatively and qualitatively the economic, industrial, and strategic implications of contemporary policy instruments-particularly the Defence Acquisition Procedure (DAP) 2020-on India's domestic defence-industrial ecosystem.
e. Seeking to propose strategic interventions and reform pathways encompassing R&D investment frameworks, innovation ecosystems, and institutional restructuring aimed at transitioning from production-centric growth to technology-intensive capability development.

5. Research Methodology

This assessment employs a triangulated research methodology approach based on qualitative content analysis of policy documents, official expenditure data, and expert analysis available within the sources [1], [4] (Fig. 5). The study follows a qualitative, systematic review protocol designed to ensure objectivity and reproducibility. Sources include government policy documents, defence budget reports, Ministry of Defence publications, the Defence Acquisition Procedure (DAP) 2020, and secondary analyses from expert defence journals and think tanks [8], [11], [21].

The primary method for evaluating indigenization across the armed forces involves classifying major military platforms and equipment into four categories based on their origin: Imported, Licensed Manufactured, Joint Venture, and Indigenous [23]. This classification provides a comparative baseline for assessing differential success rates. Furthermore, the study integrates data related to budgetary allocations, defence R&D expenditure, and export performance to quantify the economic and strategic impact of recent policy shifts [20]. Validation was achieved by triangulating data from multiple official and analytical sources to verify consistency in R&D investment trends, indigenization metrics, and export figures [21].

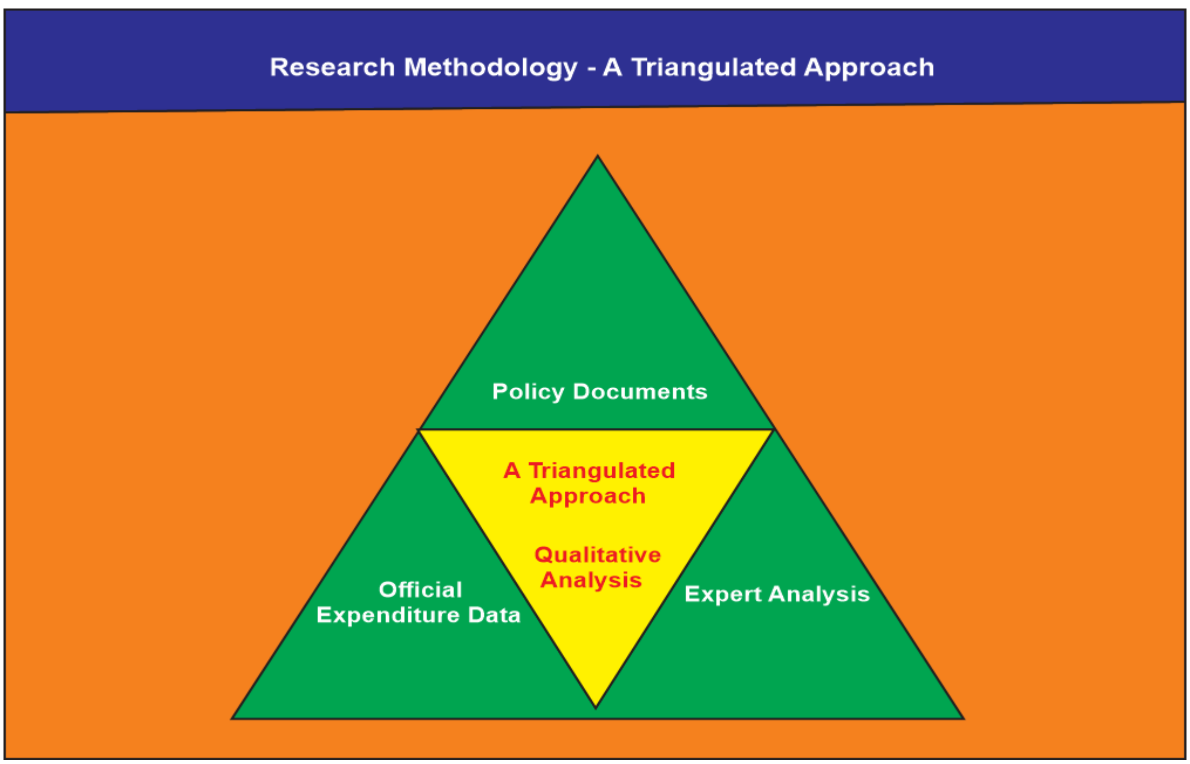

Figure 5 Research Methodology - A Triangulated Approach

6. Current Development

The Ministry of Defence (MoD) has implemented sweeping reforms that have led to measurable growth in domestic defence manufacturing and exports [20] (Fig. 4) (Table. 1 and 2).

Table 1 India's Modernization - Acquisition and Indigenization

Indian Air Force	Indian Army	Indian Navy and Coast Guard
RD 33 Engine (MiG 29 Aircraft)	Close-In Weapon System (CIWS)	Brahmos Supersonic Cruise Missiles
High-Power Radar System	Future-Ready Combat Vehicles (FRCVs)	Dornier-228 Aircraft
Air Defense Fire Control Radars	Air Defense Fire Control Radars	Next-Generation Offshore Patrol Vessels
Dornier-228 Aircraft	MQ-9B Drone	MQ-9B Drone
AL-31FP Engine (Su-30MKI Aircraft)	K9 Vajra-T Howitzers	Varunastra Heavyweight Torpedoes
MQ-9B Drone	Pinaka Rocket System	Rustom II MALE UAV
C295 Aircraft	Light Combat Helicopters (LCH) Prachand	INS Vikrant
Su-30MKI Aircraft	Advanced Tank Engines - T-72 and T-90 MBTs	INS Nilgiri Frigate
LCH Prachand	Advanced Towed Artillery Gun System (ATAGS)	LCA Navy
LCA Tejas	Nag Missile System (NAMIS)	
Rafale Aircraft	Light Specialist Vehicles (LSVs)	
AMCA	Rustom II MALE UAV	
KC 135 Flight Refueling Aircraft (FRA)		
Meteor Missile (Rafale Aircraft)		
Rustom II MALE UAV		
SWITCH V2 and NETRA 5 Drones		

6.1 Policy framework and production growth

The policy framework, driven by the Atmanirbhar Bharat Abhiyan, focuses on mandating local content and rationalizing procurement [8], [20]:

Defence Acquisition Procedure (DAP) 2020: This policy explicitly prioritizes Indian-made systems, requiring a minimum of 50% indigenous content for the highest preference category, "Buy Indian (Indigenously Designed, Developed, and Manufactured) (IDDM)" [14].

Production Mandates: The MoD publishes "Positive Indigenization Lists" (Negative Import Lists) covering over 5,500 items, of which 3,000 had been indigenized by February 2025 [20], forcing domestic procurement. For FY 2025-26, approximately 75% of the modernization budget, amounting to ₹1,11,544 crore, was earmarked for procurement through domestic industries [20].

Investment and Innovation: Foreign Direct Investment (FDI) limits in the defence sector were liberalized to 74% through the automatic route in cases involving technology transfer [20]. The Innovations for Defence Excellence (iDEX) program, launched in 2018, fosters technology development by supporting start-ups, MSMEs, and academic institutions [11]. As of February 2025, 430 iDEX contracts have been signed, and the Armed Forces have procured 43 items worth over ₹2,400 crore from iDEX-supported startups [11].

Defense Industrial Corridors (DICs): Two dedicated manufacturing corridors have been established in Uttar Pradesh and Tamil Nadu to build industrial ecosystems [11]. These corridors have attracted investments worth over ₹8,658 crore and signed 253 MoUs as of February 2025 [11].

The collective result of these reforms is tangible growth. India's indigenous defence production achieved a historic high of ₹1.27 lakh crore in 2023-24, with the private sector contributing 20.8% of this value [8], [21] (Fig. 1).

Figure 6 Advanced Missile Systems in Assembly Facility

Table 2 India's Defence Exports

India's Defence Exports
Bullet Proof Jackets
Dornier-228 Aircraft
Chetak Helicopters
Fast Interceptor Boats
Lightweight Torpedoes
Brahmos Missiles

6.2 Major defence equipment and acquisitions

Modernization involves integrating both imported and domestically developed systems: The Ministry of Defence signed 193 contracts worth ₹2,09,050 crore in 2024-25-the highest ever in a single year-with 177 contracts awarded to the domestic industry [20] (Fig. 7).

Figure 7 India's Defence Modernization - Acquisition and Indigenization

Indigenous Platforms: Major indigenous platforms include the LCA Tejas fighter, the Arjun Mk-1A Main Battle Tank (MBT), the Pinaka Multi-Launch Rocket System (MRL), the nuclear-powered ballistic missile submarine (SSBN) INS Arihant (commissioned in 2016), and the Indigenous Aircraft Carrier (IAC-1) Vikrant. In March 2025, contracts were signed for 156 Light Combat Helicopters (LCH) Prachand worth ₹62,700 crore, designed for high-altitude missions and featuring over 65 percent indigenous content (Table. 1). India also achieved a major milestone in May 2025 with the approval of the Advanced Medium Combat Aircraft (AMCA) Programme Execution Model [4], [29] (Fig. 7).

Joint Ventures and Licensed Production: Key collaborations include the Indo-Russian BrahMos cruise missile (the world's fastest cruise missile, operating at Mach 2.8), and the joint venture between Tata and Airbus to produce C-295 transport aircraft (Table. 1) (Fig. 7). The Tata Aircraft Complex was inaugurated in Vadodara in October 2024 to manufacture the C-295 aircraft. India also produces the Russian T-90S Bhishma MBT under license [26], [29].

Imports: The Indian Air Force operates imported aircraft like the Rafale (France) and has acquired systems like the Russian S-400 Triumf mobile surface-to-air missile system. India also finalized a deal for the acquisition of 31 MQ-9B drones from the United States [22] (Fig. 7).

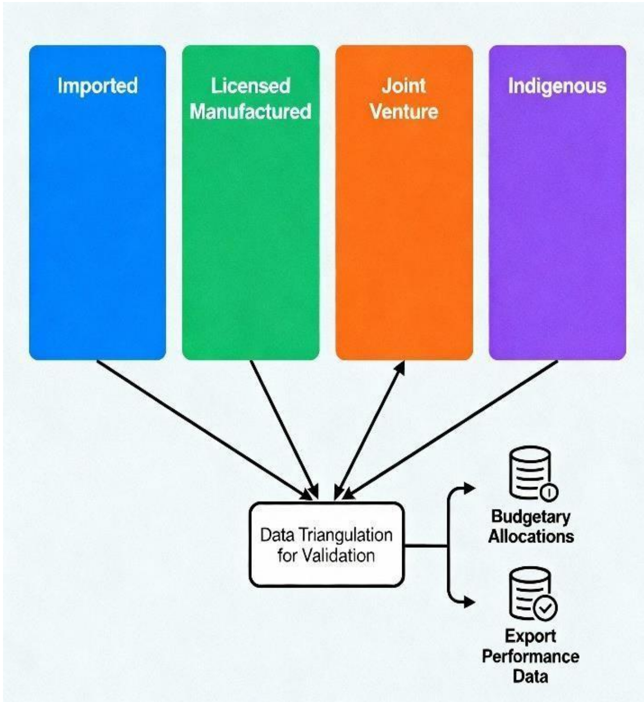

Figure 8 Data Triangulation for Validation

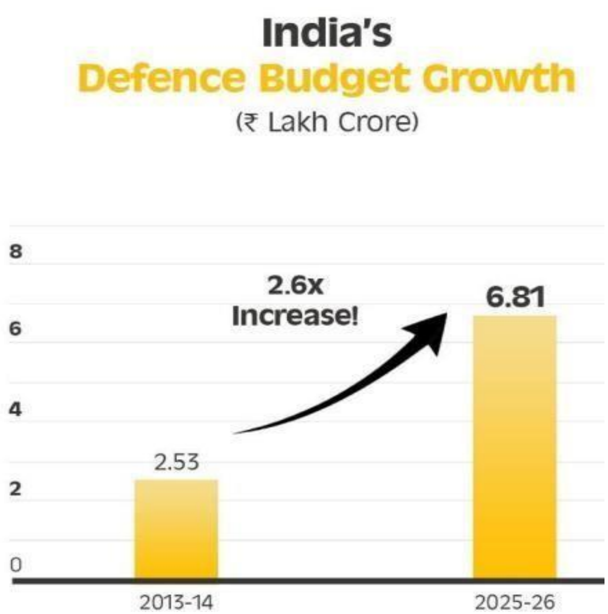

Figure 9 India's Defence Budget Growth

6.3. Defence exports

India is actively leveraging its production capabilities to become a net exporter (Fig. 4). Defence exports have grown substantially, achieving a record value of ₹23,622 crore in 2024-25, marking a 34-fold increase over the past eleven years [21]. The private sector contributed ₹15,233 crore to this total in 2024-25 [20] (Fig. 10). The government aims to achieve ₹50,000 crore in exports by 2029 [21]. Significant export items include BrahMos missiles (with a $375 million contract signed with the Philippines in January 2022), Dornier (Do-228) aircraft, and the Tejas fighter aircraft (attracting interest from the US and Australia) [11], [29].

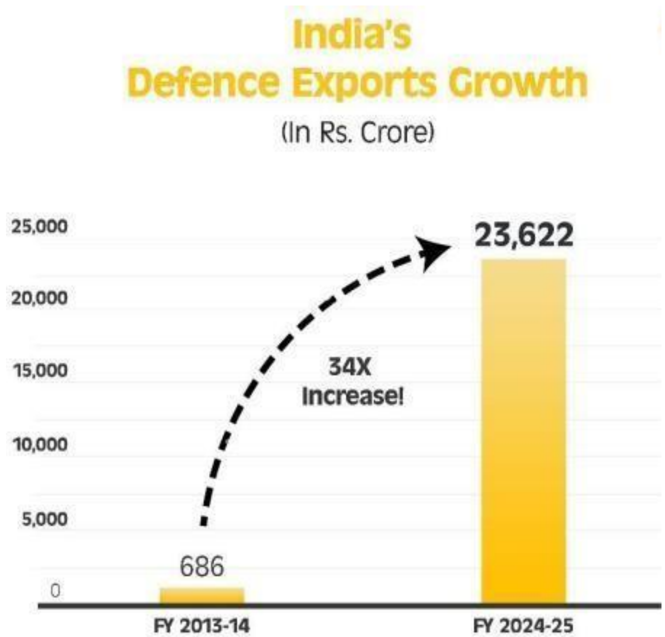

Figure 10 India's Defence Exports Growth

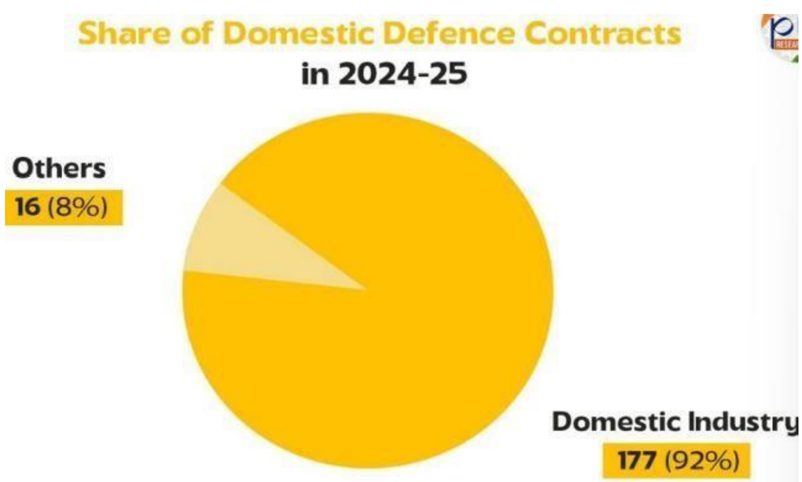

Figure 11 Share of domestic Defence contracts

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7. Challenges

Despite quantitative successes, India's modernization is constrained by systemic issues and persistent technological shortfalls [23].

7.1 Structural and financial impediments

Systemic issues originating from historical structure continue to plague the defence industrial base [23]:

State-Centric Inefficiency: The state-owned sector, dominated by DPSUs and OFs, is perceived as having no incentive to be competitive because it possesses a "captive market in the military" [20]. This monopolistic environment hinders innovation [23].

Inefficient Workforce Structure: The inefficiency is partly attributed to bloated workforces and excess productive capacity, with many facilities operating at barely 50% capacity [20]. Attempts to downsize through hiring freezes caused a loss of new talent [23].

Project Execution Issues: The acquisition and development processes are frequently marred by cumbersome procedures and lengthy delays, with projects often exceeding planned timeframes by several years [14], [15]. The Arjun MBT program is a prominent illustration of being delayed and facing massive cost overruns [23].

Inadequate R&D Investment: R&D spending remains critically low at approximately 4% of the defence budget, severely hampering long-term indigenous technological innovation necessary for self-reliance [23], [30].

7.2 Technological gaps

Modernization efforts are undermined by persistent technological shortfalls that necessitate reliance on imports for high-value subsystems [3], [16].

Propulsion Technology Deficit: A critical technological deficit exists in the field of jet engines and propulsion systems [16].

Dependency on Foreign Subsystems: India remains heavily dependent on external suppliers for essential, high-technology components, including engines, advanced sensors, electronics, and crucial avionics [3], [22].

Systems Integration Deficiency: There is a persistent difficulty with systems integration, which limits India's capacity to efficiently coordinate and assemble disparate components into complex, fully functional weapon systems [27].

Lag in Emerging Technologies: Investment lags in next-generation domains such as artificial intelligence, hypersonic technologies, and cyber security [6], [7].

Table 3 India's Global Defence Partnerships

India's Global Defence Partnerships			
Country	**Partnership Highlights (2025)**	**Key Projects**	**Strategic Focus**
USA	10-year Defense Partnership Framework, Interoperability, Technology Transfer, Reshaping, Indo-Pacific innovation landscape	Javelin Anti-Tank Missiles, Stryker Armoured Personnel Carriers	Transforming the Relationship Utilizing Strategic Technology (TRUST), India-United States Defence Acceleration Ecosystem (INDUS-X)
France	Indo-Pacific Strategy, Anti-Terrorism, Space Security, Joint Defense Production, Technology Transfer, Defense Autonomy	Rafale-M (Marine) deal, Scorpene Submarines, MRO Facilities	Maritime Security, Naval Aviation, Submarine Capability
Russia	Joint Production, Technology Transfer, Legacy Systems	Brahmos Missile, T-90 MBT, Su-57 Aircraft, AMCA	Next Gen Systems
South Africa	Undersea Warfare Technology, Joint Training and Exercises, Multilateral Forum Participation	Joint R&D in Naval Systems, Cyber Defense, Peace Keeping	Maritime Domain Awareness, Anti-Submarine Warfare Capability, Blue Economy Security

8. Recent Collaboration with Foreign Countries

8.1 South Africa Collaboration

Recent collaboration between India and South Africa has significantly strengthened, primarily focusing on defence, maritime security, and defence industrial cooperation [25] (Table. 3). This relationship is underpinned by a shared anti-colonial history and is institutionally managed through the Joint Defence Committee (JDC), which serves as the main mechanism for discussing policy, military cooperation, acquisition, and research [25]. Key recent developments include specific agreements related to submarine cooperation and rescue technology [25]:

Submarine safety and rescue: A significant recent development occurred in September 2024, when a key agreement was signed to establish a framework allowing the Indian Navy to provide rescue support to the South African Navy's submarines. This cooperation ensures that India can assist South Africa with its Deep Submergence Rescue Vehicle (DSRV) capabilities in the event of an emergency [25].

Institutional progress: Furthering this collaboration, the 9th Joint Defence Committee meeting was successfully held in Johannesburg in June 2025. During this meeting, two agreements related specifically to submarine cooperation were exchanged. The Indian delegation, led by Defence Secretary Shri Rajesh Kumar Singh, highlighted India's increasing prowess in defence manufacturing and exports, emphasizing the commitment to strengthening bilateral relations [25].

Defence industrial collaboration: Both nations are actively pursuing collaboration in defence manufacturing, with India viewing South Africa as a partner rather than a competitor. South Africa has demonstrated interest in procuring Indian defence products, notably the BrahMos missile [4]. These actions demonstrate a commitment to enhancing maritime security in the Indian Ocean Region through joint naval activities and regular staff talks, while simultaneously supporting mutual defence industry goals [25].

India's defence partnerships with the USA, France, and Russia have deepened significantly in 2025, enhancing military capabilities, technology transfer, and joint production [1], [22]. Each relationship is marked by both strategic interests and regional security priorities [18].

8.2 USA collaboration

In October 2025, India and the US signed a new, expansive 10-year defence framework aiming to deepen cooperation across all domains, including military interoperability, defence-industrial collaboration, space, cyberspace, and maritime domain awareness [22] (Table. 3). The framework provides unified policy direction to strengthen regional stability and deterrence, with both nations committing to recalibrating their partnership to safeguard a free and open Indo-Pacific [18]. This framework is also seen as a response to regional security challenges and marks a strategic convergence despite ongoing trade tensions and tariff disputes [22].

8.3 France collaboration

India and France continue to maintain a robust defence relationship through projects like the P-75 Scorpene submarine initiative and the procurement of Rafale aircraft [22] (Table. 3). On April 28, 2025, both governments signed an agreement for 26 new Rafale-Marine aircraft for the Indian Navy, which includes a commitment to indigenous production and technology transfer, supporting India’s Aatmanirbhar Bharat vision [22] (Fig. 2). There is ongoing cooperation for setting up maintenance, repair, and overhaul facilities in India, and technology transfer that enables integration of indigenous weapons. The last of the six Scorpene submarines (INS Vaghsheer) was commissioned in January 2025 [22].

8.4 Russia collaboration

Russia reaffirmed its long-standing defence push with India in October 2025, highlighting joint production and full technology-sharing on several platforms [1], [22]. Major collaborative achievements include BrahMos missiles, Su-30 MKI fighters, T-90 tanks, AK-203 rifles, and naval frigates, with future cooperation planned in areas like Su-57 fighters and India's AMCA program [22] (Table. 3). Russia remains the largest supplier to India’s armed forces, with about 70% of India’s military equipment of Russian origin, underscoring the deep operational and strategic ties spanning more than six decades [26].

India continues to balance strategic autonomy by diversifying its defence partnerships, leveraging US expertise for high-tech, France for indigenous capability, and Russia for legacy and advanced joint production [18], [26].

9. Discussion

The modern Indian state stands at the cusp of a historic transformation in its defence posture, from a dependent consumer of foreign weaponry to an emerging global supplier of advanced military systems. This metamorphosis, long in the making, is the culmination of decades-long efforts towards indigenisation, self-reliance, and strategic autonomy. India’s defence modernisation today represents not only an economic and technological agenda but also a civilisational assertion: the reclaiming of the nation’s ability to arm and defend itself by its own hand. Furthermore, the path to genuine military modernisation no longer runs solely through foreign procurement, but through the creation of an integrated national defence ecosystem, one that fuses design, manufacture, innovation, and export into a self-reinforcing cycle of capability and influence. It is important to note that India is among the 10 largest military spenders in 2024, standing in fifth position. The current developments of Indian Defence with respect to Acquisitions and Indigenization under the Make in India Program indicate the scale, progress, and direction the Indian Defence is making concerning Self-Reliance and in becoming a Global Power. The Indian Air Force Test Pilot School, part of Aircraft Systems and Testing Establishment (ASTE), is one of the eight prestigious schools that have been recognized by the Society of Experimental Test Pilots (SETP), and India is one of the six nations that have received the honour of being part of the elite nations recognized by SETP. The Test Pilots and Flight Test Engineers of ASTE have the expertise to test the indigenous and foreign platforms of various aircraft concerning Avionics, Weapon, Airframe, and Engine Systems before aircraft are handed over to Line Pilots at the operational bases.

However, despite being well-drilled, battle-tested, and respected, the Indian Defence is constrained by technological and strategic gaps. The research gaps that impede India's Defence progress and development have been clearly brought out in this paper. Furthermore, several systemic, technological, structural, and policy-level challenges continue to constrain both modernization and export competitiveness. India's defence modernization and export trajectory reflect significant strategic intent but constrained systemic execution. Despite decades of policy emphasis on self-reliance, the IAF remains entangled in systemic and structural constraints that limit its autonomy and operational resilience. The most glaring vulnerability lies in the lack of a fully indigenous jet engine. GTRE's Kaveri programme, once envisioned as the cornerstone of Indian propulsion technology, has stumbled repeatedly, requiring external validation and technical collaboration with Russia (Fig. 13). The absence of domestic altitude and endurance test facilities and a flying test bed continues to impede both development and certification, compelling reliance on foreign infrastructure for even core testing functions [7]. While Atmanirbhar Bharat has fostered indigenous capability development and policy reforms, sustained success requires deeper integration of private industry, agile acquisition frameworks, enhanced R&D funding, and globally competitive export ecosystems**.**

Nonetheless, from the foreign collaboration perspective, India's defence global partnerships have evolved into a cornerstone of its strategic modernization and export agenda, reflecting a shift from import dependence to collaborative capability development. Through frameworks such as the India-U.S. Defence Technology and Trade Initiative (DTTI)**,** India-Russia Intergovernmental Commission on Military-Technical Cooperation, and growing strategic partnerships with South Africa, France, Israel, and Japan**,** India seeks joint research, co-production, and technology transfer in critical domains like aerospace, naval systems, and cybersecurity. These diversified partnerships enhance India's strategic autonomy, embed it within global defence value chains, and support its aspiration to become a regional defence manufacturing and export hub under the Atmanirbhar Bharat initiative. The recent Indo-Pacific Strategy with the USA and France, the Joint Production Technology, and Technology Transfer with Russia, the Undersea Warfare technology, and Blue Economy Security with South Africa reflect India's interest in Global Defence partnerships.

The future framework of India's defence modernization and exports emphasizes self-reliance through strategic innovation, global collaboration, and industrial integration**.** It envisions a robust defence ecosystem driven by advanced R&D, joint ventures with global partners, and deeper private sector participation to bridge technological gaps in critical subsystems. This forward-looking framework seeks to transform India from a major importer into a competitive, technology-driven defence manufacturing and export hub, supporting both national security and economic growth. Also, the research found that integration of Human Resource Factors into Defence through Vipassana, a non-traditional approach, will have a significant impact in overcoming structural and human resource challenges. It involves integrating

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mental wellness practices, such as Vipassana meditation, into the defence ecosystem [24]. Vipassana offers specific benefits that support the objectives of defence modernization and the Atmanirbhar ethos [24] (Fig. 12). It improves organizational cohesion, integrity, decision-making, and innovation.

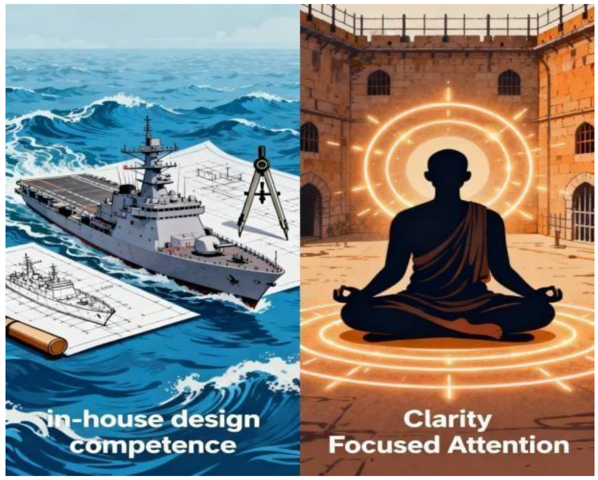

Figure 12 Integrating Human Resource Factors through Vipassana

Figure 13 Delay and Cost Overrun

10. Future Framework

Overcoming the entrenched challenges and realize technological autarky, structural and policy changes must be implemented immediately. The future framework focuses on five strategic areas: [23]

10.1 Prioritizing R&D investment and structure

Structurally and financially reinforcing the R&D base, R&D funding should be progressively elevated to 8-10% of the total defence budget. Institutional overhaul is required through the implementation of the Prof K Vijay Raghavan Committee recommendations: [23], [30]

Science and Technology Administration: Create a dedicated Department of Defense Science, Technology, and Innovation (DSTI), led by an expert technocrat, to foster R&D within academia and start-ups.[30]

Strategic Planning: Establish a Defence Technology Council, chaired by the Prime Minister, responsible for defining the nation's defence technology roadmap. [30] Research Infrastructure: Set up centralized and state-of-the-art National-Level Laboratory Facilities, moving beyond exclusive reliance on existing DRDO infrastructure. [11], [30]

10.2 Deepening technological capabilities and closing core gaps

Future strategy must emphasize capability over quantity, focusing on critical subsystems: [23].

Targeted Indigenization: Address the reliance on foreign suppliers for crucial elements such as engines, avionics, and advanced sensors. [16], [3], [4] Systems Integration Mastery: Create a specialized, high-priority national mission to staff and fund an Integrated Systems Engineering Group (ISEG), separate from platform design, mandated to master the integration of subsystems (e.g., micro-electronics, sensors) currently imported. [27], [30]

Leapfrog Technology Acquisition Strategy: Formalize a "Leapfrog Technology Acquisition and Assimilation Strategy," based on the IDAR philosophy (Introduce, Digest, Assimilate, and Re-innovate), to mandate a structured, state-sponsored national philosophy for rapidly capitalizing on acquired foreign technology using indigenous R&D input. [27]

Next-Generation Investment: Allocate sufficient investment to cutting-edge technologies like AI, hypersonic systems, and cyber security. [6], [7], [22]

10.3 Streamlining acquisition and adopting best practices

Overcome slow decision-making and production delays, the framework must institutionalize efficiency: [14], [15], [20]

Expedited Processes: Simplify documentation and reduce processing times to streamline regulatory and procurement processes. [14], [15]

Fast-Track Major Projects: Urgently implement Strategic Partnership (SP) projects and finalize pending contracts for major platforms within one to two years. [14], [15], [20]

Replicate the Naval Model: Institutionalize the Indian Navy's approach by prioritizing in-house design capabilities and fostering synergistic partnerships with DPSU shipyards and R&D agencies across all services. [4], [20], [23]

10.4 Empowering domestic industry and workforce reform

The government must ensure predictable demand and leverage the private sector's potential: [8], [11], [20].

Private Sector Support: Mandate policies that guarantee a level playing field for private defence companies. Institutionalize a policy that guarantees Minimum Order Quantity (MOQ) and first-order procurement mandates for private sector firms that successfully design and prototype indigenously developed systems (e.g., under iDEX and Make projects). [11], [20]

Workforce Revitalization: Implement policies to mandatorily shed excess non-technical and non-essential labor within DPSUs and OFs, paired with an immediate, targeted, and aggressive national program to recruit young, highly skilled scientists and engineers. [20], [23]

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Human Resource Integration: Introduce structured Vipassana meditation sessions at DRDO labs, defence academies, and administrative offices to enhance PWB, focus, and ethical reflection, integrating these modules into leadership training. [24]

10.5 Leveraging exports and diplomacy

India must continue the aggressive push to achieve the ₹50,000 crore export target by 2029. This involves proactively incorporating defence achievements, such as successful indigenous missile tests-into diplomatic outreach, transforming indigenous capability into a tool of "Defence Diplomacy 2.0". [11], [20], [21], [25], [29]

11. Conclusion

India's defence modernization, spurred by the Atmanirbhar Bharat Abhiyan, has successfully leveraged national policy goals to foster a rapidly growing indigenous industrial base, marked by record production figures (₹1.27 lakh crore in 2023-24) and substantial export growth (₹23,622 crore in 2024-25). [8], [11], [20], [21] This progress indicates partial success. However, the path to defence autarky remains incomplete. The continued dependence on external sources for highly technical subsystems, coupled with structural inefficiencies (DPSU dominance, workforce issues) and insufficient R&D investment (currently 4%), creates an enduring "autarky gap" that risks perpetually limiting true technological self-reliance. [3], [20], [23], [30].

To evolve from "Make in India" to "Innovate in India", India must transition its focus from merely increasing production volume to achieving technological depth. [23], [30] (Fig. 14) This strategic shift requires decisive implementation of structural R&D reforms (DSTI, DTC, National-Level Laboratories), a significant increase in R&D funding (to 8-10%), institutionalizing the Leapfrog Technology Acquisition strategy, and the replication of the Indian Navy's integrated, institutionalized design model across all services. [4], [11], [14], [15], [30]. Furthermore, addressing core human resource challenges through focused talent acquisition and non-traditional methods like the integration of Vipassana meditation will enhance the discipline and capacity needed for sustained innovation. [24] Only through such structured, systemic reform and sustained investment in core technological creation can India guarantee that future military capabilities are powered by genuine indigenous innovation. [30].

Figure 14 DSTI R and D Funding

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14. Conflict of Interest

The authors declare no competing conflict of interest

15. Funding

No funding was received for this research

16. Limitations of the Study

Despite providing a structured assessment of India's defence modernization and autarky efforts, this study is subject to several limitations, such as a lack of access to primary field data from DPSUs, DRDO laboratories, and defence production units. Also, the study may not fully capture internal workflow inefficiencies, human-resource constraints, and ground-level implementation challenges.

17. Author Biographies

Vidyasagar Kotha is an air and space propulsion researcher and a retired Indian Defense Personnel. He has over 25 years of work experience in preventive, corrective, and predictive maintenance of Jet engines. His experience also includes aero engine stripping, assembly, and test runs. Kotha was awarded the prestigious Sir Roy Fedden Scholarship by Cranfield University, UK in 2018 and has published Six International Journal Research Papers and an International Symposium Paper. Currently, he is pursuing his Doctoral Research in Aircraft Propulsion at the University of Witwatersrand, Johannesburg, South Africa, and working as a Founder & CEO at Kotha Aerospace Private Limited, Bangalore, India. Also, Kotha is a Member of the Prestigious Royal Aeronautical Society (MRAeS), London, UK.

Kavya Vaddadi is an Aeronautical Engineer, Design Engineer, and CFD & Structural Analyst specializing in ancient aeronautics and the scientific interpretation of Vimana Shastra. Serves as Head of Education and Awareness at the Ancient Technology Division, MAARKS Aerospace and Marine Services Pvt. Ltd., and Design Engineer in VEDAS (Vaddadi Engineering Design and Analysis Services). Research works integrate modern aerospace design with Vedic technological concepts, and her 3D-printed Marutsakha Vimana model was wind-tunnel tested at the University of California, Irvine, demonstrating aerodynamic viability. She has appeared on the History Channel's Ancient Aliens and has delivered guest lectures at several institutions, such as GITAM University, JNTU Kakinada, and Amrita University, India. Kavya is also the author of Vimanas and the Wars of the Gods and Reverse Engineering Vedic Vimanas.

P Midhun is an Aeronautical Engineer who specializes in aerodynamics, computational fluid dynamics (CFD), and aeroelastic stability. A graduate in Aeronautical Engineering from Anna University with research experience at National Aerospace Laboratories (NAL) and Aeronautical Development Establishment (ADE) under DRDO, India contributed to major projects such as SARAS Mk-II, High-Altitude Platform Station (HAPS), Long Range Land Attack Cruise Missile (LRLACM), and Supersonic Store Separation. Expertise includes aerodynamic design and optimization, turbulence modelling, and fluid-structure interaction analysis using advanced CFD and FEA tools, and proficiency in low-fidelity tools for configuration analysis during conceptual design stages. Research interests encompass aerodynamics, aeroelasticity, and CFD-FEA coupling applications. The paper "Reverse-Engineering the Divine: Stone-Carved Flight Manuals and the Ancient Vimana Blueprints of Tirupati" reflects an innovative approach integrating ancient technological concepts with modern aeronautical science.

Netra Bommena is a seasoned project and operations management specialist with a background in aviation, tech consultancy, product-led sustainability, and large-scale programme coordination. She holds an MSc in Business with Operations Management from Warwick Business School, UK, and a bachelor's degree in computer science engineering from GITAM University, India. Her professional experience includes driving organisational transformation, enhancing operational efficiency, and delivering data-informed insights for international stakeholders. She contributes to collaborative research and strategic initiatives. Netra is proficient in stakeholder engagement, regulatory alignment, and analytical problem-solving, and consistently demonstrates strong leadership, attention to detail, and the ability to manage complex projects with precision.

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