

BRIDGING THE R&D GAP - ALIGNING DEFENCE RESEARCH WITH MILITARY NEEDS

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Introduction

While speaking at the annual session of Society of Annual Defence Manufacturers on 27 Oct 2025, Defence Minister Rajnath Singh urged India's defence industry to accelerate indigenous production and augment self-reliance in anticipation of possible war-like situations.¹ Citing cross-border hostilities with Pakistan in May 2025, he stressed that the armed forces must continue to modernise and strengthen readiness. He highlighted Operation Sindoor as a case study for showcasing India's effective use of indigenously developed weapons like Akash and BrahMos missiles and the AkashTeer air defence system. He further called for greater involvement of the private sector in R&D, manufacturing and technology innovation, stressing that present global uncertainties demand a comprehensive reassessment of India's security and strategic framework.²

'Make in India' in defence has been the bedrock of India's strategic autonomy since 2014. The programme was aimed at transforming India into a global manufacturing hub and a dependable defence exporter but is yet to deliver up to the expectations.³ Though India's defence manufacturing has grown sharply, domestic production crossed 01.27 lakh cr in FY24 and is projected to exceed INR 1.5 lakh cr in FY25, with exports rising over INR 21,000 cr, it is Public Sector Undertakings (PSUs) that continue to dominate defence manufacturing.⁴ Private firms, while being agile and commercially successful, have not delivered to their full potential. They have often overpromised capabilities, under-delivered on timelines and relied heavily on government-funded Research and Development (R&D).⁵ Resultantly, India lacks world-class, high-ticket indigenous defence products, capable of competing with American, Russian or Chinese platforms. The gap between aspirations and accomplishments underscores systemic challenges that this article seeks to examine and suggest certain recommendations.

Promise vs Performance in the Defence Sector

Much of the development for Indian industry comes from hi-tech manufacturing and not proprietary platforms. This misalliance between erodes trust and extends India's dependence on foreign suppliers. Tata Advanced Systems Limited (TASL), for example, with revenues of INR 4,827 cr, has achieved manufacturing gains yet lacks a world-class defence platform. It leads the C-295 transport aircraft programme in alliance with Airbus, manufacturing forty aircraft with 85 per cent structure indigenisation.⁶ While this is a milestone, it is licensed production, not ground-up design. Similarly, defence vertical of Larsen & Toubro (L&T) accounts for record order

inflows of INR 6,185 cr, but it is only a small fraction of its INR 2,55,734 cr FY2024-25 revenues.⁷ Similarly, Bharat Forge has recorded INR 1,561 cr in defence revenue with an impressive INR 5,192 cr order book⁸ and Reliance⁹ and Adani Defence is steadily building export niches and scaling up incrementally, but with limited homegrown technology¹⁰. No Indian private enterprise has yet produced a platform on par with China's J-20 stealth fighter or Turkey's Bayraktar drones, underscoring the gap between manufacturing capability and full-spectrum indigenous innovation.

The defence industrial base continues to underinvest in strenuous R&D and technology creation and R&D intensity remains low at less than 1 per cent of turnover for most defence firms compared to 5 to 10 per cent amongst global peers like Lockheed Martin and BAE Systems.¹¹ The Technology Perspective and Capability Roadmap (TPCR 2025) provides a 10-to-15-year visibility of capability needs¹², can be converted into Technology Readiness Level (TRL) mapped challenges and funding pipelines that move projects from lab to field deployment. It can be used to reorientate industry and start-ups from build-to-print manufacturing toward demand-driven design, systems engineering and capability development. India's defence ecosystem must significantly enhance its investment in R&D, while ensuring that such efforts are closely aligned with the technological requirements projected in the Technology Perspective and Capability Roadmap (TPCR). Simultaneously, greater integration and utilisation of defence technology start-ups should be encouraged to drive innovation and agility in capability development.

Factors Hindering R&D and Innovation

Dependence on the Defence Research Development Organisation (DRDO). A critical bottleneck is underinvestment in R&D as both PSUs and private industry largely rely on DRDO for technology infusion.¹³ Indian private industry exhibits a risk-averse model as firms expect DRDO to shoulder early-stage R&D risks and private industry participates once technology matures. Though this yields modest successes like licensed production of assault rifles, C-295 assembly and Rafale fuselage production, but it also limits independent platform design.¹⁴ Incentives for disruptive technological innovations and patent creation are limited. In contrast, private firms abroad (SpaceX, Northrop) lead in developing disruptive technologies. Global defence giants spend billions annually on in-house R&D, building a self-sufficing pipeline of future technologies.¹⁵

Commercial vs Defence Divisions. The contrast is stark between the two business segments of large conglomerates. The commercial divisions are market-driven, agile and innovative, efficiently delivering global contracts and adapting rapidly to changing demands. In contrast, the defence divisions remain largely policy-driven, risk-averse, and subsidy-dependent, operating within uncertain procurement cycles that hamper sustained growth.¹⁶ A telling example is L&T, whose commercial

infrastructure revenue far exceeds that of its defence vertical, despite possessing the technical capability and scale to accomplish complex defence projects.

Tax Benefits, Offsets, and Foreign Collaborations. Private defence firms have effectively leveraged government incentives to expand their footprint, yet many collaborations continue to retain critical intellectual property abroad. For instance, the TASL-Airbus C-295 partnership has generated significant local employment but keeps core design Intellectual Property (IP) in Europe.¹⁷ Similarly, the TASL-Dassault Rafale collaboration enables fuselage assembly in India without conferring system-level design expertise. Adani Defence's joint venture with Sparton Corporation in sonobuoy manufacturing and Reliance Defence's growing ammunition export portfolio with future scale-up plans reveal industrial progress⁶, but the broader challenge persists.

The Software Paradox. India's globally acclaimed IT prowess is yet to find evocative expression in the defence domain. Leading technology giants such as TCS, Infosys and Wipro have not developed defence-grade command-and-control systems or secure battlefield software. This gap is largely due to structural barriers such as lengthy certification cycles, complex security clearance processes and a corporate penchant for commercial projects that promise quicker returns.¹⁸ As a result, yoking India's formidable software talent and technological expertise for defence applications remains a vast and largely untouched opportunity.

Reimagining India's Defence Innovation Ecosystem

Global R&D and Innovation Lessons for India's Defence Ecosystem. Global innovation models highlight the centrality of R&D intensity and private-sector dynamism in achieving technological advantage. Israel invests 6.3 per cent of its GDP (\$28.3 billion) in R&D, with 92 per cent funded by the private sector, while South Korea allocates 5.0 per cent of GDP, ensuring strong industrial integration. China, accounting for 26 per cent of global R&D spending, invests \$723 billion, with 77.6 per cent driven by private enterprises, whereas the United States leads absolutely with \$823.4 billion¹⁹ (3.4 per cent of GDP). These examples show that smaller nations gain outsized strategic returns through high R&D intensity, while major powers sustain technological dominance by leveraging private innovation at scale.

Developing Niche Strengths. India must develop niche strengths in artillery systems, aerostructures, drones and undersea-warfare technologies, while leveraging its IT expertise to build export-ready defence-grade command-and-control systems. Strengthening tier-2 and tier-3 supplier networks, modern testing and certification facilities and dedicated defence innovation labs will enhance self-sufficiency across the value chain. Integrating start-ups through streamlined grants, venture capital, and industry-academia partnerships will inject agility, innovation, and competitiveness.

Inchoating Capabilities – Aligning R&D with TPCR 2025. The Technology Perspective and Capability Roadmap (TPCR) 2025 is a cornerstone document guiding India's defence research, design and production priorities.²⁰ The 2025 edition aligns defence modernisation with emerging technological frontiers and the armed forces' long-term capability requirements. It emphasises focus areas like artificial intelligence, machine learning, autonomous, unmanned systems, cyber, space technologies, hypersonics, and advanced materials. The roadmap broadens the scope of unmanned systems across land, sea, and air domains, incorporating Manned–Unmanned Teaming and Unmanned Combat Aerial Vehicles. In the cyber domain, it prioritises zero-trust architectures, satellite cyber defence and resilience in electronic warfare. It envisions high-capacity communication satellites, enhanced space situational awareness and in-orbit refuelling and servicing for sustained strategic advantage.²¹

Translating TPCR into an R&D-to-Deployment Pipeline. The defence ecosystem must harmonise R&D, innovation and manufacturing with armed forces' capability priorities through a milestone-based, risk-sharing funding model. The approach must incentivise industry led R&D, empower start-up and MSME participation and promote dual-use technology pathways. Operationalisation requires prioritised technology challenge lists, longer-horizon procurement contracts and co-design mandates that reward indigenous IP creation and systems engineering excellence. Establishing testbeds and prototyping lanes for unmanned aerial vehicles, electronic warfare systems, and sensors will enable real-world validation, while R&D tax incentives tied to IP retention and milestone based MSME funding will de-risk innovation and strengthen the supply chain.

Institutionalising Innovation for Mission-Relevant Self-Reliance. A healthy feedback system between Services, DRDO and industry must drive adaptive planning and technology validation, ensuring indigenous research remains mission-relevant and deployment-focused. Institutionalising industry–academia–DRDO consortia in priority domains such as AI, sensors and propulsion, braced by tech-transfer onuses and procurement reforms, will entrench innovation. By aligning investments, partnerships and capability development with TPCR 2025, India can transition from a manufacturing-driven model to an innovation-led, self-reliant defence ecosystem.

Leveraging Defence-Tech Start-ups as India's Innovation Engines. Global supply chain disruptions due to conflicts in Ukraine and Gaza have underscored the urgent need for indigenous defence innovation. Start-ups are vital enablers offering agility, cost-effectiveness and the ability to develop and deploy technologies rapidly. The ecosystem now comprises over 1,000 defence start-ups and 147 specialised military technology companies, with venture capital interest in hardware and defence-tech ranking among the top investment themes. Success stories such as the ideaForge Initial Public Offering (IPO) with a 94 per cent surge, Paras Defence's strong market debut, and innovations from firms like AjnaLens and Grene Robotics, developer of the Indrajaal autonomous defence system reflect growing confidence in the sector.²²

Policy initiatives like iDEX, ADITI 1.0, Defence Export Promotion Policy, INDUS-X and the India–US Initiative on Critical and Emerging Technologies (iCET) are further nurturing this ecosystem. Collectively, these emerging enterprises have the potential to complement public sector undertakings and major private conglomerates in bridging the technology gaps identified in the TPCR 2025.

Conclusion

India's defence sector has made sound and steady progress marked by expanding manufacturing capacity through firms such as Tata Advanced Systems Limited, Bharat Forge, and L&T; growing export potential driven by Reliance and Adani; and an increasing role for start-ups in developing high-technology systems. Yet, the country still falls short of producing globally benchmarked indigenous platforms, comprehensive defence-grade software, and a seamlessly integrated civil–military innovation ecosystem. The way forward lies in harnessing private capital, start-up agility, and insights from global R&D benchmarks, while aligning efforts with the priorities outlined in the TPCR 2025. Achieving this transformation will require bold reforms in research and development, intellectual property management, and ecosystem integration to propel India from being a capable manufacturing partner to emerging as a full-spectrum defence innovator.

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² Effective use of Made-in-India equipment during Operation Sindoor bolstered India's reputation both regionally & internationally: Raksha Mantri, *Press Information Bureau*, 27 Oct 2025, accessed 04 Nov 2025, <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2182918>

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⁴ Defence production soars to an all-time high of Rs 1.51 lakh crore in FY 2024-25, *Press Information Bureau*, 09 Aug 2025, accessed 04 Nov 2025, <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2154551>

⁵ Saurabh Trivedi, Private sector share in defence production hits record 22.56% in FY 2024-25, *The Hindu*, 19 Aug 2025, accessed 04 Nov 2025, <https://www.thehindu.com/news/national/private-sector-share-in-defence-production-hits-record-2256-in-fy-2024-25/article69952036.ece>

⁶ Airbus Defence, "Airbus and Tata to deliver C295 aircraft for Indian Air Force," *Airbus.com*, 2023.

⁷ Larsen & Toubro, "L&T reports consolidated financial results for Q4 FY25," *larsentoubro.com*, May 2025.

⁸ Moneycontrol, "Bharat Forge bags Rs 4,500 cr in defence orders," *Moneycontrol.com*, 2024.

⁹ Reliance Defence, "Reliance Infra exports artillery ammunition," company reports and media coverage, 2024.

¹⁰ Adani Defence & Aerospace, "Adani and Sparton JV for sonobuoys," press release, 2024.

¹¹ Shayesta Nishat Ahmed, Strengthening Defence R&D: Role of Academia, *Manohar Parrikar Institute for Defence Studies and Analyses*, 20 Jan 2025, accessed 01 Nov 2025, <https://www.idsa.in/publisher/issuebrief/strengthening-defence-rd-role-of-academia>

¹² Adya Madhavan, "India's Military Wishlist: Understanding the Technology Perspective Capability Roadmap (TPCR)," *HighTechIR*, 2025.

¹³ *ibid*

¹⁴ Fortune India, "Tata Advanced Systems Ltd: Financial Data 2024," *fortuneindia.com*, 2024.

¹⁵ Shayesta Nishat Ahmed, Strengthening Defence R&D: Role of Academia, *Manohar Parrikar Institute for Defence Studies and Analyses*, 20 Jan 2025, accessed 01 Nov 2025,

<https://www.idsa.in/publisher/issuebrief/strengthening-defence-rd-role-of-academia>

¹⁶ Laxman Kumar Behera, India's Defence Industry: Achievements and Challenges, *Observer Research Foundation*, 06 May 2024, accessed 01 Nov 2025, <https://www.orfonline.org/research/india-s-defence-industry-achievements-and-challenges>

¹⁷ Tata Advanced Systems Limited, Annual General Meeting Notice FY2023-24, [tataadvancedsystems.com](https://www.tataadvancedsystems.com).

¹⁸ Laxman Kumar Behera, India's Defence Industry: Achievements and Challenges, *Observer Research Foundation*, 06 May 2024, accessed 01 Nov 2025, <https://www.orfonline.org/research/india-s-defence-industry-achievements-and-challenges>

¹⁹ <https://www.sipri.org/yearbook/2025>

²⁰ Technology Perspective Capability Roadmap, *Ministry of Defence*, accessed 01 Nov 2025, https://www.mod.gov.in/dod/sites/default/files/FINAL-TPCR-2025_0.pdf

²¹ Technology Perspective Capability Roadmap, *Ministry of Defence*, accessed 01 Nov 2025, <https://www.mod.gov.in/dod/en/technology-perspective-and-capability--roadmap>

²² Ankit K, "Leveraging Tech Startup Investment for India's War Readiness," *ORF Expert Speak*, 2025.

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