

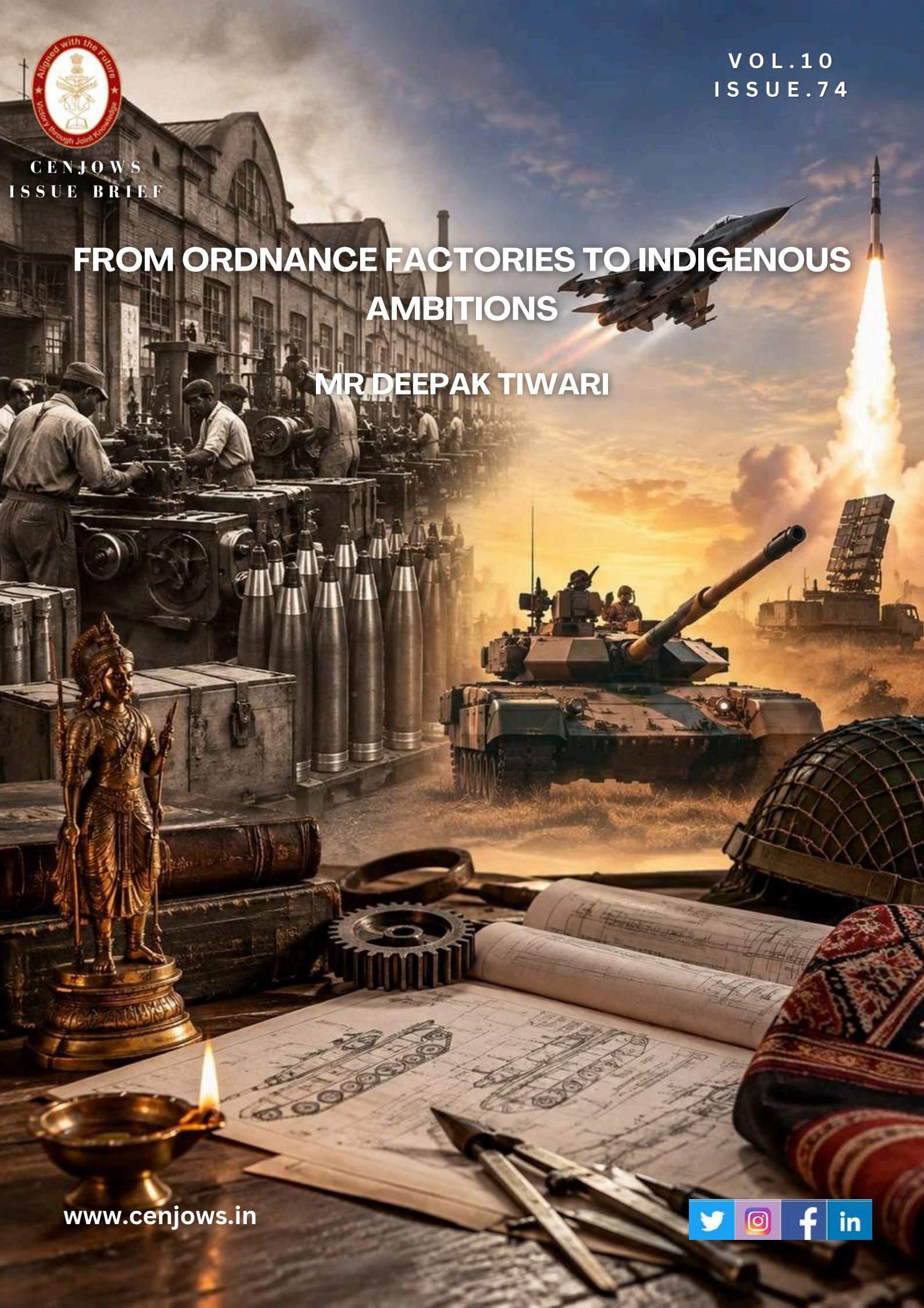


VOL.10
ISSUE.74

CENJOWS
ISSUE BRIEF

FROM ORDNANCE FACTORIES TO INDIGENOUS AMBITIONS

MR DEEPAK TIWARI



www.cenjows.in



CENJOWS ISSUE BRIEF

Volume 10 Issue 74

SEP 2026



CENJOWS

(Established: 2007)

Room No 301, B-2 Wing, 3rd Floor
Pt Deendayal Antyodaya Bhawan,

CGO Complex, Lodhi Road
New Delhi –110003 (INDIA)

Telephone Nos: 011-24364881,
24366485

Fax: 011-24366484

Website: www.cenjows.in

E-mail: cenjows@cenjows.in

ABOUT US

CENJOWS was raised in 2007 as an independent think tank, registered under the Societies Registration Act, 1860. This aims to promote Jointness as a synergistic enabler for the growth of Comprehensive National Power and provide alternatives in all dimensions of its applications through focused research and debate.

Starting Year : 2017

Year of Publication : 2026

Frequency : Weekly

Language : English

Publisher : Maj Gen (Dr) Ashok Kumar, VSM (Retd) Director General,
CENJOWS
301, B-2 Wing, 3rd Floor
Pt. Deendayal Antyodaya Bhawan CGO Complex,
Lodhi Road
New Delhi-110003

Editor : Maj Gen (Dr) Ashok Kumar, VSM (Retd) (dg@cenjows.in)

Deputy Editor : Dr Ulupi Borah, Distinguished Fellow
(distinguishedfellow1@cenjows.in)

Editorial Board :

Brig K Ranjeev Singh, VSM (ddg@cenjows.in)
Col Ajay Kumar Rajak, SM
(secy@cenjows.in)

Gp Capt Ashish Kumar Gupta (Retd)
(seniorfellow2@cenjows.in)

Dr Ulupi Borah, Distinguished Fellow
(distinguishedfellow1@cenjows.in)

Dr Monojit Das, Senior Fellow, PRO
(monojit.das@cenjows.in)

301, B-2 Wing, 3rd Floor
Pt. Deendayal Antyodaya Bhawan
CGO Complex, Lodhi Road
New Delhi-110003

Publication Head : Ms Vaibhavi Katal

All correspondence may be addressed to:

Editor

Centre for Joint Warfare Studies (CENJOWS) 301, B-2 Wing, 3rd
Floor
Pt Deendayal Antyodaya Bhawan CGO Complex, Lodhi
Road
New Delhi-110003
Telephone: (91-11) 24366485/Telefax: (91-11) 24366484 e-mails:
cenjows@cenjows.in / cenjows@yahoo.com Website: <http://cenjows.in>

© Centre for Joint Warfare Studies

Price: Rs 300/- INR

All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording or by any information storage and retrieval system without permission from the DG, CENJOWS, New Delhi.

FROM ORDNANCE FACTORIES TO INDIGENOUS AMBITIONS

CONTENTS

Title	Page No
Introduction	5
The Ordnance Factories: Provenance and Perseverance	6
Hindustan Aircraft to Hindustan Aeronautics: Ambition Meets an Engine Problem	10
An Institution for Research: The Founding of DRDO	12
The Licence-Production Model: A Critical Balance Sheet	12
Bureaucratic Inertia: The User-Developer Problem	14
The Missile Turning Point: IGMDP and a Different Institutional Logic	15
Conclusion	17
References	18

CENTRE FOR JOINT WARFARE STUDIES



CENJOWS

**From Ordnance Factories
to Indigenous Ambitions
(1947-1990)**



**Mr Deepak Tiwari is a
Technical Research
Assistant at CENJOWS**

Introduction

The defence industrial base that India inherited post-independence was built for someone else's needs. It was fragmented, built for basic, supportive and aged equipment, and incapable of addressing the immediate needs of a large nation surrounded with hostile neighbours. On a general notion, it can be characterised as a remnant of wars that India had been dragged into against its will. The 18 ordnance factories scattered across the subcontinent, the aircraft repair sheds at Bangalore, the ship-repair yards at Bombay and Calcutta, had all been designed to keep imperial forces supplied. They were not meant to, or were capable of delivering, a sovereign state the means to design and build its own weapons.¹ For the next four decades, Indian planners, scientists and soldiers worked through a slow and often frustrating process of turning a colonial repair-and-supply apparatus into something that could, at least in parts, think and build for itself. The period between 1947 and 1990 offers an uneven institutional experiment in which, genuine scientific ambition collided repeatedly with bureaucratic caution, industrial inexperience and the plain difficulty of

building complex machines. The year 1990 was a defining era for India and the world. As India entered into the 21st century amid the post-cold war geopolitical shift, the objectives and approach of gaining self-reliance through indigenisation promised by past leaders was renewed. This renewed push had to be compromised again because of the Kargil incident and various sanctions put on newly emerged nuclear India. These restraints caused the overall organisational culture to remain production-oriented, and away from innovation driven capability development consortium. Although the inconsistent attempts led by a crisis cornered planning could not deliver the intended results, it had built the institutions, trained manpower and hammered hard-won lessons that made the missile and space successes of the following decades possible. This article consolidates all these multidirectional trajectories which could not meet at their intended point of confluence but are still instrumental in establishing a foundation which can be fine-tuned to innovate and annihilate.

This article presents an interesting journey of the rise of India's flagship institutions like DRDO and HAL with an ambition and vision to create a capable defence industrial complex. Through a chronological analysis of this evolution, this article presents a distinction between the vision, planning and execution behind the organisations and their intended capabilities.

The Ordnance Factories: Provenance and Perseverance

The ordnance factories found their provenance not in 1947 but way back in 1801 when the East India Company set up a gun carriage agency at Cossipore on the banks of the Hooghly River. Even before that, the British had established a Board of Ordinance in 1775, followed by the Gun Power Factory in 1787 at Ishapore. By the time the British left, 18 ordnance factories existed on Indian soil, producing small arms, ammunition and basic ordnance items for a colonial army.² The strategic and technological core, such as the bombers, advanced aircraft and heavy engineering, remained firmly in Britain.³ Indian workers and engineers had learnt to repair, assemble and manufacture at scale, but they had not been permitted to design. The strategic capability which was kept away from Indian industries resulted in a slow and protracted process of rebuilding a capable military force post-independence.

The 18 ordnance factories were clustered into 4 functional groups based on the nature of the products they made. A quick analysis of these factories reveals that the

technology they had been producing and repairing was quite old and only meant to impart basic defensive posture against an aggressive threat.

Group	Establishment	Specialisation	Current DPSU
Group A (Small Arms & Artillery Systems)	Gun & Shell Factory, Cossipore (GSF)	Medium and large-calibre artillery shells, naval gun components, and specialized mortar systems.	Advanced Weapons and Equipment India Limited (AWEIL)
	Gun Carriage Factory, Jabalpur (GCF)	Design, carriage assembly, and system integration of heavy towed artillery and air defence gun mounts.	AWEIL
	Rifle Factory Ishapore (RFI)	Lee-Enfield rifle, the 7.62mm INSAS rifle, and modern 7.62x51mm assault rifles (like the <i>Ghatak</i>)	AWEIL
	Ordnance Factory, Kanpur (OFC)	Large-calibre gun barrels, armoured vehicle recovery mechanisms, and heavy forgings.	AWEIL
Group B (Ammunition & Explosives)	Ammunition Factory, Khadki (AFK)	Ammunition Factory, Khadki (AFK)	Munitions India Limited (MIL)
	Cordite Factory, Aruvankadu (CFA)	Blended nitrocellulose-based propellants (Cordite) and double-base propellants.	MIL

	High Explosives Factory, Khadki (HEF)	Primary and secondary high explosives, initiators, and chemical formulations.	MIL
	Ordnance Factory, Khamaria (OFK)	Multi-caliber ammunition ranging from anti-submarine rockets to large artillery shells (105mm, 122mm, 130mm, and 155mm)	MIL
	Ordnance Factory, Dehu Road (OFDR)	Pyrotechnics, hand grenades, smoke munitions, and signal flares	MIL
Group C (Metallurgical & Engineering Ancillaries)	Metal & Steel Factory, Ishapore (MSF)	Industrial metallurgy for military applications	Yantra India Limited (YIL)
	Ordnance Factory, Ambernath (OFA)	Non-ferrous extruded products (copper, brass, aluminium alloys)	YIL
	Ordnance Factory, Katni (OFKAT)	Large-scale smelting and manufacturing of copper cups, brass discs for ammunition shells, and cupro-nickel alloys	YIL
	Ordnance Factory, Muradnagar (OFM)	Heavy steel castings for armoured fighting vehicles and structural track assemblies.	YIL

	Machine Tool Prototype Factory, Ambernath (MPF)	Custom machine tool design and weapon system prototyping	Armoured Vehicles Nigam Limited (AVNL)
	Ordnance Factory, Dum Dum (OFDC)	Precision structural hardware, steel link belts for automatic machine guns, and transport containers.	YIL
Group D (Logistics, Textiles & Optical Instrumentation)	Ordnance Clothing Factory, Shahjahanpur (OCFS)	Cold-weather combat apparel, tactical gear, and extreme-altitude clothing systems.	Troop Comforts Limited (TCL)
	Ordnance Factory, Dehradun (OFDUN)	Optical instruments, targeting sights, and fire control assets	India Optel Limited (IOL)

Table 1: Erstwhile Ordnance Factory Board establishments post 1947, their specialisation and current DPSUs, **Source:** PIB Reports and MoD websites

The new government's outlook, understandably, was to treat this inherited apparatus as the foundation of a self-sufficient defence-industrial base. Nehru's government turned the ordnance factories along with core sectors such as steel and heavy machinery, into the list of industries reserved exclusively for the central government under the Industrial Policy Resolution of 1948. This plan, instead of having a review, was later reaffirmed under the Second Five-Year Plan of 1956.⁴ Yet growth in the first post-independence decade was strikingly modest. Despite fighting a war with Pakistan within months of independence, no new ordnance factory was commissioned in the entire 1950s. The existing factories kept producing what they had always produced, small arms, ammunition, mines and explosives worth roughly seven to eight million US dollars at independence.⁵ It was only after the war with China in 1962 exposed the country's military weakness that the ordnance network began to expand. As a result, the numbers grew from 18 factories in 1947 to 35 by the mid-1980s.⁶

What the ordnance factories did learn to do well, over these decades, was to absorb technology transferred from abroad. The Vijayanta tank, built under licence from the British firm Vickers at the newly established Heavy Vehicles Factory in Avadi in the

early 1960s, and later the Soviet-origin T-72, renamed Ajeya, both went through Indian production lines with steadily rising indigenous content.⁷ This was genuine industrial learning, and it should not be dismissed. But it was learning of a particular, bounded kind, in that it built the capacity to manufacture someone else's design under contract, not the capacity to develop one. This gap, although found expedient during that time, only grew and became the largest vulnerability in Indian defence.

Hindustan Aircraft to Hindustan Aeronautics: Ambition Meets an Engine Problem

If the ordnance factories represent continuity, Hindustan Aircraft Limited represents the country's first real gesture toward original aerospace design. Its story captures both the promise and the frustration of the entire period. The company was founded in Bangalore in December 1940 by the industrialist Walchand Hirachand together with the princely state of Mysore. It was built to assemble training and combat aircraft for the ongoing war efforts. The Government of India took a stake within a year and effectively nationalised the company by 1942.⁸ It spent the 1940s and much of the 1950s overhauling aircraft that Indian Air Force inherited from the British such as Hawker Tempest FB II, Supermarine Spitfire and Douglas C-47 Dakota etc. The company did not put any efforts in designing and developing its own aircrafts because of the various economic, policy and geopolitical constraints, against which the newly formed government showed no resistance whatsoever.⁹

The turning point came in the mid-1950s, when the company brought in the German aeronautical engineer Kurt Tank, designer of the wartime Focke-Wulf Fw 190, to lead a genuinely Indian fighter-bomber. The result, the HF-24 Marut, first flew in 1961 and entered service in 1967 as the first fighter jet designed and built anywhere in Asia outside the Soviet Union. It is a significant achievement and deserves to be remembered as one despite its inability to achieve intended results due to an underpowered engine.¹⁰ The Marut is also a case study of how a single unresolved technical dependency can cap an entire indigenous programme. The engine needed to power the proposed supersonic flight of this aircraft, Bristol Orpheus with an afterburner, could not be realised. After an intense lookout for an alternate engine, the indecision and geopolitical rifts, left the HAL with a choice which could only produce 21.57 kN against the original proposed thrust of 36.25 kN.¹¹ What could have been

established as a foundation of aircraft engine technology in India, eliminating the persistent critical dependency, was refused to be funded by the then government.¹² When Rolls-Royce offered to co-develop a more powerful Orpheus specifically for the Marut, the Indian government declined the offer citing roughly 3 million pounds development cost as too high. Conceived to fly at Mach 2, it never exceeded Mach 0.93, because India could never secure an engine powerful enough to realise Kurt Tank's design.¹³ With no alternative in sight, the Marut remained permanently underpowered, was capped at 147 units, and was retired by 1990 having never flown faster than sound.¹⁴

The lesson embedded in the Marut's story is not that Indian engineers lacked ability. Kurt Tank's airframe was aerodynamically sound, and the aircraft performed creditably in the 1971 war, flying hundreds of ground-attack sorties over the Rajasthan desert and returning from combat damage more than once with an engine shot away. The lesson is that propulsion, the hardest and most jealously guarded technology in military aviation, could not be bought, borrowed or licensed on Indian terms during this period.¹⁵ The fact that was denied the urgency it required was that no skill in structures and aerodynamics could substitute for an engine. It is a pattern that recurs, in different form, in the story of the Arjun tank two decades later, suggesting a sort of culture or a self-inflicted restraint that no one knows how to get rid of.

HAL itself was formally reconstituted as Hindustan Aeronautics Limited in October 1964, merging Hindustan Aircraft with the group set up to licence-manufacture the Soviet MiG-21.¹⁶ From that point, the company's core business for the better part of two decades was licence production, of the MiG-21, then the MiG-27 and the Anglo-French Jaguar strike aircraft, alongside French-designed Cheetah and Chetak helicopters. Over the year, HAL added more indigenous aircrafts to its portfolio such as Glider, HT-2, HPT32 trainer aircrafts, jet trainers such as Kiran MkI and MkII and finally the Tejas.¹⁷ However, the original weakness, the engine, it sustained and fostered, has now become a critical national security vulnerability. This was less a failure of intent than a rational response to technological isolation after 1962, when neither the Americans nor Western Europe would sell India a modern supersonic interceptor. The Soviet Union, thus, stepped in with the MiG-21, crucially, an offer of licence manufacture that no Western supplier was able to match.¹⁸

An Institution for Research: The Founding of DRDO

Parallel to the tale of India's defence industrial base runs an institutional one. In 1958, the government merged the Defence Science Organisation with the Army's Technical Development Establishments (TDEs) and the Directorate of Technical Development and Production (DTDP) of the Ordnance Factories into a single body. DRDO began small, with about ten laboratories, on the logic that India could not keep buying its way out of every capability gap and needed a dedicated scientific establishment. It was established as India's premier defence research organisation to design weapons rather than merely manufacture them under licence.¹⁹

What actually happened inside DRDO for its first two decades illustrates a structural problem that has followed the organisation ever since. The three services, having no design or development responsibility of their own, approached DRDO not as a partner in a shared national project but as an external vendor. Their attempts were judged against whatever was available and proven on the battlefield with the international arms market. As one contemporary account put it with unusual bluntness, if the services could buy a MiG-21 abroad, they wanted a MiG-21 from DRDO.²⁰ This vendor-customer dynamic can explain, for most parts, why DRDO's early projects struggled to satisfy the services. It was beyond any lack of scientific talent or shortage of funds. Project Indigo, an attempt in the 1960s to reverse-engineer the Soviet SA-2 surface-to-air missile, was abandoned without full success. Its successor, Project Devil, along with the parallel Project Valiant aimed at an intercontinental ballistic missile, likewise fell short of its goals during the 1970s ("Defence Research and Development Organisation" 2026). Yet these projects were not wasted effort. The propulsion, guidance and materials expertise that DRDO's Hyderabad-based Defence Research and Development Laboratory accumulated through these repeated attempts became, in the following decade, the technical foundation on which India's missile programme was actually built.

The Licence-Production Model: A Critical Balance Sheet

By the mid-1980s, enough time had passed for Indian analysts themselves to take stock of what nearly a quarter-century of licence production had and had not delivered. Their assessment is worth taking seriously precisely because it came from within the policy community rather than from outside critics. Deba Mohanty's detailed study for

the Bonn International Centre for Conversion, drawing on Ministry of Defence annual reports, Comptroller and Auditor General findings and interviews with serving officials, described the period from the early 1960s to the mid-1980s candidly as an "era of licence-manufacture," and little more.²¹ The analysis cites the researcher Ajay Singh's argument that India suffered close to three decades of stagnation in indigenous design and development after 1962. A quarter-century separated the Marut from the Light Combat Aircraft that would eventually replace it, and a similarly long gap separated the HT-2 basic trainer from its successor, the HPT-32.²²

The record on licence production is genuinely mixed rather than uniformly disappointing. Plants such as the Heavy Vehicles Factory at Avadi and HAL's Bangalore and Nasik complexes built real manufacturing competence: tolerances, quality assurance, supply-chain management, skills a country building an industrial base from almost nothing could not otherwise have acquired quickly. Some licensed products achieved impressively high indigenous content: the SS-11 anti-tank guided missile, produced under licence from the French firm Aerospatiale by the newly formed Bharat Dynamics Limited from 1970 onwards, reached more than seventy per cent indigenous content by value, with only the warhead remaining substantially foreign. This was exactly the kind of graduated absorption of technology by which recipient countries typically caught up: manufacturing, then modifying, then eventually originating.

The trouble is that this graduated absorption stalled at exactly the point where it mattered most for strategic autonomy: the transition from production know-how to design authority. Licence agreements transfer the right to build a fixed design; they do not transfer the underlying reasoning, the trade-off decisions and the iterative failure-and-correction process by which that design was arrived at. A technician who had spent fifteen years assembling MiG-21s to Soviet blueprints had become an excellent aircraft builder, but this did not make him, or his institution, capable of deciding what a new fighter's wing loading or engine bypass ratio ought to be. Plant utilisation across the licence-manufacturing years hovered at only forty to fifty per cent of rated capacity, even as the sophistication of what was produced remained squarely low-to-medium. Meanwhile, the proportion of the defence budget devoted to research and development stayed under ten per cent throughout these decades, a figure that alone explains much of why design capability lagged so far behind manufacturing capability.

Money went overwhelmingly into buying and building known designs, not into the riskier and slower business of creating new ones.

There is also a strategic cost to licence dependence beyond indigenous-content percentages. It ties military modernisation to the political relationship with a single supplier. India's growing reliance on Soviet equipment after 1962, eventually close to 70% of total arms acquisitions by the early 2000s, gave India a partner willing to share technology on generous terms. But it also meant Indian defence planning was hostage, in a quiet but real sense, to the health of a bilateral relationship and to Moscow's own industrial priorities. It was a vulnerability made visible when the Soviet Union itself dissolved in 1991, just past the period under discussion here.²³

Bureaucratic Inertia: The User-Developer Problem

If licence production reveals a structural limit on how far imported technology could carry Indian self-reliance, the Arjun main battle tank programme, which begun in 1974, reveals a different and more damaging criticality. The corrosive effect of an unstable relationship between the scientific developer and the military user had taken its roots as an issue that persisted in different levels. The Cabinet Committee on Political Affairs sanctioned the project in March 1974 at an estimated cost of fifteen and a half crore rupees, with the newly created Combat Vehicles Research and Development Establishment tasked with designing a forty-tonne tank around a 105-millimetre gun.²⁴ What followed over the next two decades demonstrated how repeated changes to the General Staff Qualitative Requirement, the Army's own specification document, can defeat an engineering programme regardless of the scientific competence brought to it. Midway through development the Army revised its requirement from a 105-millimetre to a 120-millimetre main gun, a change that forced a structural redesign of the entire hull and turret to absorb the greater recoil and weight. By the time trials were conducted between 1993 and 1996, the cost had risen from fifteen and a half crore to over three hundred crore rupees, and evaluators identified ten further shortcomings needing correction before induction.²⁵

What makes the Arjun case a study in bureaucratic inertia rather than simple technical failure is the funding structure underlying it. The programme was financed almost entirely by DRDO, with no comparable financial commitment from the Army as a user, an arrangement later identified as a central reason why the programme dragged on.

Neither DRDO as executing agency nor the Directorate General of Quality Assurance (DGQA) as certifying authority accepted responsibility for the delay, and each requirement revision reset the clock without anyone bearing its cost. When the Comptroller and Auditor General examined the programme in 2014, its report placed the blame for delayed induction on the Army for continually adding requirements even while placing large import orders for Russian T-90 tanks.²⁶ The tank finally entered service in 2004, three decades after sanction, by which point the very idea of what an indigenous tank ought to be had been overtaken by changing doctrine and threat perceptions.

The structural insight that emerges from placing the Marut and the Arjun side by side is this, bureaucratic inertia in Indian defence production during this period rarely took the form of simple sloth or incompetence. It took the form of divided accountability. No institution owned both the requirement and the consequence of changing it. No institution owned both the technology gap and the cost of closing it. DRDO could be blamed for delay without bearing the political cost of that delay, the services could revise requirements without bearing the engineering cost of the revision, and the ministry could authorise parallel imports without formally admitting that the indigenous programme had failed.²⁷ This diffusion of responsibility, more than any deficit of scientific talent, is what repeatedly stretched Indian development programmes across decades rather than years.

The Missile Turning Point: IGMDP and a Different Institutional Logic

Against this backdrop, the Integrated Guided Missile Development Programme, sanctioned in July 1983, stands out as a genuinely different institutional experiment, and it is worth asking why it succeeded where the Marut and the Arjun stalled. Its origins lay in DRDO's accumulated but scattered expertise from Projects Indigo, Devil and Valiant, combined with the technology demonstrated by the Indian Space Research Organisation's SLV-3, the country's first successful orbital launch vehicle in 1980.²⁸ Defence Minister R. Venkataraman made one unusually consequential decision, when scientists proposed developing each missile system one after another, he insisted that four similar such projects to be pursued simultaneously. These are, a short-range surface-to-surface missile that became Prithvi, a medium-range surface-to-air missile that became Akash, a short-range surface-to-air missile that became

Trishul, and an anti-tank missile that became Nag. A re-entry-vehicle demonstrator later named Agni was added as a fifth strand. A. P. J. Abdul Kalam, fresh from directing the SLV-3 programme at ISRO, was brought in to lead DRDO's missile laboratory with a mandate to run all five projects as one coordinated national effort rather than as separate, competing initiatives.²⁹

This structure mattered because it addressed directly the two shortfalls that had dogged the Marut and the Arjun. It concentrated authority in a single project leadership answerable for the whole programme rather than distributing responsibility across DRDO, the services and the Ministry in ways that let each add to the delay. It also treated funding and requirements as fixed once launched, rather than allowing the scope creep that had repeatedly reset the Arjun's development clock. Results followed quickly by the standards of the preceding decades. Prithvi's first test flight came in February 1988, the Agni demonstrator flew successfully in May 1989, and Prithvi entered Army service in 1994.³⁰

The programme also confronted a constraint neither the Marut nor the Arjun had faced in quite the same way, i.e., coordinated international technology denial. Following the 1987 establishment of the Missile Technology Control Regime by Canada, France, Germany, Italy, Japan, the United Kingdom and the United States, member states began systematically blocking India's access to components judged relevant to missile development. Few such critical blockages were, the phase shifters needed for Akash's radar to the magnesium alloy used in Prithvi's wings and the servo-valves required for the Agni and Prithvi control systems.³¹ Rather than abandoning the programme, as had effectively happened with the Marut's engine problem two decades earlier, the IGMDP team assembled a consortium of DRDO laboratories, private industry and academic institutions to develop each denied component indigenously. The effort slowed progress, by DRDO's own later admission, but it succeeded in the context that every component the control regime tried to deny India was eventually built domestically. Where a single unsolved propulsion problem had capped an entire aircraft programme in the 1960s, the missile establishment of the 1980s treated technology denial as an engineering problem to be solved, and had, by then, built enough institutional depth to do so.

Conclusion

By 1990, the sum of India's defence-industrial experience since independence resists any simple verdict. Successive licensed production of the Vijayanta, the MiG-21, the Jaguar and the T-72 had built genuine manufacturing depth and supply-chain competence, but not the design regime that would let India originate a fighter, tank or missile on its own specifications with confidence. The HF-24 Marut had shown that Indian engineers could design a credible combat aircraft, only to be undone by an engine dependency the country could not resolve in the 1960s. The Arjun programme, already sixteen years old by 1990 and still a decade and a half from service entry, showed how the absence of clear, singularly held accountability between developer and user could stretch a technically feasible project across a generation. Against these two cautionary stories, the Integrated Guided Missile Development Programme, only seven years into its life in 1990 but already having flown both Prithvi and the Agni demonstrator successfully, offered the clearest evidence that issues when treated as an engineering problem rather than an excuse, could deliver results within a decade rather than three.

What the 1947-1990 period actually built, then, was not self-reliance but the precondition for it: a network of laboratories under DRDO, a trained aerospace industry at HAL, an ordnance base capable of absorbing and eventually modifying foreign designs, and a set of hard institutional lessons about what happens when accountability is divided and what happens when it is not. Every major indigenous success that followed 1990, from the operationalisation of the Agni series to the Light Combat Aircraft's eventual induction, drew directly on scientists, laboratories, test ranges and organisational structures built, however unevenly, in the four decades before. The ambitions of 1947 were not fulfilled by 1990. But the institutions capable of fulfilling them, eventually, were already standing.

Declaration

I declare that this manuscript is being submitted exclusively to CENJOWS for publication consideration, is original, and has not been published or submitted elsewhere. I further certify that it contains no classified, restricted, or sensitive information and is based entirely on open-source material suitable for publication in the public domain

ENDNOTES

¹ Stephen P. Cohen and Sunil Dasgupta, *Arming Without Aiming: India's Military Modernization* (Washington, D.C.: Brookings Institution Press, 2010), 76–82, <https://www.brookings.edu/books/arming-without-aiming/>.

² Sareen, Col Rahul. EVOLUTION OF INDIA'S AMMUNITION LANDSCAPE. Web Article WA/58/25. Center for Joint Warfare Studies (CENJOWS), 2025. https://cenjows.in/wp-content/uploads/2025/12/Col_Rahul_Sareen_WA2.pdf.

³ Mohanty, Deba R. Changing Times? India's Defence Industry in the 21st Century. BICC Paper 36. Bonn: Bonn International Center for Conversion, 2004. <https://www.files.ethz.ch/isn/14474/paper36.pdf>.

⁴ Ibid

⁵ Ibid

⁶ Sareen, Col Rahul. EVOLUTION OF INDIA'S AMMUNITION LANDSCAPE. Web Article WA/58/25. Center for Joint Warfare Studies (CENJOWS), 2025. https://cenjows.in/wp-content/uploads/2025/12/Col_Rahul_Sareen_WA2.pdf.

⁷ Behera, Laxman Kumar. *Indian Defence Industry: Issues of Self-Reliance*. IDSA Monograph Series No. 21. New Delhi: Institute for Defence Studies and Analyses, 2013.

⁸ Khan, Saqib. *The History of Indian Aviation: Industry, Policy, and Development*. New Delhi: Oxford University Press, 2018.

⁹ Piramal, Gita. *Business Legends*. New Delhi: Penguin Books, 1998. (Chapter 9 details Walchand Hirachand's industrial ventures, the founding of HAL with Mysore State, and the government takeover in 1942).

¹⁰ TOI News Desk. "Marut: Before Tejas, There Was Marut: India's First Supersonic Fighter Jet and the Lessons It Offers." *The Times of India*, May 19, 2026. <https://timesofindia.indiatimes.com/defence/news/before-tejas-there-was-marut-indias-first-supersonic-fighter-jet-and-the-lessons-it-offers/articleshow/131193935.cms>.

¹¹ Ibid

¹² Pushpindar Singh, *HAL HF-24 Marut: Asia's First Jet Fighter* (New Delhi: Society for Aerospace Studies, 2007), 45–62.

¹³ Mishra, Tarun. "Meet India's HF-24 Marut: A Fighter Jet Designed by a Former Nazi Scientist, Meant to Go Supersonic." *News & Analysis. Wion, WION*, July 13, 2025. <https://www.wionews.com/photos/meet-india-s-hf-24-marut-a-fighter-jet-designed-by-a-former-nazi-scientist-meant-to-go-supersonic-1752410600942>.

¹⁴ Ibid

¹⁵ Pushpindar Singh, *HAL HF-24 Marut: Asia's First Jet Fighter* (New Delhi: Society for Aerospace Studies, 2007), 45–62.

¹⁶ Hindustan Aviation Limited (HAL). "Our History." Official Website. 2026. <https://hal-india.co.in/our-history>.

-
- ¹⁷ Jamadagni, G. S. "HAL: The Backbone of the Indian Air Force." Opinion. The Hindu, October 26, 2018. <https://www.thehindu.com/opinion/hal-the-backbone-of-the-indian-air-force/article62110256.ece>.
- ¹⁸ Mohanty, Deba R. Changing Times? India's Defence Industry in the 21st Century. BICC Paper 36. Bonn: Bonn International Center for Conversion, 2004. <https://www.files.ethz.ch/isn/14474/paper36.pdf>
- ¹⁹ Ministry of Defence, Government of India, "About DRDO: Origin & Evolution," Defence Research and Development Organisation, accessed July 23, 2026, <https://www.drdo.gov.in/about-drdo/history>. & Laxman Kumar Behera, *India's Defence Industry: Achievements and Challenges* (New Delhi: Institute for Defence Studies and Analyses / Pentagon Press, 2013), 45–48, <https://www.idsa.in/monograph/IndiasDefenceIndustry>.
- ²⁰ Mohanty, Deba R. Changing Times? India's Defence Industry in the 21st Century. BICC Paper 36. Bonn: Bonn International Center for Conversion, 2004. <https://www.files.ethz.ch/isn/14474/paper36.pdf>
- ²¹ Ibid
- ²² Richard A. Bitzinger, "Defense Industries in Asia and the Technonationalist Impulse," Contemporary Security Policy 36, no. 3 (2015): 453–472, DOI: 10.1080/13523260.2015.1111649.
- ²³ Sameer Lalwani, Frank O'Donnell, Tyler Sagerstrom, and Akriti Vasudeva, "The Influence of Arms: Explaining the Durability of India-Russia Alignment," Journal of Indo-Pacific Affairs 4, no. 1 (2021): 4–12, https://www.stimson.org/wp-content/uploads/2021/01/JIPA_Lalwani.pdf.
- ²⁴ Comptroller and Auditor General of India, *Report of the Comptroller and Auditor General of India for the Year Ended March 1997: Union Government (Defence Services)*, Report No. 5 of 1998 (New Delhi: Government of India, 1998), chap. 3, "Development of Main Battle Tank - Arjun," <https://cag.gov.in>.
- ²⁵ Stephen P. Cohen and Sunil Dasgupta, *Arming Without Aiming: India's Military Modernization* (Washington, D.C.: Brookings Institution Press, 2010), 76–82, <https://www.brookings.edu/books/arming-without-aiming/>.
- ²⁶ Comptroller and Auditor General of India, *Report of the Comptroller and Auditor General of India for the Year Ended March 1997: Union Government (Defence Services)*, Report No. 5 of 1998 (New Delhi: Government of India, 1998), chap. 3, "Development of Main Battle Tank - Arjun," <https://cag.gov.in>.
- ²⁷ Mohanty, Deba R. Changing Times? India's Defence Industry in the 21st Century. BICC Paper 36. Bonn: Bonn International Center for Conversion, 2004. <https://www.files.ethz.ch/isn/14474/paper36.pdf> & Stephen P. Cohen and Sunil Dasgupta, *Arming Without Aiming: India's Military Modernization* (Washington, D.C.: Brookings Institution Press, 2010), 76–82, <https://www.brookings.edu/books/arming-without-aiming/>.
- ²⁸ A. P. J. Abdul Kalam and Arun Tiwari, *Wings of Fire: An Autobiography* (Hyderabad: Universities Press, 1999), 105–142. & Gaurav Kampani, "Stakeholders in the Indian Strategic Missile Program," *The Nonproliferation Review* 10, no. 3 (2003): 48–70, <https://doi.org/10.1080/10736700308436943>.
- ²⁹ Ibid
- ³⁰ Chris Smith, *India's Ad-hoc Arsenal: Direction or Drift in Defence Policy* (Oxford: Oxford University Press, 1994), 152–188.
- ³¹ Gaurav Kampani, "Stakeholders in the Indian Strategic Missile Program," *The Nonproliferation Review* 10, no. 3 (2003): 48–70, <https://doi.org/10.1080/10736700308436943>.