



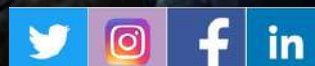
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CRITICAL MINERALS DEPENDENCE AND INDIA'S DEFENCE INDIGENISATION: EVALUATING CONSTRAINTS ON STRATEGIC AUTONOMY

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Critical Minerals Dependence and India's Defence Indigenisation: Evaluating Constraints on Strategic Autonomy



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Abstract

This paper evaluates the intersection of critical mineral supply chains and India's military modernisation, exposing what it terms the 'Atmanirbharta Paradox'. While the Atmanirbhar Bharat initiative has accelerated downstream platform assembly and expanded domestic defence exports, this success masks a profound upstream vulnerability. By decoupling downstream manufacturing from material sovereignty, the current paradigm leaves India systemically dependent on external supply chains, most notably those controlled by the People's Republic of China, for the technological components that drive advanced military hardware.

The study establishes that asymmetric reliance on a primary geopolitical adversary for fundamental inputs like gallium, germanium, and rare earth elements imposes severe material, operational, minilateral, and geopolitical constraints on India's strategic autonomy. It argues that New Delhi's contemporary countermeasures, including strategic stockpiling, overseas asset acquisition through KABIL (Khanij Bidesh India Limited), and 'friend-shoring' via minilateral frameworks like the MSP (Minerals Security Partnership) and ACITI (Australia-Canada-India Technology and Innovation Partnership), remain insufficient because they fail to address the core deficit in domestic mid-stream processing and advanced metallurgy.

The paper concludes that true self-reliance cannot be achieved through value-based metrics like those in the Defence Acquisition Procedure (DAP) 2020. Instead, it proposes a radical shift toward upstream material sovereignty. This transformation requires three institutional interventions: the convergence of the ministries of defence, mines, and environment to designate 'Strategic Defence Assets', the introduction of a Technological Criticality Index (TCI) within the procurement framework, and the aggressive utilisation of defence offsets to de-risk and build out domestic mid-stream refining infrastructure.

Keywords

Atmanirbharta Paradox, Critical Minerals, Defence Indigenisation, Strategic Autonomy, Weaponisation of Interdependence, Mid-Stream Processing, India-China Rivalry.

Introduction

Critical Minerals are at the core of the twenty-first-century global economy. They are the building blocks of high-technology, green energy transition, and advanced manufacturing. While the civilian applications of these resources dominate public discourse, their most non-negotiable and highly securitised role lies within modern military hardware. Without these minerals, a country cannot build modern military equipment or embark on space missions¹. For instance, elements like gallium and germanium are the foundational semiconductors required for Active Electronically Scanned Array (AESA) radars. Rare Earth Permanent Magnets (REPMs) are the operational core of precision-guided munitions and tactical drone actuators².

This defence-technology nexus has meant that these materials are no longer freely traded commodities governed by the laws of the open market. In a polarised world dominated by the US-China trade and technological rivalry, critical minerals have become a highly securitised geopolitical asset. Besides their military use cases, the 'criticality' of these resources now flows from what is increasingly understood as the 'weaponisation of interdependence'³.

While in the post-Cold War era globalised supply chains were viewed as a deterrent to conflict, today that same interconnectedness has transformed into a vulnerability

and a tool of coercion. The coercive leverage in the critical minerals domain does not stem from mining the raw geological ore. It stems from the People's Republic of China's (PRC) monopolistic 'chokehold' over the mid-stream processing and refining nodes⁴. Currently, China commands an overwhelming majority of global mid-stream refining capacity. This includes processing roughly 80 per cent of the world's rare earth elements⁵. Because these nodes are highly centralised, the physical architecture of the global defence supply chain is actively weaponised. Export controls on these minerals function as formal, structural instruments of statecraft and coercion⁶.

These geopolitical realities vis-à-vis critical minerals pose a strategic dilemma for India. India's defence procurement domain is witnessing an unprecedented, state-driven ambition. Under the *Atmanirbhar Bharat* (self-reliant India) initiative launched in 2020, the Ministry of Defence is overseeing a golden age of indigenous manufacturing.⁷ This is evidenced by record defence export milestones and the aggressive notification of 'Positive Indigenisation Lists', which ban the import of completely built defence platforms⁸. However, this is a downstream success. It masks a severe structural vulnerability, creating a paradox. India is successfully indigenising the outer shell of its military hardware. Yet, it remains systemically dependent on its primary strategic adversary for the technological 'hearts and brains'⁹.

This paper evaluates this 'Atmanirbharta Paradox' inherent in India's contemporary defence indigenisation efforts. It argues that downstream platform integration in Indian defence manufacturing does not yield true self-reliance when decoupled from upstream material sovereignty. Rather, it results in a state of conditional indigenisation. Evaluating critical minerals and domestic defence production through the lens of national sovereignty and strategic autonomy, the paper establishes that asymmetric reliance on a geopolitical adversary for the fundamental inputs of military deterrence is not merely an economic procurement challenge. Instead, it places a hard, structural constraint on India's strategic autonomy¹⁰. A sovereign state cannot credibly project power, maintain a posture of multialignment, or ensure escalation dominance if the adversary it seeks to deter holds a latent 'kill switch' or chokehold over its domestic defence production lines¹¹.

The Atmanirbharta Spectrum: Understanding the Upstream Material Vulnerability

To grasp the full extent of this 'Atmanirbharta Paradox' and the latent vulnerabilities embedded within critical mineral supply chains, it is imperative first to deconstruct the concept of indigenisation itself. In defence manufacturing, indigenisation does not conform to a simple imported-versus-domestic binary. Rather, it exists along a spectrum. At the surface level lies Licensed Production. This is often critiqued as the screwdriver economy, in which domestic entities merely assemble imported completely knocked-down (CKD) kits through shallow technology transfer¹². The subsequent, one level deeper, tier represents a deeper level of sovereign production. It leverages substantive Transfer of Technology (ToT) frameworks and joint ventures. This intermediate stage enables the domestic ecosystem to graduate from mere assembly to comprehensive platform design, local sub-system manufacturing, and complex system integration. However, the deepest tier is where a nation achieves true material sovereignty and indigenisation. It demands a bottom-up sovereign control over the raw materials, metallurgy, and high-end components that physically constitute the platform¹³.

Currently, India's defence-industrial base is operating predominantly in the intermediate tier. The Defence Acquisition Procedure (DAP) 2020 has a provision for the calculation of 'Indigenous Content' (IC) primarily in terms of financial cost rather than technological criticality¹⁴. This is arguably a flawed metric of success. A profound loophole in this value-based metric is that Indian defence manufacturers can theoretically achieve the mandated IC percentages through domestic labour, software programming, and the forging of basic steel hulls. As a result, the most critical, high-value technological nodes, such as advanced semiconductors and superalloys, are left heavily import-dependent. This renders the entire exercise of defence indigenisation substantially shallow. Evaluating indigenisation purely by financial value, therefore, obfuscates a severe geopolitical vulnerability. True sovereign deterrence must flow uninterrupted from the upstream (the mine and the foundry) to the downstream (the final assembly line).

This loophole in India's domestic defence production journey is not new. The country's historical defence trajectory reveals a persistent struggle to cross this foundational technological and metallurgical threshold. Modern India's defence-industrial base was largely born from Soviet-era Transfer of Technology (ToT) agreements. That era

successfully created Defence Public Sector Undertakings (DPSUs) that today excel in volume assembly. However, these enterprises lack fundamental research and development capabilities in material sciences¹⁵. Later, the Make in India initiative successfully integrated private sector players and mastered indigenous airframe and hull construction. But the fundamental nodes of high-tech engines and metallurgy are still externally sourced. This structural bottleneck is most evident at Mishra Dhatu Nigam Limited (MIDHANI). MIDHANI, a premier state enterprise tasked with forging advanced alloys for the Ministry of Defence and the Indian Space Research Organisation (ISRO), relies on imported raw ores and refined critical minerals, which act as a chokepoint for the entire indigenous manufacturing pipeline¹⁶.

The operational consequences of this metallurgical vacuum become starkly apparent when evaluating the material composition of India's most celebrated downstream platforms. Across critical hardware domains, the disconnect between downstream assembly and upstream sovereignty is vividly exposed.

In the aerospace sector, platforms like the Light Combat Aircraft (LCA) Tejas and indigenous helicopter programmes require advanced jet engines capable of operating at extreme temperatures. This necessitates single-crystal turbine blades forged from highly specialised superalloys. These alloys are fundamentally reliant on highly refined cobalt and nickel, the very minerals for which India faces near-total import dependency¹⁷. Similarly, India possesses vast reserves of ilmenite (titanium ore) in its beach sands. Yet, it has historically lacked the mid-stream processing capability to convert this into aerospace-grade titanium sponge at scale. This forces a reliance on foreign suppliers for the skeletal structure of its aircraft¹⁸.

Similarly, in the sensors and electronic warfare (EW) domain, India is critically exposed to foreign supply shocks. The Indian Navy's advanced stealth frigates and the Indian Air Force's fighter jets rely heavily on Active Electronically Scanned Array (AESA) radars, such as the indigenous *Uttam* system. The foundational wafers for these advanced radar modules rely on Gallium Arsenide (GaAs) and are rapidly transitioning globally to Gallium Nitride (GaN). China's implementation of strict export controls on gallium and germanium in 2023, for instance, directly threatened the supply chains required to field and maintain these domestic sensor arrays¹⁹.

The domain of precision munitions and unmanned systems also faces an absolute vacuum in domestic material support. Modern ballistic and cruise missiles (such as the Agni and BrahMos series), alongside tactical Unmanned Aerial Vehicles (UAVs), rely on Neodymium-Iron-Boron (NdFeB) and Samarium-Cobalt magnets for their flight-control actuators and guidance fins. Despite possessing significant raw monazite reserves managed by Indian Rare Earths Limited (IREL), India currently lacks commercial-scale manufacturing capacity for finished Rare Earth Permanent Magnets (REPMs)²⁰.

As a result, while these platforms bear the 'Made in India' label, their operational viability remains effectively tethered to foreign extraction and refining networks. The weaponisation of these supply chains has not only exposed this upstream vulnerability. It has transformed it into a pressing strategic concern, setting the stage for the broader diplomatic constraints that directly challenge India's autonomy.

Limits to Sovereignty: Mapping the Constraints on Strategic Autonomy

To situate the physical vulnerabilities of defence indigenisation within a broader geopolitical context, it is necessary to examine the mineral-capability-deficit within the contemporary debate on India's strategic autonomy. Historically rooted in the Cold War posture of 'Non-Alignment', India's strategic autonomy has evolved into a doctrine of 'Multi-Alignment'. This is the pursuit of issue-based coalitions designed to maximise national interest without becoming permanently tethered to any single geopolitical bloc. Operationally, a country's autonomy is defined as the sovereign capacity to make independent geopolitical decisions on matters of war and peace, free from external coercion²¹.

However, a state's foreign policy posturing or sovereign decision-making on matters of national interest is strictly bound by its material capabilities. Sovereign defence platforms constitute a major space in this regard²². Therefore, India's strategic autonomy is fundamentally hollow if it cannot independently sustain the military apparatus required to defend its borders. Defence indigenisation, in this context, is not merely an economic or industrial project. It is rather the foundational pillar of state sovereignty. When the material inputs for India's defence architecture are controlled

by a foreign entity, the diplomatic pursuit of multi-alignment is severely compromised by hard structural constraints.

The gravity of this strategic paradox is particularly visible in the unique context of the Sino-Indian rivalry. Here, the 'weaponisation of interdependence' highlights a detrimental asymmetry for the Indian state. India's primary border adversary is simultaneously the monopoly holder of the material and technological inputs required to deter it. This dynamic transforms India's upstream supply chain into systemic leverage at the hands of an adversary with a historical tendency for deploying economic leverage as a tool of military coercion. The concentration of critical mineral processing in Chinese hands is not merely a market reality or a price issue. It is a state-led mechanism of coercion. This imposes four distinct constraints on India's strategic autonomy.

- **The Material Constraint:** The material constraint is characterised by a domestic defence architecture dictated by foreign supply nodes. The physical factory-floor reality of India's indigenous defence platforms is subject to frequently halted operations due to international supply chain crunches. A prominent example is the delay in the delivery of the indigenous Light Combat Aircraft (LCA) Tejas Mk-1A by Hindustan Aeronautics Limited (HAL). These delays were primarily driven by global bottlenecks in the procurement of critical electronic components, sensors, and semiconductors. All of these are downstream products of critical mineral refining²³. This material reality proves that sovereign control over an outer frame of advanced defence equipment cannot bypass a mineral chokepoint. It inherently limits the speed and scale at which India can arm itself.

- **The Operational Constraint:** This factory-floor vulnerability cascades directly into the second, the operational constraint. This severely compromises sustained military deterrence on the Indian borders. Modern military deterrence requires not just the fielding of advanced weaponry, but also the capacity to sustain high-intensity operations over a protracted conflict. AESA radars deployed along the Line of Actual Control (LAC) and electronic warfare suites on naval stealth frigates, for instance, require Chinese-refined gallium or germanium for replacement parts. If these parts are inaccessible on demand or on short notice, the deterrence is operationally compromised²⁴. This means that in the event of a protracted military standoff, the

adversary holds a latent 'kill switch' over India's ability to replenish its high-tech losses. This dictates India's calculus for escalation dominance and war termination.

- **The Multialignment Constraint:** The multialignment constraint traps India in a cycle of forced Western reliance. In a bid to bypass Beijing's monopoly, New Delhi is actively pursuing 'friend-shoring' and minilateral resource partnerships with the West. However, this strategy of substituting dependence on China with dependence on a Western bloc fundamentally limits the scope of India's multialignment strategy. As scholars like Ashley J. Tellis have historically observed, the Western alliance system has a well-documented history of utilising technology-denial regimes, end-user monitoring, and secondary sanctions to enforce geopolitical compliance²⁵. By relying extensively on Western-led minilateral frameworks for critical defence inputs, India exposes its military procurement to a web of Western compliance cascades. This curbs its ability to take truly independent stances on global issues, such as its relations with Russia or Iran, owing to the inherent risk of supply chain retaliation.

- **The Geopolitical Constraint:** The fourth is the geopolitical constraint on India's strategic autonomy, which grants Beijing asymmetric leverage that extends far beyond the military domain. China's near-monopoly on mid-stream processing allows it to use the mere threat of export controls as an instrument of broader statecraft. Beijing's targeted restrictions on gallium, germanium, and antimony serve as warning shots²⁶. This leverage could be exercised over India's participation in the Quad, its maritime exercises in the Indo-Pacific, and its border infrastructure development. This forces Indian statecraft into a reactive posture, managing supply-chain risks rather than credibly projecting deterrence along its borders.

India's Policy Response and Remaining Gaps

Recognising these constraints, the Indian state has initiated a series of countermeasures. Domestically, the government launched the National Critical Minerals Mission (NCMM) to map and auction domestic mineral blocks. It mandated the creation of a six-month strategic stockpile and introduced an INR 7,280 crore scheme aimed at establishing a domestic manufacturing base for Rare Earth Permanent Magnets (REPMs)²⁷. On the diplomatic front, New Delhi joined the Minerals Security Partnership (MSP). It utilised Khanij Bidesh India Limited (KABIL) to

acquire overseas assets in Australia and Argentina²⁸. It also launched the Australia-Canada-India Technology and Innovation (ACITI) Partnership.

Furthermore, the evaluation of these state responses reveals that they remain insufficient to permanently lift the constraints on strategic autonomy. Domestically, the state's approach suffers from acute institutional siloing. The NCMM is primarily driven by the Ministry of Mines and remains overwhelmingly oriented toward the commercial civilian sector, specifically the green energy transition. It lacks a formalised, inter-ministerial synergy with the Ministry of Defence (MoD), and the Ministry of Environment, Forest and Climate Change (MoEFCC). Without a policy framework to designate specific high-yield mineral blocks strictly as strategic defence assets, India's nascent military mining capabilities are left to compete with commercial demand. It is also subjected to protracted ecological clearance loops.

Externally, the diplomatic strategy is equally constrained by the realities of the physical supply chain. KABIL's overseas acquisitions predominantly focus on securing raw, unrefined ore. Without a corresponding, massive scaling of domestic mid-stream processing capabilities, shipping raw Australian lithium or Argentine cobalt back to India does not eliminate the vulnerability. It merely diversifies the geographic origin of the unprocessed ore. Diplomatically, replacing a reliance on Chinese processing with a reliance on Western refining networks simply shifts the node of vulnerability to a different hemisphere. It fails to achieve the upstream material sovereignty required for true strategic autonomy.

These shortcomings underscore the ultimate tension embedded within the 'Atmanirbharta Paradox'. By treating critical mineral dependencies as an external procurement challenge to be managed via diplomatic diversification and strategic stockpiling, Indian statecraft inadvertently reinforces the very vulnerabilities it seeks to dismantle. The metallurgical and industrial void must be filled domestically. The structural constraints on India's strategic autonomy are therefore not mitigated by unilateral alignment; they are merely re-spatialised. As long as the mid-stream refining architectures and advanced material processing remain concentrated outside its sovereign borders, India's quest for escalation dominance along its contested frontiers will remain tethered to the strategic calculations of foreign capitals. Consequently, the current paradigm of defence indigenisation yields not true self-

reliance, but a vulnerable state of material suspension. This is a state where the operational readiness of India's frontline deterrence is continuously hostage to the geoeconomics and geopolitics of the upstream supply chain.

India's pursuit of strategic autonomy reveals a profound disconnect between the geopolitical ambitions of statecraft and the physical realities of the factory floor. While the *Atmanirbhar Bharat* initiative has successfully engineered a massive expansion of domestic platform integration and airframe assembly, this downstream success masks a systemic vulnerability. This research has uncovered the 'Atmanirbharta Paradox': While India indigenises the outer shell of its military apparatus, it fundamentally relies on external, frequently adversarial, supply chains for the technological and geological 'hearts and brains' that power them. Therefore, the current paradigm of defence indigenisation in India yields not true self-reliance, but conditional sovereignty. It represents a state of material suspension where the operational readiness of India's frontline deterrence is held hostage by the upstream geopolitics of critical minerals.

Policy Recommendations

Resolving this paradox requires a fundamental reframing of the indigenous policy ecosystem. Addressing this vulnerability demands a definitive pivot from platform-centric procurement to a bottom-up framework of material sovereignty. To bridge the chasm between the mine and the assembly line, Indian policymaking stands to benefit from targeted interventions across three domains.

First, India requires institutional convergence and the designation of 'Strategic Mines'. The current approach to critical minerals suffers from acute bureaucratic siloing. To address this, the Ministry of Defence (MoD), the Ministry of Mines, and the Ministry of Environment, Forest and Climate Change (MoEFCC) require a formalised, joint-command mechanism within the National Critical Minerals Mission (NCMM). Critical minerals can no longer be treated solely as commercial assets for the civilian green-energy transition. This joint mechanism should be empowered to evaluate both domestic mineral blocks and KABIL's overseas acquisitions through a strict national security lens. It should officially designate high-yield reserves as 'Strategic Defence Assets.' Crucially, this designation should unlock expedited environmental clearance

pathways. It must ring-fence the extracted resources exclusively for military metallurgy and strategic stockpiling, insulating them from commercial market volatility.

Second, reforming the Defence Acquisition Procedure (DAP) via a Technological Criticality Index (TCI) would foster substantial direct results in indigenisation efforts. This would permanently close the value-based loopholes present in the acquisition procedure by replacing broad platform-level financial percentages with tiered, non-negotiable domestic material mandates for high-value subsystems. Critical nodes, such as the semiconductor wafers in AESA radars or Rare Earth Permanent Magnets (REPMs) in missile actuators, necessitate strict localised sourcing requirements. These cannot be mathematically averaged out by the financial cost of the surrounding steel hull or domestic labour.

Thirdly, state efforts stand to benefit from aggressively de-risking the mid-stream processing sector. Advanced metallurgy, particularly rare-earth separation, is highly capital-intensive, energy-heavy, and ecologically complex. This has traditionally deterred private investment. For India to secure this sector, the state must absorb this initial risk. Beyond offering standard Production-Linked Incentives (PLIs), policymakers should require that future defence offset clauses with Western aerospace partners be explicitly channelled into establishing domestic metallurgy infrastructure. By leveraging foreign capital and intellectual property to build out local titanium sponge plants, single-crystal foundries, and green-refining technologies for toxic byproducts, India can organically transition entities like MIDHANI and IREL. They can evolve from mere research nodes into globally competitive, commercial-scale suppliers.

Conclusion

Ultimately, strategic autonomy is only as robust as the industrial supply chains that sustain it. In an era of deep geopolitical polarisation, a state cannot credibly maintain a posture of multialignment or project power if its primary adversary holds a structural 'kill switch' over its defence production lines. For India to claim its place as an unyielding sovereign state and a net security provider in the Indo-Pacific, it must achieve absolute upstream material sovereignty. Only then will its defence indigenisation match its grand strategic ambitions, transforming *Atmanirbharta* from a policy slogan into an unassailable instrument of sovereign deterrence.

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.

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