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**Beyond Network Centric Warfare:
India's Leapfrog Dilemma in the
Transition to Data Centric and
Algorithm Centric Warfare**

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Abstract

Rapid advances in artificial intelligence, cloud computing, autonomous systems and pervasive sensing are compressing the traditional stages of military transformation. This paper introduces the concept of Transformation Compression to explain this phenomenon and examines its implications for India's military modernisation. It argues that sequential capability development is increasingly impractical and proposes a Leapfrogging Framework to distinguish capabilities that must be built, developed concurrently or selectively leapfrogged. The paper concludes that India's future military advantage will depend not merely on acquiring emerging technologies, but on sequencing military transformation through informed choices about what to build, what to compress and what to leapfrog.

Keywords: Algorithm Centric Warfare, Data Centric Warfare, India, Military Modernisation, Network Centric Warfare, Transformation Compression

Introduction

Military history suggests that successive generations of warfare emerge through a gradual process of technological and doctrinal evolution. Military transformation, however, is no longer unfolding in such orderly stages. The rapid convergence of digital technologies, ubiquitous sensing, cloud computing, data analytics and advanced algorithms has compressed the timelines of military innovation, thus compelling the armed forces to adapt to multiple technological revolutions simultaneously rather than sequentially. The traditional assumption that one stage of transformation must be completed before the next begins, therefore merits renewed examination.

Over the past three decades, Network Centric Warfare has been the dominant paradigm for enhancing combat effectiveness through the integration of sensors, decision makers and weapon systems (Blaker, J. 2006). Interestingly, however, military advantage is being shaped not merely by the ability to connect platforms, but by the capacity to generate, integrate, exploit and act upon data at speed. Consequently, strategic discourse has expanded towards Data Centric Warfare and Algorithm Centric Warfare, wherein decision superiority is derived from data architectures and algorithm enabled decision support rather than connectivity alone.

For India, this transition presents a complex strategic challenge. As the Indian Armed Forces pursue modernisation, jointness and technological self-reliance, they must strengthen foundational Network Centric capabilities while simultaneously preparing for data driven and algorithm enabled operations within finite fiscal, organisational and technological constraints. This raises a fundamental question: Does the compression of technological evolution still permit a sequential transition from Network Centric to Data Centric and Algorithm Centric Warfare, or does it demand a new model of military transformation? This paper argues that the challenge is not whether India should embrace these emerging paradigms, but how it should sequence capability development through a judicious combination of foundational capability building, transformation compression and leapfrogging.

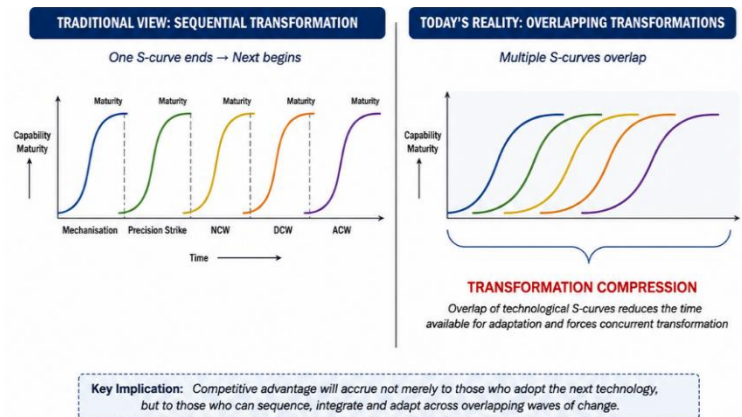
The Military S-Curve and the Compression of Military Transformation

Military transformation has rarely been instantaneous. Historically, new technologies followed a recognisable pattern of emergence, experimentation, rapid adoption and eventual maturity before being displaced by the next wave of innovation. This evolutionary pattern is broadly consistent with the technological S-curve described by Bower and Christensen (Bower, J.L. and Christensen, C.M.1995). It allowed armed forces sufficient time to absorb technological change, revise doctrine, reorganise force structures and develop the institutional competencies necessary to exploit new capabilities. Consequently, successive generations of military transformation—from mechanisation and air power to precision guided munitions and Network Centric Warfare—were largely experienced as discrete and sequential phases of evolution.

The contemporary technological environment is fundamentally different. Advances in communications, cloud computing, artificial intelligence, autonomous systems, edge computing and ubiquitous sensing are no longer evolving independently or at similar rates. Instead, they are converging, reinforcing and accelerating one another (McKinsey and Company, 2026). The result is an overlap of multiple technological S curves, reducing the time available for militaries to complete one transformation before another begins. Military organisations are therefore increasingly required to modernise existing capabilities while simultaneously adapting to emerging technologies and preparing for capabilities that are themselves still evolving.

This paper describes this phenomenon as “Transformation Compression”—the progressive overlap of successive stages of military transformation caused by accelerating and converging technological innovation. Under conditions of ‘Transformation Compression’, military modernisation can no longer be viewed as a linear sequence of independent capability upgrades. Instead, force development becomes a continuous process in which foundational capabilities must be strengthened even as higher order capabilities are simultaneously developed and integrated.

Figure 1: Military S-Curves



Source: AI Generated Image by Author

The implications are significant. Military advantage is likely to depend less on the acquisition of individual technologies than on the ability to sequence, integrate and adapt multiple technological transitions concurrently (TNN, 2026). The central challenge is therefore no longer technological adoption alone, but the management of transformation itself. It is within this context that India's future military modernisation must be examined.

India's Leapfrog Dilemma

For decades, military modernisation followed a broadly sequential trajectory. The Indian Armed Forces first established reliable communications, integrated sensors with shooters through networked command and control systems and subsequently exploited these networks to enable precision strikes, joint operations and enhanced situational awareness. Only after these foundations matured did higher order capabilities such as predictive analytics, artificial intelligence and autonomous systems become operationally viable. This evolutionary pathway reflected both technological constraints and institutional realities, allowing doctrine, organisations and training to mature alongside technological change (Kumar, M. 2026).

India's strategic environment, however, no longer affords the luxury of such sequential transformation (Nair, M.U. 2026). Rapid advances in artificial intelligence, autonomous systems, cloud computing, edge processing, commercial space capabilities and resilient communications are

unfolding simultaneously. At the same time, the Indian Armed Forces continue to modernise legacy platforms, expand joint operational structures, strengthen indigenous defence production and implement theatre level integration. Rather than progressing through clearly demarcated stages, multiple generations of military capability must therefore be developed concurrently.

This creates what may be termed India's "Leapfrog Dilemma". On the one hand, attempting to replicate the complete technological evolution experienced by advanced militaries risks significant delays, escalating costs and the danger of obsolescence before capability maturity is achieved. On the other hand, indiscriminately leapfrogging foundational capabilities in pursuit of emerging technologies risks creating technologically sophisticated but operationally fragile forces. Artificial intelligence cannot compensate for inadequate communications; autonomous systems cannot substitute for resilient command networks; and algorithm enabled decision support remains ineffective without trusted, interoperable and timely data.

The strategic challenge, therefore, is not whether India should leapfrog, but what should be leapfrogged, what should be compressed and what must still be built from first principles. Rather than viewing military modernisation as a binary choice between sequential development and technological disruption, India requires a calibrated transformation strategy that distinguishes foundational capabilities from those that can be accelerated or bypassed through technological convergence and indigenous innovation.

Accordingly, this paper argues that military transformation should be viewed through three distinct categories viz. non-negotiable foundational capabilities, compressible capabilities and leapfrog opportunities. Such a framework enables India to preserve operational resilience while exploiting emerging technologies to accelerate capability development. The objective is not to imitate the transformation pathways of other militaries, but to develop a uniquely Indian model of military modernisation aligned with national priorities, resource realities and future operational requirements. The following section proposes a framework to operationalise this approach.

A Framework for Leapfrogging

The preceding discussion suggests that military transformation can no longer be approached as a sequential progression from one capability generation to the next. Equally, indiscriminate adoption of emerging technologies without adequate institutional and technological foundation risks creating fragmented capabilities with limited operational utility. The challenge, therefore, is to

identify which capabilities constitute enduring foundations, which can be developed concurrently and which may be selectively leapfrogged through technological innovation.

This paper proposes a Leapfrogging Framework comprising three interdependent capability categories: Foundational Capabilities, Compressible Capabilities and Leapfrog Opportunities. Together, these categories provide a practical decision framework for sequencing military transformation under conditions of technological convergence.

- ***Foundational Capabilities.*** Foundational capabilities represent those elements that cannot be bypassed without degrading the overall combat effectiveness. They provide the essential architecture upon which all higher order capabilities depend. These include resilient communications, secure and interoperable networks, assured positioning, navigation and timing (PNT), cybersecurity, common data standards, identity and access management and joint command and control architectures. Regardless of advances in artificial intelligence or autonomous systems, these capabilities remain indispensable prerequisites for effective military operations (US Department of Defense, 2023).
- ***Compressible Capabilities.*** The second category comprises capabilities that need not await the completion of foundational modernisation. Data governance, cloud enabled command and control, software defined operational systems, digital twins, predictive maintenance, edge computing and decision support tools can be developed alongside improvements in network infrastructure. Technological convergence enables these capabilities to mature in parallel, thereby shortening overall transformation timelines without compromising operational coherence (McKinsey & Company, 2026).
- ***Leapfrog Opportunities.*** The third category consists of capabilities wherein India possesses opportunities to bypass legacy pathways altogether. Artificial intelligence enabled planning, autonomous systems, commercial satellite constellations, low cost attritable platforms, software defined radios, modular open system architectures and commercial cloud services enable the rapid adoption of advanced operational capabilities without replicating decades of incremental technological evolution. Leapfrogging should therefore focus on areas where commercial innovation is rapid, indigenous capability is growing and dependence on legacy infrastructure is limited.

Table 1: Illustrative Capability Prioritisation

Capability Area	Build (Foundation)	Compress (Concurrent Development)	Leapfrog (Accelerated Adoption)
Secure Communications	✓		
Joint Command & Control	✓		
Cybersecurity	✓		
Data Standards & Interoperability	✓		
Cloud Infrastructure		✓	
Data Governance		✓	
Edge Computing		✓	
Digital Twins		✓	
AI-enabled Decision Support			✓
Autonomous Systems			✓
Commercial Space Integration			✓
Swarm & Attritable Systems			✓
Open Modular Architectures			✓

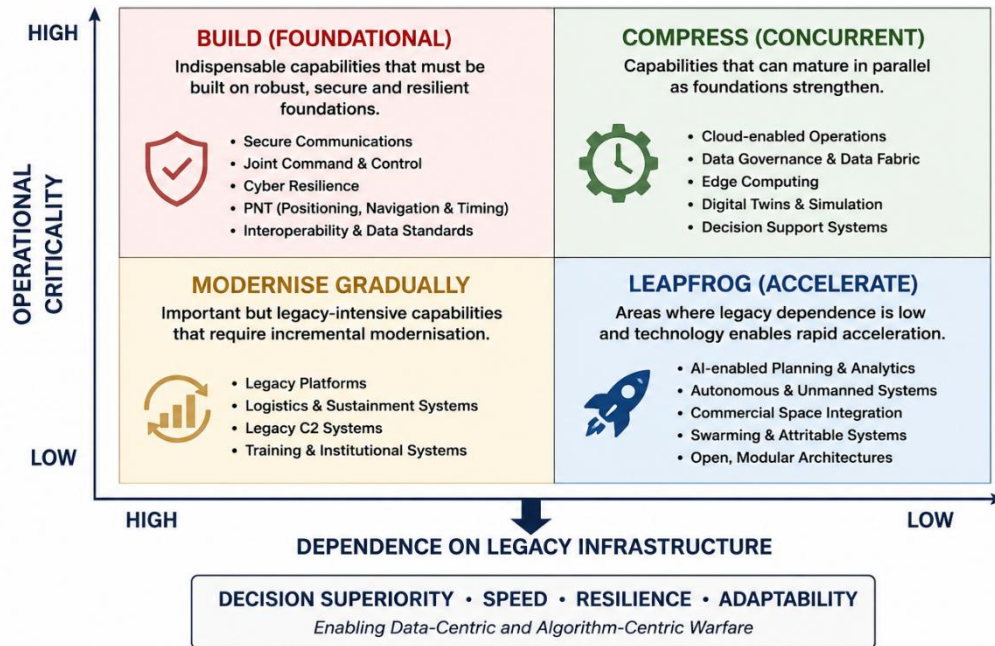
Source: Author Construct

However, leapfrogging should not be interpreted as technological substitution. Artificial intelligence cannot compensate for fragmented data; autonomous platforms cannot overcome inadequate command and control; and sophisticated algorithms cannot generate decision superiority in the absence of trusted and timely information. The effectiveness of leapfrogged capabilities remains fundamentally dependent upon the robustness of foundational military architecture.

- **Minimum Viable Network Centric Capability.** The framework therefore introduces the concept of Minimum Viable Network Centric Capability. Rather than pursuing exhaustive network centric modernisation before embracing data centric and algorithm centric warfare, militaries should identify the minimum threshold of networking, interoperability and data integrity necessary to enable higher order capabilities. Once this threshold is achieved, resources can increasingly shift towards data exploitation, decision support and autonomous operations while foundational capabilities continue to mature incrementally.

The objective is therefore not to complete one generation of military transformation before commencing the next, but to maintain an operational equilibrium in which foundational capabilities remain sufficiently robust to support continuous technological innovation. Under conditions of “Transformation Compression”, successful militaries will increasingly be distinguished not by the technologies they acquire, but by the sequencing logic through which they integrate, prioritise and institutionalise capability development.

Figure 2: Leapfrogging Matrix
Balancing Operational Criticality and Dependence on Legacy



Source: AI Generated Image by Author

Imperatives for India's Military Transformation

The proposed Leapfrogging Framework suggests that India's military modernisation should prioritise transformation sequencing over technology acquisition. The objective is not to replicate evolutionary pathways followed by technologically advanced militaries, but to adopt a capability development strategy aligned with India's operational requirements, industrial capacity and fiscal realities. Transformation Compression changes the central question of military modernisation 'from' What technologies should be acquired? 'to' in what sequence should capabilities be developed? Four strategic imperatives emerge.

- **Build Enduring Digital Foundations.** The first priority is the establishment of resilient foundational capabilities. Secure communications, interoperable command and control systems, cyber resilience, assured positioning, navigation and timing (PNT) and common data standards should constitute the bedrock of future force development. Without these enablers, advanced technologies such as artificial intelligence and autonomous systems risk becoming isolated capabilities rather than integrated combat multipliers.
- **Adopt a Parallel Transformation Model.** India should avoid treating military modernisation as a sequence of discrete programmes. Instead, foundational capabilities, data architectures

and advanced applications should evolve concurrently. Cloud enabled command systems, data governance frameworks, edge computing and decision support tools can mature alongside improvements in communications and networking. Such parallel development shortens transformation timelines while reducing technological obsolescence (McKinsey & Company, 2026).

- **Leverage Military-Civil Innovation Ecosystems.** Rapid advances in artificial intelligence, commercial space, autonomous systems and software are increasingly being driven by the civilian technology sector. India's growing innovation ecosystem, including startups, academia, DRDO and private industry, offers opportunities to accelerate capability development through collaborative innovation rather than exclusive reliance on traditional defence procurement. Open architectures and modular system design will be essential to integrate emerging technologies as they mature.
- **Institutionalise Continuous Adaptation.** Military transformation is ultimately an institutional challenge rather than a technological one. Doctrine, professional military education, experimentation, wargaming and acquisition processes must evolve continuously to absorb technological change. Organisations should develop mechanisms for rapid learning, iterative capability development and regular reassessment of transformation priorities. In an environment characterised by technological convergence, the ability to adapt may become a greater source of military advantage than any individual technology.

Rather than pursuing technological parity across every domain, India's objective should be to achieve decision superiority through a balanced combination of foundational capability building, transformation compression and leapfrogging. Such an approach offers a pragmatic pathway for modernisation while preserving strategic flexibility in an increasingly dynamic security environment.

Conclusion

The framework presented is conceptual and requires empirical validation across different operational contexts. Future research may examine its applicability to specific capability domains such as long-range fires, integrated air defence, or maritime operations. The convergence of artificial intelligence, autonomous systems, cloud computing and pervasive sensing is compressing the traditional stages of military transformation. This paper argues that “Transformation Compression” fundamentally alters the logic of military modernisation, thus making sequential capability development increasingly impractical. For India, the challenge is therefore not simply to acquire

emerging technologies, but to determine the optimal sequence for building, integrating and employing them in pursuit of operational advantage.

The Leapfrogging Framework proposed in this paper offers a pragmatic approach by distinguishing between capabilities that must be built, those that can be developed concurrently and those that can be selectively leapfrogged. Rather than attempting to replicate the transformation pathways of technologically advanced militaries, India should pursue a context specific strategy that balances foundational capability development with accelerated technological adoption. In an era of compressed technological change, military advantage will depend less on the pace of acquisition and more on the wisdom of what to build, what to compress and what to leapfrog.

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Colonel AK Singh is an alumnus of the NDA and was commissioned in the Regiment of the Artillery in Jun 2007. He has served in CI Ops in Assam and J&K and HAA in Kargil & Tangdhar. The Officer has done JC & DSSC course. He has been GSO-2 in Mtn Arty Bde and GSO-1 in an Inf Bde on Western Sector. He has also been a MILOB in UN Msn at MONUSCO. He is presently commanding a Med Regt in a Strike Corps.



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