

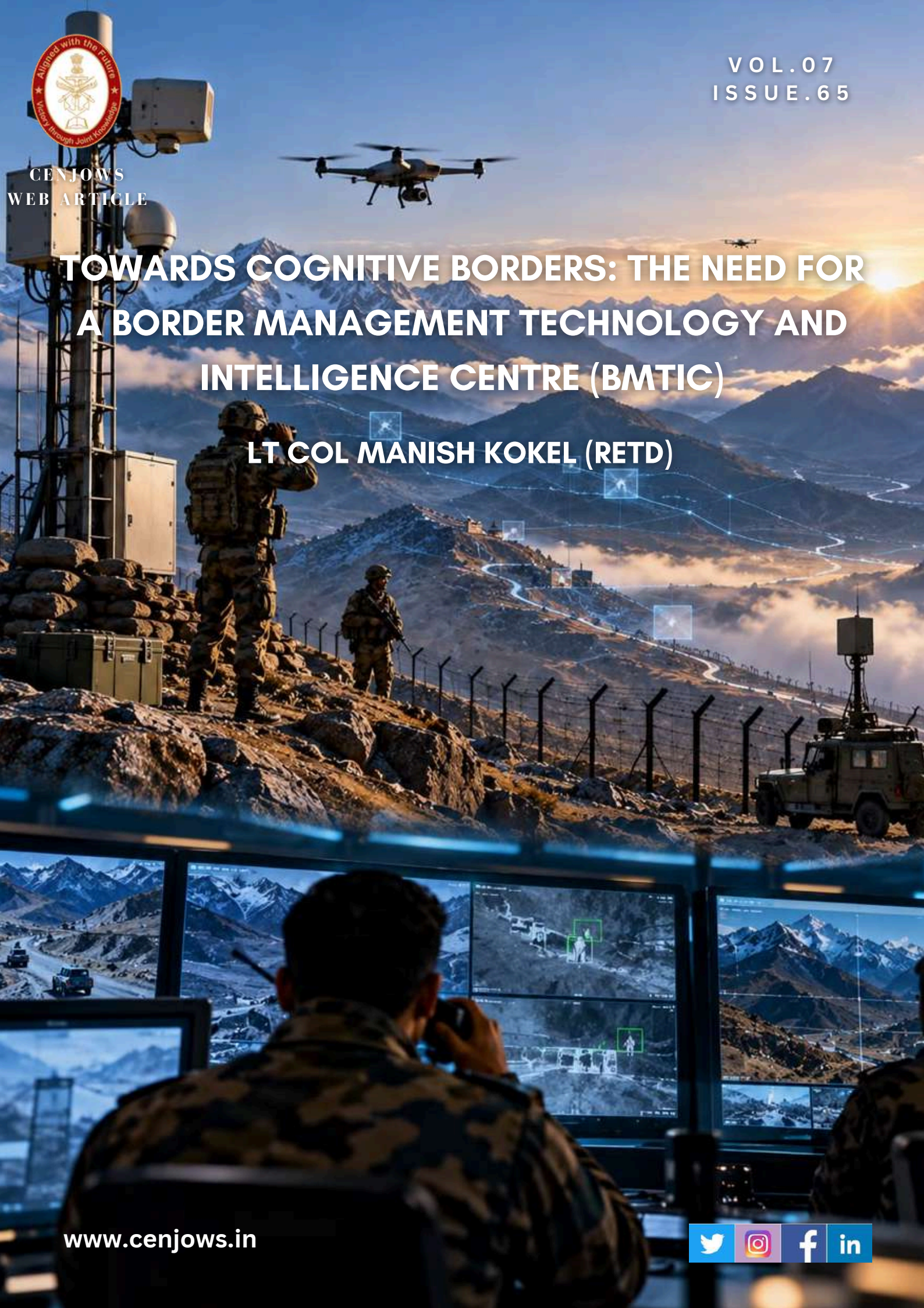


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TOWARDS COGNITIVE BORDERS: THE NEED FOR A BORDER MANAGEMENT TECHNOLOGY AND INTELLIGENCE CENTRE (BMTIC)

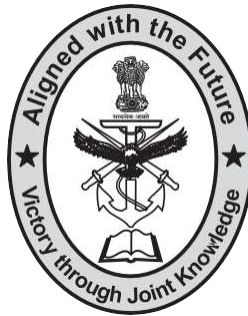
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Towards Cognitive Borders: The Need for a Border Management Technology and Intelligence Centre (BMTIC)



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Abstract

India's borders have traditionally been managed through physical infrastructure, deployment of border guarding forces, surveillance, intelligence and diplomatic engagement. However, the nature of threats along these borders is changing. Infiltration, smuggling and territorial incursions continue to remain concerns, but the growing use of drones, autonomous systems, cyber capabilities and information operations has added new dimensions to border security.

India has a land boundary of approximately 15,106.7 km with seven neighbouring countries: Bangladesh, Pakistan, China, Nepal, Bhutan, Myanmar and Afghanistan. Each border presents its own set of challenges. While some stretches pass through densely populated areas, rivers and plains, others extend across deserts, dense forests and high-altitude mountainous terrain, including disputed areas.

Border management in India is also witnessing a gradual shift from dependence on manpower and physical patrolling towards greater use of technology. An important step in this direction is the Comprehensive Integrated Border Management System (CIBMS), which brings together manpower, sensors, communication networks, intelligence and command-and-control systems to improve surveillance and enable a quicker response to emerging threats.

This paper argues that the next stage should be the evolution from an instrumented and integrated border to a cognitive border. It proposes a Border Management Technology and Intelligence Centre (BMTIC) as an institutional and technological architecture capable of integrating multi-domain sensors, intelligence, artificial intelligence, data analytics, enterprise architecture, digital-twin technology and human decision-making into a common operational framework.

The paper conceptualises the transition as: Physical Border → Instrumented Border → Integrated Border → Intelligent Border → Cognitive Border.

BMTIC is not intended to replace the existing border guarding forces or command structures. Rather, it is proposed as a system that brings them together by facilitating the sharing of data, intelligence and information and providing common standards and decision-support mechanisms.

Keywords

Border Management, Cognitive Border, BMTIC, Artificial Intelligence, Enterprise Architecture, CIBMS, Digital Twin, Intelligence Fusion, Border Technology, India

Historical and Geostrategic Context

A border is not merely a line separating two countries. It has geographical, political, legal, economic, social and security dimensions. This is particularly relevant in India, where different parts of the international boundary have their own geographical features and strategic challenges. Territory and security are closely linked, as territory can contribute

to conflict and can itself become a source of conflict. Borders also influence interactions during conflict, trade, war and peace.

Harvey Starr similarly argues that borders continue to perform important functions across security, economics, politics and social interaction, while delineating areas of legal competence and territorial sovereignty.¹ The concept of the border has also evolved historically. Giuliano Bellezza describes an evolution from broad no-man's-land frontiers towards increasingly defined linear boundaries, while technological and geographical developments changed the means by which territorial limits were established and controlled.² John Agnew further treats borders as evolving constructions that have practical effects while also shaping how territorial space is understood.³

India's land borders extend across approximately 15,106.7 km and involve seven neighbouring countries. The Ministry of Home Affairs identifies the following border lengths:⁴

Neighbour	Approx. border length	Indian States/UTs involved	Broad characteristics
Bangladesh	4,096.7 km	West Bengal, Assam, Meghalaya, Tripura, Mizoram	Riverine, plains, populated areas
China	3,488 km	Ladakh, Himachal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh	High altitude, mountainous, disputed LAC
Pakistan	3,323 km	Gujarat, Rajasthan, Punjab, J&K, Ladakh	Desert, plains, LoC/IB, high security sensitivity
Nepal	1,751 km	Uttarakhand, Uttar Pradesh, Bihar, West Bengal, Sikkim	Open-border environment, plains and mountains

Myanmar	1,643 km	Arunachal Pradesh, Nagaland, Manipur, Mizoram	Mountainous/jungle terrain, insurgency and trafficking concerns
Bhutan	699 km	Sikkim, West Bengal, Assam, Arunachal Pradesh	Mountainous and cooperative security environment
Afghanistan	106 km	Ladakh	Officially recognised Indian border; presently inaccessible from Indian-controlled territory

Table 1: India's Borders

Pakistan

The India-Pakistan border has its contemporary origins in the 1947 Partition and Radcliffe boundary. Subsequent wars in 1947–48, 1965 and 1971, followed by the 1972 Simla Agreement and establishment of the Line of Control, shaped the security environment. The border combines the International Border, the Line of Control, desert terrain, agricultural and populated areas, riverine and creek environments, counter-infiltration requirements and cross-border terrorism concerns. Consequently, technology-enabled surveillance has become particularly important.⁵

China

The India-China boundary is characterised by unresolved territorial differences and the Line of Actual Control (LAC). Historical developments involving Tibet, the McMahon Line, the 1962 war and subsequent boundary-management agreements have shaped contemporary relations. The geography presents an entirely different technological challenge: extreme altitude, limited road connectivity, severe weather, large distances, difficult logistics and persistent surveillance requirements. Here, border management overlaps significantly with military operational requirements.⁶

Nepal

The India-Nepal border has historically been characterised by comparatively extensive cross-border social and economic interaction. The 1816 Treaty of Sugauli forms an important historical reference point. The principal border-management challenge is therefore not simply physical exclusion but management of unauthorised movement, trafficking, organised crime, smuggling, identity-related issues and legitimate movement across an open-border environment.⁷

Bhutan

The India-Bhutan border is characterised by a cooperative security relationship. The border environment nevertheless has strategic significance because of its geographical relationship with India's northeastern region and the India-China frontier.⁸

Myanmar

The 1,643-km India-Myanmar border passes through Arunachal Pradesh, Nagaland, Manipur and Mizoram. MHA's 2024 annual report records that 1,472 km had been demarcated and that hybrid surveillance-system pilot projects were being undertaken in Arunachal Pradesh and Manipur.⁹ The terrain creates a particularly strong case for technology-enabled surveillance because dense forests and mountains make continuous physical observation difficult.

Bangladesh

At 4,096.7 km, the India-Bangladesh border is India's longest international land boundary. Its characteristics vary from densely populated land areas to rivers, wetlands and difficult terrain. The Dhubri sector illustrates the problem particularly well. The Brahmaputra's riverine environment makes conventional fencing impractical, resulting in the use of technology-enabled surveillance.¹⁰

Current Border Management

India's border management is based on a combination of physical infrastructure, border guarding forces, surveillance technology, intelligence, infrastructure, inter-agency coordination and diplomatic engagement. The principal border-guarding forces include the Border Security Force (BSF) on the Pakistan and Bangladesh borders, the Indo-

Tibetan Border Police (ITBP) on the China border, the Sashastra Seema Bal (SSB) on the Nepal and Bhutan borders, and the Assam Rifles on the Myanmar border. The Indian Army is particularly relevant to the management of the Line of Control and Line of Actual Control.¹¹ The precise deployment of personnel by border sector is operationally sensitive; consequently, force-wide manpower figures should not be treated as border-specific deployment figures.

A 2025 parliamentary answer gives the force-wide in-position strength as of 1 January 2025 as approximately 61,749 for Assam Rifles, 257,980 for BSF, 88,587 for ITBP and 92,689 for SSB, a combined figure of 501,005.¹² These figures provide an indication of the scale of the organisations involved, but not of the number of personnel physically deployed on any particular border.

Force	In-position strength
Assam Rifles	61,749
BSF	257,980
ITBP	88,587
SSB	92,689
Combined	501,005

Table 2: Force-wide Strength along India's Borders

Surveillance and Technology

India's border-management technology has progressively moved beyond visual patrolling and static observation. The surveillance environment now includes thermal imagers, night-vision devices, CCTV and PTZ systems, electro-optical and infrared sensors, ground-surveillance radar, fibre-optic and unattended ground sensors, UAVs and other networked surveillance systems.¹³ In difficult riverine areas, radar, electro-optical systems

and other specialised technologies provide alternatives where conventional physical barriers are impractical.

CIBMS represents an important stage in this transition. The Ministry of Home Affairs describes CIBMS as the integration of manpower, sensors, networks, intelligence and command-and-control solutions to improve situational awareness and facilitate prompt response. Pilot implementation has included two five-kilometre stretches in Jammu and a 61-kilometre stretch in Dhubri, Assam.¹⁴ The technology concept therefore moves beyond individual sensors towards an integrated surveillance and response architecture.

The contemporary threat environment is also becoming more technologically complex. Drones illustrate this change particularly clearly because they can cross difficult terrain, carry payloads, conduct surveillance and exploit gaps in conventional border arrangements. Their detection and mitigation increasingly require the combination of radar, radio-frequency detection, electro-optical and infrared systems and appropriate counter-UAS measures.¹⁵ The broader lesson is that border threats are becoming multi-domain while border-management systems have historically been organised largely around individual agencies and physical sectors.

Accordingly, the central challenge is no longer simply to increase the number of sensors. It is to transform the growing volume of sensor information into integrated intelligence and timely decisions across organisational boundaries.

The Need for BMTIC: Proposed Cognitive Border Architecture

The evolution of border management can be conceptualised in five stages: Physical Border, Instrumented Border, Integrated Border, Intelligent Border and Cognitive Border. The physical border is characterised by fencing, roads, floodlighting, border outposts, patrols and observation posts. The instrumented border supplements these with thermal imagers, night-vision systems, CCTV, electro-optical sensors, radar, fibre-optic sensors, unattended ground sensors, UAVs and communications systems. The integrated border connects these technologies through networks, intelligence and command-and-control systems such as CIBMS. The intelligent border adds automated processing, AI-assisted analytics, anomaly detection, predictive analysis, pattern recognition, geospatial intelligence and multi-sensor fusion.

The cognitive border goes beyond automation. It combines sense, understand, correlate, predict, decide, act and learn. Its defining characteristic is therefore not simply the presence of AI but the creation of a continuous intelligence-to-decision cycle.

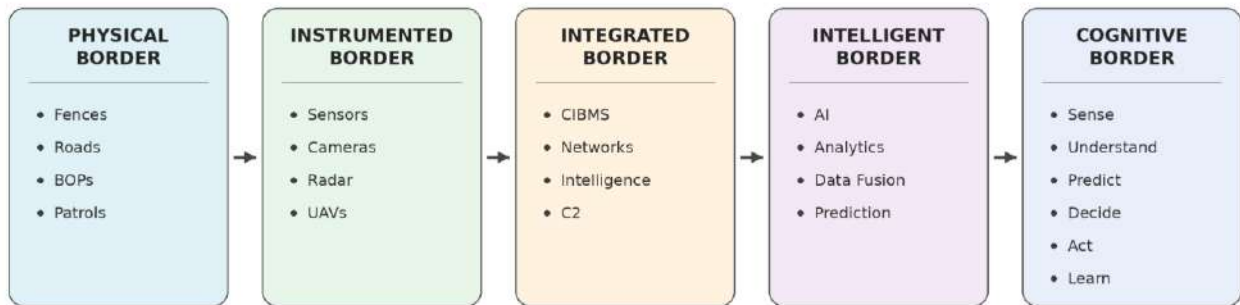


Figure 1: Evolution towards the Cognitive Border

The Border Management Technology and Intelligence Centre (BMTIC)

This paper proposes a Border Management Technology and Intelligence Centre (BMTIC) as an integrated architecture for India's future border management. BMTIC would not replace the BSF, ITBP, SSB, Assam Rifles, Indian Army, intelligence agencies or existing operational command structures. Instead, it would provide a technology, intelligence, data and decision-support layer connecting relevant organisations. Its fundamental purpose would be to convert multiple streams of information into a common understanding of the border environment.

The BMTIC concept would bring together data fusion, intelligence, AI and analytics and a digital twin of the border environment to support a common operational picture. The resulting information would then be made available to authorised human decision-makers and operational agencies. This creates a closed information-to-decision architecture rather than a collection of disconnected surveillance systems.

Technology Architecture

At the physical and sensing layer, BMTIC could receive inputs from EO/IR cameras, thermal imagers, ground radar, UAVs, satellite imagery, unattended ground sensors, fibre-optic sensors, acoustic sensors, authorised communications-intelligence sources

and environmental sensors. At the connectivity layer, resilient fibre, radio, satellite communications, microwave, tactical communications and secure IP networks would provide the transport architecture.

The data layer would establish common standards for data formats, metadata, geospatial information, timestamps, sensor identity, classification, access control, retention and auditability. The intelligence-fusion layer would correlate information from different sources. For example, radar detection combined with UAV imagery, historical patterns, terrain and intelligence inputs could produce a higher-confidence assessment than any individual sensor.

AI and analytics could assist with anomaly detection, object classification, behaviour recognition, pattern identification, route analysis, predictive threat assessment, prioritisation of alerts and sensor-tasking recommendations. AI should, however, remain decision-support rather than an uncontrolled decision-maker in consequential border-security decisions. The principle should therefore be human-in-the-loop, AI-assisted border management.

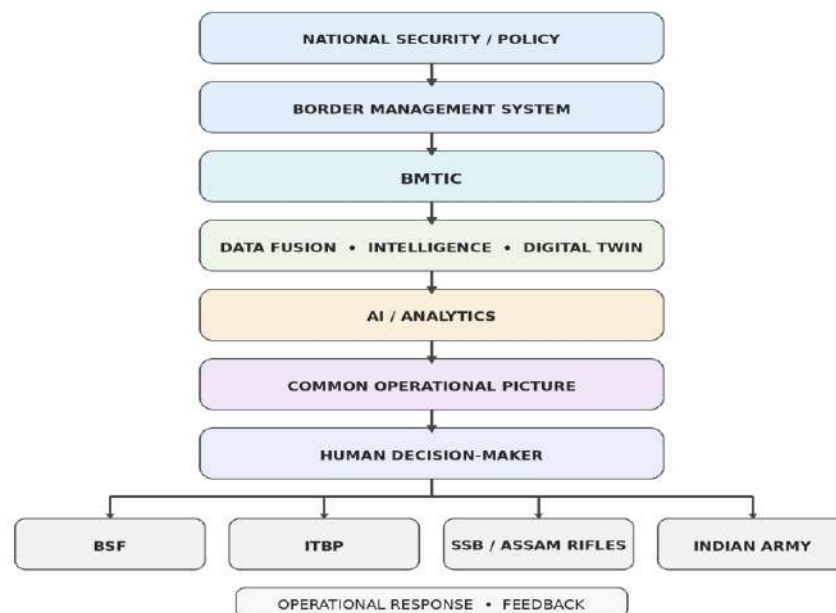


Figure 2: Proposed Border Management Technology and Intelligence Centre (BMTIC) Architecture

Digital Twin of the Border Environment

One of the more ambitious components of BMTIC could be a digital twin of the border environment. The Digital Twin would create a dynamic digital representation incorporating terrain, roads, rivers, bridges, fencing, border outposts, sensor locations, patrol routes, weather, satellite imagery, UAV feeds, infrastructure, historical incidents, population patterns and threat patterns.

The Digital Twin could support three levels of questions: What is happening? What has changed? What could happen? The first would provide real-time situational awareness; the second would identify deviations from the normal baseline; and the third would support scenario modelling and predictive analysis. It could also support what-if analysis, such as examining how the loss of a sensor, a change in patrol pattern, a weather event or the movement of a response unit could affect border coverage. This would move border management from a primarily reactive model towards a more anticipatory one.

Threats and Technology Response

The key change is that threat detection should no longer be treated as a collection of isolated sensor problems. BMTIC would treat them as components of one border intelligence environment.

Threat	Detection	Possible response
Infiltration	EO/IR, thermal, UGS, radar	QRT/interception
Drone intrusion	Radar, RF detection, EO/IR	Electronic and kinetic counter-UAS measures
Smuggling	UAV, cameras, intelligence fusion	Interdiction
Riverine infiltration	Radar, sonar, EO/IR, UAV	River patrol/QRT

Tunnelling	Ground sensors, specialised detection	Engineering/interdiction
Vehicle movement	Radar, cameras, geospatial analytics	Checkpoints/interception
Coordinated hostile activity	Multi-source intelligence fusion	Multi-agency response
Information/cyber activity	Cyber/intelligence monitoring	Attribution, mitigation and appropriate response

Table 3: Use of Technology to respond to Modern Threats along Borders

Enterprise Architecture and Human-Centric Decision-Making

The diversity of India's border environment creates a major interoperability challenge. Different forces and agencies may have their own sensors, networks, databases, command systems, procurement processes, data formats and security classifications. Merely connecting these systems does not mean that they can work together effectively.

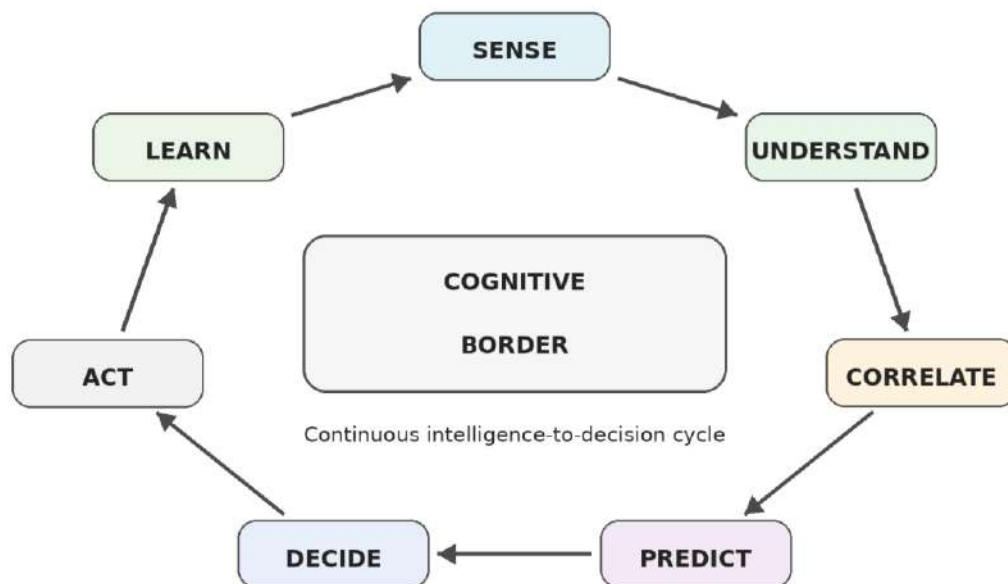


Figure 3: Cognitive Border Decision Cycle

An Enterprise Architecture approach can help establish common principles, standards and data models, along with interoperable systems, integrated processes and a shared operational picture. The focus should therefore be on developing the architecture first and then bringing the systems together. BMTIC could provide the necessary architectural oversight to ensure that technologically advanced systems do not remain disconnected from one another at the organisational level.

The concept of a cognitive border does not mean replacing human border guards with artificial intelligence. Human judgement remains essential because border management involves uncertainty, political sensitivities, legal authority, the risk of escalation, ethical issues and an understanding of the local situation. AI may identify an unusual activity, but understanding its wider strategic significance requires human assessment.

The proposed approach is therefore to combine machine-based perception and analysis with human judgement and accountable action. This is important because AI systems working with incomplete or biased data may produce false alarms, miss genuine threats or draw misleading connections. BMTIC should therefore incorporate explainable AI, confidence levels, human verification, audit trails, data provenance, cybersecurity and regular validation of its models.

Institutional, Doctrinal and Training Requirements

Technology alone cannot create a cognitive border. Border doctrine would need to recognise data and information as operational resources alongside manpower and physical infrastructure. Personnel would require skills in sensor operation, AI-assisted decision-making, data interpretation, geospatial intelligence, cyber hygiene, UAV operations, counter-UAS systems and digital intelligence.

A common inter-agency framework would be required for information sharing, data classification, incident reporting, intelligence fusion and joint response. Future procurement should increasingly emphasise interoperability, open standards, scalability, cybersecurity and lifecycle support rather than procurement of isolated platforms. Commanders would need to understand not merely how to operate technology but how to make decisions in technology-rich environments.

International Comparison

The purpose of international comparison should not be to identify a universally superior border-management model. Border systems are shaped by geography, threat perception, political institutions and legal frameworks. The United States has increasingly combined physical infrastructure, sensors, surveillance, autonomous systems and data-enabled border operations.¹⁶ China has pursued digital and technology-enabled approaches to border and customs management, including increasing use of data and AI.¹⁷ Russia has combined physical security, surveillance and technologically assisted border control in difficult environments.¹⁸ India's own trajectory has involved physical infrastructure increasingly supplemented by CIBMS, sensors, UAVs, surveillance and intelligence.¹⁹

The relevant lesson for India is therefore not technological imitation, but architectural integration adapted to India's geographical and institutional requirements.

Country	Broad technological approach	Relevant lesson for India
United States	Integrated physical infrastructure, sensors, surveillance, autonomous systems and data-enabled border operations ¹⁶	Integration of multiple surveillance technologies
China	Increasing use of digital systems, AI, data and smart border concepts ¹⁷	Importance of technology-enabled border governance
Russia	Emphasis on physical security, surveillance and technologically assisted border control in difficult environments ¹⁸	Combining physical and technological control

India	Physical infrastructure increasingly supplemented by CIBMS, sensors, UAVs, surveillance and intelligence ¹⁹	Opportunity to move from integration towards an architecture of cognition
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Table 4: Lessons for India's Border Management from Other Countries

Conclusion

India's border-management environment is undergoing a transition. Traditionally, a border was mainly a physical space secured through manpower, patrolling, barriers and infrastructure. With the introduction of technology, border management gradually moved towards an instrumented border, where cameras, thermal imagers, radars, sensors and UAVs improved surveillance, particularly in difficult terrain. CIBMS marks an important step towards an integrated border by bringing together manpower, sensors, networks, intelligence and command-and-control systems.

The next step should be to move towards an intelligent and eventually a cognitive border. The aim should not be limited to improving surveillance but also to making better sense of the information collected, identifying patterns, anticipating possible threats and supporting timely and informed human decisions.

This paper proposes the Border Management Technology and Intelligence Centre (BMTIC) as a possible institutional architecture for achieving this transition. BMTIC would integrate multi-domain sensing, intelligence fusion, artificial intelligence, enterprise architecture, digital-twin technology and human decision-making into a common framework.

The conceptual journey can therefore be summarised as: Physical → Instrumented → Integrated → Intelligent → Cognitive.

The objective is not to replace the soldier, border guard or commander with technology. It is to give the human decision-maker a more complete, timely and coherent understanding of the border environment. The future border may therefore remain physically defined by a line, fence, mountain or river. But its effective management will

increasingly depend upon the quality of the information architecture that exists behind that line.

List of Abbreviations and Acronyms

Abbreviation	Full Form
AI	Artificial Intelligence
BMTIC	Border Management Technology and Intelligence Centre
BOP	Border Out Post
CIBMS	Comprehensive Integrated Border Management System
COP	Common Operational Picture
EO/IR	Electro-Optical / Infrared
IB	International Border
ITBP	Indo-Tibetan Border Police
LAC	Line of Actual Control
LoC	Line of Control
MHA	Ministry of Home Affairs
NVD	Night Vision Device
QRT	Quick Reaction Team
RF	Radio Frequency
SSB	Sashastra Seema Bal

UGS	Unattended Ground Sensor
UAV	Unmanned Aerial Vehicle

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

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