



Cyber-Physical Systems

Foundation for a Technology-Driven Future

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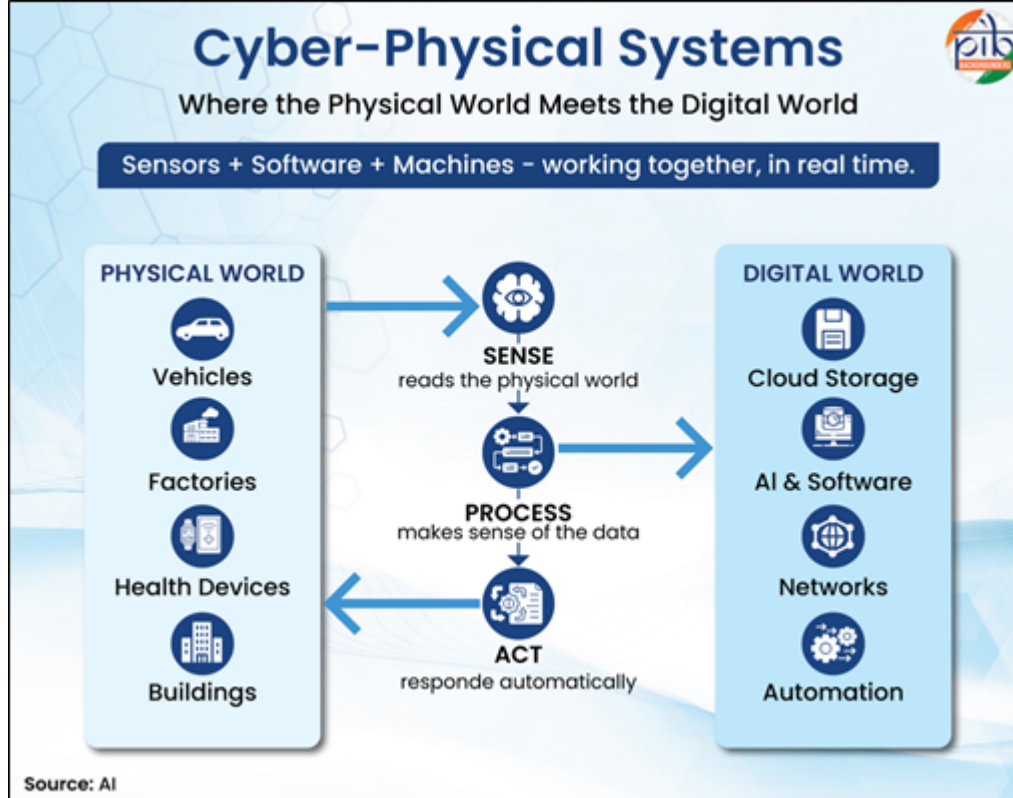
Cyber-Physical Systems connect the digital and physical worlds, enabling machines to sense, analyse and respond intelligently. India is developing a strong CPS ecosystem through the National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS). The Mission links research institutions, industry, Government and global partners to advance indigenous CPS capabilities. Its Technology Innovation Hubs and Translation Research Parks are converting research into applications across critical sectors. These efforts are supporting India's journey towards a technology-driven, innovative and self-reliant Viksit Bharat.

Understanding Cyber-Physical Systems

The world is moving from machines that simply perform tasks to systems that can *sense, think and respond*. This convergence of the **physical and digital worlds** is giving rise to a new generation of intelligent systems called **Cyber-Physical Systems (CPS)**.

A CPS connects computing technologies with physical systems through sensors, software and communication networks. It enables machines to sense their surroundings, process information and respond to changing conditions in real time. For example, driverless cars can navigate roads with limited human intervention. Smart factories can monitor production processes and adjust operations automatically. Medical devices can continuously track patients and support timely interventions. Smart buildings can regulate lighting, temperature and energy use based on real-time conditions. Even everyday devices, such as cleaning robots and fitness trackers, use similar capabilities.

At its core, CPS brings together **computation, communication and physical processes**. This integration is creating a new generation of intelligent, connected and responsive systems.



Government of India's CPS Initiatives



As CPS increasingly shapes critical infrastructure and emerging technologies, indigenous capabilities in this domain are becoming strategically important for India. Recognising this importance, the **Department of Science and Technology (DST)** is implementing the **National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS)**. The Union Cabinet approved the Mission in 2018, with an **outlay of ₹3,660 crore for nine years**. NM-ICPS provides a national framework for advancing CPS research, innovation and applications across priority sectors.

The mission brings **academia, industry, Government and international organisations** onto a common platform. This convergence connects scientific research with national priorities, industrial capabilities and emerging market opportunities. It covers the complete innovation journey, from **R&D and translational research to product development and start-up incubation**.

NM-ICPS is developing **national-priority technologies, core competencies and specialised talent** in emerging CPS domains. It is also establishing **world-class interdisciplinary Centres of Excellence** across the country. These centres serve as focal points for advanced research, technology development, expertise and policy inputs.



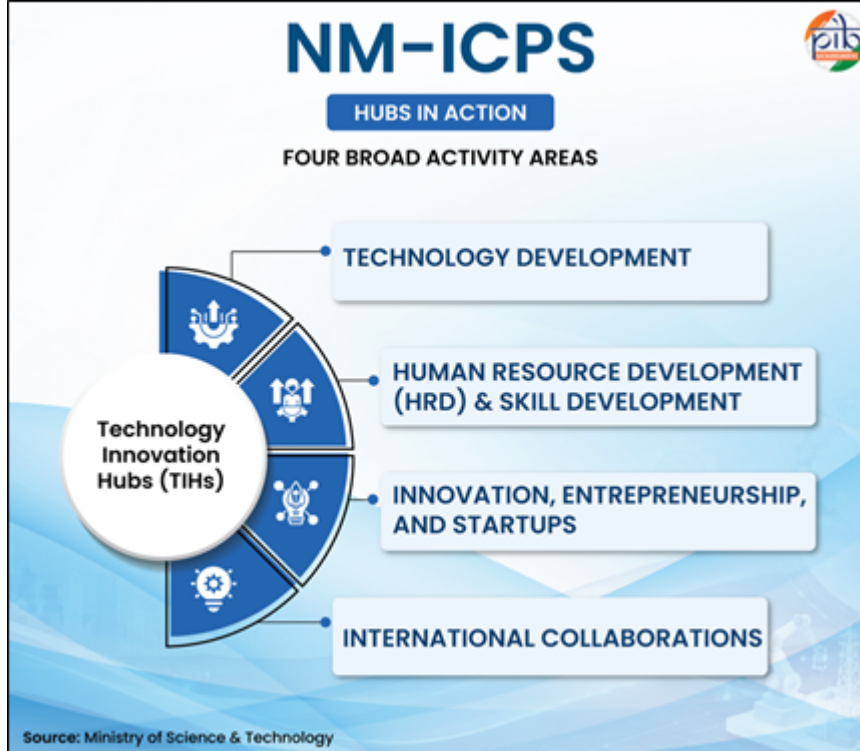
Through this coordinated approach, NM-ICPS is building India's capacity to develop **indigenous CPS solutions for critical national challenges**. It is laying the institutional foundation for a technology-driven future shaped by Indian research, innovation and entrepreneurship.

India's Leap Towards a Cyber-Physical Future

India is building a national ecosystem to take CPS from research laboratories to practical applications. NM-ICPS is developing this ecosystem through specialised institutions, skilled talent and industry partnerships.

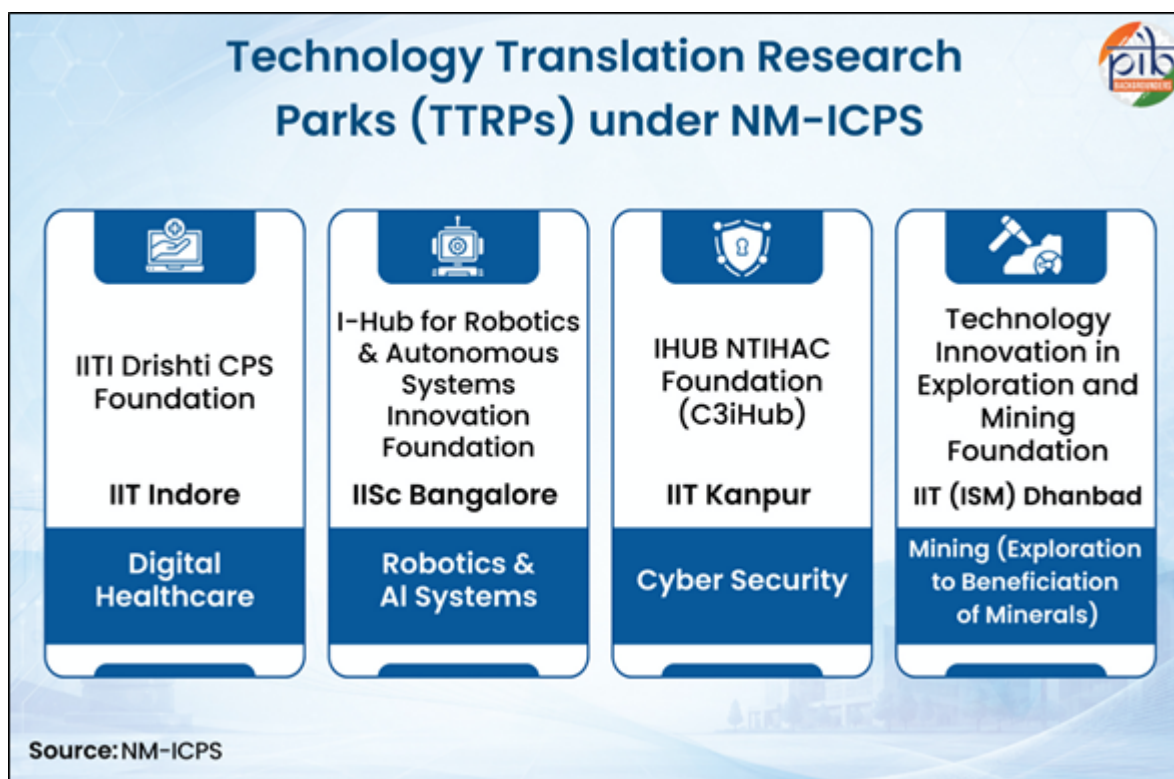
Under the mission, the Government has established **25 Technology Innovation Hubs (TIHs) as Section 8 companies**. These hubs are hosted by premier academic institutions across the country. The TIHs work across four broad areas: *Technology Development; Human Resource Development and Skill Development; Innovation, Entrepreneurship and Start-up Development; and International Collaborations*.

The hubs go beyond conventional research activities. They develop technology platforms, translate research into products and nurture technology-based start-ups. They also engage with Government Ministries to identify national challenges and develop practical solutions. This approach connects scientific capabilities with the needs of society and the economy.



From Technology Development to Technology Translation

The mission is now placing greater emphasis on taking promising technologies towards deployment and commercialisation. **In 2025, four high-performing TIHs were selected and supported as Technology Translation Research Parks (TTRPs).** These parks were established at IIT Kanpur, IISc Bengaluru, IIT (ISM) Dhanbad and IIT Indore. Each TTRP focuses on a strategic technology domain. **IIT Kanpur** focuses on Cybersecurity, while **IISc Bengaluru** focuses on Robotics and AI Systems. **IIT (ISM) Dhanbad** focuses on Mining Technologies, covering exploration to mineral beneficiation. **IIT Indore** focuses on Digital Healthcare. The four TTRPs are designed to accelerate technology translation and commercialisation.



Building Technology, Talent and Enterprise

NM-ICPS is building an integrated ecosystem that connects **technology, talent and enterprise** through its TIHs and TTRPs. As of August 2026, the Mission has enabled **1,146 technologies** and supported intellectual property creation and licensing. It has also contributed to **1,329 technology products** across

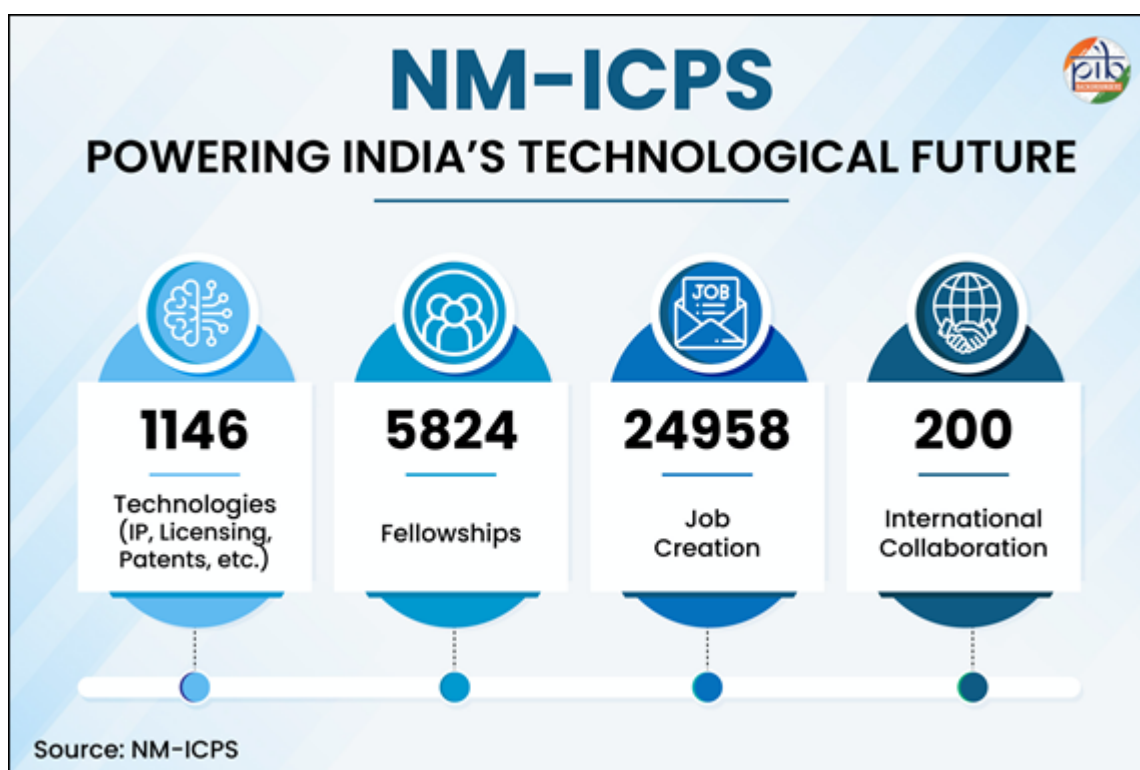
agriculture, healthcare, mining, cybersecurity, advanced communication and positioning, among other domains.

Human resource development and skill enhancement remain key pillars of this ecosystem. The **CHANAKYA (Comprehensive and Holistic Advancement of National Knowledge Yield and Analytics) Fellowship Programme** supports undergraduate, postgraduate, PhD and postdoctoral researchers. It funds projects addressing real-world CPS challenges through specialised Technology Innovation Hubs. As of August 2026, the mission has awarded **5,824 fellowships**.

These efforts are complemented by wider skill development initiatives that strengthen India's specialised CPS talent pool. The Mission has provided skills development training to **more than 2.46 lakh professionals**.

The Mission is also nurturing entrepreneurship by helping research-based innovations move towards commercialisation. It has **incubated 1,136 start-ups and spin-offs**, contributing to more than **24,000 jobs**.

International partnerships have further expanded India's CPS capabilities. The Mission has established **200 international collaborations**, strengthening India's engagement in this emerging technology domain.



The growing network of TIHs and TTRPs is strengthening India's CPS ecosystem across research, skills, entrepreneurship and industry. NM-ICPS is accelerating the journey from innovation to deployment and building indigenous solutions for national priorities.

BharatGen: Strengthening the Intelligence Layer of Cyber-Physical Systems



As CPS becomes more intelligent, AI is emerging as an important layer connecting machines, people and physical environments. In this direction, **BharatGen**, supported under NM-ICPS, is developing sovereign AI capabilities tailored to Indian languages and contexts.

Led by **IIT Bombay** with a consortium of academic institutions, BharatGen spans text, speech and vision-language technologies. Its latest **Param-2** foundation model has **17 billion parameters** and supports all **22 Scheduled Indian languages**.

BharatGen has also developed **Shrutam** speech-to-text and **Sooktam** text-to-speech models supporting **12 Indian languages**. **Patram**, developed under the **DocBodh framework**, enables multilingual access to complex Indian documents.

Domain-specific models include **Ayur Param** for Ayurveda, **Agri Param** for agriculture and **Legal Param** for the Indian legal domain. These capabilities can make CPS more responsive to India's linguistic diversity and sector-specific requirements.

By combining indigenous AI with connected physical systems, BharatGen can enable more accessible human-machine interaction. It can also support locally relevant decision-making across healthcare, agriculture, governance and other public-interest applications. BharatGen thus complements India's CPS ecosystem by adding a **sovereign, multilingual and multimodal intelligence layer**.

NM-ICPS: Translating Innovation into Real-World Impact

The strength of CPS lies in its ability to solve problems beyond the laboratory. NM-ICPS-supported technologies are now addressing challenges across healthcare, agriculture, mining, communications, cybersecurity and mobility.

Healthcare

CPS is transforming continuous monitoring, simulation-based treatment and earlier disease detection. The Drishti CPS Foundation at IIT Indore has developed **CharakDT**, a digital twin of the human body. It simulates the lungs, eyes and heart to study disease progression and test treatments virtually.

Digital Twin

A digital twin is a live, virtual copy of a real-world physical object, process, or system. It uses real-time data from smart sensors to mirror, track, and study how the real thing works and behaves.

Agriculture

CPS is helping farmers make decisions using real-time data on crops and field conditions. Researchers at IIT Bombay developed the **Agri-IoT Farm Management System** to monitor soil, weather and micro-climate conditions. The technology supports efficient use of water and fertilisers while improving farm productivity.

Mining

Mining operations often involve hazardous and remote locations. CPS is improving safety through drones, robotics and remote monitoring. The TEXMiN hub at IIT (ISM) Dhanbad has developed **drones capable of transmitting data up to 50 km**. This enables real-time monitoring while reducing exposure to hazardous locations.

Advanced Communication & Positioning

CPS technologies are supporting reliable and affordable connectivity in underserved regions. A key achievement is the 5G-Advanced **ORAN Massive MIMO Radio Unit (32TR RU)** developed at IIIT Bengaluru. The indigenous technology enables high-speed, reliable and cost-effective 5G connectivity. It is particularly relevant for extending advanced communication infrastructure to remote areas.

Cybersecurity

As physical infrastructure becomes digitally connected, protecting CPS from cyber threats becomes increasingly important. The IHUB NTIHAC Foundation at IIT Kanpur is developing solutions to secure critical infrastructure and CPS. Its **IT-OT Security Operations Centre** continuously monitors Information Technology and Operational Technology environments. The hub has also developed **Crypto-Forensic Tools** to support Law Enforcement Agencies in investigating cryptocurrency-related crimes.

Mobility, Robotics & Autonomous Systems

CPS is enabling safer deployment of autonomous vehicles and drones through controlled testing and intelligent systems. The TiHAN Foundation at IIT Hyderabad has established **India's first dedicated proving ground for autonomous navigation**. The testbed validates aerial and terrestrial autonomous vehicles before their real-world deployment. At IISc Bengaluru, the I-Hub for Robotics and Autonomous Systems is advancing **intelligent mobility solutions**. Its **iRASTE application** identifies accident-prone locations and provides real-time alerts to drivers. The system is currently being piloted in Nagpur, with plans for expansion to other cities.

These applications demonstrate how NM-ICPS is translating advanced research into practical solutions for critical sectors. By enabling indigenous technologies, skills and innovation, the mission is enabling safer, smarter and more efficient systems. These efforts are advancing India's capabilities towards a technology-driven and self-reliant Viksit Bharat.

Towards a Technology-Driven and Self-Reliant Viksit Bharat

Cyber-Physical Systems are opening new possibilities for intelligent infrastructure and advanced public services. Through NM-ICPS, India is building capabilities that connect scientific research with national development priorities.

The mission is nurturing indigenous solutions across healthcare, agriculture, mining, communications, cybersecurity and mobility. Its TIHs and TTRPs are accelerating the journey from research to validation, deployment and commercialisation.

BharatGen like initiative is adding sovereign, multilingual AI capabilities to this emerging technology landscape. Together, these efforts can make connected systems more intelligent, secure, accessible and responsive to Indian needs. Stronger academia-industry partnerships will further accelerate innovation and technology adoption. Skilled talent, start-ups and global collaborations will expand India's capabilities across emerging technology domains.

The wider deployment of indigenous CPS can support smarter infrastructure, efficient services and new economic opportunities. NM-ICPS is therefore contributing to a **technology-driven, innovation-led and self-reliant Viksit Bharat**.

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