विज्ञान एवं प्रौद्योगिकी विभाग
DEPARTMENT OF
SCIENCE & TECHNOLOGY
सत्यमेव जयते

National Mission on Interdisciplinary Cyber-Physical Systems
NM-ICPS

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DREAM 2047

National Mission on Interdisciplinary Cyber-Physical Systems

Advancing Translational Research in Cyber-Physical Systems and Associated Technologies

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DEPARTMENT OF
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Four Strategic Pillars of the National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS) is being implemented with all Technology Innovation Hubs (TIHs) undertaking activities under the following four major categories:

1

Technology Development

TIHs are developing cutting-edge technologies, prototypes, and products in Cyber-Physical Systems (CPS) to address societal and industrial challenges.

2

Entrepreneurship Development

The TIHs support innovation and entrepreneurship by providing funding and resources to startups. These initiatives enhance core competencies and build capacities for startups, fostering a robust innovation ecosystem for the translation and commercialization of technologies and products developed in collaboration with government and private organizations for real-world applications

3

Human Resource Development (HRD)

The TIHs are fostering human capital by offering fellowships to undergraduate, postgraduate, doctoral, post-doctoral scholars, and faculty members engaged in CPS research. In addition, short- and long-duration skill development programs are being conducted across emerging technology domains to build a future-ready workforce and next-generation technologists.

4

International Collaborations

By fostering International Collaborative Research, TIHs enable cross-fertilization of ideas and best practices. This enhances the visibility of Indian R&D and strengthens partnerships with global research organizations and industries.

सत्यमेव जयते

डॉ. राजेश सु. गोखले
Dr. Rajesh S. Gokhale

सचिव
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Department of Science and Technolog

04th June, 2026

FOREWORD

It gives me great pleasure to present this special issue of Dream 2047. popular science magazine of Department of Science and Technology, dedicated to the National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS), a flagship initiative of the Government of India aimed at promoting innovation, research, entrepreneurship, and technological excellence in emerging domains.

The rapid convergence of physical and digital systems is transforming the way we live, work, and solve societal challenges. Through its focus on areas such as Artificial Intelligence, Robotics, Internet of Things, Smart Manufacturing, and Intelligent Infrastructure, NM-ICPS is creating a vibrant ecosystem that empowers researchers, innovators, and entrepreneurs to develop solutions for a technologically advanced and self-reliant India.

This special issue brings together insights, achievements, and opportunities emerging from the NM-ICPS ecosystem. It highlights the importance of interdisciplinary collaboration in addressing complex challenges and advancing India's vision of becoming a global leader in frontier technologies.

I appreciate the editorial team of Dream 2047 for bringing out this timely and informative issue and extend my best wishes to all readers. May this publication serve as a catalyst for ideas, collaborations, and innovations that contribute to the Nation's aspirations for 2047 and beyond.

(Rajesh S. Gokhale)

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FROM THE **CHIEF EDITOR'S** DESK

Smt. A. Dhanalakshmi

Joint Secretary
Department of Science & Technology
Government of India

The rapid advancement of emerging technologies is redefining economies, industries, and societies across the world. For India, this transformation presents a significant opportunity to build technological leadership while addressing national priorities through innovation-led development. The National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS) is an important step in this direction, enabling a strong foundation for research, technology development, and innovation in critical sectors.

This special issue of Dream 2047 highlights the evolving role of NM-ICPS in strengthening India's capabilities in areas such as intelligent systems, robotics, advanced manufacturing, smart mobility, data-driven technologies, and autonomous platforms. Through its network of Technology Innovation Hubs and Technology Translation Research Parks (TTRPs), the Mission has created a collaborative framework that supports technology development, application-oriented research, and industry engagement.

The Mission, through its network of TIHs and TTRPs, is making significant contributions in major technology areas such as Artificial Intelligence & Machine Learning, Digital Healthcare, Robotics & AI Systems, Cyber Security, Fintech, IoT & IoE, Autonomous Navigation Systems, Sensors & Networking, Mining Technologies, Quantum Technologies, etc. The Mission is also strengthening translational research, industry collaboration, start-up innovation, and indigenous technology development through TTRPs established at IIT Kanpur, IISc Bangalore, IIT (ISM) Dhanbad, and IIT Indore. A major initiative under the mission is BharatGen: A Suite of Generative AI Technologies for India, India's multilingual and multimodal Generative AI programme, which is advancing inclusive AI technologies and creating impactful solutions across 22 scheduled Indian languages and sectors.

One of the important outcomes of the Mission has been the emergence of a vibrant innovation ecosystem involving researchers, start-ups, students, and industry partners. The ecosystem has encouraged interdisciplinary problem-solving and provided opportunities for translating research ideas into practical solutions. It has also contributed to building skilled human resources in advanced technology domains, which will be essential for India's long-term growth and competitiveness.

The Mission has further encouraged innovation-led entrepreneurship by supporting start-ups working on deep-tech solutions relevant to sectors such as healthcare, agriculture, mobility, infrastructure, manufacturing, and public services. Access to shared facilities, mentoring support, testing platforms, and collaboration networks has helped create an enabling environment for technology-driven enterprises.

As India moves towards becoming a knowledge-based and technology-enabled economy, the integration of cyber-physical systems with Artificial Intelligence, machine learning, and intelligent automation will become increasingly important. Future growth will depend on the ability to create reliable, scalable, and inclusive technological solutions that can respond to complex societal and industrial needs. In this context, closer convergence between NM-ICPS initiatives and the national AI ecosystem can open new pathways for innovation and deployment.

Future will also require stronger industry participation, sustained investments in research and development, international collaborations, and greater emphasis on commercialization and technology adoption. Equally important will be the need to promote indigenous innovation and strengthen India's position in emerging technology value chains.

This issue presents insights into the progress, opportunities, and future directions of NM-ICPS as India advances towards the vision of Viksit Bharat 2047. It reflects the growing importance of mission-driven innovation programmes in shaping a technologically empowered and globally competitive nation.

EDITOR'S NOTE

Dr Kinkini Dasgupta Misra

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Advances in intelligent systems, connected devices, automation, and data-driven innovation are transforming the global technology landscape. Technologies that once operated independently are now converging to create integrated cyber-physical ecosystems with applications across manufacturing, healthcare, transportation, agriculture, communication, and governance. In this context, the Department of Science and Technology (DST), Government of India, launched the National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS) to strengthen national capabilities in emerging technologies and support the growth of India's innovation ecosystem.

Over the past few years, NM-ICPS has emerged as an important platform for scientific advancement, technology translation, entrepreneurship, and human resource development. Through its network of Technology Innovation Hubs (TIHs) the Mission has enabled institutions across the country to collaborate in developing indigenous technologies aligned with national priorities and future industrial needs.

The achievements of the Mission reflect both the scale and impact of this effort. NM-ICPS has supported the development of 1,872 technologies and technology products, while facilitating intellectual property generation through 767 patents filed and 221 patents granted. More than 3,400 publications and related intellectual contributions have also emerged from the ecosystem, indicating growing research strength in cyber-physical systems and allied domains.

The Mission has also contributed significantly towards strengthening research and innovation capabilities in emerging technology areas. More than 2,600 research activities have been supported alongside extensive investments in human resource development. Thousands of students and researchers have benefited through graduate, postgraduate, doctoral, postdoctoral, faculty, and chair professor fellowships. In addition, skill development initiatives have reached over 2.37 lakh beneficiaries, helping create a future-ready workforce equipped for advanced technology domains.

NM-ICPS has supported the growth of India's deep-tech entrepreneurship ecosystem by enabling nearly 1,000 startups and spin-off companies working in areas such as robotics, AI-enabled systems, smart infrastructure, mobility technologies, healthcare devices, and industrial automation. These initiatives have also contributed to employment generation, with over 46,000 jobs created through Mission-supported activities.

The Mission has further encouraged international collaboration and research partnerships with institutions and organisations across the world, enabling knowledge exchange, joint research, and technology cooperation in emerging domains.

As India progresses, cyber-physical systems and intelligent technologies are expected to play an increasingly important role in driving innovation and economic growth. The NM-ICPS framework has laid a strong foundation for advancing research, innovation, technology deployment, and industry collaboration in this evolving technological landscape.

This edition of Dream 2047 focuses on NM-ICPS presents perspectives on the achievements, opportunities, and future directions of the Mission, and highlights the role of science, innovation, and collaborative research in building a technologically empowered and globally competitive Bharat.

Reimagining NM-ICPS
The Way Forward for India's Deep-Tech and AI Transformation

Prof. Abhay Karandikar

Member, NITI Aayog
Former Secretary
Department of Science & Technology
Government of India

India is at a transformational phase in its technological journey. As the global economy undergoes rapid technological change, future leadership will increasingly depend on a nation's ability to convert scientific research into deployable technologies, globally competitive industries, scalable enterprises, and strategic capabilities. In this evolving landscape, innovation ecosystems that integrate research, technology development, entrepreneurship, and industry collaboration are becoming critical drivers of economic growth and technological leadership.

In this context, the National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS), launched by the Department of Science and Technology (DST), has emerged as one of India's most significant deep-tech initiatives. Conceived as a mission-mode programme to strengthen national capabilities in emerging technologies, NM-ICPS has built a comprehensive ecosystem that integrates research, innovation, translational development, entrepreneurship, and technology deployment within a unified national framework.

The Mission recognized early that the future of economic competitiveness and strategic autonomy would be shaped by technologies such as Artificial Intelligence (AI), robotics, autonomous systems, sensors, smart manufacturing, advanced communication systems, cybersecurity, intelligent mobility, and digital infrastructure. These technologies collectively form the foundation of cyber-physical systems (CPS), where physical systems are deeply integrated with computational intelligence, sensing, communication networks, and real-time decision-making capabilities. The Mission was designed not simply to support isolated research activities, but to build an interdisciplinary innovation ecosystem capable of generating large-scale impact.

The way forward for NM-ICPS lies in scaling innovation into impact through stronger innovation pipelines, global partnerships, and mission-driven deployment. Our focus is to transform ideas into national capabilities that position India as a leader in technology and innovation.

One of the most important achievements of NM-ICPS has been the establishment of a nationwide network of 25 Technology Innovation Hubs (TIHs) across leading academic and research institutions in India. These TIHs represent a unique institutional innovation of the Department of Science and Technology, with each hub established as an independent Section 8 company within

a host institution. This structure has enabled the creation of an agile and professionally governed translational research ecosystem that bridges academic research and technology commercialization. It stands as one of DST's most significant institutional experiments to help academic institutions move beyond conventional research models and actively contribute to technology translation and innovation-led growth.

Unlike traditional academic structures that often operate in silos, the TIHs have evolved into collaborative platforms that connect academia, industry, startups, investors, researchers, and government agencies. Through this network, NM-ICPS has demonstrated how academic institutions can serve as catalysts for technology-driven economic growth and societal impact.

NM-ICPS has significantly strengthened India's innovation ecosystem by creating structured pathways for translational research, prototyping, validation, pilot deployment, and commercialization. While India historically produced strong academic research, the conversion of research outcomes into products and globally competitive technologies remained a major challenge. The Mission has helped address this gap through institutional mechanisms that support the entire innovation lifecycle from research and ideation to deployment and market adoption. Through shared infrastructure, testing facilities, industry partnerships, funding support, and mentorship networks, NM-ICPS has accelerated the movement of technologies from laboratories into real-world applications.

A major pillar of the NM-ICPS programme has been its focus on deep-tech entrepreneurship and startup development. Rather than treating startups merely as beneficiaries of innovation support, the Mission has positioned them as active participants within India's emerging deep-tech ecosystem. An integrated ecosystem has enabled the growth of deep-tech ventures across sectors such as healthcare, smart mobility, autonomous systems, industrial automation, defence technologies, agriculture, and digital infrastructure.

Moreover, the startups emerging from the NM-ICPS ecosystem can become a strong pipeline for the Research Development and Innovation (RDI) Fund. Many are already progressing beyond early-stage research into validation, commercialization, and deployment. Unlike conventional digital enterprises, deep-tech startups require sustained infrastructure support, long development cycles, interdisciplinary expertise, and high-risk experimentation. NM-ICPS has helped create these enabling conditions within academic and innovation ecosystems, leading to the emergence of indigenous intellectual property, advanced engineering capabilities, and globally competitive technologies that strengthen India's technological self-reliance.

Another major contribution of the Mission has been the development of a continuous innovation pipeline connecting education, research, skilling, entrepreneurship, and deployment. Through interdisciplinary training programmes, fellowships, internships, and research opportunities in frontier technologies, NM-ICPS has contributed to building a future-ready workforce capable of operating across AI, robotics, embedded systems, cybersecurity, advanced manufacturing, and intelligent systems. This skilled talent base is essential for sustaining India's long-term innovation capacity and global competitiveness.

Beyond technology development, NM-ICPS has demonstrated how mission-driven innovation frameworks can generate broad socio-economic impact. Technologies emerging from the ecosystem are contributing to sectors such as healthcare, defence, manufacturing, agriculture, transportation, digital education, and secure digital infrastructure, reflecting the Mission's strong alignment with national priorities and applied innovation needs.

A recent and important institutional expansion under the Mission has been the upgradation of 4 TIHs into Technology Translation Research Parks (TTRPs). These TTRPs have been identified from among the highest-performing TIHs to further strengthen translational research, technology validation, industrial engagement, pilot deployment, and commercialization activities. The TTRPs represent the next stage in the evolution of the NM-ICPS ecosystem and are designed to operate at a larger scale with deeper industry integration and stronger deployment capabilities. Institutions such as IIT Kanpur, IISc Bengaluru, IIT (ISM) Dhanbad, and IIT Indore have been selected for this transition based on their demonstrated strengths in technology development, startup ecosystems, and industry collaboration.

Going forward, stronger linkages between TIHs and TTRPs will be important to create a seamless national innovation continuum connecting research generation, translational development, pilot deployment, commercialization, manufacturing, and societal adoption. Such integration will reduce fragmentation across the innovation value chain and strengthen India's ability to scale deep-tech innovation systematically.

The future direction of NM-ICPS is closely connected with the rapid rise of Artificial Intelligence and the emergence of "Physical AI," where AI systems interact with and operate within physical environments through robotics, autonomous systems, industrial automation, intelligent mobility, healthcare devices, drones, smart infrastructure, and embedded systems. This convergence of AI with cyber-physical systems represents the next frontier of technological transformation globally.

In this context, NM-ICPS has already created much of the foundational architecture required for India's Physical AI ecosystem. Cyber-physical systems inherently combine sensing, computation, communication, control, and real-world actuation, the same technological layers that underpin Physical AI systems. Through its nationwide network of TIHs, advanced testbeds, translational research platforms, and industry-linked innovation ecosystems, NM-ICPS provides a ready institutional framework for deploying AI-enabled physical systems at scale.

This positions the Mission to play a strategic national role in accelerating AI-driven transformation across manufacturing, mobility, healthcare, agriculture, mining, logistics, defence, and smart infrastructure. As India seeks to build sovereign capabilities in next-generation technologies, NM-ICPS can evolve into a critical national platform for the development, testing, validation, and commercialization of Physical AI systems.

India's expanding investments in AI through initiatives such as BharatGen and the IndiaAI Mission further strengthen the strategic relevance of NM-ICPS. Aligning the Mission with the broader national AI ecosystem can create integrated platforms for datasets, compute infrastructure, simulation environments, AI validation, edge computing, and sector-specific deployment across manufacturing, healthcare, agriculture, mobility, defence, and urban infrastructure.

At the same time, future growth will require stronger industry participation, deeper international collaborations, trusted digital infrastructure, resilient cybersecurity frameworks, and sustained long-term investment. India's technological leadership will increasingly depend on its ability to build and own foundational technologies, globally competitive intellectual property, advanced engineering platforms, and scalable deep-tech enterprises.

Viewed in its entirety, NM-ICPS represents a major shift in India's innovation strategy – moving from fragmented research funding toward an integrated national innovation ecosystem that connects science, engineering, entrepreneurship, translational research, industry, and societal deployment. The Mission has demonstrated that coordinated innovation ecosystems can accelerate technology development, improve commercialization outcomes, and strengthen national technological capability.

Shri Kris Gopalakrishnan
Chairman
Axilor Ventures Private Limited and
Mission Governing Board
NM-ICPS

NM-ICPS and the Next Phase of Deep-Tech Growth

India's technological future is increasingly shaped by the convergence of the physical and digital worlds. Recognising the importance of cyber-physical systems across sectors such as manufacturing, mobility, healthcare, and artificial intelligence, the Government of India launched the National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS) to build strong deep-tech capabilities in the country.

With a nationwide network of Technology Innovation Hubs, translational research initiatives, and a growing startup ecosystem, the Mission is helping India move from technology adoption to technology leadership.

In this conversation, Dr Kris Gopalakrishnan, Chairman of the Mission Governing Board, NM-ICPS, shares his perspectives on the vision behind the Mission, its progress so far, and the way forward. He reflects on the origins of NM-ICPS, its evolving ecosystem, key achievements, and the challenges ahead, while highlighting the importance of collaboration and long-term ecosystem building in shaping India's technological future.

Q NM-ICPS was launched with a Rs 3,660 crore outlay to strengthen India's capabilities in frontier cyber-physical technologies. Sir, what structural gap in India's science and innovation ecosystem was the Mission designed to address?

India's science and innovation ecosystem has historically been strong in fundamental research and academic output, but relatively weaker in translating that research into deployable products and scalable technologies. There has been a persistent structural gap between laboratory innovation and market adoption, often referred to as the "valley of death" in innovation cycles.

The NM-ICPS was conceived specifically to bridge this gap by institutionalising the translational research layer. It focuses on taking ideas beyond proof-of-concept into prototypes, validation, and eventually commercialisation. By building dedicated infrastructure, fostering industry collaboration, and enabling startup creation, the Mission ensures that research outcomes do not remain confined to academic publications but evolve into real-world solutions. In essence, it strengthens the entire innovation value chain from discovery to deployment.

Q From advanced manufacturing and smart mobility to healthcare devices and digital infrastructure, CPS technologies are increasingly central to national competitiveness. Why are these systems strategically critical for India at this stage of development?

Cyber-physical systems (CPS) lie at the intersection of physical processes and digital intelligence, making them foundational to next-generation industries. For India, which aims to become a developed nation by 2047, mastering these technologies is not optional, it is essential.

Strategically, CPS technologies enable productivity gains, efficiency improvements, and entirely new business models across sectors such as manufacturing, agriculture, healthcare, and urban infrastructure. They also play a critical role in ensuring technological sovereignty, reducing dependence on imported high-end systems, and strengthening national security.

India must move from being primarily a service-driven economy to a product-driven and innovation-led economy. Developing indigenous CPS technologies not only supports domestic needs but also positions India as a global exporter of advanced technological solutions. The Mission's focus on translation ensures that India builds globally competitive products rather than remaining a consumer of imported technologies.

Q Twenty-five TIHs have been established across leading institutions. How were their domains selected, and how do you ensure that they function as an integrated national network rather than isolated centres of excellence?

The domains of the Technology Innovation Hubs (TIHs) were carefully selected to cover both horizontal and vertical dimensions of cyber-physical systems. Horizontal technologies include core enablers such as sensors, communication systems, cybersecurity, and data analytics. Vertical domains address sector-specific applications such as autonomous mobility, robotics, healthcare technologies, agriculture systems, and water management.

To avoid fragmentation, the Mission adopts a hub-and-spoke-and-spike architecture. Each TIH acts as a central node, supported by spokes that focus on enabling technologies and spikes that address niche innovation areas. This structure encourages interdependence and collaboration across domains.

Additionally, a wide network of academic institutions, industry partners, and startups is integrated into the ecosystem. Regular knowledge exchange, joint projects, and shared infrastructure ensure that these hubs operate as a cohesive national innovation network rather than isolated silos.

Q Sir, to take it further, four TIHs have recently been upgraded into Technology Translation Research Parks (TTRPs). What role do TTRPs play in accelerating commercialisation and bridging the "lab-to-market" gap?

Technology Translation Research Parks (TTRPs) represent the next stage in the innovation lifecycle, where the emphasis shifts from research to productisation and commercialisation. Their primary role is to identify high-potential technologies emerging from TIHs and develop clear product roadmaps for them.

TTRPs provide the necessary ecosystem for scaling, which includes advanced prototyping facilities, pilot manufacturing support, industry partnerships, and access to funding. They also help in navigating regulatory pathways and market entry strategies.

By focusing on the last-mile challenges of innovation, such as manufacturability, reliability, and scalability, TTRPs significantly accelerate the transition of technologies from the lab to the marketplace. Over time, they are expected to catalyse the emergence of globally competitive deep-tech products originating from India.

Q Sir, in 2025 alone, 297 technologies crossed TRL-7 and 112 were commercialised. What does this signal about India's maturing deep-tech ecosystem?

These numbers are a strong indicators that India's deep-tech ecosystem is moving from early-stage experimentation to tangible outcomes. Crossing Technology Readiness Level (TRL) - 7 signifies that technologies have moved beyond prototypes into system-level validation in operational environments, a critical milestone for commercialisation.

Over the past several years, India has witnessed the emergence of a robust deep-tech ecosystem, with over 5,000 startups working in areas such as AI, robotics, quantum technologies, and semiconductors. Government initiatives, including NM-ICPS, the National Quantum Mission, semiconductor programs, and the establishment of the Anusandhan National Research Foundation (ANRF), have created a strong enabling environment.

This momentum reflects a broader shift in India's innovation narrative from services to products, from adoption to creation, and from incremental improvements to breakthrough technologies. It signals growing confidence in India's ability to compete in global deep-tech markets.

Q Hundreds of startups have emerged from the Mission's ecosystem. How does NM-ICPS support ventures that require hardware validation, regulatory approvals, and long gestation cycles?

Deep-tech startups, particularly those in hardware and CPS domains, face unique challenges such as high capital requirements, long development cycles, and complex regulatory landscapes. NM-ICPS addresses these challenges through a multi-layered support system.

The Technology Innovation Hubs provide access to advanced testing and validation infrastructure, mentorship from domain experts, and connections with industry stakeholders. They also facilitate regulatory approvals by guiding startups through compliance requirements and certification processes.

Importantly, the governance structure of these hubs includes significant industry participation around 50% of board members are from industry. This ensures alignment with market needs and provides startups with direct access to potential customers, partners, and investors. While challenges remain, this integrated approach significantly reduces barriers for deep-tech entrepreneurship.

Q India often pilots promising technologies but struggles with large-scale deployment. At this stage, how is the Mission ensuring that CPS solutions scale across sectors such as agriculture, healthcare, manufacturing, and public safety?

Scaling remains one of the most critical challenges in India's innovation ecosystem. While NM-ICPS has successfully enabled the development of technologies and prototypes, large-scale deployment is still evolving. However, an important shift has occurred, the academic ecosystem has begun to internalize the importance of technology transfer, product development, and market alignment. This cultural transformation is a key enabler for future scale.

The Mission is also fostering stronger industry partnerships and encouraging startups to focus on scalable business models. As more products mature and demonstrate reliability, adoption across sectors is expected to accelerate. The next phase of the Mission will likely focus more intensively on scaling mechanisms, including public procurement, industry integration, and global market access.

Q With thousands of fellowships and training programmes conducted annually, how is NM-ICPS reshaping India's interdisciplinary talent pipeline?

Human resource development is a cornerstone of the NM-ICPS. Cyber-physical systems require expertise that spans multiple disciplines, including engineering, computer science, data analytics, and domain-specific knowledge.

Each TIH has clearly defined targets for training students, researchers, and faculty. The programmes emphasise hands-on learning, interdisciplinary collaboration, and exposure to real-world problem-solving. This approach is creating a new generation of engineers and researchers who are not only technically proficient but also innovation-oriented.

By aligning education with emerging technological needs, NM-ICPS is helping to build a talent pipeline that can sustain India's long-term leadership in deep-tech domains.

Q BharatGen aims to develop multilingual, multimodal foundational AI models rooted in Indian languages and contexts. How does this initiative strengthen India's AI sovereignty and inclusive digital infrastructure?

BharatGen represents a significant step towards building indigenous AI capabilities that are inclusive and contextually relevant. Developed under an IIT Bombay-led consortium, it focuses on creating large language models that support all 22 scheduled Indian languages.

This initiative addresses two critical challenges: accessibility and sovereignty. By enabling AI systems to operate in multiple Indian languages, it ensures that the benefits of AI reach a much broader segment of the population, including non-English speakers.

At the same time, developing domestic foundational models reduces dependence on foreign technologies and strengthens India's control over its digital infrastructure. This is essential for ensuring data security, cultural representation, and long-term technological independence.

Q Looking ahead, as the Mission approaches its later phase, what will define its long-term legacy, technological breakthroughs, industrial competitiveness, startup creation, or strategic autonomy?

The legacy of NM-ICPS will likely be defined by a combination of all these factors, but perhaps its most enduring impact will be the cultural transformation it has initiated within India's academic and innovation ecosystems.

The Mission has embedded a strong orientation towards translation, entrepreneurship, and industry collaboration across leading institutions. It has catalysed the creation of hundreds of startups, strengthened academia-industry linkages, and laid the foundation for a product-driven economy.

In the long term, some of the technologies and startups emerging from this ecosystem will contribute to India's strategic autonomy and global competitiveness. The key challenge ahead is scaling, ensuring that these innovations achieve widespread adoption and global market presence. Consolidating these gains and building a

I am confident that through collective efforts involving the Government, Industry & Academia, India will be able to take a leadership position in the areas of CPS in times to come.

Dr Ekta Kapoor
Scientist-G and Head
Frontier and Futuristic Technologies (FFT) Division
Department of Science & Technology
Government of India

NM-ICPS: Powering India's Next-Generation Technologies

India's technological evolution is entering a decisive phase in which digital intelligence increasingly interacts with and controls physical systems. From autonomous mobility and smart agriculture to AI-driven healthcare diagnostics and secure communication networks, the convergence of cyber and physical systems is reshaping economies and governance frameworks worldwide.

At the forefront of this transformation in India stands the National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS)—a flagship initiative of the Department of Science and Technology (DST), is designed to position the country as a global leader in next-generation technologies.

NM-ICPS represents a strategic national effort to build indigenous capabilities in Cyber-Physical Systems (CPS), strengthen deep-tech innovation ecosystems, and accelerate India's transition toward a knowledge-driven and technology-enabled economy. By fostering interdisciplinary research, enabling translational innovation, nurturing startups, and developing a future-ready workforce, the Mission is laying the technological foundation for self-reliant and inclusive national growth.

Cyber-Physical Systems integrate computation, communication, sensing, and control with physical processes, enabling real-time monitoring, predictive analytics, and intelligent decision-making. These technologies form the backbone of Industry 4.0 and are transforming sectors including manufacturing, transportation, infrastructure, healthcare, agriculture, defence, energy, and urban governance.

India's vision under NM-ICPS extends beyond adopting global technological advancements. The Mission seeks to develop indigenous, scalable, and socially relevant

Genesis of a Transformative National Initiative

Launched in December 2018 with an outlay of Rs 3,660 crore, NM-ICPS marked a decisive step toward strengthening India's strategic technological capabilities. The Mission emerged from the recognition that emerging technologies–such as artificial intelligence, robotics, advanced sensing, communication networks, and automation–would define global competitiveness in the decades ahead.

solutions aligned with national developmental priorities. It reflects India's strategic aspiration to move from technology consumption to technology creation, thereby strengthening economic resilience and technological sovereignty.

The Mission is guided by a robust governance architecture comprising a Mission Governing Board, an Inter-Ministerial Coordination Committee, and a Scientific Advisory Committee. This multi-tiered framework ensures coordinated implementation, inter-sectoral convergence, and scientific excellence.

Vision and Objectives

The core vision of NM-ICPS is to establish India as a global hub for CPS technologies and applications. The Mission adopts a holistic approach that integrates research, innovation, entrepreneurship, human resource development, and technology commercialization.

Key objectives

- Promoting advanced translational research in CPS and allied domains
- Developing deployable prototypes aligned with national priorities
- Expanding India's skilled talent base in frontier technologies
- Strengthening deep-tech startups and innovation ecosystems
- Fostering international collaborative research partnerships

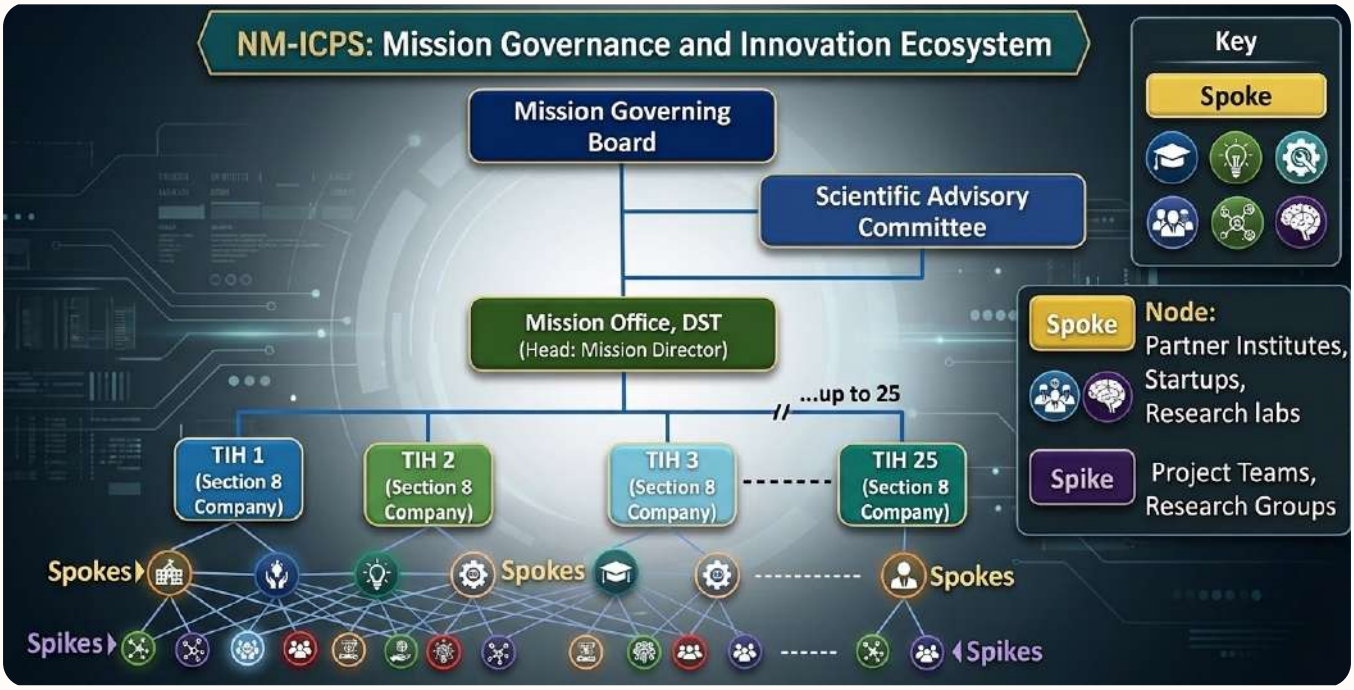
A defining strength of NM-ICPS is its emphasis on translational research. Unlike conventional research initiatives that often culminate in academic publications, NM-ICPS actively supports the transformation of research outcomes into deployable technologies and market-ready solutions. This orientation ensures that scientific innovation directly contributes to industrial modernization, employment generation, and societal advancement.

Mission Architecture: A Nationwide Innovation Network

NM-ICPS operates through a distributed and collaborative implementation model anchored by twenty-five Technology Innovation Hubs (TIHs) established across premier academic institutions in the country.

Each TIH functions as a Section-8 company embedded within its host institution, providing operational flexibility while maintaining institutional accountability. These hubs focus on specialised technological verticals collectively spanning Artificial Intelligence and Machine Learning, Robotics and Autonomous Systems, Quantum Technologies, Cybersecurity, Advanced Communication Systems, Data Science, Internet of Things, Agriculture and Water Technologies, Mining Technologies, Human-Computer Interaction, and Precision Positioning Technologies.

The hub-and-spoke model promotes interdisciplinary collaboration, regional innovation outreach, and industry engagement. By establishing hubs



Structural Overview of Mission Governance and Innovation Ecosystem in NM-ICPS

across diverse geographic regions, the Mission ensures balanced national capacity building and strengthens local innovation ecosystems.

Four Pillars of Implementation

The operational framework of NM-ICPS rests on four integrated pillars:

1. Technology Development and Innovation

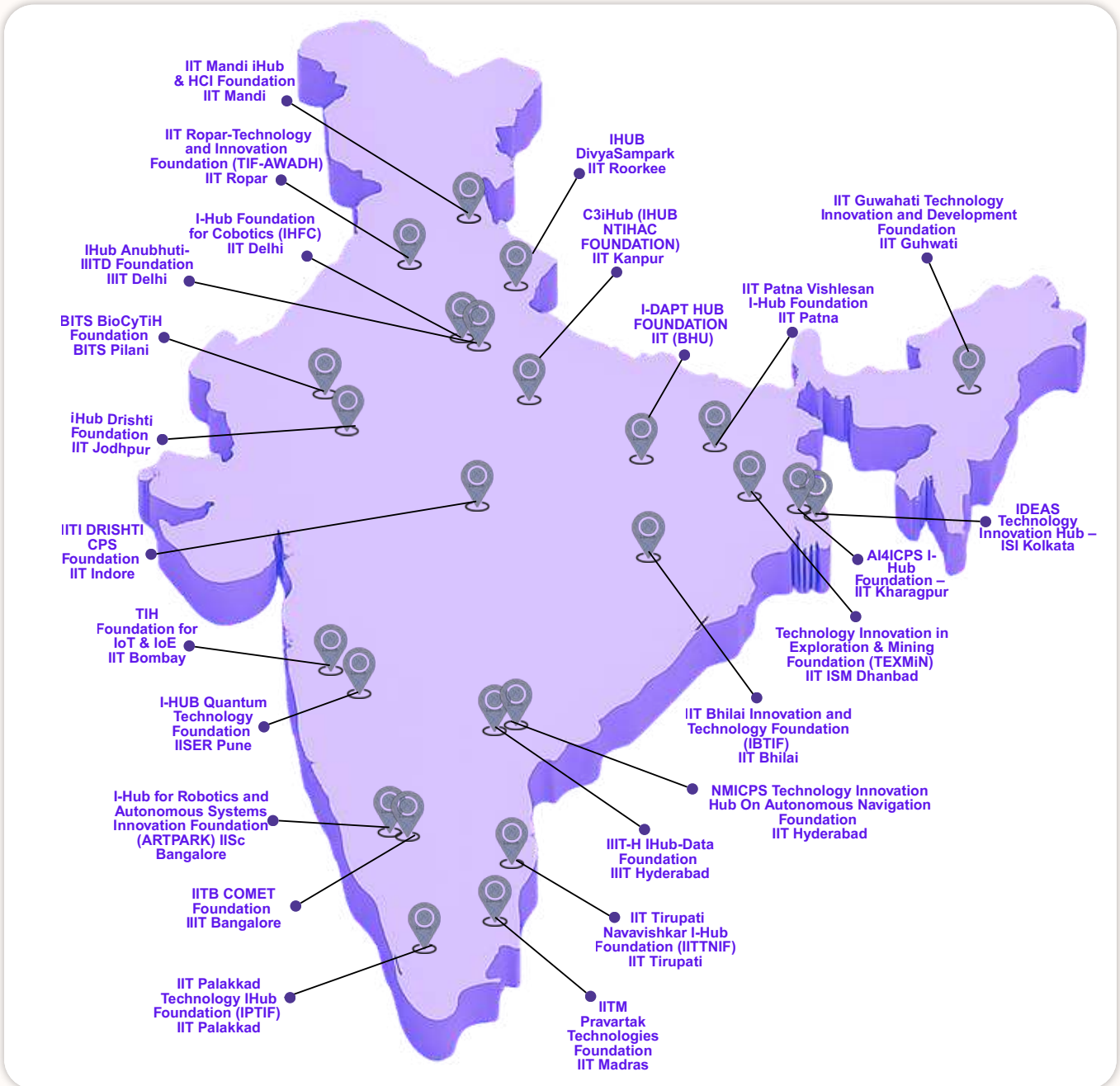
TIHs undertake advanced interdisciplinary research to develop indigenous CPS technologies, prototypes, and deployable solutions. Multi-institutional collaborations integrate expertise from academia, industry, startups, and government departments to address complex socio-technical challenges.

2. Entrepreneurship Development

The Mission actively promotes deep-tech entrepreneurship by supporting startups and spin-offs emerging from TIH research ecosystems. Through incubation, seed support, mentorship, and industry linkages, NM-ICPS facilitates commercialization of cutting-edge technologies across domains such as drone systems, quantum communication, semiconductor design, healthcare diagnostics, and digital security.

3. Human Resource Development

Recognizing that technological leadership depends on skilled human capital, NM-ICPS supports fellowships at undergraduate, postgraduate, doctoral, and post-doctoral levels. Large-scale skilling initiatives in CPS domains are strengthening India's talent pipeline in emerging technologies.



Pan-India presence of 25 Technology Innovation Hubs (TIHs)

4. International Collaborations

The Mission fosters partnerships with leading global academic institutions and research organizations. These collaborations promote knowledge exchange, joint research, and enhanced global research visibility for Indian institutions.

Technology Translation Research Parks: Accelerating Commercialization

Following an independent third-party evaluation that reaffirmed its strategic relevance, the NM-ICPS has been strengthened and extended beyond its initial five-year horizon. The Mission has undergone a strategic progression with select high-performing TIHs being upgraded into Technology Translation Research Parks (TTRPs). These include the I-HUB for Robotics and Autonomous Systems Innovation Foundation at IISc Bengaluru, focusing on Robotics & AI Systems, IHUB NTIHAC Foundation at IIT Kanpur, focusing on Cybersecurity, Technology Innovation in Exploration & Mining Foundation at IIT (ISM) Dhanbad focusing on Mining & Mineral Beneficiation and IITI Drishti CPS Foundation at IIT Indore focusing on Digital Healthcare.

These TTRPs operate as advanced translational ecosystems that integrate research validation, testing, pilot deployment, industry collaboration, and technology scaling. By effectively bridging the gap between laboratory research and industrial application, they represent a significant step in restructuring the Mission towards outcomes-driven innovation and strengthening India's deep-tech commercialization pipeline.

BharatGen: Strengthening Indigenous Generative AI

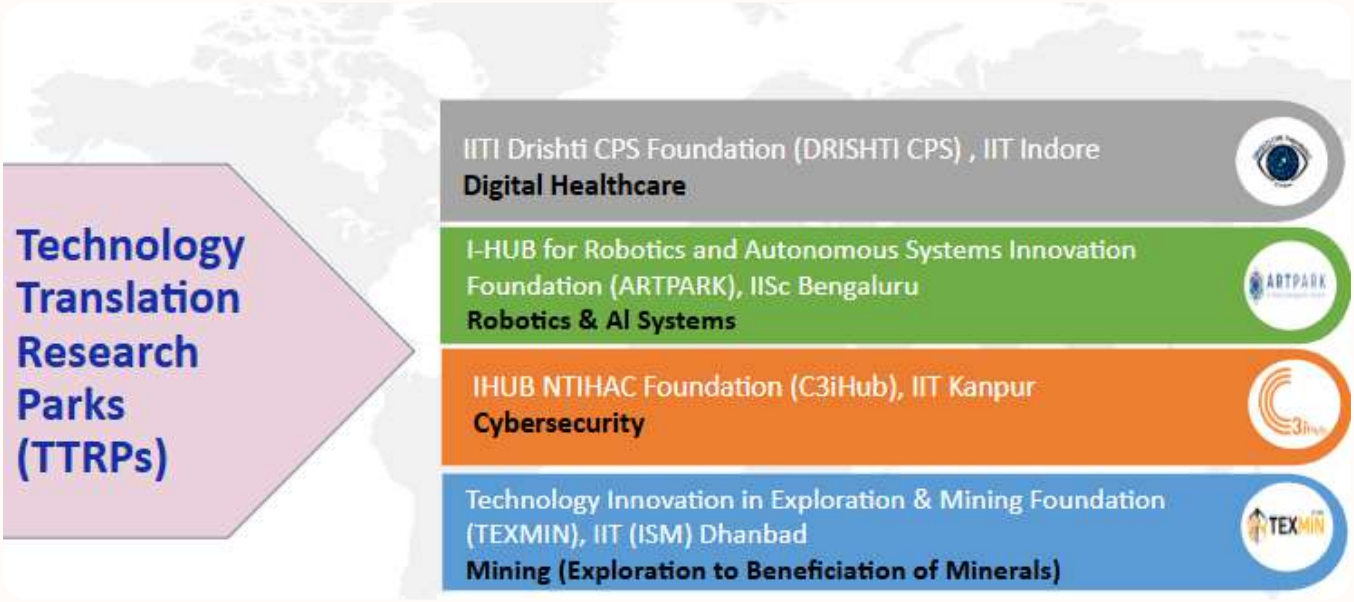
One of the major initiatives implemented under NM-ICPS is BharatGen, a multi-institutional programme aimed at developing indigenous generative artificial intelligence (GenAI) capabilities. The initiative seeks to build linguistically diverse and culturally contextual AI models aligned with India's governance and public service ecosystem.

With a focus on multilingual and multimodal large language models supporting 22 scheduled Indian languages across speech, text, and vision modalities, BharatGen is expected to enhance digital public infrastructure, improve accessibility of digital services, and promote inclusive digital governance. The initiative underscores India's commitment to responsible and sovereign AI development.

Alignment with National Priorities

NM-ICPS supports multiple national missions and strategic sectors:

- **Defence and Security:** Secure communication networks, surveillance systems, and autonomous platforms
- **Healthcare:** AI-driven diagnostics, digital screening, and remote monitoring technologies
- **Agriculture and Water:** Precision farming, climate-adaptive systems, and smart irrigation
- **Mobility and Infrastructure:** Intelligent transport systems and AI-enabled traffic management



- **Energy and Urban Systems: Smart grids, predictive maintenance, and integrated smart city solutions**

By enabling data-driven decision-making and intelligent infrastructure, CPS technologies are strengthening service delivery, sustainability, and resilience across sectors.

Industry–Academia Collaboration: A Public-Private Partnership Model

NM-ICPS operates through a Public-Private Partnership framework that encourages co-development of technologies, joint intellectual property creation, and accelerated commercialization. Industry partners contribute to real-world challenges, infrastructure, and deployment pathways, while academic institutions provide research excellence and skilled human resources.

TIHs facilitate technology transfer, IP management, and startup incubation, thereby strengthening supply chains and promoting indigenous product development in strategic sectors.

Economic and Societal Impact

The Mission has catalysed the development of a vibrant innovation ecosystem connecting academia, industry, startups, and government agencies. By supporting indigenous technology development and deep-tech entrepreneurship, NM-ICPS is generating high-quality employment opportunities and strengthening India's advanced manufacturing and technology sectors.

Beyond economic growth, the Mission contributes to digital inclusion, climate resilience, smart resource management, and equitable access to technology-driven services, particularly in underserved regions.

The Road Ahead: Enabling Viksit Bharat 2047

As India advances toward its vision of becoming a developed nation by 2047, NM-ICPS is poised to play a transformative role in shaping next-generation technologies. The establishment of TTRPs, scaling of startup ecosystems, and development of indigenous CPS and AI platforms will further accelerate commercialization and global competitiveness.

Sustained policy support, deeper industry participation, and expanded international partnerships will enhance the Mission's long-term impact.

NM-ICPS represents more than a technology programme—it embodies India's confidence in its scientific capabilities and innovation potential. By fostering interdisciplinary research, translational excellence, and human capital development, the Mission is strengthening the technological foundations of a self-reliant, resilient, and globally influential India.

India's deep-tech revolution is not just about innovation, but about translating imagination into impact at scale, where ideas meaningfully reach and benefit millions. Initiatives like NM-ICPS reflect a powerful blend of vision, collaboration, and purpose, shaping a future-ready nation committed to technological progress for societal good.

Prof. Anurag Kumar
Former Director
IISc Bengaluru
Chairman, Scientific Advisory
Committee (SAC), NM-ICPS

Third Party Evaluation and Way Forward

India's National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS) is among the country's major initiatives aimed at building a coordinated deep-tech innovation ecosystem by bringing together research institutions, startups, industry, and talent development under a common national framework.

As the Mission entered an important phase of review and consolidation, an independent Third-Party Evaluation Committee was constituted to assess its progress, outcomes, implementation model, and long-term sustainability.

Chaired by Prof. Anurag Kumar, the Committee carried out a detailed review of Technology Innovation Hubs across the country, examining not only measurable outputs, but also translational potential, institutional engagement, and future readiness. The evaluation has since informed key decisions related to the Mission's extension, restructuring, and the direction of its next phase.

In this conversation, Prof. Kumar reflects on the thinking behind the evaluation process, the key observations that emerged from it, and the broader lessons for strengthening India's cyber-physical systems and deep-tech ecosystem.

Q When the evaluation exercise began, what were the fundamental questions the committee wanted to answer about the mission?

At the outset, the committee revisited the origins of both the technology and the mission. Cyber-physical systems (CPS), though rooted in earlier industrial applications, emerged as a major research area only in the first decade of the 21st century, with advances in low power sensors and actuators, computing, and communication technologies, and the increasing need to monitor and manage the natural and human-made world around us. Recognising this global shift, India launched the National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS) around 2017–18 with a novel model of Technology Innovation Hubs (TIHs), supported by significant public investment.

Given the scale and ambition of the program, and the strong translational emphasis,, the committee felt that conventional metrics such as publications, patents, or the number of trained personnel were not sufficient to capture its true impact. Instead, the central question was: Has the mission created meaningful and visible impact at a national or global level?

Accordingly, the evaluation focused on quality rather than quantity. Each hub was asked to present its most significant contributions in research, technology, startups, and products. The emphasis was on identifying where the mission had genuinely made a difference, rather than simply measuring the volume of outputs.

Q Large national missions require assessment beyond outputs Sir, how did the committee balance immediate deliverables with indicators of long-term impact and sustainability?

We looked at this aspect in terms of impact and sustainability together. One of the important design decisions in the mission was to create Section 8 companies embedded within academic institutions, with the flexibility to work across research, development, and implementation, while drawing on the knowledge base of the host institution.

A key aspect we examined was whether this model had worked in practice, whether professors were meaningfully involved, and whether there was a real connection between academic research and the translational work in the TIHs. The expectation was that discovery and invention would proceed hand-in-hand, with academic researchinforming the applications, and, in turn, implementation challengesdrawing upon academic expertise. While there were some examples of this, overall, this integration was not very strong.

On sustainability, the question was whether these Section 8 companies could continue beyond the mission period. In many cases, sustainability efforts were based on training and educational activities, which were not the intended objective. The expectation was that sustainability would come from taking research to higher technology readiness levels, developing products, and eventually monetising them.

At the time of evaluation, this aspect was still evolving. Overall, while the structure was in place, both integration between academia and implementation and long-term sustainability through technology outcomes still required strengthening.

Q With diverse domains and institutions involved, how did the committee ensure that the assessment remained objective and comparable?

The evaluation was carried out in a two-phase process to ensure objectivity and comparability across a diverse set of hubs.

In the first phase, a ten-point questionnaire was developed and shared with all hubs. Based on their responses, along with online interactions and a few in-person visits, an overall mission-level assessment was prepared. This exercise also helped identify aspects in the questionnaire where additional clarifications were required; these were incorporated into the questionnaire for use in the second phase.

In the second phase, a more detailed hub-level evaluation was undertaken using the same framework, but with improved clarity on the expectations of the committee. Each hub was first engaged through an online interaction to understand its responses to the questionnaire, and to address the hubs' questions on the review process. This was followed by in-person visits by committee members.

During these visits, the TIH representatives were dissuaded from making presentations. Instead, the emphasis was on observing the actual work that had been done, interacting with engineers, researchers, and Startup teams, and examining laboratories and demonstrations. All hubs were assessed in a similar and consistent manner.

Importantly, the evaluation did not rely only on numerical indicators. Instead, hubs were asked to present their best work, and the committee assessed the depth, quality, and significance of these contributions.

This structured and uniform approach ensured that the assessment remained objective, comparable, and focused on meaningful outcomes across diverse domains.

Q Sir, during your visits to TIHs, what common strengths and recurring challenges emerged across the hubs during the evaluation?

A clear strength across the network was that institutions had diligently established the required structures. They created the Section 8 companies, set up governance mechanisms, appointed leadership, and provided ample space and operational support. This was done almost universally, reflecting that institutions had taken the mission seriously and aligned with its design.

At the same time, a set of recurring challenges emerged. The interaction between academia and the Hubs was generally weak, even in hubs that were otherwise performing well. The expected integration of academic knowledge with implementation efforts was not sufficiently strong.

Q The Mission has now been extended to December 2027 without additional financial outlay. What did the evaluation reveal that justified this continuation?

The evaluation revealed not just areas for improvement, but a strong and encouraging foundation to build upon. It highlighted a clear shift in mindset, one where academia and industry are beginning to engage more meaningfully, moving beyond traditional boundaries to collaborate on solving real-world problems. This cultural change, supported by significant public investment, has already started to yield early successes and promising examples of impactful work.

At the same time, much of the work remained fragmented. Different hubs had developed individual components, but complete cyber-physical systems had not yet emerged. The mission had created important building blocks, but these had not come together into full, demonstrable solutions.

The extension, therefore, provides an opportunity to build on these foundations and move towards integration. The emphasis going forward is to bring together the work of multiple hubs and develop a smaller number of complete, high-impact systems, rather than continuing with dispersed efforts.

In this sense, the continuation is aimed at moving from pieces to full systems, and from early progress to visible, impactful outcomes.

It must be emphasised, however, that while participating in the realisation of specific CPS verticals, lead by a few TIHs, each hub will continue to strengthen the scientific and translational activities as part of third party evalution, that they had taken responsibility for.

Q A new structure involving anchor hubs and collaborative nodes has been proposed. How will this improve collective performance?

Until now, the hubs have largely been operating as individual entities. We started with the Technology Innovation Hubs, and over time, based on performance reviews, some were elevated, and others categorised. But structurally, they have still remained somewhat independent.

Going forward, the idea is to move towards a more coordinated and mission-oriented approach. Instead of each hub working in isolation, we envisage a system where a few hubs take the lead as anchor hubs in specific application verticals, and the others align with them as collaborative nodes, contributing according to their expertise.

If you look at any real problem say, healthcare or vaccine delivery, it is dependent on a whole range of technologies . Multiple components need to be broughttogether. You may need drones for delivery, sensors and actuators, materials for safe handling, cybersecurity to ensure the system is protected, and data systems to manage and monitor the entire operation. These capabilities already exist across different hubs, but they are currently dispersed. The aim now is to integrate them into complete systems.

In this structure, one hub may lead a particular vertical, but other hubs can contribute across verticals depending on their strengths. For example, a cybersecurity group can support healthcare as well as transportation, and a data analytics group can contribute wherever that expertise is required. This kind of cross-linking is natural and necessary.

What this does is to bring alignment. Instead of producing isolated components, the network can deliver full systems solutions that can be taken up by industry, implemented by government, or used in societal applications. It also ensures better utilisation of resources and reduces duplication of effort.

So, the focus shifts from individual outputs to collective outcomes. The idea is to bring together these smaller pieces from different hubs and build something much larger and more impactful.

Q Restructuring can affect institutional morale. Sir, how did the committee approach performance categorization?

The committee approached this from the standpoint of professional responsibility and accountability. The mission involves significant public funding and provides institutions with a high degree of autonomy in how they operate and utilise resources. With this autonomy comes a clear expectation of performance and outcomes.

In this context, the view was that performance must be reflected in evaluation. Hubs that performed well should be supported and strengthened, while those that did not meet expectations should receive clear signals for improvement. At this level of maturity, the emphasis was on outcomes rather than accommodation.

The categorisation was therefore not seen as a simple ranking exercise, but as a mechanism to ensure effective use of public resources, reinforce accountability, and drive the mission towards its intended goals. It was aimed at encouraging better performance and course correction, so that the overall mission delivers meaningful results.

Q The elevation of selected hubs into Technology Translational Research Parks (TTRPs) marks a new phase. How do you see this shaping industry engagement?

The concept of Technology Translational Research Parks (TTRPs) was already part of the mission design, and the role of the evaluation was to identify those hubs that are ready to be elevated based on their performance.

More broadly, the mission itself aims to change how academic institutions engage with real-world applications and industry. The creation of Section 8 companies was intended to facilitate this by enabling institutions to take knowledge from academia and move it towards implementation and the market.

TTRPs are expected to strengthen this translational effort, with a greater focus on technology development, productisation, and deployment. They represent a progression towards more direct and effective engagement with industry.

At the same time, the system is dynamic. Future evaluations will depend on how institutions perform and contribute to the mission's objectives, and such progression is expected to be earned through demonstrated outcomes.

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From Digital India to Intelligent India

The Next Technological Leap

A decade ago, accessing essential services often meant navigating long queues, manual records, and fragmented information systems. Patients carried paper prescriptions from one hospital to another, farmers relied largely on experience and uncertain weather patterns for crop decisions, and commuters faced unpredictable travel times with little real-time information. Decision-making depended heavily on delayed or incomplete data, making services less efficient and often difficult to access.

Today, digital platforms have transformed many of these experiences. Health records are increasingly available electronically, farmers receive timely advisories on their mobile phones, and commuters can monitor traffic conditions in real time. Digital technologies have made services faster, more accessible, and more transparent, fundamentally changing how citizens interact with institutions and infrastructure.

Journey Towards Digital India

As the saying goes, "Information is power." Over the past decade, India has empowered millions through access to information.

Beyond Access: The Need for Intelligence

Digital transformation represents only the beginning of India's technological evolution. Digital technologies have made information easier to access and services more convenient, but most digital systems still depend on human input and decision-making. A commuter may be able to check traffic conditions on a mobile phone, but still has to decide the best route. A farmer may receive weather updates, but must interpret the information before taking action. Similarly, digital health records store patient information, but diagnosis and monitoring continue to rely largely on periodic consultations.

As systems become more complex and operate at larger scales, relying entirely on human intervention becomes increasingly difficult. The next stage of technological evolution therefore goes a step further, enabling systems not only to store and process information but also to sense their environment, analyse data automatically, and respond in real time. **Instead of only informing people, technologies are gradually becoming capable of assisting decisions and supporting actions**. India is now moving towards this next phase, the transition from Digital India to Intelligent India.

If the first phase connected people to information, the next phase connects information to action.

Cyber-Physical Systems: Intelligence in Action

At the heart of this transformation lies Cyber-Physical Systems (CPS) which means integrated technologies that connect computation, communication, sensing, and control with real-world environments. These systems enable machines and infrastructure not only to process information but also to interact with the physical world in meaningful and adaptive ways.

Although the term Cyber-Physical Systems may sound technical, many such technologies have quietly become part of everyday life. When navigation apps suggest faster routes based on live traffic conditions, when wearable devices continuously track health parameters, or when automated systems regulate temperature and energy use in buildings, Cyber-Physical Systems are at work in the background. These technologies often go unnoticed because they operate seamlessly, yet they represent a fundamental shift from systems that merely provide information to systems that can observe conditions and respond intelligently.

The most transformative technologies are often the ones we barely notice.

Why CPS Matters for India

For a country of India's scale and diversity, the importance of Cyber-Physical Systems is particularly significant. Traditionally, many services and infrastructure systems in India have relied on extensive human effort for monitoring and decision-making. While this approach has allowed systems to function at scale, it often involves delays, variability in response, and significant operational effort. As infrastructure expands and services become more complex, there is a growing need for systems that can operate continuously and respond quickly to changing conditions.

Cyber-Physical Systems complement human effort by enabling real-time monitoring, faster analysis, and timely responses. Whether it is managing transportation networks, supporting healthcare services, improving industrial productivity, or

Cyber physical systems in intelligent India

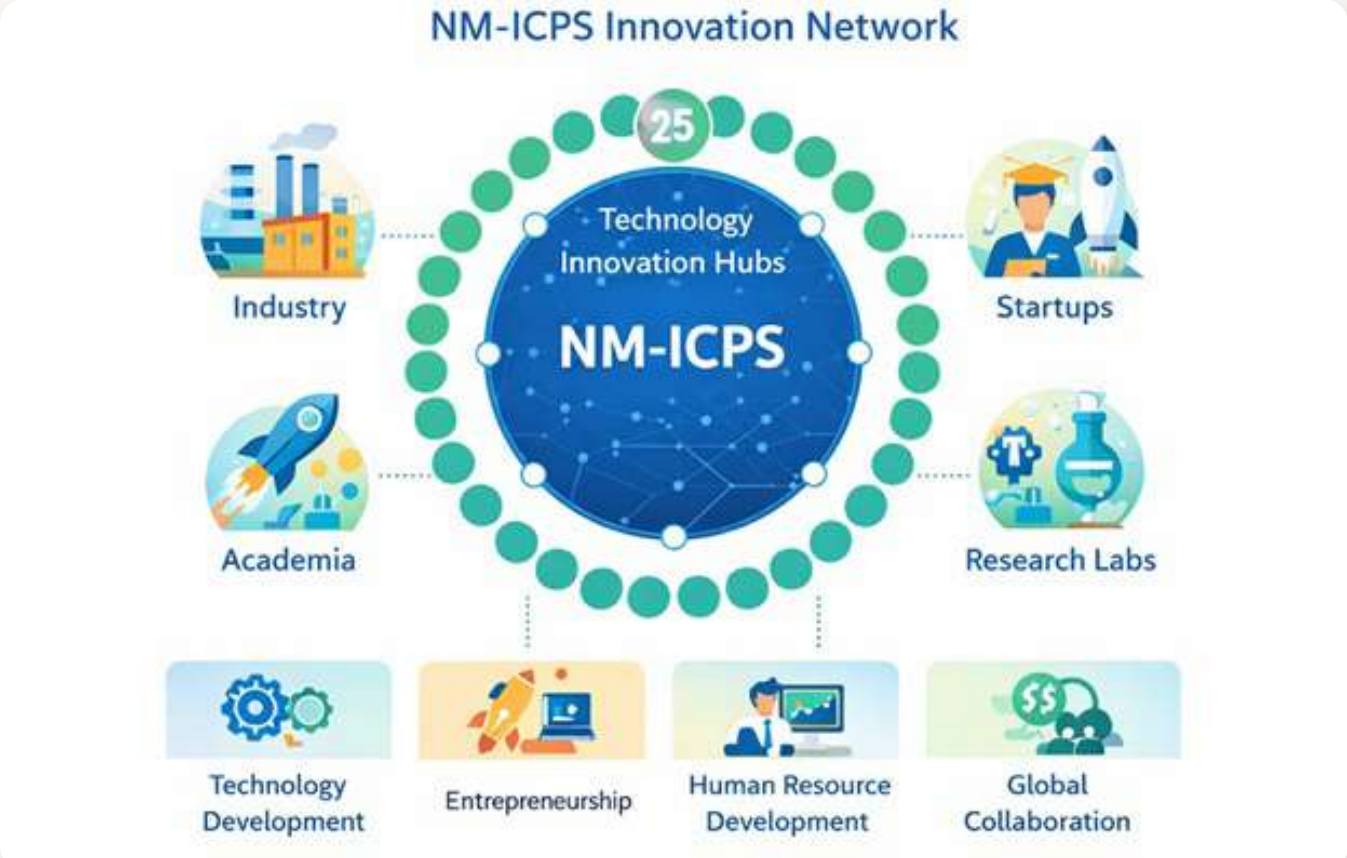
enabling precision agriculture, CPS technologies make it possible to operate systems more efficiently and reliably. In this sense, Cyber-Physical Systems form a crucial technological foundation for the transition from Digital India to Intelligent India.

NM-ICPS: Enabling Intelligent India

Recognizing the central role of Cyber-Physical Systems in building next-generation infrastructure and services, India has adopted a mission-oriented approach to strengthen capabilities in this domain. The National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS) was established to support research, innovation, and technology development in CPS and related deep-technology areas. In many ways, NM-ICPS is emerging as a key enabler of Intelligent India by creating the technological and institutional foundations required for the development and deployment of Cyber-Physical Systems at scale.

Rather than focusing on isolated technology efforts, NM-ICPS promotes an integrated approach where sensing, communication, computing, and control technologies evolve together. By supporting interdisciplinary research and collaborative innovation, the Mission is helping build capabilities that allow intelligent systems to operate reliably across diverse sectors and real-world environments. In many ways, the emergence of Cyber-Physical Systems represents a natural evolution of India's digital journey. The digital infrastructure created over the past decade provides a strong foundation on which intelligent systems can be built. As connectivity becomes universal and computing capabilities expand, Cyber-Physical Systems will increasingly enable real-time decision-making and automation across sectors.

Great transformations are rarely accidental, they are built through deliberate missions.



NM-ICPS Innovation Network

Connecting the Digital and the Physical

The transition from Digital India to Intelligent India reflects a broader shift in how technology interacts with society, from systems that connect people and information to systems that continuously sense, respond, and adapt. With Cyber-Physical Systems forming the technological core of this transformation and initiatives such as NM-ICPS strengthening national capabilities, intelligent infrastructure is steadily becoming a reality.

If Digital India connected the nation through information, Intelligent India will connect the digital and physical worlds.

Empowering SC/ST Communities through Emerging Technologies under NMICPS

The National Mission on Interdisciplinary Cyber-Physical Systems (NMICPS) has established a comprehensive and inclusive framework to empower Scheduled Caste (SC) and Scheduled Tribe (ST) communities through focused interventions in education, research, innovation, and entrepreneurship. The Mission seeks to enhance participation of these communities in emerging technology domains and strengthen their role in India's growing innovation-driven economy.

Mission Initiatives for SC/ST Communities

NMICPS places strong emphasis on human resource development, capacity building, and technology-enabled inclusion. Through targeted programmes, SC/ST beneficiaries are provided opportunities to engage with frontier technologies such as Artificial Intelligence (AI), Machine Learning (ML), Robotics, Internet of Things (IoT), Autonomous Systems, Cyber Security, and Drone Technologies. Key interventions include:

1. Fellowships and Research Support

» Fellowships and research opportunities for SC/ST students and scholars at undergraduate, postgraduate, and doctoral levels.
» Support for participation in cutting-edge research and technology development activities.

2. Skill Development and Outreach Programmes

» Industry-oriented training programmes designed to enhance employability and technical competencies.
» Special outreach initiatives in rural, remote, and underserved regions to ensure wider participation.

3. Startup Incubation and Entrepreneurial Support

» Assistance for technology-based startups through funding, mentoring, incubation facilities, and access to advanced research infrastructure.
» Promotion of innovation-led entrepreneurship among SC/ST youth.

These initiatives are implemented through the network of Technology Innovation Hubs (TIHs) established across premier academic and research institutions, ensuring pan-India outreach and equitable access to opportunities.

The Mission promotes inclusive innovation ecosystems that support employment generation, job readiness, and the development of indigenous technological capabilities. By creating sustainable pathways into deep-tech sectors, NMICPS is enabling SC/ST communities to actively contribute to India's digital transformation and innovation landscape.

Aligned with the vision of Viksit Bharat 2047, the Mission continues to emphasize need-based indigenous technologies and community-centric innovation, fostering equitable growth, technological self-reliance, and long-term socio-economic empowerment for all sections of society.

NM-ICPS: Deep Tech Innovation for Viksit Bharat@ 2047

This section focuses on the technologies, systems, and translational efforts emerging from the NM-ICPS ecosystem, highlighting the role of collaborative research and institutional partnerships in advancing cyber-physical systems towards deployment and wider societal applications.

Prof. Ganesh Ramakrishnan
Principal Investigator and Board Member
BharatGen Technology Foundation

Shri Rishi Bal
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BharatGen: India's First Government-Funded AI Initiative

A farmer in Madhya Pradesh who wants to know why her onion crop is yellowing gets an answer, in Hindi, through a voice message on WhatsApp. A government officer in Maharashtra who needs to trace the full amendment history of a decade-old policy circular receives a precise, sourced answer in Marathi within seconds. A student of Sanskrit who chants a sloka and instantly receives phoneme-level feedback on exactly where her pronunciation deviated from canonical tradition. These are not hypothetical futures. They are use cases already built and running under BharatGen(bharatgen.com), India's first government-funded sovereign Generative AI initiative.

Launched under the National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS) of the Department of Science and Technology (DST), BharatGen represents a fundamental rethinking of what AI can and should mean for a country as large, diverse, and linguistically rich as India. At its core is a simple but transformative proposition: that India's 1.4 billion people deserve AI that works in their languages, understands their contexts, and serves their real needs.

BharatGen ecosystem diagram showing the four model families (Param, Shrutam, Sooktam, Patram) radiating from Bharat Data Sagar

What is BharatGen?

BharatGen is India's sovereign multilingual, multimodal foundational large language model (LLM) initiative, covering all 22 Scheduled Indian languages for text, 12 languages for speech, and bringing document vision

capability to the written word. Unlike general-purpose global AI systems, BharatGen's models are trained from the ground up on India-centric datasets, designed to understand the nuances of Indian language, culture, and context.

The initiative is institutionalised as BharatGen Technology Foundation, a Section 8 not-for-profit company hosted at IIT Bombay's Technology Innovation Hub. It is funded under NM-ICPS (DST) and additionally supported by the IndiaAI Mission under MeitY (the Ministry of Electronics and Information Technology). The BharatGen ecosystem rests on two pillars: foundational model development through a national academic consortium, and real-world deployment through domain-specific applications.

What Makes BharatGen Special?

A National Consortium, Not a Single Institution

One of BharatGen's most distinctive features is its architecture as a distributed national consortium. Spearheaded by IIT Bombay, the initiative brings together IIT Madras, IIT Kanpur, IIT Kharagpur, IIT Hyderabad, IIIT Hyderabad, IIT Mandi, IIM Indore, and IIIT Delhi. This is not merely a coordination arrangement. It is a genuinely distributed model of intellectual contribution, with each institution leading research in its area of deepest expertise and contributing to a shared national AI infrastructure.

National Consortium of BharatGen

The consortium model produces something that no single institution, however excellent, could achieve alone: a system of checks, specialisations, and shared resources that mirrors the diversity of India itself. It also ensures that BharatGen's outputs, including models, datasets, benchmarks, and applications, remain open and accessible rather than proprietary to any one organisation.

Truly Indian Data, At Scale

The Bharat Data Sagar, BharatGen's India-centric data repository, has been built through a painstaking ground-level effort: door-to-door outreach, engagement with Padma Shri awardee authors, digitisation of physical manuscripts, and collection of oral dialects spoken by millions of Indians who have never seen their language on a computer screen. Data has been gathered across Hindi, Malvi, Nimadi, Hadoti, Kannada, Marathi, Sanskrit, Tamil, and many more. This effort has involved over 100 contributors with formal consent for all data usage and has drawn national attention, including questions in the Lok Sabha.

The result is a dataset that is distinctly, substantively Indian. Not a token representation of Indic languages appended to a corpus built for other contexts, but a foundation designed from the ground up to reflect India's linguistic diversity and socio-cultural realities.

Frugal AI for a Billion People

Sovereign AI alone is not enough. For AI to matter to a rural health worker in Jharkhand or a small trader in Rajasthan, it must also run affordably, on a standard mobile phone rather than an expensive data centre. BharatGen's central design philosophy is frugal scaling: building AI that performs at world-class levels while remaining deployable on low-resource hardware. This involves cross-lingual distillation, where a large multilingual model trains a smaller and more affordable one, and phonetic design for handling code-mixed speech, which is the natural way most Indians mix languages in daily conversation.

What Does BharatGen Do? Models, Applications, and Research

BharatGen has developed a comprehensive suite of foundational AI models, with the second generation unveiled at the IndiaAI Impact Summit 2026:

- **Param2:** A 17 Billion parameter Mixture-of-Experts (MoE) large language model, trained on 22 trillion tokens across all 22 Scheduled Indian languages including Assamese, Bengali, Bodo, Dogri, Gujarati, Kannada, Konkani, Kashmiri, Maithili, Malayalam, Manipuri, Marathi, Nepali, Odia, Punjabi, Sanskrit, Santali, Sindhi, Tamil, Telugu, and Urdu, with capabilities in coding, mathematics, and reasoning. It builds on Param1, the original 2.9 billion parameter bilingual LLM trained on 7.5 trillion tokens.
- **Shrutam2:** An Automatic Speech Recognition (ASR) model that understands Indian accents, is robust to background noise, and supports 12 Indian languages including Hindi, Marathi, Gujarati, Tamil, Telugu, Kannada, Bengali, Malayalam, Odia, Urdu, Punjabi, and Indian English. Trained on 12,000+ hours of speech data, it represents a significant advance over the original Shrutam model.
- **Sooktam2:** A Text-to-Speech (TTS) model suite that converts written text into natural-sounding speech in 12 Indian languages, using high-quality studio-recorded Indian voices.
- **Patram-7B-Instruct:** A 7 Billion parameter Vision-Language Model (VLM) built specifically for document understanding, enabling automated analysis of scanned and photographed documents including handwritten forms, bank statements, legal notices, and government circulars in Indic languages.

BharatGen has developed a comprehensive suite of foundational AI models, with the second generation unveiled at the IndiaAI Impact Summit 2026

Applications Across Sectors

Foundational models are only as meaningful as the problems they solve. BharatGen has built a growing set of domain-specific applications that translate model capabilities into tangible real-world impact:

- **Governance with MahaGPT:** An AI assistant for the Maharashtra state government that allows officials, clerks, and administrators to instantly access and interpret Government Resolutions spanning over a decade. It supports English, Marathi, and Hindi, handles complex amendment linkages and chains, and adapts to the language in which a question is asked, helping government function faster and more transparently.
- **Healthcare with MedSum and Amrita Healthcare:** A clinical AI application being piloted with Amrita Healthcare to support both patients and physicians. For doctors, it generates structured notes, prescriptions, and patient summaries from clinical conversations. For patients, it explains medical reports, prescriptions, and discharge summaries in accessible language. Already being experienced by several hundred patients and their doctors in Hindi, Malayalam, and Marathi, it demonstrates how multilingual sovereign AI can bridge the communication gap in Indian healthcare settings.
- **Education with BharatGen Yojaka and Kotak Education Foundation:** An AI-assisted spoken English and communicative skills evaluation platform designed to address the high cognitive load teachers face in assessing individual students at scale. The system evaluates spoken English fluency and other communicative competencies using CEFR-aligned assessment models, generating objective evaluation scores while keeping teachers as the final decision-makers. Following a completed pilot study, it is planned for rollout to 10,000 students across Maharashtra in early 2026, with subsequent scale to several lakh students across four states.
- **Agriculture with Krishi Sathi:** A voice-enabled WhatsApp application that provides farmers with personalised agricultural guidance in their native language, making expert advice accessible to those who may have never owned a desktop computer.
- **Financial Services:** The Patram document-vision model extracts data from handwritten and regional-language forms in the insurance sector, reducing processing errors and accelerating claim settlements for policyholders who communicate in their native scripts.
- **Insurance Underwriting with Insure Copilot:** An AI underwriting assistant that extracts and correlates information from medical examination reports, pathology results, and identity documents, automatically flagging deviations and categorising application risk. Approximately 70% of routine cases can be processed with minimal human intervention, freeing underwriters to focus on complex cases.

BharatGen has built a growing set of domain-specific applications that translate model capabilities into tangible real-world impact

- **Sanskrit Education with Gyan Samvad and Uccārinikkā:** An AI-powered Sanskrit learning platform that bridges digitised manuscript archives with structured learning and phoneme-level pronunciation diagnostics. Students chant a sloka and receive colour-coded feedback on vowel length errors, aspiration mismatches, and consonant clarity, restoring traditional oral pedagogy in a scalable digital format that supports first-generation Sanskrit learners and institutional cohorts alike.

Research that Pushes the Frontier

Behind every application is a research foundation that addresses questions no global AI lab has prioritised for India. IIT Kanpur's Lab is building India's a suite of Legal AI tools, covering judgment prediction, retrieval-augmented legal reasoning, and handwritten court record digitisation.

IIT Mandi has created a benchmark for various dialects, comprising 23,000 sentences collected from scratch by human annotators across states, ensuring that AI reaches not just speakers of standardised languages but the millions who use regional varieties that have never had a digital presence. IIM Indore has developed rigorous evaluation frameworks tailored specifically to Indian knowledge: IndicParam draws from UGC-NET question papers across 11 Indic languages, while ParamBench covers more than 17,000 Hindi-language questions spanning 21 subjects. These benchmarks hold Indian AI accountable to Indian standards, rather than to evaluation frameworks designed for entirely different cultural contexts.

Building India's AI Talent

A sovereign AI initiative is only as enduring as the talent ecosystem it builds. BharatGen places significant emphasis on training the next generation of Indian AI researchers and engineers. The initiative engages PhD scholars, MTech students, and undergraduate researchers across its consortium institutions, with open datasets and models published globally. Interns and early-career researchers have contributed to model training, benchmark creation, data collection, and application development, gaining hands-on experience with cutting-edge AI infrastructure designed for India's own needs.

What's Next for BharatGen?

BharatGen's roadmap reflects the ambition of India's broader AI vision. With text models now complete across all 22 Scheduled Indian languages and deployment-ready platforms live across governance, healthcare, education, finance, and cultural preservation, the initiative is turning toward scale, sustainability, and strategic depth.

On the infrastructure front, strategic partnerships with organisations in the semiconductor and engineering sectors reflect BharatGen's evolution toward India's complete sovereign AI stack, from chips and silicon at the hardware layer to models and applications at the software layer. This vertical integration is essential because sovereign AI that depends on foreign hardware infrastructure remains, in important ways, not fully sovereign.

On the enterprise and private sector front, the same foundational models that power government applications are being deployed in financial services, insurance, e-commerce, and healthcare, demonstrating that sovereign AI and commercial viability are not competing goals. BharatGen's models offer Indian enterprises a compelling alternative to expensive proprietary foreign APIs: high-quality, multilingual, India-aware AI that can be deployed on their own infrastructure. As the portfolio of enterprise pilots matures, BharatGen is actively working to grow partnerships with Indian industry that can bring these capabilities to scale.

BharatGen also aims to become a shared national platform, an open foundation upon which startups, government agencies, NGOs, and researchers can build inclusive AI applications without incurring the enormous cost of training foundation models from scratch. By making its models, datasets, and benchmarks publicly available, BharatGen lowers the barrier for thousands of downstream innovators, multiplying its impact far beyond what any single organisation could achieve alone.

A Foundation Built Together

BharatGen would not exist without the vision, resources, and trust of the National Mission on Interdisciplinary Cyber-Physical Systems. NM-ICPS provided not only the funding to initiate this work, but the institutional framework anchored in India's premier academic institutions that allowed a genuinely national effort to take shape. The DST's foresight in recognising that AI infrastructure is as strategic as physical infrastructure, and in backing an Indian answer to a global challenge, has made possible everything described in this article.

The IndiaAI Mission under MeitY has further accelerated BharatGen's transformation into a national-scale ecosystem. The cumulative support of these government missions reflects a clear understanding: sovereign AI capability is a public good that must be built in the commons, not left solely to private enterprise.

India is at a remarkable inflection point. The technological choices made today will determine who benefits from AI over the next several decades. BharatGen's bet is that an AI built by India, for India, grounded in India's languages and realities, and governed in India's interest, will serve the nation's 1.4 billion people far better than any imported alternative. That bet is already beginning to pay off, and it has been made possible, above all, by the National Mission that dared to fund it.

Shri Ashutosh Dutt Sharma
Chief Executive Officer
I-Hub Foundation for Cobotics (IHFC)
IIT Delhi

Innovating Deep Tech For New Bharat

Collaborative robotics or cobotics represents a transformative evolution in automation, where intelligent machines are designed not to replace humans but to work alongside them. Enabled by Cyber-Physical Systems (CPS) that integrate sensing, computation, communication, and control, cobots bring adaptability, safety, and precision into dynamic environments such as manufacturing floors, hospitals, farms, and field operations. As global industry transitions toward flexible, AI-driven production systems, leadership in collaborative robotics has become both an economic and strategic imperative.

For India, this transition offers a historic opportunity. Indigenous capabilities in cobotics can strengthen manufacturing competitiveness, enhance healthcare accessibility, improve agricultural productivity, and generate high-value employment. Recognizing this potential, the Government of India launched the National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS) under the Department of Science and Technology (DST) to establish domain-focused **Technology Innovation Hubs (TIHs)** across critical sectors. Under this mission, the **I-Hub Foundation for Cobotics (IHFC) was established at IIT Delhi in June 2020,** at a time of global uncertainty during the pandemic, as a mission-driven institution to advance collaborative robotics in India.

Conceived as a Section 8 Company, IHFC was structured to integrate academia, industry, and government within a single translational framework. IHFC operates across **four verticals: Industry X.0, Defence, Medical, and Agriculture**. Over the years, it has evolved into a national platform for Research Translation, Startup and Entrepreneurship, Education and Upskilling, and International Collaboration, aligned with the vision of Atmanirbhar Bharat and Viksit Bharat 2047.

R&D: From Research to Commercialization for Atmanirbhar Bharat

At the core of IHFC's journey lies a strong R&D ecosystem designed not just for publications, but for deployment and commercialization. Its project lifecycle follows a structured process from calls for proposals, expert evaluations, and board reviews, to MoUs, milestone-based funding, industry validation, and market linkage. **IHFC has supported more than 50 translational R&D projects** in collaborative robotics and CPS domains, with a strong emphasis on Technology Readiness Level (TRL) progression and commercialization outcomes.

What distinguishes IHFC's R&D approach is its clear focus on advancing technologies systematically across defined Technology Readiness Levels (TRLs), from lab validation to real-world deployment. IHFC supported innovations such as the self-powered sensor system and the automated orthopaedic reconstruction plate bending machine developed by faculties at IIT Delhi

have progressed from early-stage TRL 3–4 laboratory validation to TRL 6–7, demonstrating prototype validation in relevant environments and moving closer to real-world deployment. These progression reflects IHFC's commitment to bridging the gap between academic research and industrial application.

IHFC has established advanced technology development centres such as the **Drone Technology Park (DTP)** at the **IIT Delhi Sonipat Campus** and the **Medical Cobotics Centre (MCC)** at **IIIT Delhi (IIITD)**, strengthening sector-specific research and validation capabilities. In addition, IHFC has created **10 Co-Innovation Centres (CICs)** as **strategic spokes** extending innovation beyond IIT Delhi to partner institutions across the country. These include **3 in Tamil Nadu** (Karunya Institute of Technology and Sciences; B.S. Abdur Rahman Crescent Institute of Science and Technology; SRM Institute of Science and Technology), **2 in Karnataka** (PES University; Nitte Meenakshi Institute of Technology), **2 in Delhi** (IIIT Delhi; Delhi Technological University), and **one each** in **West Bengal** (IIEST Shibpur), **Gujarat** (IIT Gandhinagar), and **Punjab** (Thapar Institute of Engineering & Technology). These state-of-the-art Centres of Excellence strengthen academia–industry collaboration and provide infrastructure for testing, validation, and pilot deployment. By decentralizing innovation and creating a distributed national R&D network, IHFC has built a backbone for indigenous collaborative robotics development.

Emerging from these efforts are also impactful, ground-level solutions such as the Unmanned Coconut Harvester being developed in collaboration with Parachute Kalpavriksha and ICAR-CCARI and Goa University, addressing labour and safety challenges in agriculture, and ENRICH, an EMG controlled Prosthetic limb in collaboration with Tezpur University, offering an affordable medical solution at the grassroots level. These examples reflect IHFC's philosophy: solving real problems through scalable, indigenous deep-tech innovation. Through this translational R&D approach, IHFC is contributing directly to Aatmanirbhar Bharat by strengthening domestic capability in robotics and cyber-physical systems.

Enabling Entrepreneurship: From READY to Growth-Stage Scaling

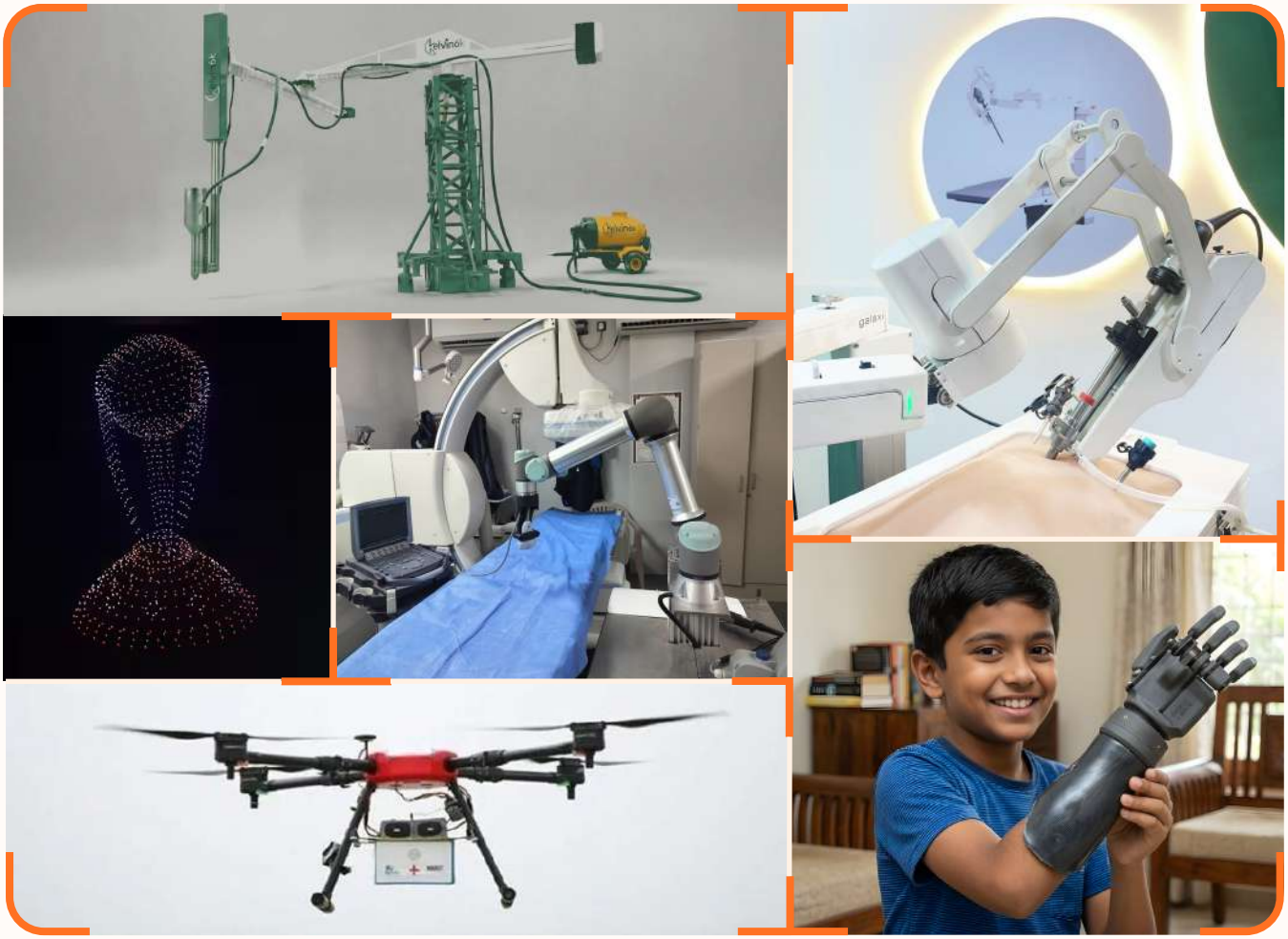
Parallel to its R&D efforts, IHFC has built a robust startup ecosystem with a clear 360-degree approach, nurturing innovation from early-stage ideas to growth-stage enterprises with global potential. Through its **READY (Research, Entrepreneurship and Development for Youth)** pre-seed incubation program, IHFC supports innovators at the idea and prototype stage with mentoring, laboratory access, validation support, and industry connect.

Several READY-supported ventures have evolved into impactful deep-tech startups. **Neurodrishti**, for instance, developed smart AI-enabled glasses for the visually impaired, offering text reading, navigation assistance, face recognition, and environmental awareness. **Diagnovate's KAERE** breath analyser represents another breakthrough, providing a pocket-sized, non-invasive solution for early diabetes screening. In healthcare robotics, **Vitachyon** built a tele-robotic ultrasound system enabling real-time remote scans, significantly improving diagnostic access in rural and underserved areas — with deployment extending to India's **Maitri research station in Antarctica**, demonstrating reliability in extreme conditions.

IHFC has supported more than 50 deep-tech startups in collaborative robotics, AI-enabled systems, and CPS integration. Beyond incubation infrastructure, IHFC actively facilitates external funding, investor connect, and pilot opportunities. As a result, **six startups have secured external funding post incubation, more than ten have expanded their product portfolios, and over 25 are revenue-generating**, reflecting strong commercialization outcomes.

Among the growth-stage successes, IHFC incubated startup **Arka Aerospace** (TRL 9) develops advanced UAV platforms for commercial and defence missions; its systems were deployed during **Operation Sindoor**, underscoring operational reliability. In construction robotics, **Kelvin 6K (TRL 9)** leverages 3D printing and automation to deliver rapid, cost-effective housing solutions and secured funding after being featured on **Shark Tank India**. In drone intelligence, **Botlab Dynamics (TRL 9)** has pioneered swarm drone systems capable of coordinating hundreds of drones simultaneously, earning a **Guinness World Record** for one of the world's largest drone light shows. In medical and rehabilitation robotics, **Exobot Dynamics (TRL 6)** designs lightweight bionic limbs such as the Carbon Hand, improving prosthetic accessibility, while **Articulus Surgical (TRL 5)** has developed modular robotic systems for minimally invasive surgery and secured external funding to advance commercialization. In autonomous robotics, **xTerra Robotics (TRL 7)** builds quadruped robots with advanced autonomy software for inspection, security, and defence applications.

This structured pipeline from ideation to validation, deployment, and scaling reinforces indigenous product development and reduces reliance on imported technologies. IHFC's startup support model ensures that research outcomes translate into scalable enterprises,



Products from incubated startups at IHFC

generating employment, strengthening supply chains, and contributing meaningfully to India's deep-tech economy.

By bridging academia and industry, IHFC ensures that technologies are not confined to labs but deployed on the ground addressing industrial automation, medical assistance, agricultural mechanization, and safety challenges. This seamless transition from R&D to startup to deployment reflects IHFC's mission-driven commercialization strategy.

Bringing NEP 2020 to Life - Upskilling for a Future-Ready India

Education and capability building remain important enablers of this ecosystem. Through its Education, Research, and Upskilling (ERT) vertical, IHFC aligns with NEP 2020 to strengthen employability and future readiness in deep-tech sectors.

IHFC collaborates with universities, boards, and technical institutions to modernize curriculum in AI, Robotics, IoT, EVs, and Industry X.0. Partnerships such as with the Uttarakhand Board of Technical Education (UBTE) have modernized diploma programs, integrating project-based learning and digital tools. Collaborations with CISCE, DBSE, and Kendriya Vidyalaya Sangathan aim to build early exposure to deep-tech domains at scale.

Through structured training programs, hackathons, and robotics competitions, IHFC nurtures technical confidence, problem-solving ability, and industry relevance. This continuum — from school students to undergraduates to professionals — ensures a skilled workforce capable of designing, deploying, and scaling CPS technologies. Empowered youth create empowered industries — and ultimately, an empowered India.

Technology for Each Section of Society

IHFC's work goes beyond laboratories and industry to ensure that technology reaches people across all sections of society. Through initiatives such as the **Transformative Learning in STEM (TLS) programs**, the nationwide **Nurture Program**, and focused drone and robotics upskilling workshops, IHFC has impacted over **50,000 students across 600+ institutions in 20+ states**.

These efforts introduce students from schools to young professionals to robotics, AI, and emerging technologies, equipping them with practical skills and confidence for future careers. At the same time, IHFC supports the development of indigenous technologies with direct social impact, including solutions for safer agriculture, smarter farming, and industrial safety.

By combining skill development with purpose-driven technology innovation, IHFC is narrowing the urban–rural gap and ensuring that collaborative robotics serves both national growth and community well-being.

Global Partnerships, Global Pathways

IHFC's global partnerships strengthen India's position in collaborative robotics. Joint R&D engagements with the **National Science Foundation (USA)** have enabled advanced research collaboration, while partnerships with **Odense Robotics (Denmark)** connect Indian startups to one of Europe's leading robotics ecosystems. Participation at the **ITU, Geneva** has allowed innovators to benchmark their technologies globally. In Asia, collaborations with **NEDO (Japan)** and the **National Association of Entrepreneurship (Vietnam)** support drone technology development, co-creation, and market expansion. Together, these engagements help Indian innovations move beyond domestic pilots toward international deployment.

For IHFC-supported startups and R&D Projects, such collaborations mean exposure to global best practices, validation against international benchmarks, and access to new markets. For India, they represent something larger: the gradual positioning of indigenous collaborative robotics solutions on the world stage.

The goal is not only to learn from global leaders but to stand alongside them ensuring that Indian cobotics technologies are globally competitive, export-ready, and recognized for their quality and innovation.

The Road to 2047: From Mission to Global Leadership

Five years after its establishment, IHFC stands as a living example of mission-mode implementation under NM-ICPS. What began as a strategic vision in 2020 has evolved into a structured, results-driven ecosystem that integrates translational research, startup enablement, state-of-the-art infrastructure, education reform, and global partnerships within a single national framework. By bringing together academia's scientific depth, industry's practical insight, and government's strategic direction, IHFC has demonstrated how collaborative innovation can move from intent to impact.

As the world transitions toward intelligent, human-centric automation, leadership in collaborative robotics will increasingly define industrial competitiveness, economic resilience, and technological sovereignty. Nations that design, manufacture, and export their own advanced robotic systems will shape global value chains. Through more than 40 translational research initiatives, support to over 50 deep-tech startups, the creation of advanced Centres of Excellence, large-scale capability-building programs, and meaningful international collaborations, IHFC is steadily positioning India within this global landscape.

The significance of this journey extends beyond institutional success. It reflects a broader national lesson, that innovation flourishes when it is mission-driven, systematically executed, and socially anchored. Collaborative robotics in India is no longer an emerging aspiration; it is becoming an indigenous capability, built with purpose and aligned with national priorities.

Under the NM-ICPS mission, IHFC is not only advancing technology; it is strengthening India's ability to design, build, commercialize, and export its own deep-tech solutions. As India moves toward Viksit Bharat 2047, collaborative robotics and cyber-physical systems will be central to industrial growth, employment generation, and global competitiveness. IHFC's mission-driven 360-degree ecosystem, from nurturing young innovators to scaling startups, lays a strong foundation for that future. India is not merely adapting to technological change; it is preparing to lead it.

Shri Somjit Amrit
Chief Executive Officer
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Sovereignty Cannot Be Solitude

As India tool the lead in the India AI Summit, 2026, conversations around sovereign AI and its critical role in today's geopolitical landscape are more relevant than ever. Artificial intelligence is no longer just about innovation; it is about capability, resilience, and long-term national strength. The need to build AI systems that are both globally engaged and strategically secure is becoming increasingly clear. This conversation becomes even more important as AI itself evolves, particularly with the rapid rise of multimodal systems that integrate text, vision, audio, and beyond.

We at IIT Mandi TIH are stepping into the era of Multimodal AI with the establishment of the Multimodal AI Lab. An era where text understands images, audio interacts with vision, and intelligence flows across multiple streams of data at once. AI is no longer single dimensional. It is layered. Connected. Interdependent.

For a nation or a research lab, building AI today is not about shutting doors. It is about choosing what to open, what to protect, and how to contribute without losing identity.

Then does Sovereign AI mean being in solitude? Being secluded? Living in Isolation?

As we build Sovereign AI, we need to clarify the openness of technology. We must navigate 4 distinct layers of "openness" that define how technology needs to be shared while owning the digital rails of the intelligent economy:

1. Open Source

The scope here is code and process. Here the training code, model architectures and evaluation pipelines are made transparent and full access is provided. This enables reproducibility, third party audits, bias detection and security validation.

Think of it like sharing the recipe for baking a cake. The method is visible. Trust is earned because the process can be examined.

2. Open Weights

The scope here is the model output. Here sharing the trained model parameters ("brains") while safeguarding sensitive training code and datasets and proprietary training strategies (call it the "recipe") is possible. This allows local fine tuning of global models (e.g. Llama and Mistral) and deployment without exporting critical data.

It is like sharing a prepared base to make the cake. Others can build on it, adapt it, innovate on top of it, without accessing your core ingredients.

3. Open Standards

The scope here are the protocols. Defining common APIs and interoperability protocols is key here. This prevents vendor lock in and ensures systems can communicate across borders and platforms.

Common "languages" (like HTTP or UPI-style Aps) allow different AI systems to talk to each other. It prevents vendor lock-in.

With respect to the similar analogy of baking a cake, this is agreeing on common measurements and temperature settings. Without shared standards, even the best systems cannot collaborate.

4. Open Infrastructure

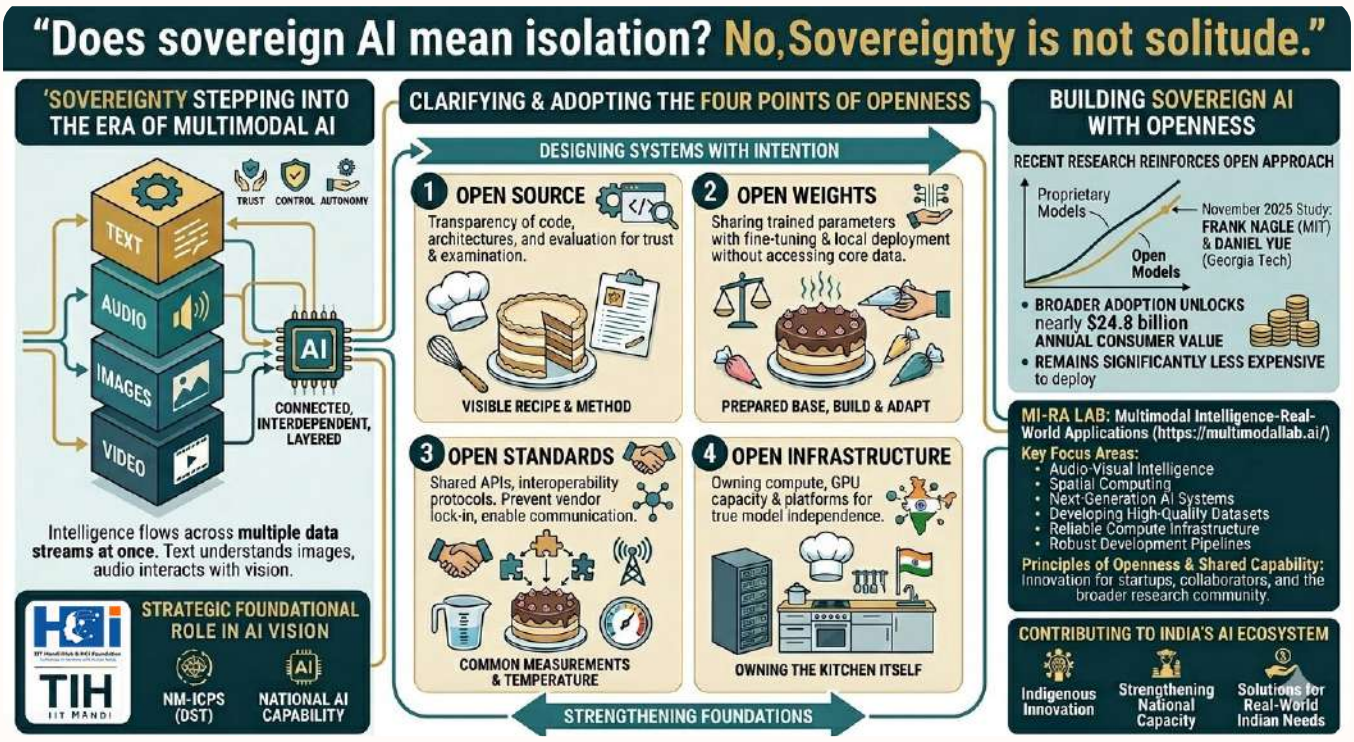
This is all about Hardware and Access. Publicly accessible compute (GPU clusters and data repositories) the examples being AI Compute Portal, AI Kosh respectively. Without infrastructure control, model independence remains fragile.

This is the public kitchen itself with defined access. Without it, even the best recipe remains on paper.

Recent research reinforces this approach. A November 2025 study by Frank Nagle (MIT) and Daniel Yue (Georgia Tech), titled "The Latent Role of Open Models in the AI Economy," finds that open models are rapidly narrowing the performance gap with proprietary systems while remaining significantly less expensive to deploy. The authors estimate that broader adoption of open models could unlock nearly $24.8 billion in annual consumer value. In short, openness is not only about trust and control, it is a source of economic strength.

The lab by the Technology Innovation Hub (TIH), at the IIT Mandi campus, supported by DST under NM-ICPS, would play a catalytic role in strengthening these foundations. Initiatives such as the India AI Mission and the Startup India Seed Fund Scheme illustrate how targeted support can nurture deep-technology innovation. With this support, the lab can develop high-quality datasets, reliable compute infrastructure, and robust data and development pipelines. Government-supported infrastructure and funding mechanisms ensure that AI capability remains broad-based, inclusive, and strategically aligned with India's long-term vision.

Sovereign AI is not about closing systems; it is about designing them with intention. It means sharing what builds trust, protecting what secures autonomy, shaping the standards that define the ecosystem, and investing in the infrastructure that sustains it. In a connected world, strength does not come from standing alone. It comes from participating with clarity, control, and confidence. Sovereignty cannot be solitude. It must be strategic and collaborative.



The variants of "openess" in technology

At the TIH, IIT Mandi, we are committed to advancing this frontier. A state-of-the-art multimodal AI research facility (MI-RA (Multimodal Intelligence-Real-World Applications) Lab: **https://multimodallab.ai/)** is being established to lead research in audio-visual intelligence, spatial computing, and next-generation AI systems. The focus is not only on building advanced models, but on creating strong foundational capabilities such as high-quality datasets, reliable compute infrastructure, and robust development pipelines.

The lab will operate on the principles of openness and shared capability described above based on the merit and the applicability. The aim is to create an environment where innovation is not restricted to a few teams, but can extend to startups, collaborators, and the broader research community. More importantly, the technologies and capabilities developed here are intended to contribute to India's AI ecosystem at large by supporting indigenous innovation, strengthening national capacity, and enabling solutions that address real-world Indian needs.

Acknowledgement

Shri Somjit Amrit with inputs from **Shri Rahul Sharma** and **Ms Srishti Sharma** ©IIT Mandi iHUB and HCi Foundation

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Building India's Robotics & AI Future A Deep-Tech Venture Model

India's aspiration to become a global leader in advanced manufacturing, defence technologies, and intelligent systems requires more than breakthrough research—it demands translational ecosystems that move ideas from laboratories to real-world deployment at national scale. In critical sectors such as defence, manufacturing automation, mobility, healthcare, and strategic infrastructure, cyber-physical systems (CPS)—integrating AI, robotics, sensing, embedded intelligence, and advanced computing, are becoming foundational to competitiveness and sovereignty.

Recognizing this imperative, the Department of Science and Technology launched the National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS) to build long-term national capabilities in CPS domains. As part of this mission, ARTPARK (AI & Robotics Technology Park) was established by the Indian Institute of Science (IISc) as a Technology Innovation Hub and now upgraded to TTRP with a focused mandate: to bridge the gap between research excellence and deployable AI & Robotics systems that serve India's economy, society, and strategic interests.

> **ARTPARK's mission is clear: To build India's next-generation AI & Robotics innovations and innovators—for economy, society, and sovereignty**

In just a few years, this mission has translated into a deep-touch innovation and venture-building model that is helping India reduce import dependency, accelerate commercialization, and nurture world-class deep-tech entrepreneurs.

A Deep-Touch Innovation Model for Translational Impact

Across the world, deep-tech ecosystems struggle at the "valley of death"—the gap between proof-of-concept (Technology Readiness Levels 3–4) and field-ready systems (TRL 6–7). Early research often lacks sustained funding, infrastructure, and industry integration required for real-world validation.

ARTPARK was designed specifically to address this structural gap. Over the past few years, the hub has emerged as a strong catalyst for deep-tech innovation and entrepreneurship. It has built and invested in 29 startups while supporting the development of nearly 60 technologies across critical sectors. By enabling Technology Readiness Level (TRL) progression from 3–4 to 6–7, the hub has successfully bridged the gap between research and commercialization, achieving an impressive commercialization rate of nearly 50%. Its growing innovation ecosystem has enabled venture valuations exceeding Rs 1300 crore and mobilized more than Rs 312 crore in capital support, reflecting its significant contribution to India's technology and startup landscape.

These outcomes reflect not only startup success but also systemic ecosystem strengthening. This progress has been enabled by sustained financial support stitched together across multiple sources and a strong ecosystem connect involving over 100 industry, government, nonprofit, and research partners

ARTPARK follows a deep-touch venture-building approach focused on nurturing breakthrough innovation from idea to deployment. It provides long-term funding support spanning two to four years, along with access to a state-of-the-art 75,000 sq. ft. Robotics and AI facility. Startups benefit from advanced prototyping and pilot manufacturing infrastructure, a dedicated 5G testbed, and high-performance GPU compute clusters. ARTPARK also strengthens ventures through talent recruitment support beyond IISc, Innovators-in-Residence programs, and structured industry co-development, creating a robust ecosystem for scalable deep-tech innovation.

ARTgarage at ARTPARK, IISc Bangalore

This integrated framework reduces iteration cycles, strengthens product-market fit, and ensures that high-risk deep-tech ventures are not prematurely abandoned.

Case Study 1

COMRADO Aerospace – Indigenous Long-Endurance ISR UAVs

One of the most significant outcomes of this model is COMRADO Aerospace, a defence-focused startup addressing India's dependence on imported long-endurance ISR (Intelligence, Surveillance, Reconnaissance) UAVs.

The National Challenge

Historically, the Indian Army has relied on costly imported UAV systems for long-endurance surveillance. Indigenous alternatives have largely been limited to small drones with restricted endurance, altitude, and mission flexibility. Imported systems not only strain defence budgets but also pose long-term risks related to maintenance, upgrades, obsolescence, and supply chain vulnerabilities.

For a country of India's scale and security requirements, indigenous ISR capability is not optional—it is strategic.

The CPS Solution

COMRADO has developed an advanced 4.5-meter wingspan hybrid VTOL UAV designed for long-range and high-altitude operations. The platform offers an operational range of 150 km, endurance of up to 6 hours, and the capability to operate at altitudes reaching 21,000 feet. Combining vertical take-off and landing with extended flight performance, the UAV is built for demanding surveillance, reconnaissance, and strategic mission applications.

The platform integrates aerostructures, AI-enabled navigation, embedded control systems, and indigenous components, the platform represents a true cyber-physical system tailored for Indian operational conditions.

Beyond hardware, COMRADO also developed advanced simulators to accelerate pilot training and lifecycle readiness within India, reducing dependence on foreign training ecosystems.

Measurable Impact

The startup has demonstrated strong commercial traction with simulator revenues reaching an annual recurring revenue (ARR) of $1 million. The Indian Army has emerged as an active customer, validating the platform's operational relevance and reliability. The company has also secured maintenance contracts and reseller agreements while establishing contract manufacturing partnerships to support scale-up. Further strengthening its market presence, the startup successfully launched its MVP in December 2024.

COMRADO Aerospace – Indigenous Long-Endurance ISR UAVs

COMRADO's journey reflects how translational ecosystems can convert advanced aerospace research into mission-critical national assets—reducing import dependency and strengthening sovereign defence capabilities.

Case Study 2

TWARA – Democratizing Industrial Robotics

While defence represents one frontier, advanced manufacturing represents another. India's manufacturing sector faces a structural bottleneck: robotic automation remains expensive, fragmented, and often inaccessible to small and medium enterprises (SMEs).

Industrial robot deployment frequently involves multi-vendor integration, and even individual actuator joints can cost thousands of dollars. For many Indian SMEs, this creates prohibitive barriers to automation.

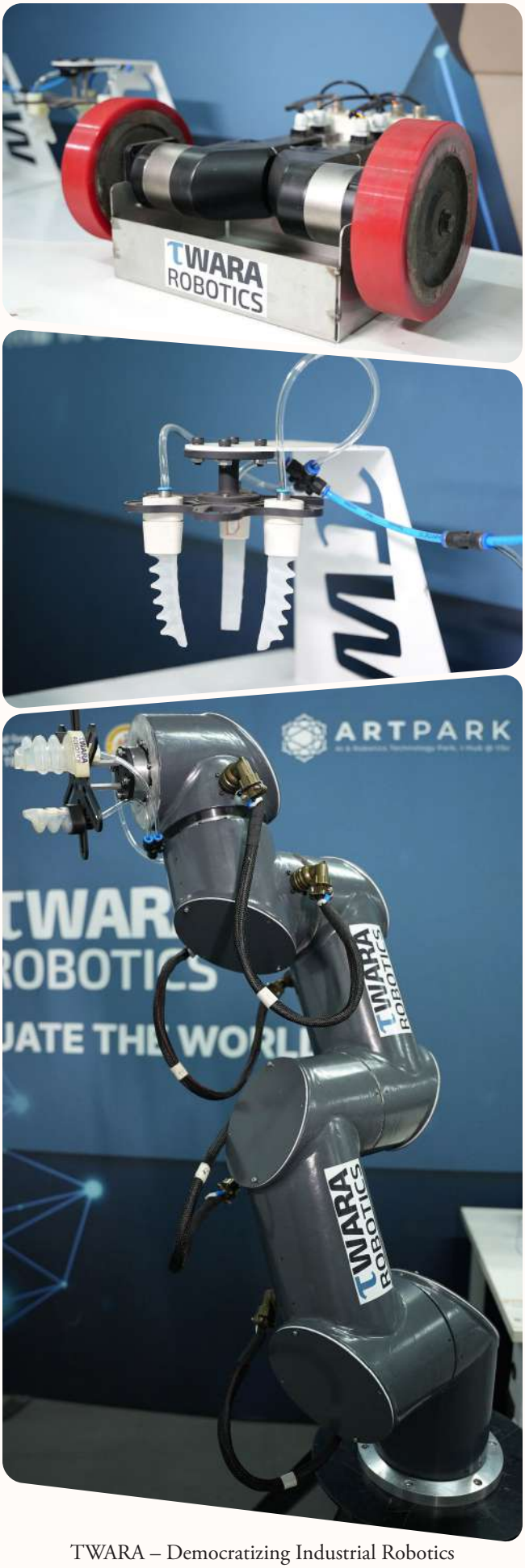
TWARA addresses this gap.

The Manufacturing Challenge

Indian SMEs often hesitate to adopt robotics due to the high cost of imported actuators, complex system integration requirements, limited customization options, and lengthy deployment timelines. As a result, advanced automation technologies remain largely accessible only to large enterprises with higher capital and technical resources. The lack of affordable and indigenous robotic solutions continues to be a major barrier to widespread automation adoption among small and medium industries.

The CPS Innovation

TWARA is developing indigenous robotic technologies with advanced actuators and soft grippers that combine hardware, embedded intelligence, and AI-driven coordination. Its solutions enable cost-effective robotic arms, Autonomous Mobile Robot (AMR) kits, conveyor drives, and customizable automation architectures for SMEs. Designed specifically for Indian manufacturing conditions, TWARA delivers scalable, efficient, and affordable robotic systems to accelerate industrial automation adoption.



TWARA – Democratizing Industrial Robotics

Ecosystem Integration and Scale

TWARA's translational journey highlights the strength of collaborative innovation and industry-driven technology development. The startup secured major funding from a leading Indian machine tool manufacturer and earned a US patent for its novel actuator design. Its solutions have been deployed with prominent organizations including L&T, ACE, ATI Motors, Rane, and BITS Hyderabad, while strategic manufacturing partnerships have been established to support large-scale commercialization and deployment.

In a notable evolution, a manufacturing partner became both a strategic investor and customer—aligning market demand with indigenous innovation.

TWARA illustrates how AI and robotics can move from elite industrial deployments to broader manufacturing democratization.

Ecosystem Outcomes Beyond Individual Ventures

While individual startups demonstrate impact, the deeper success lies in ecosystem building.

ARTPARK's model emphasizes five structural pillars:

1. Infrastructure-Led Acceleration

Large-scale robotics prototyping and pilot manufacturing facilities significantly reduce iteration cycles and improve reliability validation.

2. Sustained Innovation Funding

Pre-commercial R&D requires patient capital. Structured 2–4 year funding windows enable ventures to mature before facing market pressures.

3. Talent Magnetism

Approximately 200 hires have been enabled across ventures, drawing interdisciplinary talent beyond IISc and fostering cross-domain collaboration.

4. Iterative Co-Innovation

Early engagement with industry and government ensures solutions are demand-driven rather than technology-pushed.

5. Experienced Core Leadership

A dedicated core team with depth in deep-tech, policy, and venture building provides hands-on mentorship and structured execution support.

Together, these pillars reduce systemic friction in India's deep-tech commercialization pipeline.

National Outcomes Under NM-ICPS

Under NM-ICPS, the objective is not merely startup creation but national capability creation.

ARTPARK's experience demonstrates that successful Cyber-Physical Systems (CPS) hubs must go beyond conventional incubation by integrating research, manufacturing, and market access within a unified innovation ecosystem. A strong emphasis on indigenous intellectual property development, industry co-creation aligned with national mission priorities, and access to real-world testbeds is essential for accelerating technology translation. Such an approach enables startups and innovators to validate, refine, and deploy scalable deep-tech solutions effectively.

The hub's achievements—29 ventures, 60 technologies, Rs 1300 crore cumulative valuation impact, and strong commercialization outcomes—demonstrate that India can build globally competitive AI and robotics systems when structural ecosystem gaps are addressed intentionally.

Importantly, the success of such hubs strengthens India's technological sovereignty by reducing external dependencies in strategic sectors.

The Road Ahead: Scaling India's Robotics & AI Leadership

India now stands at a pivotal inflection point. Robotics and AI systems are becoming foundational not only to defence preparedness but also to advanced manufacturing competitiveness, resilient supply chains, digital public infrastructure, and next-generation mobility.

The next phase of NM-ICPS will require a stronger and more integrated innovation ecosystem to accelerate India's leadership in Cyber-Physical Systems technologies. This includes establishing larger shared national testbeds and pilot manufacturing zones, enabling deeper alignment between public and private capital, and building scalable talent pipelines across CPS domains. Greater focus is also needed on secure and sovereign AI-enabled robotics platforms, along with strategic international collaborations that align with national priorities and technological self-reliance.

To multiply its impact, ARTPARK has proposed expanding its efforts through a new 9-acre campus–BRAINZ (Bengaluru Robotics & AI Innovation Zone)–with plans to mobilize Rs 2000 crore over the next five years to scale its innovation velocity.

Such expansion represents not just infrastructure growth, but a step toward establishing India as a global exporter of AI and robotics systems rather than a consumer of imported technologies.

Conclusion

India's journey toward technological self-reliance in robotics and AI will not be defined solely by research excellence. It will be defined by the nation's ability to convert interdisciplinary innovation into reliable, deployable, and scalable cyber-physical systems.

Through its deep-touch venture-building model, ARTPARK demonstrates how integrated infrastructure, sustained funding, industry co-creation, and mission-driven leadership can bridge the translational gap in CPS domains.

Under NM-ICPS, this model offers a replicable template for building sovereign, scalable, and globally competitive Robotics & AI ecosystems, advancing India's economy, strengthening national security, and empowering the next generation of innovators.

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India's Tech Revolution

How NM-ICPS Is Rewriting the Rules of Innovation

India is in the midst of a vibrant technological transformation, advancing with purpose and continuously enriching industries, communities, and everyday life while paving the way for a future defined by innovation and opportunity. The transformation is unfolding deep inside laboratories, testbeds, factory floors, power grids, hospitals, and data centres—where software increasingly senses, decides, and acts upon the physical world.

This convergence of computation, communication, and control—known globally as Cyber-Physical Systems (CPS)—has become the backbone of modern economies. Autonomous vehicles, smart grids, AI-enabled medical devices, precision agriculture, secure financial networks, and intelligent manufacturing lines all rest on this integration. Over the past two decades, leading economies have recognized CPS not merely as a technological field, but as strategic infrastructure.

India's response to this global shift came in 2018 with the launch of the National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS) implemented by the Department of Science and Technology. The noteworthiness of the mission lies not just what it funds, but how it reimagines the architecture of public innovation itself.

From Global Paradigm to National Imperative

As the global economy entered the 21st century, the convergence of computing, communication, and physical infrastructure began to fundamentally reshape industrial competitiveness and national security. The concept of Cyber-Physical Systems (CPS) emerged in the mid-2000s as a formal research paradigm, gaining academic recognition around 2006–2007 and rapidly evolving into a strategic priority for leading economies. The United States institutionalized CPS through the launch of the National Science Foundation's Cyber-Physical Systems Program in 2008, supporting research in embedded systems, smart infrastructure, medical devices, autonomous systems, and resilient control networks. Around the same time, Germany operationalized CPS at industrial scale through its Industry 4.0 initiative, integrating sensors, machine-to-machine communication, digital twins, and intelligent automation into manufacturing. Japan expanded the CPS paradigm beyond industry through its Society 5.0 vision in 2016, positioning cyber-physical integration as the foundation of a "super-smart society" spanning healthcare, mobility, disaster management, and energy systems. Parallel efforts in the European Union

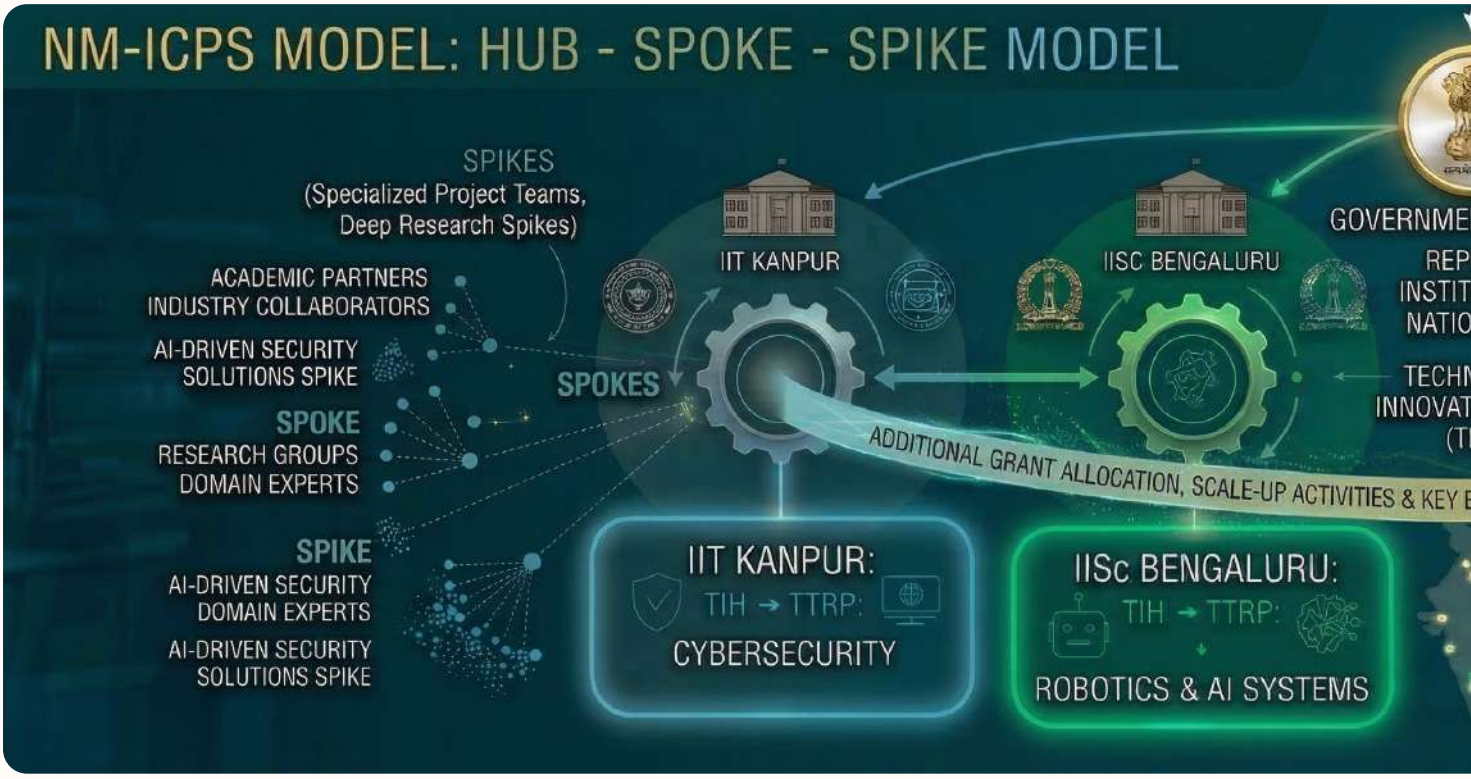
through ARTEMIS (2008) and Horizon programmes (2014), promoting embedded intelligence, cross-border industrial research, and smart systems integration across member states. and in China through its 2015 industrial modernization & Made in China 2025 roadmap, further underscored that CPS had moved from an academic construct to a determinant of national competitiveness, technological sovereignty, and infrastructure resilience.

Advancing Beyond Standard Frameworks

It was against this evolving global backdrop that India articulated its own mission-mode programme. Recognizing the strategic importance of CPS for economic transformation and national capability building, the Government of India approved the National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS) in 2018 to be implemented by the Department of Science and Technology (DST). The Mission was designed as a comprehensive, pan-India initiative, aimed to build indigenous capabilities in technologies that integrate sensing, computation, communication, control, and actuation. The objective was to modernize critical sectors such as advanced manufacturing, robotics and autonomous systems, energy, mobility, healthcare and medical devices, agriculture, infrastructure, cyber security and Quantum technologies while ensuring technological self-reliance and global competitiveness in alignment with the vision of Viksit Bharat 2047. Unlike conventional research schemes, the Mission was explicitly designed with defined thematic focus areas, measurable outcomes, and clear translational pathways from laboratory research to real-world deployment.

The National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS) is anchored in a robust and multi-layered governance framework designed to ensure strategic direction, scientific excellence, and effective implementation. At the apex is the Mission Governing Board, which provides overall policy guidance and strategic oversight, ensuring alignment with national priorities. Complementing this is the Scientific Advisory Committee, which offers expert technical and research guidance to maintain global competitiveness and scientific rigour. The Mission Office at the Department of Science and Technology (DST), led by the Mission Director, serves as the central coordinating and implementation body, overseeing the Mission's day-to-day operations and monitoring progress across initiatives.

At the core of implementation are the Technology Innovation Hubs (TIHs), established across leading academic and research institutions to drive technology development, translational research, skill development, and entrepreneurship. Each TIH is further supported by a dynamic network of 'Spokes,' comprising partner institutions, startups, and research laboratories that extend collaboration and enable real-world deployment. At the grassroots level, 'Spikes' represent specialized project teams and research groups that undertake focused research and innovation activities. Together, this integrated



NM-ICPS Model: Hub-Spoke-Spike Model

structure fosters a collaborative ecosystem that accelerates technology development, strengthens industry–academia partnerships, and advances India's leadership in cyber-physical systems and emerging technologies.

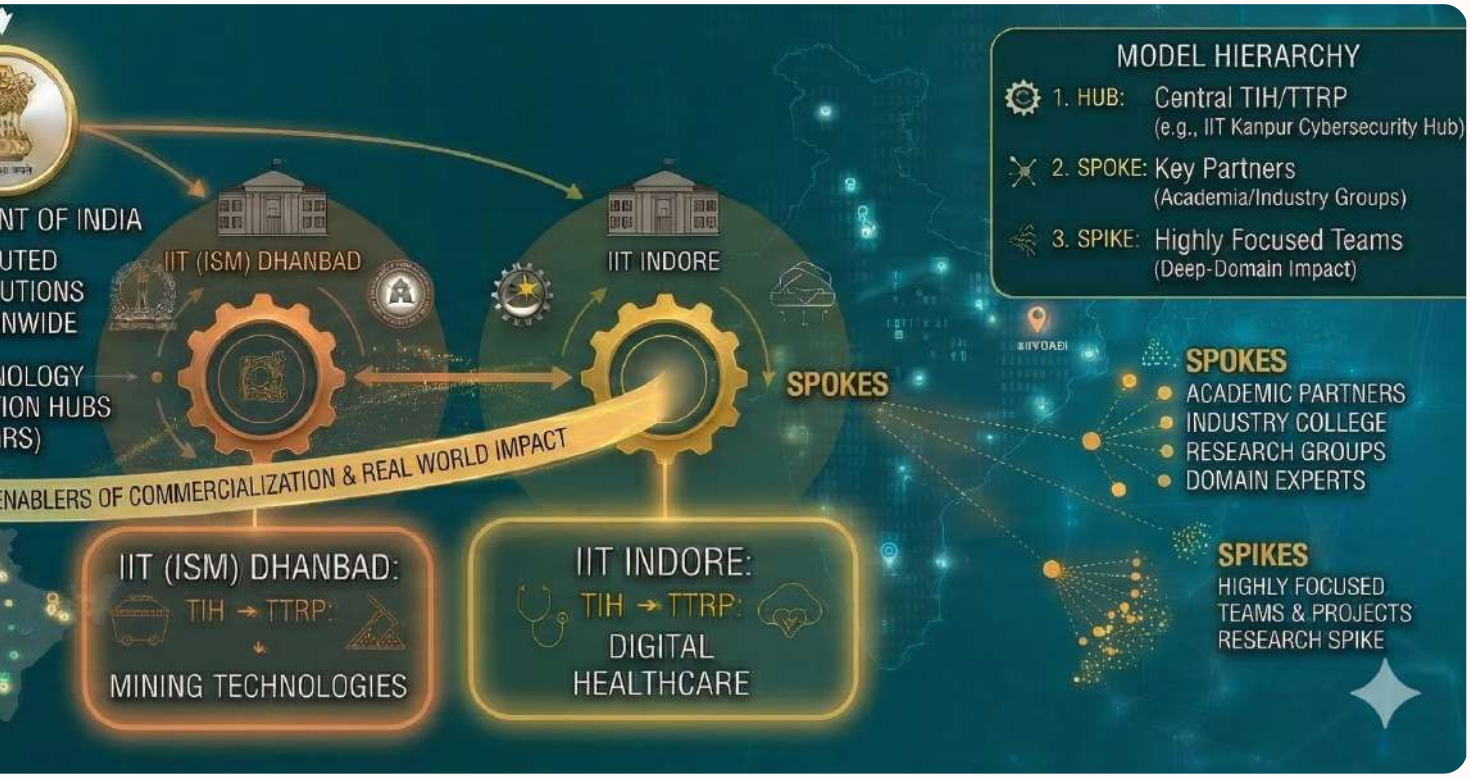
The implementation architecture of NM-ICPS introduced a significant structural reform in India's science and technology funding landscape. Traditionally, government grants were routed directly to academic and research institutions for specific projects. While this approach strengthened research depth, it often resulted in fragmented outputs and limited cross-institutional integration. NM-ICPS adopted a hub-and-spoke model comprising Technology Innovation Hubs (TIHs), Technology Translation Research Parks (TTRPs) in reputed institutions across the country.

Four top-performing Technology Innovation Hubs (TIHs) under the Mission at IIT Kanpur, IISc Bengaluru, IIT (ISM) Dhanbad, and IIT Indore have been upgraded to Technology Translation Research Parks (TTRPs), with focus areas on Cybersecurity, Robotics and AI Systems, Mining Technologies (from exploration to beneficiation), and Digital Healthcare, respectively, along with additional grant allocations to scale up existing activities and serve as key enablers of technology commercialization and real-world impact through close collaboration with all TIHs, relevant ministries, and industry partners. Under this structure, the Government of India, within a capital outlay, enabled the creation of a larger, diversified pool of research groups, startups, industry collaborators, and domain experts interconnected through the hubs. Instead of isolated project funding, the Mission fostered ecosystem development—bringing together academia, industry, startups, investors, and policymakers on a common platform. This diversification of assets and knowledge significantly amplified national capacity.

The hub-and-spoke approach enabled pooling of infrastructure such as advanced laboratories, simulation platforms, testbeds, prototyping facilities, and incubation centres. It facilitated interdisciplinary research across engineering & science domains. Startups and innovators gained access to institutional expertise and shared facilities, accelerating technology maturation. Thus, within the same financial envelope, the Mission achieved a multiplier effect—expanding both research depth and translational breadth, and fostering a collaborative CPS ecosystem across reputed institutions nationwide.

Redefining Governance for a New Era

A defining and transformative feature of NM-ICPS is the establishment of Technology Innovation Hubs as Section 8 companies under the Companies Act, 2013. This governance innovation distinguishes NM-ICPS from many global counterparts. Section 8 companies are non-profit entities with limited liability, professional board governance, statutory compliance, financial transparency, and operational autonomy. By adopting this structure, the Mission ensured that the hubs operate with corporate agility while remaining mission-driven. The Board of Directors model allows strategic oversight,



faster decision-making, and industry representation. Operational flexibility in recruitment, procurement, intellectual property management, and collaboration agreements significantly reduces procedural delays often associated with traditional academic systems.

This structure also enables diversified stakeholders, including central and state governments, industries, start-ups, research and academic institutions, thereby enhancing financial sustainability. Limited liability protects members, while perpetual succession ensures institutional continuity. Most importantly, this model accelerates technology development cycles. Faster procurement processes allow timely acquisition of advanced equipment; agile hiring enables onboarding of specialized technical talent; and flexible partnership mechanisms facilitate rapid prototyping and commercialization. As a result, NM-ICPS hubs have been able to translate research outputs into technology-based products, pilot deployments, and startup ventures at a significantly faster pace, demonstrating that governance reform can be as impactful as technological innovation.

Beyond Conventional Research Domains

Beyond its structural innovation, NM-ICPS distinguishes itself through strategic sectoral interlinkages. While CPS traditionally encompasses robotics, autonomous systems, and smart manufacturing, the Mission has consciously extended its scope into sectors such as mining, energy, and fintech. In mining, CPS technologies enable real-time environmental monitoring, predictive maintenance of heavy machinery, autonomous drilling systems, and worker safety surveillance. Intelligent sensing and control systems improve operational efficiency while reducing risk in hazardous environments. In the energy domain, CPS supports smart grids, renewable energy forecasting, decentralized energy management, and resilient transmission systems. By integrating digital intelligence into physical infrastructure, energy systems become adaptive, efficient, and secure.

In the fintech sector, CPS principles underpin secure digital payment systems, fraud detection mechanisms, real-time transaction analytics, and blockchain-enabled validation frameworks. Financial transactions today operate on interconnected cyber-physical infrastructures—data centres, network systems, user devices, and transaction platforms. Robust cybersecurity architectures ensure integrity, authenticity, and reliability, making cybersecurity a universal enabler across all CPS applications. In the context of financial transactions, cyber resilience safeguards digital trust, protects national economic interests, and ensures continuity of services. By embedding cybersecurity into CPS frameworks, NM-ICPS strengthens secure communication protocols, encryption standards, intrusion detection systems, and resilient control architectures across sectors.

The integration of mining, energy, fintech, and cybersecurity within the CPS ecosystem demonstrates the Mission's forward-looking approach. These sectors may not be traditionally labelled as CPS domains, yet they generate vast real-time data streams, depend on intelligent automation, and require secure digital-physical integration. By expanding into these areas, NM-ICPS amplifies national impact, enhances industrial safety, supports sustainable resource management, strengthens financial security, and builds infrastructure resilience.

The Mission is being implemented with a firm focus on advancing India's core national priorities while contributing meaningfully to the Sustainable Development Goals (SDGs). The Mission aligns with national objectives of economic self-reliance, infrastructure modernization, digital security, sustainable industrialization, and inclusive growth. By fostering indigenous technological capabilities and reducing import dependence in critical domains, it strengthens national sovereignty and long- term competitiveness. Simultaneously, NM-ICPS supports SDG commitments related to industry, innovation and infrastructure; affordable and clean energy; sustainable cities and communities; climate resilience; and strong institutions. Its emphasis on efficiency, safety, transparency, and secure digital systems contributes to responsible production, environmental sustainability, and. institutional robustness. Through mission-mode implementation, the programme ensures that technological advancement directly serves developmental imperatives- balancing growth with sustainability, security with accessibility, and innovation with societal impact--thereby reinforcing India's pathway toward sustainable and nationally aligned progress.

In essence, NM-ICPS represents India's strategic response to a globally evolving technological paradigm. It combines international best practices with indigenous institutional innovation, integrates research with deployment and scalable impact, and aligns technological advancement with national development priorities as well as sustainability, resilience, and inclusive growth imperatives. Through mission-mode implementation, diversified ecosystem development, Section 8 governance reforms, and cross-sectoral integration, the Mission lays a robust cyber-physical foundation for India's secure, self-reliant, and sustainable journey toward Viksit Bharat 2047.

Technology Translation Research Parks (TTRPs)
Translating Deep Tech for National Impact

Under NM-ICPS, Technology Translation Research Parks (TTRPs) have been established to support this journey by strengthening technology development, validation, and industry engagement.

This section presents the work of the TTRPs and their efforts to transform research outcomes into technologies and solutions that can create impact for industry and society.

Dr Dheeraj Rane
Scientific Officer
IITI DRISHTI CPS Foundation
IIT Indore

Intelligent Cardiac Care & Intervention Platform at IITI DRISHTI CPS Foundation

Cardiovascular diseases remain a leading cause of mortality, with a significant proportion of deaths occurring due to sudden cardiac arrest, often without sufficient prior warning. A key limitation in current healthcare systems is the absence of continuous, predictive, and patient-specific modelling that can anticipate such critical events.

In response, DRISHTI – Technology Translation Research Park (TTRP) is developing an Intelligent Cardiac Care Platform that brings together machine learning, IoT-enabled monitoring, immersive virtual reality simulation using the NeoCath platform, and the emerging concept of a **digital twin of the human heart**.

This initiative is being envisioned as a next-generation translational research effort, where predictive analytics, real-time physiological monitoring, simulation-driven intervention planning, and patient-specific modelling converge into a unified cardiac care ecosystem.

Translational Research: Toward a Living Model of the Heart

The platform is being developed around an AI-driven **Heart Health Scoring System**, designed to overcome the limitations of traditional risk calculators. Existing systems fail to capture the dynamic and interdependent nature of cardiovascular risk factors. DRISHTI is addressing this through a **graph-based modelling approach**, where clinical parameters are represented as interconnected nodes, enabling the system to reflect real clinical reasoning.

Building upon this foundation, the research is now evolving toward the creation of a **cardiac digital twin** - a virtual, continuously updated representation of an individual's heart. This digital twin is not merely a static model but a dynamic system that integrates:

- **Real-time physiological data from IoT devices**
- **Historical clinical records**
- **Machine learning-based risk predictions**
- **Simulated physiological responses**

The digital twin is being conceptualized as a **Living Model**, capable of mirroring the current state of a patient's cardiovascular system and predicting its future behaviour under different conditions.

Machine Learning Framework: Enabling Predictive Intelligence

The computational backbone of the system is being developed using a hybrid machine learning architecture. The Heart Health Score is being modelled using a graph-based formulation where individual risk factors and their interactions are jointly considered. This is being extended through **Combinational Gradient Boosting Trees with Graph Neural Networks (GNN)**, enabling the system to learn higher-order dependencies among parameters.

Simultaneously, deep learning models are being designed to process continuous streams of ECG and physiological signals. These models aim to detect subtle patterns such as arrhythmogenic signatures, ischemic trends, and autonomic imbalances that may precede cardiac events.

In the context of the digital twin, these models will play a crucial role in **state estimation and prediction**, continuously updating the twin based on incoming data and forecasting potential risk scenarios. The inclusion of **confidence intervals**, as described in the proposal, will allow clinicians to assess the reliability of predictions, enhancing trust in AI-driven decision support.

Virtual Reality and NeoCath Simulation: From Prediction to Intervention

A unique dimension of this platform is the integration of **NeoCath VR simulation (EndoVision)** into the cardiac care workflow. While machine learning and IoT focus on prediction and monitoring, VR simulation addresses intervention planning and clinician training.

The NeoCath simulator is being explored as a tool to create **patient-specific procedural** simulations. By linking the digital twin with the VR environment, clinicians will be able to:

- **Visualize patient-specific coronary anatomy**
- **Simulate catheter navigation and stent placement**
- **Evaluate multiple intervention strategies before actual procedures**

This integration represents a significant step toward predictive and pre-emptive cardiology, where interventions can be planned and optimized using virtual replicas of the patient's heart.

Ecosystem Development and Collaborative Innovation

The development of this platform is being supported by a multi-stakeholder ecosystem involving clinicians, AI researchers, IoT developers, and simulation technology providers. Startups are being incubated to contribute to various components of the system, while academic researchers are advancing the underlying algorithms.

Clinical partners are playing a critical role in validating both the Heart Health Score and the digital twin concept. This collaborative approach ensures that the system is not only technologically advanced but also aligned with real-world clinical needs.

Anticipated Real-World Impact: Reducing Sudden Cardiac Deaths

One of the most transformative aspects of this initiative lies in the potential impact of the **cardiac digital twin**. Sudden cardiac arrest often occurs without clear prior symptoms, making it difficult to predict using conventional methods. However, with a continuously updated digital twin, it becomes possible to:

- **Detect subtle precursors to cardiac arrest**
- **Simulate future risk scenarios based on current trends**
- **Identify high-risk states before they manifest clinically**
- **Enable timely preventive interventions**

The integration of predictive models, real-time data, and simulation capabilities is expected to significantly **reduce the incidence of sudden cardiac deaths**. By shifting from reactive care to proactive and predictive management, the system has the potential to save lives on a large scale.

In addition, the Heart Health Score will serve as a unified, interpretable metric for risk communication, enabling both clinicians and patients to understand and act upon evolving cardiac risk. The NeoCath simulation will enhance procedural precision, reducing complications and improving outcomes.

Future Directions: Toward Precision and Preventive Cardiology

As development progresses, the platform is expected to incorporate genomic data, enabling deeper personalization of the digital twin. Polygenic risk scores and genetic markers will be integrated into the graph model, further refining risk predictions.

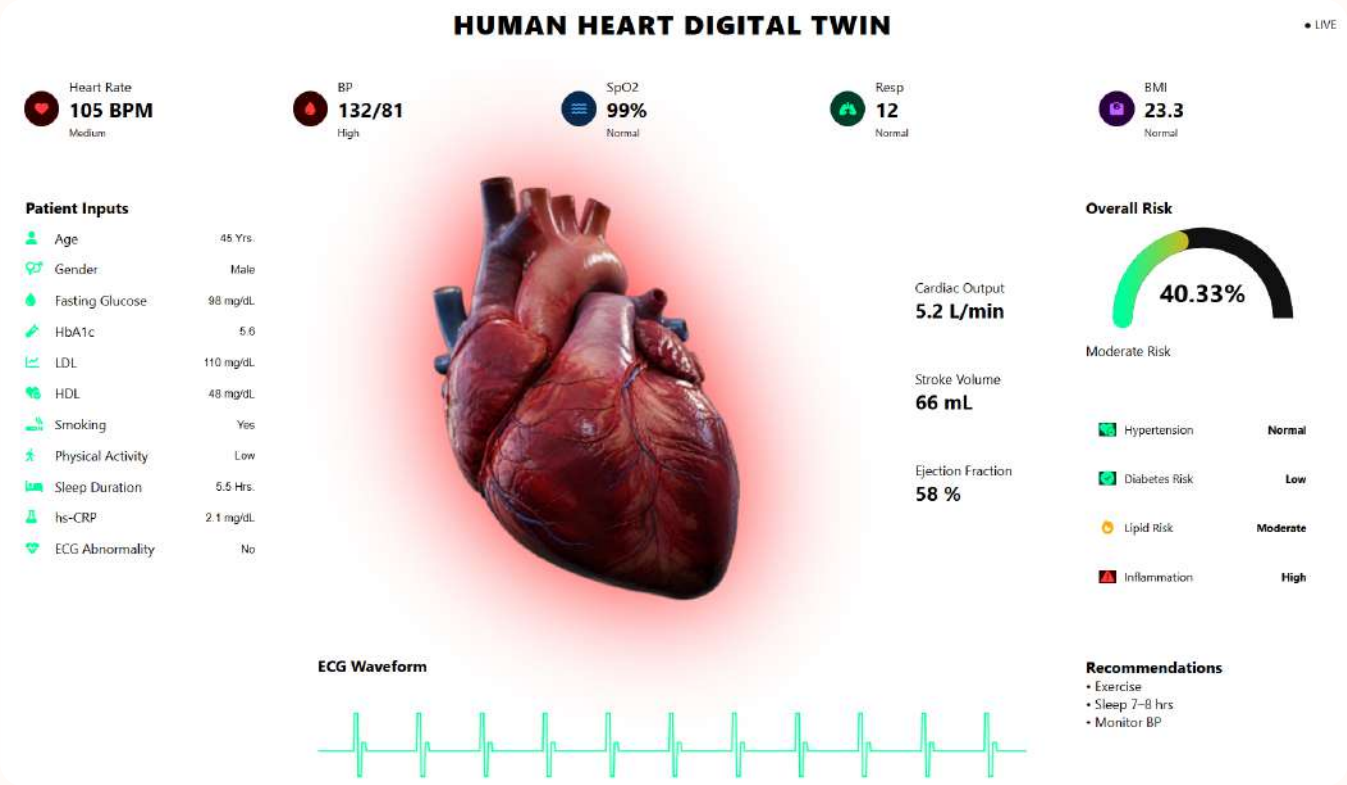
The long-term vision is to create a **fully integrated digital cardiology ecosystem**, where each patient has a continuously evolving digital twin that informs prevention, diagnosis, and treatment.

Conclusion

The Intelligent Cardiac Care Platform being developed at DRISHTI TTRP represents a paradigm shift in cardiovascular healthcare. By integrating machine learning, IoT, virtual reality, and the concept of a cardiac digital twin, it moves toward a future where healthcare is predictive, personalized, and proactive.

The introduction of a digital twin of the heart is particularly transformative, as it enables continuous risk assessment and simulation-driven decision-making. Once fully realized, this approach has the potential to significantly reduce sudden cardiac deaths, marking a major advancement in global healthcare.

This case study reflects not a completed system, but an evolving and ambitious effort—one that is poised to redefine the way cardiac diseases are understood, monitored, and managed.



Human Digital Twin Application Interface

Dr Tanima Hajra

Chief Executive Officer
IHUB NTIHAC Foundation
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The Story of C3iHub

Indigenous Cybersecurity Technology Innovation Hub at IIT Kanpur

India's aspiration for technological leadership by 2047 depends not only on breakthrough research but also on the ability to translate innovation into deployable, scalable, and commercially viable solutions. As India made an unprecedented major leap into science, technology, economy, and governance over the past decade, the physical processes across industries and organizations became integrated with cyber to leverage the leap, making India one of the most lucrative nations for cyber attacks. To protect national security, economic stability, and societal trust in digital public infrastructure systems, the development of robust indigenous cybersecurity technologies has emerged as critical, where C3iHub, a Technology Innovation Hub established in 2020 under the Department of Science and Technology's National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS), is playing a major role.

C3iHub means Cybersecurity and Cybersecurity for Cyber-Physical Systems innovation Hub. It has been C3iHub's objective from the inception to create and nurture a completely indigenous ecosystem of cybersecurity innovation, services, tools, technologies, and workforce development. C3iHub has been contributing to the strategic missions of the Government of India – 'Atma-Nirbhar Bharat', 'Startup India', 'Skill India'- and working towards 'Vikshit Bharat' by 2047. With the upgradation to Technology Translation Research Park (TTRP) status in 2025, today C3iHub stands as a national model of how Technology Innovation Hubs can catalyze productization for industries, strategic industry partnerships in co-innovation, and foster startup growth for field-level impact in cybersecurity for cyber-physical systems.

Productization for Industries for Resilient Infrastructure

Indigenous IT-OT Security Operations Center

For protecting country's critical infrastructure, continuous monitoring of threats, detection in real-time, and response are critical. C3iHub's flagship technology product, indigenous IT-OT Security Operations Center (SOC), enables 24×7x365 monitoring of threats on both IT & OT assets of organizations and provides real-time threat detection and alerts with remediation workflow, ensuring vulnerability fixation after detection. The SOC has 100% indigenous SIEM (Security Information and Event Management), integrates in-house developed indigenous security solutions - host & network intrusion detection systems, deception technology solutions, malware detection & classification, endpoint detection & response, and can be custom tailored and scaled as per organization security posture. C3iHub SOCs have been successfully deployed at National Highways Authority of India headquarter, Indian Ports Association headquarter;

Commissioning Ceremony of C3iHub's IT-OT SOC at Bhilai Steel Plant

the recent commissioning of SOC at the critical IT-OT environment of Bhilai Steel Plant has demonstrated how indigenous cybersecurity architectures can secure live industrial control systems at scale, reducing reliance on imported security frameworks.

Industry-scale Critical Infrastructure Security Testbeds

C3iHub hosts country's only academic industry-scale test beds (power and energy (distribution, transmission, generation, 4-stage water treatment plant, manufacturing automation & industrial robotics). The test beds comprise key Industrial Control Systems (ICS) elements including RTUs, PLCs, SCADA, DCS, HMIs from national as well as international Original Equipment Manufacturers (OEMs). The test beds are used for testing OT compatibility of hub-developed security solutions and offering hands-on ICS security exercises. Through advanced vulnerability detection mechanisms, our hub OT experts detect vulnerabilities in the ICS elements and report to respective OEMs.

Piloting Cybersecurity Maturity Model with CII (Critical Information Infrastructure) Organizations

C3iHub has developed sector-specific and sector-agnostic Cyber Security Maturity Models to assess cybersecurity readiness of country's seven critical sectors

OT SOC & SCADA with PHIL (Power Hardware-in-the-Loop) Test Bed

(BFSI, Power & Energy, Health, Government, Telecom, and Transport & Strategic), along with scoring tools for automated maturity evaluation. This development is majorly sponsored by NSCS and partially supported by DST, with NCIIPC as the main user agency & regulatory body. CSCMM features a comprehensive online assessment platform tailored for Indian Critical Sector Entities (CSEs), enabling a 360-degree evaluation of cybersecurity practices across strategic, tactical, and operational domains, and provides a centralized metrics system synchronizing compliance requirements across multiple regulatory bodies in India. The scoring tool is live and accessible through both web-based self-assessment platform (online) and desktop application (offline), ensuring flexibility and wider adoption across diverse organizational environments. An AI-based scoring tool is being piloted across CII organizations, including industries in power and energy, transport, and telecom domains.

Co-Research & Innovation with Industry

Under a project sponsored by Microsoft and Cyberabad Police Commissionerate, C3iHub developed Tactics, Techniques, & Procedures-based framework & framework navigator interactive tool for cybercrime incident response, assisting cybercrime investigators. The tool allows crime classification, modus operandi comparison, and approximate execution path creation.

These engagements reflect a deliberate strategy: combining academic rigor with industry-grade engineering to produce field-validated, deployment-ready solutions.

Commercialization Outcomes: Measuring Impact

C3iHub's commercialization metrics underscore the strength of its translation ecosystem. Over fifteen major technologies are deployed, and more are being piloted in operational environments. There are over hundreds of publications and intellectual property contributions towards these industry-grade technology developments and deployments. C3iHub technology commercialization outputs are more than just deployments; they actively secure highways, ports, and industrial plants, and during Operation Sindoor, none of these organizations faced CPS functionality compromise. Last quarter only, C3iHub has signed new partnerships with National Mineral Development Corporation, Delhi Metro Rail Corporation, Maharashtra Metro, and Automotive Research Association of India, for joint cyber security research and development, capacity building, and other IT/OT cyber security engagements, demonstrating real-world commercial and strategic impact.

Building a National Cybersecurity Startup Ecosystem

Technology translation under NM-ICPS is incomplete without entrepreneurial momentum. C3iHub has developed a structured startup supporting architecture that nurtures growth and productization from innovation and innovation from ideation to scale. C3iHub collaborates with IIT Kanpur's incubator FIRST (Foundation for Innovation & Research in Science & Technology) to provide integrated incubation, funding access, and ecosystem networking.

Cybersecurity Startup Incubation Program

C3iHub fosters a vibrant startup ecosystem by incubating and mentoring new ventures in cybersecurity. Till now, C3iHub has launched six cohorts with over fifty startups innovating in diverse cybersecurity fields, including threat intelligence, application security, blockchain technology, authentication & authorization, LLM security, and cyber insurance. The startups receive structured support comprising grants and fellowships along with IIT Kanpur ecosystem access.

Cybersecurity Startup Accelerator Program (CSAP)

The accelerator program selects high-potential ventures, provides higher financial support for scaling up, and connects with investor networks, industry mentors, and commercialization partners, enabling them to scale beyond prototype stages. Over fifteen startups have been given such support.

Innovation Showcase Platforms Promoting National-International Visibility

Startups are given multiple platforms in a year to showcase and launch new products and raise external funding. The yearly initiatives, such as Demo Day, hackathon HACK IITK, new cohort launches, national and international conference events, bring together leaders from academia, startups, investors, policymakers, and industries, promoting startup products and ideas and strengthening private sector participation in cybersecurity innovation, translation, and commercialization.

Capacity Building: Securing the Future Workforce

A secure digital economy requires not only technology but also skilled workforce. C3iHub has created multi-layered skilling programs - large-scale basic cyber safety & cyber defense programs for students and public employees, professional cybersecurity certification programs catering to working professionals and engineers, and advanced tailor-made hands-on certification training programs for senior security professionals, CISOs, and strategists. The Hub has offered over two hundred fellowships and trained more than two lakhs so far, fueling cybersecurity workforce generation and growth in the country. The officials from the Ministry of Power, NIC, IPA, Bhilai Steel Plant, Army Central Command, various security agencies, and state police departments (cyber commandos) receive C3iHub's hands-on training through multiple cohorts. Moreover, C3iHub has developed and introduced an in-house Learning Management System (LMS) to deliver direct and effective learning to training audiences, aiming to revolutionize the future of education in the country.

Future Roadmap

While C3iHub is already committed to indigenous cybersecurity developments and deployments through itself or its created ecosystem, under TTRP, C3iHub aims to further strengthen industry linkage, scale successful technology deployments, and enhance translational output. As cyberattacks surge on critical infrastructure, mobile and other digital assets, and linked supply chains, C3iHub will strongly focus on these areas. A dedicated facility will be created for innovation, translation, and productization, integrating academia, startups, and industries, fostering partnership in innovation and productization. Through its initiatives, C3iHub aims to emerge as the development center for affordable indigenous cybersecurity solutions and serve as a think tank for cyberattack and cybercrime defense for Indian organizations, where the workforce being created by the Hub will help users in solutions management.

A Blueprint for Viksit Bharat 2047

C3iHub's evolution from a Technology Innovation Hub to a Technology Translation Research Park encapsulates the spirit of NM-ICPS: research that leads to resilience, innovation that leads to industry adoption, and technology that strengthens national sovereignty.

As India advances toward Viksit Bharat 2047, such integrated ecosystems will be central to ensuring that emerging technologies are not only invented in India but deployed, commercialized, and scaled for national impact.

C3iHub demonstrates that when academia, industry, startups, and government converge within a mission-driven framework, technology translation becomes a force multiplier for economic growth, strategic autonomy, and digital trust.

Advanced Cybersecurity Training for Headquarters Central Command (HQCC) of the Indian Army, based in Lucknow

Shri Suraj Prakash
Chief Executive Officer
Technology Innovation in Exploration & Mining Foundation
IIT (ISM) Dhanbad

Road to Bharat

India stands at a defining moment where mineral security and technological capability are shaping its long-term growth. As Bharat moves towards Viksit Bharat 2047, minerals will remain foundational to infrastructure, manufacturing, and clean energy systems.

Mining is evolving from an extractive activity into a technology-driven and sustainability-focused ecosystem. This transformation is aligned with national priorities such as the National Critical Mineral Mission, India AI Mission, Net Zero commitments, and the broader push toward digital and industrial transformation.

In this changing landscape, TEXMiN is evolving as a Technology Translation Research Park (TTRP), building on its foundation as a Technology Innovation Hub under the National Mission on Interdisciplinary Cyber-Physical Systems. This transition reflects a sharper focus on scale, deployment, and global competitiveness.

As a TTRP, TEXMiN bridges the gap between research, industry, and commercialization by enabling end-to-end translation of technologies across the mining value chain, from exploration to extraction and beneficiation. Its core objective remains clear: to translate research into deployable solutions while strengthening India's capabilities in Mining 4.0 and critical mineral security.

From Research to Impact: TEXMiN's Translational Approach

Mining environments are inherently complex and uncertain. Solutions must perform reliably in real operating conditions, not just in controlled laboratory settings. This makes translational research critical to the sector's progress.

TEXMiN's focused efforts toward technology innovation and industry-driven research have delivered significant outcomes across the mining sector. The hub has supported the development of more than 55 prototypes and enabled over 45 market-ready solutions, with 35 technologies already deployed in operational environments. These innovations have the potential to generate over ₹50 crore in revenue while contributing to estimated annual savings of nearly ₹300 crore for the mining industry through improved efficiency, safety, and automation.

These outcomes reflect a major shift toward research-driven technologies directly enhancing operational efficiency, safety, and sustainability in the mining sector. Key deployments include AI-driven air quality monitoring systems that strengthen environmental compliance and worker safety, real-time mine monitoring platforms powered by GIS and data analytics, and flood risk assessment solutions for vulnerable riverine mining regions. Advanced smart systems such as SMILE and WISE are improving mine safety and productivity, while Project Nakshatra is enabling indigenous underground wireless communication for reliable and connected mining operations.

Together, these innovations demonstrate how technology is directly enhancing safety, efficiency, and sustainability across mining operations.

Building the Foundation for Mining 4.0

Mining 4.0 is being shaped by the seamless integration of digital intelligence with physical mining operations, enabling safer, smarter, and more

efficient resource management. TEXMiN is driving this transformation through the adoption of advanced technologies such as Artificial Intelligence and Machine Learning for exploration and predictive operations, IoT and sensor-based systems for real-time monitoring and compliance, and digital twins for simulation, planning, and optimization. The hub is also advancing next-generation communication systems including private 5G and underground networks, alongside robotics, drones, and autonomous systems that are redefining modern mining operations.

These technologies are enabling mines to become more connected, intelligent, and adaptive, shifting from reactive operations to predictive and optimized systems.

Strategic Collaborations Powering Transformation

Mining transformation requires deep collaboration across industry, academia, and global partners. TEXMiN's ecosystem enables faster innovation, validation, and large-scale deployment. Some of the key collaborations shaping this ecosystem include:

- BSNL partnership for private 5G in mining: Enabling connected mining operations through integration of AI, IoT, drones, and digital twins, forming the backbone of digital mining infrastructure.
- University of Cambridge partnership under India–UK collaboration: Establishment of the Critical Mineral Global Supply Chain Observatory, strengthening India's position in global mineral value chains.
- Coal India collaboration through IMiN Centre of Excellence: Focused on Mining 4.0 technologies including automation, safety systems, and sustainable mining practices at scale across one of the world's largest mining organizations.

In addition, TEXMiN collaborates with industry leaders such as Tata Steel, Adani, Hindalco, and global technology partners including Dassault Systems, ESRI, Hexagon, and Sandvik, along with leading academic institutions.

MoU signing between TEXMiN and the University of Cambridge for establishing the satellite campus of the Critical Mineral Global Supply Chain Observatory

TEXMiN and BSNL collaborate to build connected, intelligent mining ecosystems. MOU signing during III-2026

Beyond technology, these collaborations are enabling large-scale capacity building. TEXMiN has trained over 1000 industry professionals across organizations such as Coal India, OMC, MOIL, and Tata Steel, while also building a strong pipeline of students in digital mining and emerging technologies.

Together, these partnerships create an integrated ecosystem where technology, talent, and industry needs converge to drive scalable transformation.

Startups Driving the Next Wave of Innovation

Startups are emerging as key drivers of transformation in the mining sector by bringing agility, innovation, and technology-focused solutions to longstanding industry challenges. TEXMiN has played a significant role in nurturing this ecosystem, supporting more than 28 startups and enabling the commercialisation of over 50 products. The innovation ecosystem has also resulted in six granted patents and a combined startup valuation exceeding ₹550 crore, reflecting the growing impact of deep-tech entrepreneurship in mining and allied sectors.

Startups are contributing across AI analytics, drone mapping, underground communication, and sustainability solutions, accelerating the pace of innovation and adoption.

Strengthening Critical Mineral Security

As global demand for critical minerals intensifies, securing reliable supply chains has become a strategic priority for India. TEXMiN is contributing through initiatives spanning extraction, beneficiation, and circular resource utilisation.

Key initiatives are being undertaken to strengthen India's critical mineral ecosystem and support long-term resource security. These include the establishment of Centres of Excellence under the National Critical Mineral Mission (NCMM) of the Ministry of Mines, and the creation of a Global Supply Chain Observatory for critical minerals. Efforts are also focused on supporting startups working in critical mineral domains, developing advanced processes for rare earth element extraction, creating efficient separation and recovery technologies, and identifying alternative mineral sources such as industrial by-products to enable sustainable and strategic resource utilisation.

These efforts aim to reduce import dependence while strengthening domestic capabilities.

Sustainability remains central to this work. Technologies focused on environmental monitoring, waste reduction, and efficient resource utilisation are enabling a transition toward greener and more responsible mining practices.

The Future of Mining in India

Looking ahead to 2047, India's mining sector is expected to transform into a highly digital, intelligent, and sustainable ecosystem. Mining operations will increasingly rely on fully connected infrastructures, autonomous and remotely operated systems, and AI-driven exploration and resource estimation for greater efficiency and precision. The future sector will also feature integrated and transparent critical mineral supply chains, environmentally sustainable and low-carbon mining practices, and circular economy models focused on resource recovery and reuse, positioning mining as a technology-driven pillar of national growth and resource security.

Emerging initiatives such as digital twins of mines, AI-enabled mineral administration, and supply chain observatories will redefine how resources are explored, managed, and utilized. Mining will not only support economic growth but also play a critical role in energy transition, climate goals, and national security.

Conclusion

The journey toward Viksit Bharat 2047 will depend on how effectively India secures and manages its mineral resources. Mining technologies will be central to this transformation, enabling efficiency, sustainability, and strategic resilience.

TEXMiN, as a Technology Translation Research Park, demonstrates how research, collaboration, and innovation can transform a traditional sector into a future-ready ecosystem.

The road to mineral security is already being built. The opportunity ahead is not just to mine resources, but to redefine how the world mines them.

Shri Raghu Dharmaraju
Chief Executive Officer
ARTPARK
IISc Bangalore

Navigating India's Deep-tech Valley of Death

India's research benches are world-class and its venture capital is flowing again. NMICPS is creating the missing appetite and ability for the messy work of turning a TRL 3 lab demo into a products that are used and paid for.

A robotic arm that can weld precisely, a four-metre-wingspan VTOL drone that loiters for six hours, an AI that warns a Bengaluru ward officer of a dengue outbreak two weeks before it surfaces in clinics, and an AI assistant that helps health workers in remotest UP manage high risk pregnancies. None of these are American or Chinese. All of them were built in India in the last few years, by Indian innovators and founders, on Indian capital. And all of them very nearly did not happen.

They very nearly did not happen because India's deep tech ecosystem has, until recently, been organised to support almost every part of a technology's life except the part that matters most: the long, badly lit "marathon" between a working lab demonstration and a product that customers use and pay for. That stretch is what the literature calls the valley of death, and at ARTPARK (short for AI and Robotics Technology Park) at IISc (Indian Institute of Science) — it is the only stretch we work on. We see ourselves as sherpas through it. After five years and 34 portfolio companies, I can report that the trail is becoming clearer, but India has begun to solve the underlying problem.

The Bench is not the Bottleneck

It is fashionable to argue that India does not produce frontier research. That is wrong. At the lab and prototype stage, Indian researchers are thinking as ambitiously as anyone in Cambridge, Palo Alto or Tel Aviv. The bottleneck is not novelty; it translation. We haven't routinely seen that work leave the labs.

The reason is structural. A typical Indian venture investor enters at TRL 6, 7 or 8 essentially when a product already exists and the question is how fast it can scale. ARTPARK's entry points have been at TRL 2, 3, 4. At that level, technology readiness is somewhat assessable; almost nothing else is. What is the market? What is the pain point? What is the product, and within the product, what is the core technology? You may have begun with a particular piece of physics and slowly realised it does not fit the customer you imagined. This iterative, expensive,

India's research benches are world-class and its venture capital is flowing again. NMICPS is creating the missing appetite and ability for the messy work of turning a TRL 3 lab demo into a products that are used and paid for.

often humiliating, process is what the venture industry calls product–market fit. The Indian ecosystem has historically had no obvious institutional home for this process.

A Non-profit doing Venture-shaped Work

ARTPARK was set up about five years ago at IISc, under DST's National Mission on Interdisciplinary Cyber-Physical Systems, to address these structural challenges. We are a non-profit, but the work we do is venture-shaped. The unit of production, as our Project Director, Prof. Bharadwaj Amrutur, puts it, is an innovation project: an idea, a market need, sometimes a piece of laboratory IP, that we take all the way to a product someone uses and pays for. Many of these projects begin as internal R&D under the ARTPARK umbrella, and only later spin out as for-profit companies or, where the market path is not viable despite impact potential, as social innovations and digital public goods.

The reason this matters is that the early money does not arrive as a venture investment. It arrives as pre-commercial R&D capital that goes into advancing the technology while understanding customer needs before there is even a company to invest in. We have been able to deploy this kind of patient capital because of DST funding, supplemented by the Government of Karnataka and the Ministry of Heavy Industries. It is an unusual financing shape. It is also, I would argue, the missing piece in most national deep-tech strategies.

This is very different from funding startups at a late stage close to the finish line. This is what NMICPS is about.

What our Portfolio Actually Looks Like ?

Of the 34 startups we have funded so far, roughly a half have customers and have crossed TRL 6; several have raised follow-on funding from external investors. Twenty percent are in the middle stages: they have co-creators, sometimes pilot customers, but not yet external capital. Another thirty percent are early enough that they are still building the prototype that will let them prove the product in a real customer environment. The first few teams took two to four years to mature. We treat that as the cycle time for serious deep tech.

A handful of examples make the texture of this work concrete. TWARA's genesis was inside an early humanoid project, and along the way the team realised that one critical missing piece in Indian robotics was precise actuation. Several global companies make these actuators; but we don't have the same customizability and usability. The team built a novel harmonic actuator gearbox, secured a US patent on it, and critically did not stop with the component. They went on to build robotic arms now being used by industrial customers like L&T, and recently raised investment from one of India's major manufacturing equipment makers Ace Designers.

Comrado is building hybrid VTOL drones with more than 100 kilometres of range and six hours of endurance; defence has picked them up for surveillance. Zenteiq, founded by an IISc faculty member, is building scientific foundation models for engineering design a category I expect to become a core component of how industry creates and validates designs over the next few years. And in a different register entirely, work by Prof. Rajesh Sundaresan (IISc) and Prof. Siva Athreya (ICTS-TIFR) has been turned, with our help, into a dengue outbreak prediction system now being deployed with the State of Karnataka and the City of Bengaluru. We are doing similar work on health risks of heatwaves at a population scale.

Some of these will become billion-dollar companies. Some will not. Some are not even trying to. We are upfront about which is which: the question of whether a project should be a venture or a public good is, in practice, a question about the market. A robotics software stack for mining and space has a for-profit value chain. An LLM-based clinical assistant for frontline health workers managing high-risk pregnancies is serving a population at the bottom half of the economic pyramid; it will scale through government and non-profit channels, not through profitable revenues. The Venn diagram overlap between economic returns and broad societal impact has a smaller overlap than most policy-makers understand.

The Physical-AI Moment

There is a reason why our startup examples skew towards hardware. Indian software entrepreneurship has been impressive for two decades, but Indian robotics is genuinely new, and it is arriving at a moment when global AI is shifting from purely digital to "phygital" (physical + digital). We now have multiple Indian teams working on vision-based intelligence that lets a robot, like you and me walking through an unfamiliar room, navigate without bumping into things. We have teams working on dexterous manipulation, the miracle of holding a phone

at twenty different angles without dropping it. And we have teams working on actuation, the actual mechanics of motion. These problems are interlinked, and India now has credible players across all three.

Dexsent, a startup that recently joined us from IIT Gandhinagar, is building a three-fingered manipulator with twelve degrees of freedom — the kind of system in which the mechanics and the perception stack must evolve together. Kinesthetic, another portfolio company, has set up a small robot data-harvesting farm at ARTPARK, because the latest generation of vision-to-action models means you no longer need to train each step of the sensing/perception–reasoning–action pipeline separately. Beyond our ecosystem too, there are great companies taking shape; Perceptyne in Hyderabad is doing excellent work; and Addverb has frankly graduated past the startup label.

India is, in short, beginning to assemble a real robotics stack. Where I worry is the bottom layer: chips, sensors, and magnets. If India wants strategic autonomy in robotics and AI — and given the geopolitics of compute, it should — we must get materially better at core hardware. The various government missions – NMICPS, Semiconductors, ANRF, and RDIF – are a start. We will not outbuild Nvidia's Blackwell overnight; nobody will. But there is no version of strategic autonomy that does not begin with the will to start.

The Capital Problem

Even if the technology lands, the second hurdle is harder: growth capital. The honest truth is that most of the deep tech companies we are building today do not have a large enough domestic market to scale into. They have to think globally from day one, and to compete in global markets they will need growth capital at a scale that is, today, available almost exclusively in international venture pools.

This is what makes the recently launched Research, Development and Innovation Fund from DST Rs 1 lakh crore in size such a consequential intervention. The fund's structure is what matters. The government puts up 50% of the capital and asks corporates, investors and high-net-worth individuals to match the rest. That one-to-one match meaningfully de-risks early deep tech bets and, if executed well, could unlock a different class of risk-taking from Indian VCs.

The Policy is Mostly Already There

A common complaint about Indian deep-tech ecosystem is that the policy framework is hostile to academic founders. It is not, or at least not any more. A professor at a reputed Indian institution can take a sabbatical, take their technology out, raise substantial funding, build a team, and give the institution only single-digit equity. IISc, for example, no longer evaluates faculty by publication volume only by the quality of their best one or two papers. Through ARTPARK, a faculty founder can get started with around one crore rupees, sometimes two. By global benchmarks, this is competitive.

What India has not yet done and what we might consider carefully is the kind of proactive funding that other countries direct at strategically important moonshot projects to drive core technologies. For a small number of areas – chips, sensors, certain physical-AI primitives, the right answer may not be incremental.

Our Next Campus

Currently ARTPARK runs out of an HMT (MHI) facility in northern Bengaluru. It has already become a much sought-after address for AI and robotics teams. The Karnataka government has now signed an MoU with us to develop a new 9-acre site into BRAINz the Bengaluru Robotics and AI Innovation Zone in addition. Between the two campuses, we expect to be home to about 100 startups at any given time, alongside global innovation centres by larger companies working in manufacturing, aerospace, space, defence, and medical – all in AI, Robotics, and closely associated technologies.

Five years ago, that sentence would have sounded like a pitch. Today it is a plan. The talent is ready. The capital is starting to arrive. The valley of death is getting shorter too. The work now is to help hundreds of innovators through it and build innovations for India's society, economy and sovereignty.

Innovations

This section showcases selected technologies, research outcomes, and innovations developed under the NM-ICPS, highlighting the growing impact of India's deep-tech ecosystem.

Compiled by Ms. Rajani Kushwaha and Ms. Narbada Sharma

1 Holographic Digital Twin of Mine

Technology Innovation in Exploration & Mining Foundation,

IIT(ISM) Dhanbad

Area

Mines (Both Coal and Metal)

About the Innovation

This innovation uses holography, sensors, and digital twin technologies to create intelligent and autonomous mine ecosystems. Successfully deployed at Tata Steel, Adani, and OMC mines, it enables smarter planning, enhances operational efficiency, improves safety, and supports the digital transformation of coal and metal mining operations.

2 Adbhut Multifunctional Defense Unmanned Ground Vehicle (UGV)

I-HUB for Robotics and Autonomous Systems Innovation Foundation

IISc Bengaluru

Area

Autonomous Defence and Extreme Terrain Mobility

About the Innovation

This all-terrain unmanned ground vehicle (UGV) is redefining mobility in defence and disaster-response operations. Designed for harsh terrains, it supports autonomous navigation across mud, sand, water, and steep slopes. Successfully demonstrated at Babina, with the Ashva variant undergoing Army and NDMA testing in Pune, showcasing India's growing capabilities in advanced autonomous mobility systems.

3 VIRAAT UAS

I-HUB for Robotics and Autonomous Systems Innovation Foundation

IISc Bengaluru

Area

Defence Surveillance and Autonomous Aerial Systems

About the Innovation

The VIRAAT UAS is an indigenous long-range hybrid VTOL platform enhancing India's intelligence, surveillance, and reconnaissance capabilities. Designed for diverse terrains and extreme weather conditions, it delivers real-time target tracking, reconnaissance, and artillery correction. Its deployment strengthens border surveillance, improves operational accuracy, and advances India's self-reliance in advanced defence technologies.

4 Magister Pro - Simulator

I-HUB for Robotics and Autonomous Systems Innovation Foundation
IISc Bengaluru

Area

Defence Aviation Training and Simulation Technologies

About the Innovation

This advanced flight training simulator is strengthening UAV and aircraft pilot training through realistic and immersive mission environments. Inducted by the Indian Army, the system enhances operational readiness, improves safety, and reduces training costs. Its applications across military and educational institutions are supporting scalable, technology-driven training for future UAS operators.

5 Autonomous Campus Shuttle Vehicle

NMICPS Technology Innovation Hub on Autonomous Navigation Foundation (TiHAN), IIT Hyderabad

Area

Autonomous Navigation and Connected Mobility Systems

About the Innovation

This map-based autonomous navigation platform is advancing connected and intelligent mobility through real-time environment awareness, edge-cloud connectivity, and secure vehicle communication. Supporting autonomous passenger movement, traffic management, and infotainment services, the technology enhances safety, operational efficiency, and sustainability while contributing to the future of smart transportation and autonomous mobility ecosystems.

6 YODHA - UAS

I-HUB for Robotics and Autonomous Systems Innovation Foundation IISc Bengaluru

Area

Tactical Defence Drones and Autonomous Combat Systems

About the Innovation

This close-proximity kamikaze multi-rotor UAS strengthens tactical military operations through rapid surveillance and precision target engagement. Designed for both indoor and outdoor missions, it enables forces to quickly identify and neutralize threats with minimal logistical complexity. The system enhances operational effectiveness and provides a powerful indigenous solution for high-risk combat scenarios.

7 Autonomous Drone Operations using Drone Docking Stations

I-HUB for Robotics and Autonomous Systems Innovation Foundation
IISc Bengaluru

Area

Autonomous Drone Infrastructure and Wireless Charging Systems

About the Innovation

This innovation is enabling sustainable and autonomous drone operations through advanced docking stations, wireless charging, and battery management solutions. Supporting applications from surveillance and logistics to asset inspection, the technology ensures 24x7 drone readiness, improves operational scalability, and enables long-duration deployments in remote regions using renewable energy-powered autonomous infrastructure.

8 IT & OT Security Operation Center (IT-OT SOC)

IHUB NTIHAC Foundation
IIT Kanpur

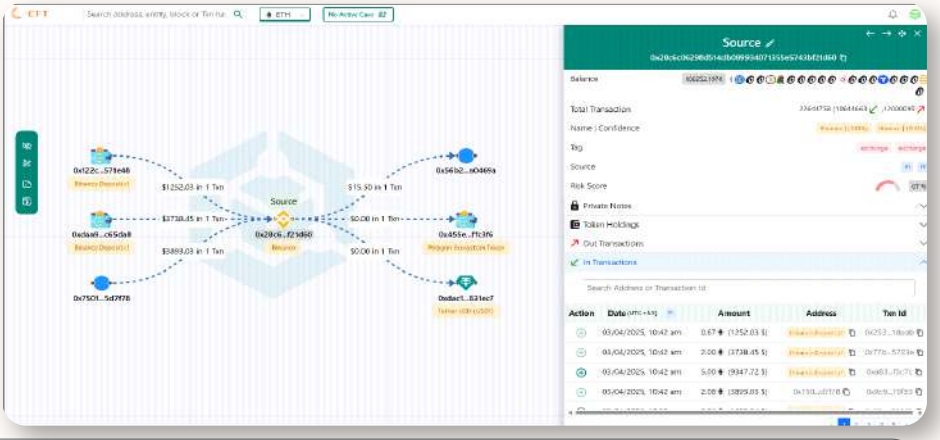
Area

Cybersecurity and Critical Infrastructure Protection

About the Innovation

This indigenously developed cybersecurity platform enables 24x7 monitoring and remediation of cyber threats across IT and OT infrastructure. Designed to be scalable and sector-agnostic, it supports critical industries including power, water treatment, and refineries. Successfully deployed at NHAI, Indian Ports Association, BIT Mesra, and Bhilai Steel Plant, it strengthens India's cyber resilience and infrastructure security capabilities.

9 Cryptocurrency Forensic Tool



IHUB NTIHAC Foundation
IIT Kanpur

Area

Blockchain Analytics and Cybercrime Investigation

About the Innovation

This indigenous blockchain-based platform is empowering law enforcement agencies with 24x7 surveillance and investigation of crypto-related crimes. Equipped with multi-blockchain analytics, automated investigation tools, and network visualization capabilities, it enhances cybercrime detection and intelligence gathering. Commercialized for state law enforcement agencies and being scaled nationally with NSCS support, it strengthens India's digital security ecosystem.

10 Autonomous Navigation Testbed

NMICPS Technology Innovation Hub on Autonomous Navigation Foundation (TiHAN), IIT Hyderabad

Area

Autonomous Mobility Testing and Validation Infrastructure

About the Innovation

India's first integrated autonomous navigation testbed is accelerating innovation in aerial and terrestrial mobility systems. Equipped with advanced proving grounds, drone runways, simulation labs, and smart infrastructure, it enables full-stack validation aligned with global standards. Adopted by industry leaders including ZF, Suzuki Japan, LTTS, and DANLAW, the platform is strengthening India's autonomous mobility and smart transportation ecosystem.

11 CharakDT- Unified Human Digital Twin Platform

IITI DRISHTI CPS Foundation

IIT Indore

Area

Healthcare

About the Innovation

This scalable healthcare platform leverages AI/ML-powered digital physiology models to deliver personalized clinical decision support. By enabling intelligent treatment planning, rehabilitation, disease monitoring, and outbreak prediction, it is transforming patient care across hospitals and healthcare systems. Its interoperable and secure architecture supports large-scale deployment and advances data-driven healthcare innovation in India.

12 Personalized Air Vehicles

NMICPS Technology Innovation Hub on Autonomous Navigation Foundation (TiHAN), IIT Hyderabad

Area

Urban Air Mobility and Autonomous Aerial Logistics

About the Innovation

TiHAN's autonomous air mobility platforms are advancing next-generation transportation and logistics through AI-driven navigation systems. The successful development of a 100 kg payload Personalized Air Vehicle and testing of a 200 kg cargo drone demonstrate India's growing capabilities in urban air mobility, high-altitude logistics, disaster response, and autonomous aerial operations for civilian and defence applications.

13 Indigenous O-RAN/5G-Advanced Massive MIMO Radio Platform

IIITB COMET Foundation
IIIT Bangalore

Area

5G/6G Communications and Open RAN Technologies

About the Innovation

This indigenously developed O-RAN/5G-Advanced massive MIMO radio platform is strengthening India's next-generation telecom ecosystem. Successfully demonstrated through live PoCs at IIT Hyderabad, the technology delivers higher spectral efficiency, reduced network costs, and open interoperable connectivity solutions. With planned deployments across rural India, it supports Digital India, Industry 4.0, defence communications, and future-ready 6G innovation.

14 Reconfigurable Intelligent Surfaces (RIS)

IIITB COMET Foundation

IIIT Bangalore

Area

6G Communication and Reconfigurable Intelligent Surface (RIS) Technologies

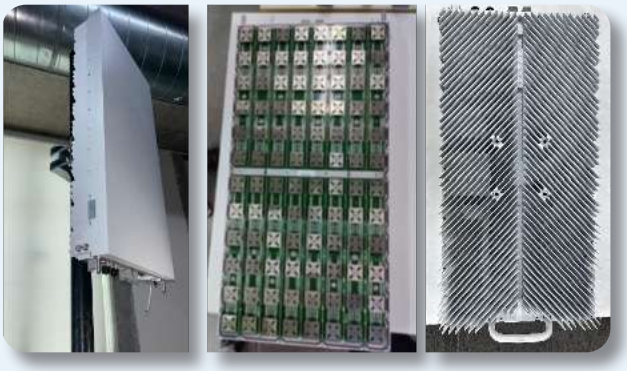
About the Innovation

This indigenous RIS technology is enabling smarter and more efficient wireless communication environments for 5G-Advanced and future 6G networks. Developed through collaboration among premier Indian institutes, it enhances network capacity, optimizes wireless channels, and supports applications across telecom, Industrial IoT, automotive, defence, and smart factories, positioning India as a potential global leader in next-generation communication technologies.

15 5G-Advanced ORAN Massive MIMO Base Station

IIITB COMET Foundation

IIIT Bangalore



Area

Indigenous 5G-Advanced and Open RAN Communication Systems

About the Innovation

Developed through collaboration among leading Indian institutes, this indigenous 5G-Advanced base station platform is advancing India's self-reliance in next-generation telecom technologies. Compliant with 3GPP and O-RAN standards, the system integrates advanced beamforming, AI-driven network management, and mmWave capabilities, supporting applications across telecom, defence, healthcare, agriculture, and Industrial IoT while reducing import dependency and strengthening national technological sovereignty.

16 AyuSynk Bluetooth-enabled Smart Stethoscope

TIH Foundation for IoT & IoE
IIT Bombay

Area

Healthcare

About the Innovation

AyuSynk is transforming healthcare delivery through an AI and IoT-enabled smart stethoscope designed for remote diagnostics and intelligent clinical support. With advanced heart and lung sound analysis, real-time data sharing, and early anomaly detection capabilities, the platform has achieved over 10,000 deployments across clinics and telemedicine networks, strengthening accessible and technology-driven healthcare services.

17 The Vortexenergy Generator

IIT Guwahati Technology Innovation and Development Foundation
IIT Guwahati

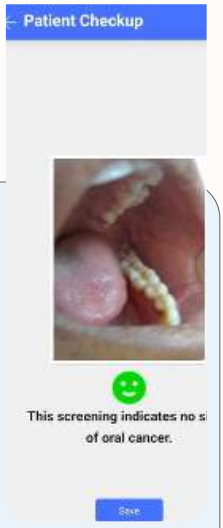
Area

Renewable Energy and Hydro-kinetic

About the Innovation

This indigenous hydro-kinetic energy technology harnesses vortex-induced vibrations to generate clean power without the need for dams. By eliminating large-scale environmental and social disruptions associated with traditional hydropower, it offers a scalable and sustainable solution for grid energy, green hydrogen production, defence applications, and electric mobility infrastructure, advancing India's renewable energy and energy security goals.

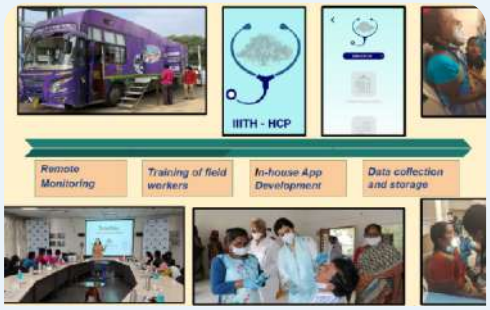
18 Oral Cancer Screening App



IIIT-H Data I-Hub Foundation
IIIT Hyderabad

Area

AI-driven Healthcare Screening and Digital Diagnostics



About the Innovation

This AI-based screening platform is improving early detection of oral cancer through mobile-enabled data collection and automated analysis of oral cavity images. Designed for large-scale deployment in rural and urban communities, it enhances accessibility, affordability, and continuity of care while supporting telehealth consultations and population-level health screening initiatives across underserved regions.

19 Project iRaste

IIIT-H Data I-Hub Foundation
IIIT Hyderabad

Area

AI-driven Road Safety and Intelligent Transportation Systems

About the Innovation

Project iRASTE is transforming road safety through AI-powered predictive analytics that identify accident risks before incidents occur. Deployed for urban roads and highways, the platform supports early detection of black spots, improves driver behavior, and enhances transport infrastructure planning. Its implementation is contributing to safer mobility ecosystems and reducing fatal road accidents through intelligent traffic management.

20 ENRICH-EMG Controlled Prosthetic Arm

IHFC- IHub Foundation for Cobotics

IIT Delhi

Area

Assistive Healthcare and Advanced Prosthetic Technologies

About the Innovation

This EMG-controlled prosthetic hand is restoring mobility and independence for upper-limb amputees through human-like grasping and movement capabilities. Designed to be lightweight, affordable, and easy to use, the system closely mimics natural hand functionality with rapid response times and ergonomic comfort, addressing a critical national healthcare need through accessible indigenous assistive technology.

21 Pre-harvest Agri Monitoring and Advisory System

TIH Foundation for IoT and IoE

IIT Bombay

Area

AI-driven Smart Agriculture and Precision FarmingPower Technologies

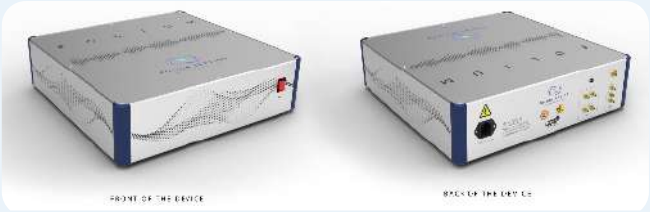
About the Innovation

This AI-powered precision agriculture platform is transforming farm management through disease prediction, drone-based yield estimation, automated field monitoring, and real-time irrigation advisory systems. By optimizing resource utilization and enabling data-driven farming decisions, the technology helps reduce crop losses, lower input costs, and improve agricultural productivity and sustainability for farmers.

22 Optical-based Sensing Solution

IITM Pravartak Technologies Foundation

IIT Madras



Area

Optical Fibre Sensing and Industrial Monitoring Technologies

About the Innovation

Folium Sensing Pvt. Ltd. is advancing real-time infrastructure monitoring through innovative optical fibre sensing technologies, including distributed acoustic, temperature, and strain sensing systems. By converting passive optical fibres into intelligent monitoring networks, the technology enables early detection of leaks, vibrations, and structural stress, strengthening industrial safety, infrastructure reliability, and perimeter security across large-scale deployments.

23 Computer Vision-based and AI/ ML-powered Quality Inspection for Textile Industries – Device-Led Technologies

IIT Mandi iHub and HCi Foundation

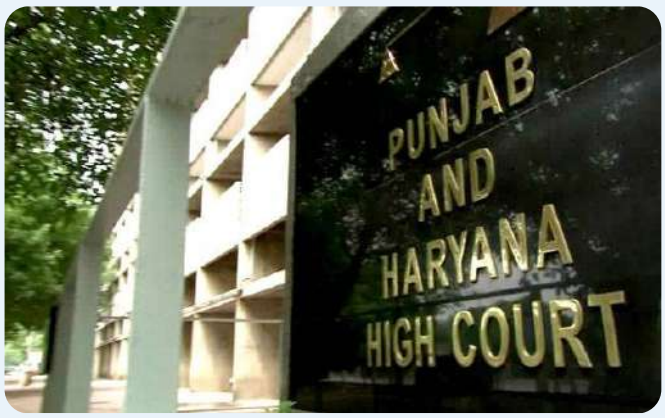
IIT Mandi

About the Innovation

This AI and computer vision-based textile inspection technology is enabling real-time detection of yarn defects at the raw material stage, improving quality control in the textile industry. Successfully deployed at Shingora Textiles, Ludhiana, the system reduces downstream losses, minimizes rework, and supports affordable, automated, and high-accuracy manufacturing processes, strengthening India's smart textile manufacturing ecosystem.

24 Legatease: Building the New-Age Digital Infrastructure for High-Court

IIT Mandi iHub and HCi Foundation
IIT Mandi



Area

AI-driven Legal Technology and Digital Judiciary InfrastructureProsthetic Technologies

About the Innovation

Legatease is transforming India's judicial ecosystem through AI-powered digital infrastructure and domain-specific legal LLMs for high courts. Developed by IIT Mandi iHub and HCi Foundation, the platform enhances accessibility, automates legal workflows, and improves case management efficiency. Successfully implemented at the Punjab and Haryana High Court, it aims to reduce judicial pendency and modernize court processes across multiple states.

25 An Electronic Nose to Detect the Organic Content in the Soil using AI

IIT Mandi iHub and HCi Foundation
IIT Mandi

Area

AI-enabled Smart Agriculture and Soil Health Monitoring

About the Innovation

This indigenous AI-powered electronic nose technology is enabling real-time soil analysis to support sustainable and organic farming practices. Combining advanced gas sensors, portable hardware, and AI-based classification models, the system helps farmers reduce dependence on chemical fertilizers while improving soil health monitoring, food safety, and environmentally sustainable agricultural productivity across Indian farming ecosystems.

Startups & Entrepreneurship Ecosystem

The NM-ICPS has created a strong foundation for innovation by supporting startups across the country through its network of Technology Innovation Hubs. With access to funding, mentorship, infrastructure, and industry linkages, these startups are transforming research into real-world solutions.

This section highlights the growing startup ecosystem under the mission, along with selected success stories that showcase innovation, impact, and the journey from idea to implementation.

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Institutionalizing Deep-Tech Commercialization in Agriculture and Water Systems

Abstract

India's journey toward becoming a technology-driven economy requires more than research excellence; it demands institutional mechanisms that translate innovation into scalable enterprises. While India now hosts over 2 lakh recognized startups and more than 3,600 deep-tech ventures, commercialization in agriculture and water systems remains complex due to capital intensity, long gestation cycles, and field-level deployment challenges.

Under the Department of Science and Technology's National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS), Technology Innovation Hubs (TIHs) were established to bridge this gap. This article presents the experience of IIT Ropar's Technology and Innovation Foundation (iHub – AWaDH), introducing a 3I3P framework Innovation, Investment, and Implementation aligned with Policy, Process, and Program to explain how mission-driven institutional models can accelerate TRL 4+ technologies toward market readiness. Drawing on measurable outcomes and ecosystem engagement, the article situates agriculture and water technologies within India's deep-tech growth phase and outlines pathways toward structured commercialization by 2047.

From Research Expansion to Commercialization Architecture

India's startup ecosystem has expanded rapidly over the past decade. With over 2.07 lakh DPIIT-recognized startups and growing deep-tech participation, the country has demonstrated entrepreneurial momentum across sectors. However, the translation of research into commercially viable deep-tech enterprises especially in agriculture and water—remains structurally demanding.

Unlike digital-first startups, agriculture and water technologies require hardware validation, pilot testing in real landscapes, regulatory alignment, and integration with public systems. These sectors operate within physical ecosystems where sensing, data analytics, and automation must function reliably under field conditions.

Recognizing this complexity, the National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS) established 25 Technology Innovation Hubs across India. These hubs were envisioned as institutional bridges—supporting progression from laboratory prototypes (TRL 4) to scalable deployment (TRL 8–9).

This article examines the evolution of such institutional architecture through the case of iHub - AWaDH at IIT Ropar, focusing on agriculture and water technologies as strategic sectors linked to climate resilience, food security, and water governance.

The 3I3P Framework: A Structured Approach

The institutional model observed by IIT Ropar (iHub - AWaDH) under NM-ICPS can be analytically framed through a 3I3P construct:

The **operational model** emerging under mission-driven innovation hubs can be analytically understood through a **3I3P framework comprising Innovation, Investment, and Implementation, embedded within an enabling architecture of Policy, Process, and Program**. Innovation within this model is anchored at Technology Readiness Level (TRL) 4 and above, ensuring that ventures entering the ecosystem have moved beyond proof-of-concept toward functional validation. The emphasis is on Cyber-Physical Systems (CPS) integration, where artificial intelligence, IoT-enabled sensing, robotics, geospatial intelligence, and distributed analytics converge to address real-sector challenges in agriculture and water systems. This TRL discipline reduces early-stage technological uncertainty and strengthens deployment readiness.

Investment operates as catalytic capital rather than a subsidy. Given the long gestation cycles and high technical risk associated with deep-tech ventures, capital deployment is structured through equity participation, staged disbursement linked to milestones, valuation-based entry, and rigorous due diligence. Such mechanisms introduce financial discipline while preserving patient capital characteristics essential for technology maturation. The objective is to crowd in private investors by de-risking early phases rather than permanently substituting market capital.

Implementation constitutes the third dimension, emphasizing field validation district-level pilots, industry convergence & global collaboration. Technologies are tested within real agricultural landscapes and water management systems prior to scale, ensuring contextual adaptability and adoption viability.

Supporting these three pillars are:

- **Policy alignment** with NM-ICPS, Startup India, ANRF, and RDIF
- **Process discipline** through structured monitoring and governance
- **Programmatic interventions** SAMRIDHI (Strategic Acceleration for Market, Research, Innovation & Development: a Holistic Initiative

Report published by IIT Ropar (iHub- AWaDH)

for ICPS Startups), SPRINT(Strategic Program for Research Innovation and Next-Gen Tech Commercialization), 100Startups100Days etc

Together, the 3I3P framework integrates speed, measurable outcomes, and systemic impact within deep-tech commercialization ecosystems.

Empirical Observations from the IIT Ropar Model

Within this structured commercialization framework, more than 160 startups have been supported across agriculture, water, AI, robotics, and geospatial domains. Approximately Rs 16+ crore has been deployed across 130+ ventures, including 30+ equity investments exceeding

Rs 8.0 crore. Notably, 46 startups have mobilized Rs 123+ crore in follow-on funding, reflecting a nearly 7x multiplier effect and contributing to a portfolio valuation surpassing Rs 1,500 crore. These outcomes indicate that disciplined TRL progression and governance oversight strengthen investor confidence in deep-tech ventures operating in complex real-sector environments.

Sectorally, the portfolio is anchored in AgriTech (47.92%), followed by IoT & Hardware Technologies (29.69%) and WaterTech (8.33%), underscoring alignment with climate-resilient agriculture and water security priorities. From a systems perspective, 47.12% of ventures integrate both hardware and software components, while 33.51% are hardware-intensive and 17.80% are primarily software-driven, reflecting the embedded and feedback-driven architecture of Cyber-Physical Systems in field-based applications. Geographically, participation spans multiple innovation clusters, including Maharashtra (12.76%), Uttar Pradesh (11.73%), Delhi (7.14%), and Chandigarh (6.63%), with 48% of supported startups including women co-founders—signaling distributed and inclusive deep-tech entrepreneurship.

Complementing startup incubation, 21 CPS laboratories have been established across India, including in Ladakh, Sikkim, and Tamil Nadu, functioning as distributed nodes for experimentation, skilling, and localized technology validation. Programmatic platforms such as SAMRIDHI, SPRINT, PRAGATI, WATER Innovation Challenge (HDFC), Operation Dronagiri (IIT Tirupti), ASAP (Seafund), IMPACT (KIMSDU), Global Micro Accelerator (Embassy of Israel in India & Reichman University). India AI Impact Summit and other initiatives institutionalise structured acceleration pathways.

Programmatic Acceleration in Action

Layered programs reinforce the commercialization pathway, some example includes:

- **SAMRIDHI (4 editions):** 800+ participants, 60+ investors, Rs 13+ crore commitments
- **SPRINT (13 editions):** 380+ pitches, 74 startups incubated
- **PRAGATI:** 200+ applications, CSR-linked support

- **Operation Dronagiri:** 800+ applications across 5 pilot states
- **100 Startups 100 Days:** 800+ applications; majority revenue-generating ventures

These initiatives strengthen the "Program" and "Process" dimensions of 3I3P converting validated prototypes into investment-ready enterprises.

Beyond venture metrics, systemic strengthening is reflected in 25+ TRL 8–9 real-field deployments, 15+ commercially licensed technologies, an in-house IP & Technology Commercialization Office managing 36 IP assets, over 200 active partnerships across government, industry, academia, CSR, and global collaborators, and 300+ CPS training programs impacting more than 8,000 participants. Reinforced governance through a high-level Board and DSIR–SIRO recognition further consolidates the hub's role as a national node for technology validation, commercialization, and ecosystem convergence.

These interventions illustrate the Program dimension of 3I3P, while structured due diligence, milestone-based investment, and governance oversight reflect the Process component.

Capital Architecture and the RDIF-ANRF Alignment

India's innovation capital architecture is entering a structural consolidation phase with the establishment of the Anusandhan National Research Foundation (ANRF) and the Research Development and Innovation Fund (RDIF). The RDIF mandate explicitly prioritizes TRL 4+ technologies, blended finance mechanisms, and mobilization of private capital toward strategic sectors—principles closely aligned with the 3I3P framework of innovation, investment, and implementation supported by policy and process discipline. Programmatic accelerators further institutionalize deal flow, converting validated prototypes into investment-ready ventures.

At IIT Ropar, over 60 investors and 220 ecosystem partners have engaged across thematic platforms, and under the evolving RDIF-aligned approach, commitments of 2,000 Cr+ have recently been secured from six venture capital partners to strengthen deep-tech co-investment pathways .

Announcement of RDIF Funds commitment by Hon'ble Minister, Sh. Gulab Chand Kataria Hon'ble Governor of Punjab

Concurrently, India AI Impact platforms demonstrate that applied AI startups in agriculture and water are increasingly revenue-generating rather than pilot-dependent, reflecting maturation within India's deep-tech commercialization landscape and growing convergence between public innovation missions and private capital ecosystems.

Institutional Evolution and Entrepreneurial State Capacity

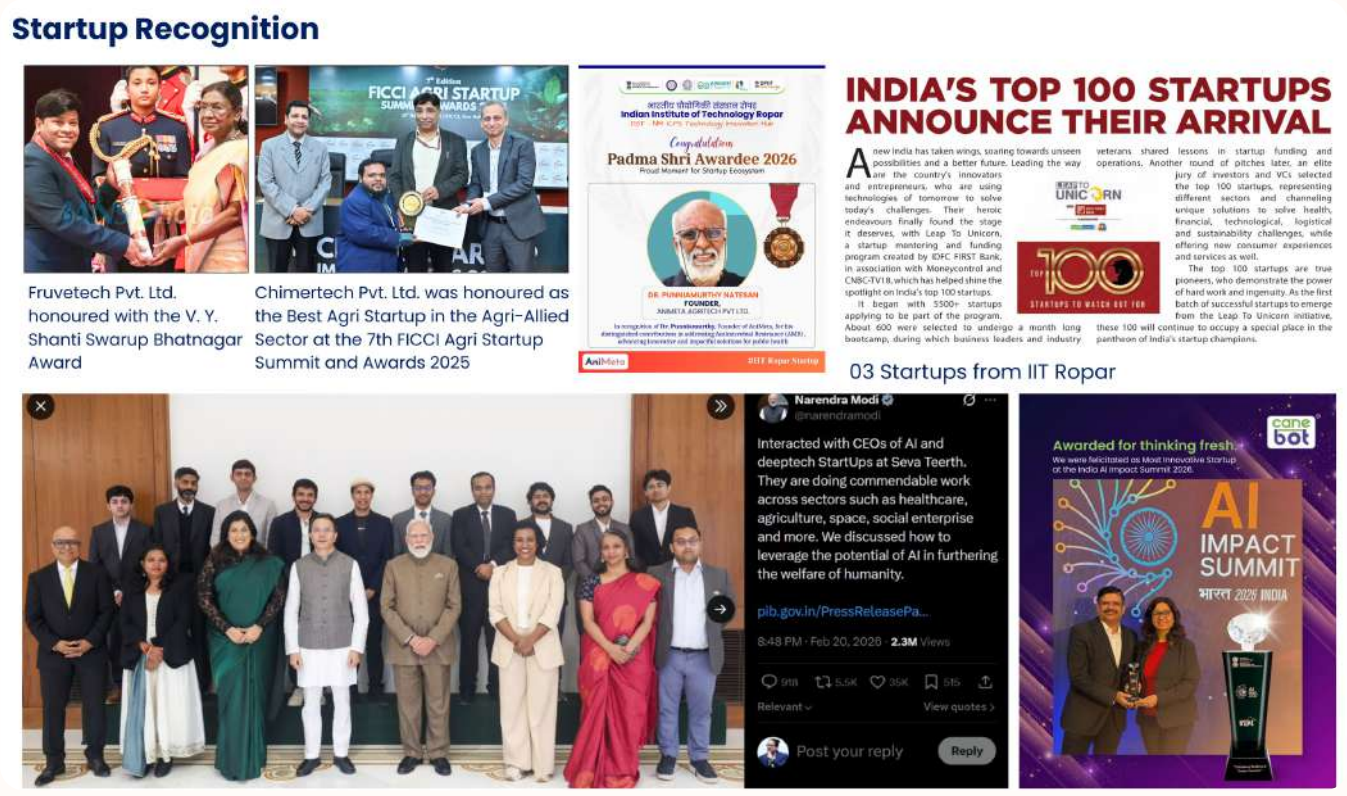
The NM-ICPS model reflects a maturing approach to innovation governance—one in which government-backed institutions act not as market substitutes, but as structured de-risking platforms for frontier technologies until private capital participation becomes viable. In this context, the 3I3P framework emphasizes synchronization across technological validation, financial discipline, field-level implementation, policy alignment, and governance oversight. Such coordinated architecture is especially critical in agriculture and water systems, where climate variability, resource stress, and infrastructural complexity heighten both technological uncertainty and adoption risk. Institutional alignment across these dimensions enables deep-tech ventures to move from experimental prototypes to scalable, investment-ready enterprises.

The experience at IIT Ropar's Technology and Innovation Foundation (iHub – AWaDH) illustrates this transition in practice.

The strength of the ecosystem is reflected in the trajectory of its startups. Ventures such as **Indra Water**, deploying AI-enabled decentralized wastewater treatment systems, **Fruvetech**, advancing patented technologies for digital agricultural traceability and shelf-life

enhancement, and **Chimertech**, recognized nationally in the Agri-Allied sector, illustrate how research-driven innovation can evolve into commercially viable enterprises. Fruvetech's scientific contribution received national validation when its Co-Founder, **Dr Jagadis Gupta Kapuganti**, was conferred the prestigious Vigyan Yuva – Shanti Swarup Bhatnagar Award by the Hon'ble President of India at Rashtrapati Bhavan in 2025.

CaneBot and other AI-led ventures have been featured at the India AI Impact Summit, while three startups were recognized under the IDFC Program among India's Top 100 Startups, reflecting growing market maturity and sectoral relevance. **qZense Labs**, focused on IoT-enabled food quality analytics, has secured backing from HAX (SOSV's global hard-tech accelerator), highlighting international confidence in Indian agritech deep-tech innovation. **Innogle Technologies** has participated in high-level CEO roundtable engagements alongside national leadership, signaling the growing visibility of emerging deep-tech ventures. These examples represent only a fraction of the 160+ startups supported under the ecosystem, collectively demonstrating how structured institutional support under NM-ICPS is enabling Indian deep-tech enterprises to gain national recognition, investor trust, and global relevance.



These entrepreneurial outcomes have, in turn, strengthened institutional standing. Recognition through awards such as the Agriculture Leadership Award, Innovation Program Leadership Award, Bharat Incubator Award, and Best Incubator honours reflects not isolated achievements but the cumulative effect of structured innovation pathways. Accreditation as a **DSIR–SIRO** Scientific and Industrial Research Organization further reinforces research credibility, governance discipline, and translational capacity.

Together, startup success and institutional recognition form a reinforcing cycle: validated technologies attract investment and national visibility; institutional credibility strengthens investor confidence and policy convergence. Through this alignment, IIT Ropar – iHub AWaDH has emerged as a catalytic node in India's deep-tech ecosystem, advancing commercialization, industry collaboration, and innovation-led entrepreneurship in agriculture and water systems.

Towards 2047 and Structured Deep-Tech Maturity

The NM-ICPS model represents an evolution toward an entrepreneurial state architecture where government-backed institutions function as structured de-risking mechanisms until market capital becomes viable. For agriculture and water sectors where climate variability, resource stress, and infrastructural complexity increase uncertainty such institutional coordination is essential.

As India approaches 2047, technology translation must move from isolated success stories to systemic architecture. Structured TRL monitoring, catalytic capital deployment, CPS integration, and ecosystem convergence will be central to enhancing productivity, strengthening water security, and building climate-resilient economic systems.

The 3I3P framework offers one pathway toward that institutional maturity.

Shri Mohan Satyaranjan
Chief Technology Officer
Pravartak Technologies Foundation
IIT Madras

Building India's Deep-Tech Future

IITM Pravartak's SNACS Startup Ecosystem

India's journey to a developed, technology-powered nation by 2047 needs thousands of innovators who can turn real-world problems into smart, connected solutions—and that is exactly what IITM Pravartak is building through its deep-tech startup ecosystem.

From Cyber-Physical Vision to a Startup Engine

IITM Pravartak is the Technology Innovation Hub on **SNACS**—Sensors, Networking, Actuators and Control Systems—set up under the National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS) of the Department of Science & Technology (DST). Hosted at IIT Madras as a Section-8 company, it acts as a bridge between research labs, industry partners, investors and young entrepreneurs, turning advanced CPS research into deployable products and startups.

The larger IIT Madras incubation ecosystem has already supported more than 500 startups with a combined valuation exceeding Rs 53,000 crore, over 700 patents and 11,000+ direct jobs as of late 2025, demonstrating a mature model for deep-tech venture creation. Pravartak draws upon this experience, tailoring it to SNACS by combining problem-driven R&D, structured funding schemes, mentoring and access to testbeds, so that ideas can rapidly progress from lab prototypes to scalable companies.

The Pravartak Incubation Model

At the heart of Pravartak's model are four complementary programmes—PRAYAS, DIAL, SSS and Entrepreneur-in-Residence (EIR)—through which more than 200 entrepreneurs are being nurtured today. Each programme is designed around a specific stage of the innovation journey, but all are anchored in CPS technologies such as intelligent sensing, secure connectivity, embedded control and AI-driven decision making.

- **PRAYAS (Idea to Prototype)** supports faculty-led and early-stage projects that build core SNACS technologies or platforms. Examples range from smart water network management and AI-enhanced NIR spectrometers to microfluidic soil-nutrient sensors and anti-drone laser systems, all of which integrate sensing, communication and control.
- **DIAL (Lab to Pilot)** focuses on productization and field trials. Projects include portable eye-screening devices, wearable health monitors, distributed acoustic sensing for underground vibration detection and human-motion capture platforms for sports and healthcare.
- **SSS & EIR (Startup to Scale-up)** back dedicated founders who turn these technologies into companies. The current portfolio spans semiconductors, quantum-

secure communication, medical devices, smart manufacturing, agritech, cleantech, mobility and advanced security systems.

What makes this model distinctive is that Pravartak does not treat hardware, software and AI separately. Every team is mentored and encouraged to think in terms of full sensor-to-cloud stacks—robust edge devices, reliable networking, secure data platforms and intelligent control—so that solutions are field-ready, not just proof-of-concept demos.

Blending Tradition and AI: Music Temple and "Gurushis"

One of the most striking examples of innovation powered by SNACS is Music Temple Private Limited, creator of the Gurushis Music Learning Management System. Indian classical music is rich in micro-nuances—gamakas, slides and oscillations—that traditional notation cannot capture precisely; GBNS, invented & patented by the Music Temple founder, encodes these elements visually and digitally so that they can be stored, analyzed and taught consistently.

Music Temple uses AI and machine learning to preserve civilizational music heritage through the Gamaka Box Notation System (GBNS)

Music Temple is now building AI/ML models that can listen to monophonic music and automatically generate GBNS notation, turning sound into structured data that can be archived, searched and transformed into interactive lessons. This creates the foundation for intelligent music tutors, personalized practice feedback and cross-cultural music discovery, while also preserving India's civilizational music heritage in a machine-readable form.

For a non-engineer, this is SNACS in action: microphones as **sensors**, secure cloud platforms as **networks**, notation engines and learning apps as **actuators**, and AI models as **control systems** guiding how a student learns.

Reinventing Infrastructure Intelligence: Folium Sensing

Folium Sensing shows how the same cyber-physical principles can transform heavy infrastructure. The startup uses already-laid optical fibre cables not just for communication but also as long, continuous sensors that detect strain, temperature changes, vibrations and acoustic patterns along tens of kilometres.

Folium Sensing leverages spare fibers in optical cables to detect movement, temperature change and vibrations across kilometers, enabling predictive maintenance for railways, pipelines and critical infrastructure

By converting faint light back-scatter into real-time data, Folium's distributed sensing systems can spot pipeline leaks, ground movement near railway tracks, intrusion along perimeters or structural stress in bridges long before visible damage occurs. AI-based analytics on this data help operators prioritize maintenance, prevent accidents and optimize asset life, dramatically reducing both cost and risk.

Folium Sensing's innovation was recognized as the **winner of the Google Cloud Future X Challenge 2025**, underscoring its potential to revolutionize infrastructure monitoring.

Making Work Safer: PARV AI's Human-Machine Insight

Safety-critical environments—air-traffic control centres, industrial control rooms, defence operations—depend on alert humans working with complex machines. ParvAI Labs, another Pravartak-incubated startup, builds eye-tracking and vision-analytics systems that monitor fatigue and attention levels in such settings.

For readers outside engineering, this is an example of "digital ergonomics": sensors watch over people, algorithms interpret subtle behavioural signals, and machines adapt to keep humans safe and productive.

ParvAI Labs' AI-powered eye-tracking solutions detect fatigue and attention deficits in mission-critical operations, enhancing safety for air traffic controllers, industrial operators and defence personnel

Eon Space Labs democratizes Earth observation through cutting-edge optical payloads and AI-driven solutions for satellites, UAVs and drones. The company raised $1.2 million in Pre-Series A funding to advance its technology

Watching the Hills: Intiot and Landslide Early-Warning

Landslides are among the most devastating natural disasters in hilly regions, often striking without warning. Intiot Services Private Limited, incubated by IITM Pravartak and based in Mandi, Himachal Pradesh, has developed low-cost, patented Landslide Monitoring Systems that continuously track rainfall, soil moisture, ground movement and local weather conditions.

Intiot has already deployed its systems across multiple sites in Himachal Pradesh and is expanding to other Himalayan states as well as the Konkan and Malabar coasts, helping protect lives and infrastructure in some of India's most landslide-prone regions.

This is SNACS solving a very human problem: sensing instability deep inside a hill, networking that information to decision-makers, and triggering sirens or warnings as actuators when risk crosses a safe limit.

Beyond Planet Earth: Eon Space Labs

Pravartak's startups are not confined to Earth's surface. Eon Space Labs, a space-defence deep-tech company in the portfolio, builds advanced optical payloads for satellites, UAVs and drones, enabling high-resolution Earth observation with compact, lightweight systems.

In a sobering reminder of the risks of deep space ventures, the company's MIRA payload was lost in the PSLV-C62 launch mishap, but the team continues to push forward with new missions and innovations.

By combining precision optics **(sensors)**, on-board compression and encryption **(networks)**, gimbal mechanisms **(actuators)** and autonomous targeting algorithms **(control systems)**, the company exemplifies how SNACS fuels the NewSpace economy.

A Nationwide Network of Entrepreneurs

These five stories above represent only a fraction of Pravartak's portfolio. The PRAYAS-DIAL-SSS-EIR pipeline has already led to dozens of incorporated startups and many more technology teams, spanning domains from semiconductor design, quantum-secure communications and solar-PV diagnostics to smart mobility devices, agritech platforms and hyperloop transportation.

Geographically, the entrepreneurs come from across India—illustrating that deep-tech innovation no longer belongs only to a few metros.

Working with Industry, Investors and Ecosystem Partners

A key feature of IITM Pravartak's approach is close engagement with industry and investors from the earliest stages of technology development. Corporate partners provide challenge statements, datasets and test environments; in return, they get access to cutting-edge solutions and talent in SNACS domains.

Pravartak also collaborates with venture funds, angel networks and CSR programmes to create a blended financing pathway—from grants and seed support to equity funding and revenue-sharing models—so that promising teams do not stall for lack of capital.

Roadmap to 2047: Taking SNACS to Every Sector

Looking ahead, IITM Pravartak aims to expand its impact along three axes—reach, depth and outcomes.

On the **reach** front, the hub is strengthening outreach to universities, polytechnics and innovation hubs across India, so that students and professionals in non-engineering disciplines—agriculture, arts, medicine, humanities, design, law and social sciences—can learn how SNACS can solve problems in their own fields.

In terms of **depth**, Pravartak plans to scale shared infrastructure for design, sensor development, SNACS for Drones, secure communication and AI testbeds, making it easier for startups to build globally competitive solutions efficiently.

Enabling SNACS for Non-Engineers

Cyber-physical systems are no longer confined to factories and satellites; they are quietly entering classrooms, farms, hospitals, courts, music schools and city streets. Every time you think about a problem that needs better **sensing** (what is happening?), **networking** (who should know?), **actuation** (what should change?) and **control** (how do we decide?), you are already thinking in the language of SNACS.

Non-engineers bring the most critical ingredient to this mix: deep understanding of real-world contexts—culture, behaviour, institutions, markets and human needs. Pravartak's experience shows that when artists, doctors, lawyers, social entrepreneurs and field practitioners collaborate with technologists, the result is not just smarter gadgets but sustainable, inclusive solutions—from preserving rare ragas to protecting remote villages from landslides.

Conclusion

IITM Pravartak's invitation to readers of Dream 2047 is simple: bring your toughest problem, your strongest domain insight and your imagination. With the right blend of sensors, networks, actuators and control systems, India can build not only successful startups but also a resilient, innovation-driven society ready for 2047 and beyond.

As India marches toward its centenary of independence, the SNACS ecosystem at IITM Pravartak stands as a testament to what is possible when research excellence, entrepreneurial energy, patient capital and institutional support come together. The journey from lab to market, from idea to impact, is long and demanding—but with over 200 entrepreneurs already on this path, we can sense the future: bright, connected and intelligently controlled.

Shri Kiran Shesh

Chief Executive Officer
TIH Foundation For IOT And IOE
IIT Bombay

Powering the Next Wave of DeepTech Innovators

Inside TIH, IIT Bombay's Journey in Building a Strong IoT Startup Ecosystem

When you think of remarkable deep-technology innovation in India-solutions that blend engineering, data, hardware, and societal impact it is impossible not to talk about the fast-rising world of the Internet of Things (IoT). These technologies quietly power our farms, hospitals, factories, and cities. At the center of this change are bold entrepreneurs building products that were once thought too complex or too expensive to develop in India.

At TIH, IIT Bombay, we have the privilege of working closely with such founders. Over the last few years, our Hub has become a home for innovators who dream big, design fearlessly, and solve real-world challenges with IoT driven solutions. Our role? To make sure these ideas don't just stay prototypes but grow into full-scale, market-ready companies.

This is the story of how we do it.

A Hub Where Ideas and Engineering Come Together

Every startup that walks into TIH brings with it a unique spark. Some are building next-generation agricultural sensors, some are designing advanced patient-monitoring devices, and some are creating industrial automation systems that rival global standards.

Our focus areas are clear and purposeful: Agriculture IoT-feeding India smarter; Healthcare IoT / HealthTech-bringing patient-centric innovation to life; and Industrial IoT making manufacturing faster, safer, and more efficient. These are sectors where technology truly touches everyday life. And that makes our work even more meaningful.

Investment That Goes Beyond Money

One of the biggest hurdles Deep Tech founders face is funding. Hardware is expensive. Field trials take time. Certification and testing need expertise.

To bridge this gap, **TIH offers investment support of up to INR 1.2 Crores to promising IoT startups.** But what's important is how we evaluate and support them.

Experts Take a Hard Look at the Technology

Before anything else, domain experts examine what's unique about the startup's technology, whether the idea is feasible, and whether the team has the technical capability to execute it. This ensures that only truly strong engineering-driven ideas move ahead.

Enmaz Engineering

Investment Committee Evaluates Business Viability

The startups that pass technical evaluation then meet our Investment Committee, which focuses on market potential, competitive landscape, revenue model, and scalability. Only startups that stand strong in both rounds receive investment. This rigorous process helps us build a portfolio that is not only innovative but also commercially promising.

Mentors Who Become a Startup's Inner Circle

After receiving investment, every TIH portfolio startup gets access to our Mentor Pool-a community of people who've built companies, run industries, shaped sectors, and invested in future technologies. Our pool includes senior industry professionals, domain specialists in agriculture, healthcare, and industrial systems, and experienced VCs and angel investors. These mentors don't just advise-they walk with founders through real decisions, real challenges, and real opportunities.

Industry & Investor Connections That Open Doors

A big part of our work is helping startups meet the right people at the right time. We connect founders with hospitals and healthcare networks, agritech organizations and FPOs, manufacturing and industrial partners, and venture funds and angel networks. For IoT innovators, these connections often lead to pilot deployments, customer validation, follow-on investments, and long-term partnerships. This is where startups make their first real leap beyond the lab.

Ayati Devices

ATMAN 3.0: A Spotlight on HealthTech

One of our most exciting recent initiatives has been ATMAN 3.0, the third edition of TIH's flagship accelerator program. This edition focused exclusively on HealthTech, and the energy in the cohort was inspiring.

What made ATMAN 3.0 special? 13 high-impact HealthTech startups were chosen from across India. They spent 8 intensive weeks strengthening their product, business, and regulatory readiness. The program ended with a high-energy Demo Day attended by industry leaders, investors, clinicians, and academicians.

Many of these startups left the program with new partnerships, pilot opportunities, and investor interest. Most importantly, they left stronger and more confident about taking their products into the market.

Our Impact in Numbers

In a relatively short span, TIH has built one of the most vibrant Deep Tech communities in India. We have made investments in 40 startups. These startups are developing solutions that could redefine the way India farms, heals, manufactures, and manages its resources.

A Broader Mission: Growing the Deep Tech Culture

Beyond supporting individual founders, TIH is committed to strengthening India's Deep Tech movement as a whole. This includes encouraging ecosystem conversations through workshops, talks, and events, we bring together researchers, entrepreneurs, and students to explore how Deep Tech can shape India's future. We provide access to infrastructure, startups often need world-class labs and test facilities, a big advantage of working with IIT Bombay's ecosystem. And we support commercialization, helping founders navigate patents, manufacturing, pilots, and customer deployment-areas that often decide a Deep Tech startup's future.

Why IoT Matters to India's Future

IoT isn't just about connecting devices, it's about connecting possibilities.

It helps us answer questions like: How do we improve farm productivity with fewer resources? How can we bring better health diagnostics to smaller towns? How do factories become smarter without huge costs?

Deep Tech startups working in IoT are building India's next leap forward-solving high-impact problems with technology that's home-grown, affordable, and scalable.

Looking Ahead: A Future Full of Innovation

As we look forward, our vision at TIH is clear: nurture more IoT startups, build deeper partnerships with industries and investors, create sector-specific accelerators, support founders through global opportunities, and enable more market-ready innovation. Our journey has only begun, and the energy in the ecosystem tells us that the next wave of Deep Tech growth will be even more transformative.

In Closing

Every startup we work with reminds us why Deep Tech matters: it takes patience, courage, and relentless problem-solving. At TIH, IIT Bombay, we are proud to stand behind founders who are choosing this challenging path and building technologies that can change the world.

As we continue to grow the ecosystem, support more startups, and expand our reach, we are excited to see how these innovators will shape India's future across Agriculture, Healthcare, and Industrial IoT.

And if our journey so far is any indication, the best is yet to come.

Startup Testimonial

Ayu Devices, a TIH portfolio company, is a health tech startup building IoT- and AI-enabled diagnostic tools, including a smart stethoscope designed to amplify, record, and analyse heart and lung sounds to support better respiratory and cardiovascular care.

Since our onboarding by TIH, IIT Bombay through the Aarohan 2.0 call in 2024, we have seen significant momentum. The strategic funding, expert mentorship, and technical guidance from TIH have been pivotal in expanding from a specialised product-focused startup to a team developing a broader, integrated healthcare solution suite.

With TIH's continued support, we have scaled our AI-enabled diagnostic solutions, strengthening the link between technology development and clinical adoption. TIH has also facilitated introductions to industry partners, and we are currently conducting a collaborative research study with Kokilaben Hospital in Mumbai.

We are proud to be part of the TIH portfolio and remain committed to innovating at the intersection of technology and human health.

AyuDevices

Startups
Success Stories

Compiled by Ms. Rajani Kushwaha and Ms. Narbada Sharma

Name of TIH & Host Institute	Startup Name	Technology/Product	Area
BITS BioCyTiH Foundation BITS Pilani	Tishya's Medical Device Development Solutions Pvt. Ltd.	IXanner® for early detection of eye diseases	Healthcare

Success Story

IXanner® is transforming eye care with its portable, affordable screening device that detects major blindness-causing diseases early. By enabling proactive mass screening, it aims to cut preventable blindness by 60%. Now deployed across seven countries, including the USA and UK, the startup generates ₹3.5 crore annually, blending impact with global success.

Name of TIH & Host Institute	Startup Name	Technology/Product	Area
BITS BioCyTiH Foundation BITS Pilani	Flic Farm Pvt Ltd	AI-Powered Electric Unmanned Ground Vehicles (UGVs)	Agriculture

Success Story

XMachines is redefining outdoor automation with AI-powered, modular unmanned ground vehicles built for rugged terrains. Enabling precision farming tasks, its Robots-as-a-Service model cuts labour costs by up to 30%. Backed by ₹4 crore funding and a Shark Tank India boost, the startup is scaling rapidly to power sustainable agriculture worldwide.

Name of TIH & Host Institute	Startup Name	Technology/Product	Area
I-HUB for Robotics and Autonomous Systems Innovation Foundation IISc Bengaluru	COMRADO Aerospace	Aruna: VTOL Multirotor with redudant powerplant	Unmanned Aerial Systems & Simulation

Success Story

Aruna is a versatile multirotor UAS built for multi-mission efficiency, from cargo delivery and surveillance to disaster response. Its adaptable design cuts operational costs while performing reliably in high-altitude conditions. With proven trials, six units sold, and extended 12 km range, the startup is advancing scalable, real-world drone operations.

Name of TIH & Host Institute	Startup Name	Technology/Product	Area
IIT Bhilai Innovation and Technology Foundation IIT Bhilai	Tadoba Solutions Private Limited	Battery Swapping station with energy Trading	Energy, Environment & Climate

Success Story

A solar-powered battery swapping station uses renewable energy to charge and store batteries for electric vehicles (EVs) and e-bikes. It enables quick battery replacements, reducing downtime and reliance on fossil fuels. This eco-friendly solution promotes clean transportation, lowers emissions, and ensures sustainable energy utilization for a greener future.

Name of TIH & Host Institute	Startup Name	Technology/Product	Area
I-DAPT-HUB Foundation, IIT (BHU) Varanasi	Everse AI	Everse AI(Connected Cow, Green Cow)	Agritech, Cleantech

Success Story

eVerse.AI is transforming dairy and livestock with AI- and IoT-driven solutions that boost productivity and cut methane emissions. Impacting over 5 lakh farmers and 20 lakh animals, it enhances incomes while reducing carbon footprints. Backed by a landmark Maharashtra partnership, the startup is scaling globally with carbon credit–driven climate innovation.

Name of TIH & Host Institute	Startup Name	Technology/Product	Area
NMICPS Technology Innovation Hub on Autonomous Navigation Foundation (TiHAN) IIT Hyderabad	RobotoAI Technologies Pvt Ltd	Autonomous Mobile Robots for Material Handling and Healthcare	Robotics & Automation

Success Story

This startup is transforming logistics with AI-powered Autonomous Mobile Robots that streamline material handling and healthcare operations. From factories to hospitals, its self-navigating systems boost efficiency, safety, and hygiene while reducing costs. Recognized as an iDEX DISC Challenge winner by the Indian Army, it is driving scalable automation across critical sectors.

Name of TIH & Host Institute	Startup Name	Technology/Product	Area
TIH Foundation For IOT And IOE IIT Bombay	Ayu Devices pvt ltd (AyuSynk.ai)	AyuSynk digital steth, CardioSynk 12 lead ECG integrated steth	Health Tech

Success Story

AyuSynk is advancing cardiac care with an AI-IoT enabled device that uses ECG and PCG signals for early detection and continuous monitoring of heart disease. By enabling remote auscultation and screening in villages, it delivers quality healthcare to underserved regions, reducing risks and transforming access to life-saving diagnostics.

Name of TIH & Host Institute	Startup Name	Technology/Product	Area
I-Hub Foundation for Cobotics (IHFC) IIT Delhi	Exobot Dynamics Pvt Ltd	Exobot GripX	Assistive Tech

Success Story

Exobot GripX is redefining prosthetics with a lightweight, AI-driven myoelectric hand built on affordability and accessibility. Using advanced EMG sensors, it enables natural movement and all-day comfort. Launched in 2026 with early user success, the startup secured a ₹30 lakh innovation award, accelerating its mission to restore independence and dignity.

Name of TIH & Host Institute	Startup Name	Technology/Product	Area
NMICPS Technology Innovation Hub on Autonomous Navigation Foundation (TiHAN) IIT Hyderabad	Menthosa Solutions Pvt. Ltd	Suparna Class 5G Drone Platform; iDronam Drone Control Software; AI-Based Asset Management & Digital Twin Platform	5G-enabled UAVs, AI-driven analytics, Digital Twin creation, Indigenous Drone OEM, Command-and-Control Software Platforms. Operational orchestration.

Success Story

Menthosa Solutions is advancing indigenous drone technology with a 5G-enabled UAV ecosystem powered by AI analytics and Digital Twin capabilities. Supporting critical sectors from infrastructure to disaster response, it strengthens real-time decision-making and national security. As a DoT partner and DCIS award winner, the startup is driving scalable, self-reliant deep-tech innovation.

Name of TIH & Host Institute	Startup Name	Technology/Product	Area
NMICPS Technology Innovation Hub on Autonomous Navigation Foundation (TiHAN) IIT Hyderabad	RobotoAI Technologies Pvt Ltd	Autonomous Mobile Robots for Material Handling and Healthcare	Robotics & Automation

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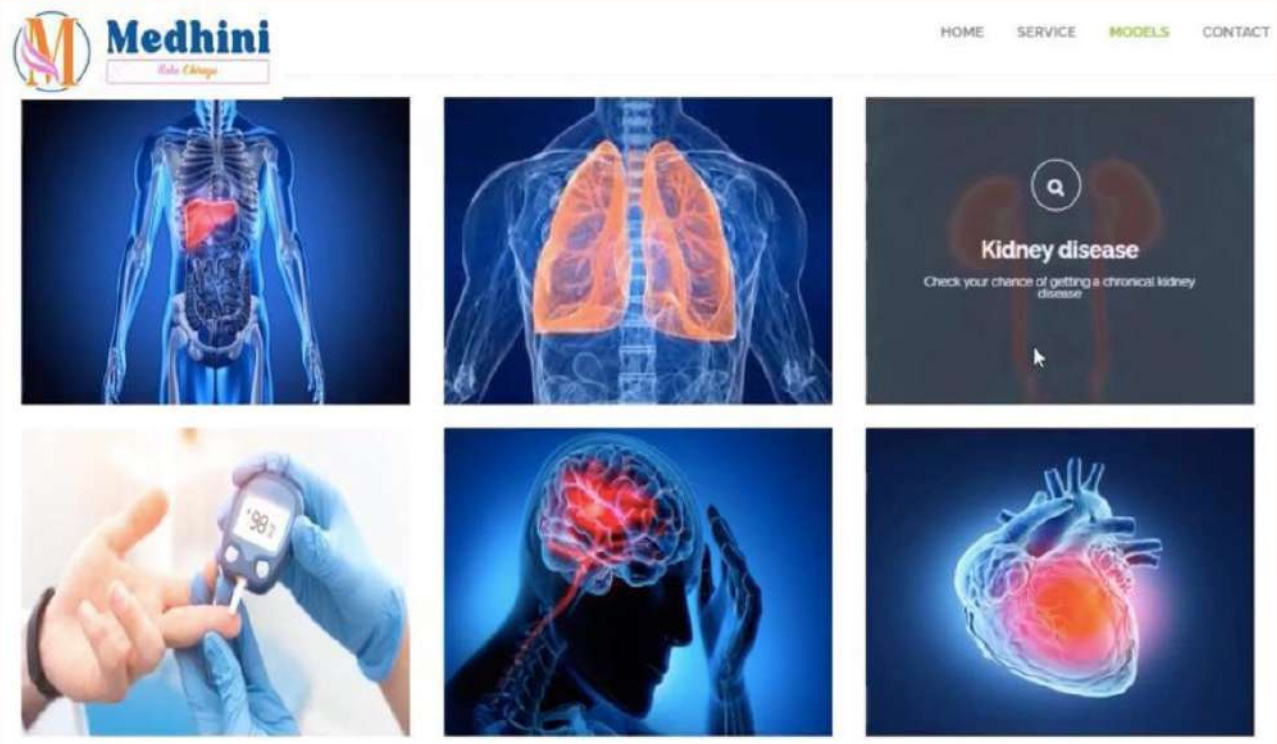
Name of TIH & Host Institute	Startup Name	Technology/Product	Area
IITI Drishti CPS Foundation IIT Indore	Arficus Private Limited	Medhini	Digital Healthcare

Success Story

Medhini by Arficus is redefining healthcare with the world's first genomics-based generative AI diagnostic platform. Delivering results in seconds with 99%+ accuracy, it cuts costs by up to 95% while enabling predictive, preventive care. Impacting millions across 21 countries, the startup is making advanced diagnostics accessible to underserved populations worldwide.



Name of TIH & Host Institute	Startup Name	Technology/Product	Area
IITI Drishti CPS Foundation IIT Indore	Vigorus AI Private Limited	Chikitsa	Digital Healthcare

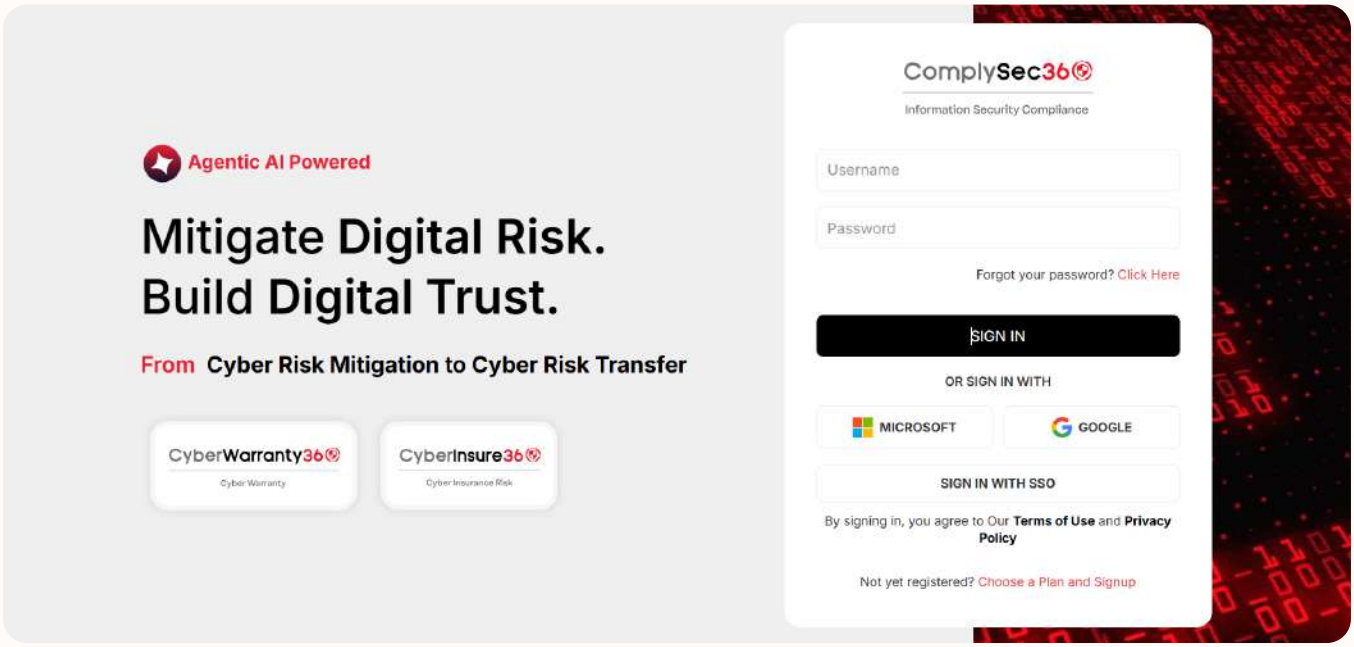
Success Story

Chikitsa is transforming healthcare delivery with a smart, AI-driven ecosystem that digitizes patient and hospital journeys end-to-end. Integrating blockchain, IoT, and real-time analytics, it ensures secure, compliant, and seamless care. Already deployed at Goa Medical College, the platform is scaling to manage thousands of patients daily across the state.

Name of TIH & Host Institute	Startup Name	Technology/Product	Area
IHUB NTIHAC Foundation IIT Kanpur	Engaiz GRC Solutions Pvt. Ltd.	a. ComplySec360 b.CyberInsure360	Cyber Insurance

Success Story

ENGAIZ is transforming cybersecurity compliance with ComplySec360™ and CyberInsure360™, automating audits, risk monitoring, and certification readiness. Enabling SMEs to achieve SOC 2 and ISO standards faster, it reduces effort while strengthening security. By integrating cyber insurance and risk insights, the startup turns compliance into a growth driver across industries.



Name of TIH & Host Institute	Startup Name	Technology/Product	Area
IIT Ropar Technology and Innovation Foundation IIT Ropar	Inphlox Water Systems Private Limited	ElectroX Series (Nano, S01, L01)	Wastewater management recycling

Success Story

INDRA is transforming wastewater management with patented, modular systems that enable decentralized, high-efficiency treatment and recycling. Powered by smart automation and analytics, it recovers up to 99% of water while minimizing energy use and sludge. With multiple patents and large-scale deployments, the startup is driving sustainable water solutions across industries.

Name of TIH & Host Institute	Startup Name	Technology/Product	Area
Divyasampark IHUB Roorkee for Devices Materials and Technology Foundation IIT Roorkee	Dtown Robotics Pvt. Ltd	RHINO UGV	Defense

Success Story

RHINO UGV is a mission-ready unmanned ground vehicle built for defense operations in the toughest environments. With cyber-hardened architecture and AI-driven navigation, it ensures secure, reliable performance under jamming and extreme conditions. Successfully showcased to the Armed Forces in 2026, the startup is advancing resilient, next-generation military mobility solutions.

Name of TIH & Host Institute	Startup Name	Technology/Product	Area
Divyasampark IHUB Roorkee for Devices Materials and Technology Foundation IIT Roorkee	Nexactly AI Solutions Pvt. Ltd	REHABVEDA	Healthcare

Success Story

RehabVeda is transforming neurorehabilitation with a brain-computer interface platform that accelerates recovery in stroke and paralysis patients. Combining EEG-based neurofeedback, robotics, and digital therapeutics, it delivers data-driven, scalable care. Recognized with the Ramaiah Evolute Star Startup Award, the startup is advancing accessible, technology-led rehabilitation with measurable patient outcomes.

Name of TIH & Host Institute	Startup Name	Technology/Product	Area
IIT Ropar Technology and Innovation Foundation IIT Ropar	Qzense Labs Private Limited	Q-Scan & Q-Log	Agriculture Automation & Information systems

Success Story

This startup is revolutionizing the food supply chain with IoT-driven automation and analytics, improving efficiency, reducing food loss, and ensuring safety. Recognized with the National Technology Award 2023 and featured by MIT Technology Review and Forbes Asia, it has gained strong industry backing and national visibility through Shark Tank India.

Name of TIH & Host Institute	Startup Name	Technology/Product	Area
IIT Ropar Technology and Innovation Foundation IIT Ropar	Ekosight Technologies Private Limited	Soil Doctor Kit	Water & Soil Assessment Processes

Success Story

EkoSight is transforming agriculture with a portable, affordable soil testing device that delivers instant insights via a mobile app. Empowering farmers to boost productivity and reduce waste, it supports sustainable farming. Backed by leading investors and award recognition, the startup is rapidly growing with strong revenue traction and innovation.

Name of TIH & Host Institute	Startup Name	Technology/Product	Area
IIT Ropar Technology and Innovation Foundation IIT Ropar	Froots Technologies Private Limited	IPhy (Device) & AgriQ (Platform)	Agriculture Automation & Information systems

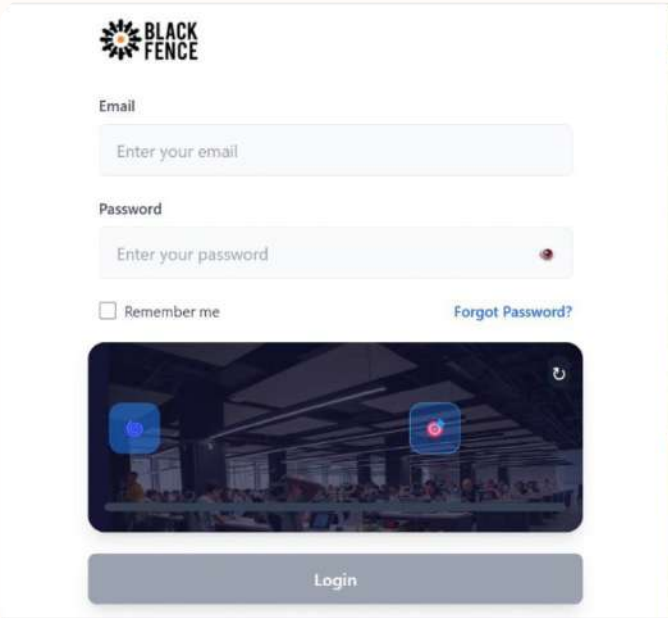
Success Story

Froots Technologies is digitizing food quality management with a platform that connects businesses to trusted suppliers, ensuring quality, transparency, and cost efficiency. By reducing waste and strengthening supply chains, it drives safer food systems. Backed by RKVY-RAFTAAR support and showcased at Gulfood 2026, the startup is gaining strong global traction.

Name of TIH & Host Institute	Startup Name	Technology/Product	Area
IHUB NTIHAC Foundation IIT Kanpur	Saptang Labs Private Limited	a. Sarvagya b. SarvagyaX c. Electron d. FilterCoffee e. BlackFence	Threat Intelligence

Success Story

This startup is redefining threat intelligence with platforms like Sarvagya, SarvagyaX, Electron, FilterCoffee, and BlackFence. Leveraging AI for real-time monitoring, fraud detection, and compliance, it secures enterprises and governments across sectors. With successful POCs, global clients, and expanding telecom partnerships, the startup is rapidly scaling next-generation cybersecurity solutions.



The Growing Impact of NM-ICPS

The impact of NM-ICPS extends beyond technology development and innovation. Through fellowships, skill development initiatives, and international collaborations, the mission is helping strengthen the ecosystem that supports research, innovation, and human resource development.

Fellowship Programmes under NM-ICPS

To build a strong pipeline of next-generation researchers, innovators and technology leaders, the National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS) has placed major emphasis on fellowships, advanced training and interdisciplinary human resource development. The Mission recognises that Cyber-Physical Systems are inherently multidisciplinary and require expertise across artificial intelligence, robotics, IoT, embedded systems, data science, quantum technologies, cybersecurity and advanced manufacturing. Through its Technology Innovation Hubs (TIHs), NM-ICPS has created opportunities for students, researchers, faculty members and young professionals to engage in cutting-edge translational research and innovation.

The fellowship and HRD ecosystem under NM-ICPS has been designed to address India's long-term technological and innovation requirements. The Mission supports learners and researchers across multiple stages from undergraduate education to advanced postdoctoral research and faculty leadership. It emphasises that CPS technologies require interdisciplinary expertise and therefore the Mission promotes cross-domain learning integrating engineering, computer science, electronics, AI, automation, communication systems and data sciences.

The fellowship programmes are closely linked with translational research, industry collaboration and startup development. Scholars and researchers are encouraged to work on real-world societal and industrial problems aligned with national priorities such as Digital India, Smart Cities, Industry 4.0, Sustainable Development Goals (SDGs), Healthcare, Agriculture and Intelligent Mobility. The Mission also supports the creation of testbeds, advanced laboratories and innovation platforms that enable practical technology development and commercialisation.

FELLOWSHIP & PROGRAMME CATEGORIES

Eligibility / Target Groups and Number of Beneficiaries

FELLOWSHIP / PROGRAMME CATEGORY	ELIGIBILITY / TARGET GROUP	NUMBER OF BENEFICIARIES
Graduate Fellowships	Undergraduate students in engineering, science and technology disciplines	6750+
Post Graduate Fellowships	M.Tech/M.E./M.Sc. and equivalent students	1250+
Doctoral Fellowships	PhD scholars in science and engineering disciplines	1000+
Postdoctoral Fellowships	Researchers with doctoral degrees	250+
Faculty Fellowships	Faculty members and academic researchers	150+
Chair Professors	Distinguished academicians and domain experts	50+

Skill Development and Human Resource Capacity Building

Skill development is one of the core pillars of the National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS). The Mission was designed not only to promote advanced research but also to build a future-ready workforce for emerging technologies. Through its Technology Innovation Hubs (TIHs), NM-ICPS has undertaken large-scale training programmes in Artificial Intelligence, Robotics, Internet of Things (IoT), Quantum Computing, Cybersecurity, Smart Manufacturing and Data Analytics. These initiatives aim to bridge the gap between academia and industry while supporting national priorities such as Digital India and Industry 4.0.

NM-ICPS promotes interdisciplinary learning, hands-on training and innovation-driven skilling through certification programmes, hackathons, internships, incubation support and industry collaborations. The Mission has benefited more than 2,37,200 students, researchers, industry professionals, startups and technicians across the country, helping create a skilled workforce equipped to drive India's leadership in the digital and deep-tech economy.

Meeting and showcasing drone training program (Drone Didi) to Hon'able President Smt. Droupadi Murmu

Drone Training at Technology Innovation Hub, IIT Mandi

Drone Training at Technology Innovation Hub, IIT Mandi

AI Vidya Setu 1.0

AI Vidya Setu 1.0 Nationals

Data Annotation Training Program

Drone Training at Technology Innovation Hub, IIT Mandi

Inter-School Robotics Championship (IRC)

Short-Term Faculty Development Program (FDP) on Emerging Technologies for the Faculty of Uttarakhand Board of Technical Education (UBTE)

AI Vidya Setu 1.0 Nationals

AI Vidya Setu 1.0

Robotics for Good Youth Challenge India

Robotics for Good Youth Challenge India

International Collaborations under NM-ICPS

International collaboration forms a critical pillar of the National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS). Recognising that Cyber-Physical Systems and emerging digital technologies evolve rapidly across global innovation ecosystems, the Mission was designed to actively engage with leading international universities, research laboratories, innovation centres and industry partners. It specifically emphasises the importance of "international collaborative research for cross-fertilisation of ideas" and highlights the need to connect Indian researchers with global research paradigms.

Over the years, the NM-ICPS ecosystem, particularly through its Technology Innovation Hubs (TIHs), has established more than 140 international collaborations with globally reputed universities, research organisations, and innovation ecosystems. These collaborations span countries including the United States, United Kingdom, Germany, France, Canada, Singapore, Australia, Japan, South Korea, Israel and several European nations.

The collaborations cover a broad spectrum of frontier technologies such as Artificial Intelligence, Robotics, Autonomous Systems, Smart Manufacturing, Quantum Technologies, Cybersecurity, Intelligent Mobility, Human-Machine Interaction, Digital Health, Advanced Communication Systems and Industrial IoT. Through joint research projects, faculty exchanges, researcher mobility programmes, collaborative workshops, global hackathons, international conferences and shared testbeds, Indian institutions are gaining access to world-class expertise, advanced infrastructure and global best practices.

NM-ICPS also aims to leverage the expertise of the Indian scientific diaspora and Non-Resident Indian (NRI) researchers working in leading global institutions. It highlights that many of the world's top researchers in emerging technologies are of Indian origin and can significantly contribute toward solving India-specific societal and technological challenges.

Several international partnerships have supported joint publications, patent generation, technology transfer and startup acceleration activities. These engagements are helping Indian institutions strengthen their research capabilities while also positioning India as a major global player in Cyber-Physical Systems and deep-tech innovation.

The Mission has further aligned its international strategy with national priorities such as Digital India, Make in India, Industry 4.0, Smart Cities, Sustainable Development Goals (SDGs) and Atmanirbhar Bharat. By integrating global collaboration with indigenous innovation, NM-ICPS is creating a robust framework for India's long-term technological leadership.

MoU signed between Fraunhofer IGB and IIT Ropar, represented by Prof. Rajeev Ahuja, Director, IIT Ropar, and Dr Pushpendra P. Singh, Project Director, iHub – AWaDH

TEXMiN, IIT (ISM) Dhanbad and GIREDMET, Russia, signed a Statement of Intent in the presence of leading experts, policymakers, and delegates from 20 countries

IIT Mandi TIH team members attending CHI 2025 at Yokohama, Japan a premier (A Grade) international conference in the field of Human-Computer Interaction (HCI)

Dr Mukesh Kastwal, Chief Innovation Officer, iHub–AWaDH, IIT Ropar (DST NM-ICPS), represented India as part of a select 12-member innovation delegation to Israel, organized by the Embassy of Israel in India

Testimonials and Reflections

from the NM-ICPS Community

The journey of the National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS) is reflected through the experiences of those who have helped shape it. This section presents a curated collection of testimonials and reflections from key stakeholders, including leaders of Technology Innovation Hubs (TIHs) and partner institutions.

These perspectives highlight the Mission's progress, collaborative efforts, and impact in bridging research with real-world applications. Together, they provide a concise and insightful overview of NM-ICPS's achievements and contributions to India's innovation ecosystem.

Technology Innovation Hub on Autonomous Navigation (TiHAN) at IIT Hyderabad, established in 2020 under DST NM-ICPS mission to catalyse India's deep-tech capabilities in Autonomous Navigation. TiHAN has multidisciplinary research ecosystem, delivering indigenous end-to-end autonomous navigation stacks integrating AI/ML, multi-sensor fusion based LLM/VLM-driven perception, path planning, control algorithms, GPS-denied, anti-jamming secure telemetry, edge-cloud, and software-defined vehicle architectures. TiAND – multimodal traffic data collected across the country spanning over 60 cities, enables robust driving stack development. We have established the state of the art, first of its kind, Testbed on Autonomous Navigations (Aerial and Terrestrial) over 10 acres in IITH campus, a platform for collaborative research between academia, industry, startups and national laboratories, enable cutting edge technology development at higher TRL, with standards compliance. Our autonomous platforms span from micro to heavy payload drones integrating urban air mobility and ground vehicles operating at varying speeds, terrains, light and weather conditions, deployed in real-world operations. TiHAN has strong engagement with industry, other line ministries, supports over 100+ spokes as R&D collaborators, nurtures over 50+startups. As India advances toward Viksit Bharat 2047, TiHAN at IITH is spearheading next generation multi-modal mobility technologies to enable intelligent, resilient, and sustainable transportation networks.

Dr P. Rajalakshmi

Project Director, NMICPS Technology Innovation Hub on Autonomous Navigation Foundation (TiHAN)
IIT Hyderabad

From the Himalayan heights of Himachal Pradesh, the IIT Mandi iHub and HCI Foundation, supported by the Department of Science and Technology (DST) under NM-ICPS, has transformed "remote" into "remarkable," advancing technology for human good and contributing to Viksit Bharat 2047 while ensuring inclusion.

Sovereign AI: Our world-class laboratories develop human-centred, multimodal AI with India-centric data sovereignty, delivering real-world solutions.

Social Uplift: We have trained underserved youth and enabled nearly 7,000 students with AI-age skills and employment.
Sustainability: Our self-sustaining ecosystem connects research, skilling, incubation, and industry, delivering patents, publications, and startups nationwide aligned with national priorities through DST leadership vision.

Shri Somjit Amrit

Chief Executive Office
IHub and HCI Foundation
IIT Mandi

NM-ICPS has rapidly emerged as a transformative, future-shaping national mission truly a game changer for India's deep-tech ecosystem. It has built a dynamic, multi-stakeholder platform where academia, industry, startups, and government come together, enabling ideas to hit the ground running as scalable, real-world solutions. Through its network of TIHs and TTRPs, the Mission has effectively bridged the gap between research and application. With a strong focus on AI, robotics, and cybersecurity, mining, etc., it is helping India hold its own globally while strengthening indigenous capabilities.

By fostering innovation, entrepreneurship, and future-ready talent, NM-ICPS is raising the bar for national missions. It is not just supporting innovation, it is rewriting the rulebook for a self-reliant, globally competitive India.

Ms. Narbada Sharma
Associate Manager (Liaisoning & Governance)
TEXMIN
IIT (ISM) Dhanbad

It is indeed an incredible experience to be part of C3iHub journey from foundation to implementation. We started with the goal of creating affordable indigenous cybersecurity solutions for critical sector organizations of India. By now, our SOCs are successfully deployed at NHAI, IPA, and Bhilai Steel Plant IT-OT environment. Our blockchain solutions are implemented with DRDO, Rajasthan State Government. With continuous support of the DST, we have established robust R&D and startup ecosystem in cybersecurity across India and trained over two lakhs in basic and advanced cybersecurity in the country. We are thankful to DST for promoting us to TTRP status; it gives us even better chance of serving the country.

Dr Tanima Hajra

Chief Executive Officer IHUB
NTIHAC Foundation
IIT Kanpur

As the Chief Technology Consultant to IITM Pravartak, I have had a front-row seat to the TIH journey—from concept to a vibrant, national-scale deep-tech ecosystem. Over these years, we have transformed SNACS from an academic theme into a powerful engine that now supports more than a hundred teams and startups working on sensors, networking, actuators and control systems across diverse domains. A key lesson is that technology alone is never enough; what truly creates impact is an ecosystem that combines mentorship, cross-disciplinary talent, regulatory support, and a culture of ethical, mission-driven innovation. Going forward, I believe TIHs must prioritise sharper focus on globally competitive products and intellectual property. It will require much higher investments.

Shri Mohan Satyaranjan

Chief Technology Officer
Pravartak Technologies Foundation
IIT Madras

When DST's National Mission on Interdisciplinary Cyber-Physical Systems entrusted IIT Ropar with building iHub AWaDH, it placed extraordinary faith in a young campus in Punjab to become a national engine for deep-tech translation. Today, with 170+ startups onboarded, a portfolio valuation exceeding Rs 1600 Crore, 17+ technologies commercially transferred, and innovations like India's first cold-chain data logger AmbiTag, AI-powered MoohSense livestock monitor, Biodiversity Monitoring Ecosystem, Nano Bubble technology, we are reaching the ground in support with our 220+ partnerships and 20+ spoke institutions network. We deeply acknowledge DST for designing NM-ICPS not merely as a funding instrument, but as a national architecture for translation.

Dr Radhika Trikha

Chief Executive Officer
Technology and Innovation Foundation
IIT Ropar

I have been closely part of building and supporting the ecosystem on the ground, and I take immense pride in contributing to it through IIT Ropar TIH, supported by DST NM-ICPS. Over the years, I have seen how the mission has helped move ideas from labs into real-world deployment, supporting startups, enabling technologies, and creating impact in deeptech sectors & played crucial role by brinign together academia, startups, and industry in a very practical way. To me, NM-ICPS is a mission that is actively driving and shaping India's deep-tech ambitions towards Viksit Bharat 2047.

Dr Mukesh Kestwal

Chief Innovation Officer
Technology and Innovation Foundation
IIT Ropar

Leading TIH has been an inspiring journey of building bridges between industry, academia, and government. We are proud to have supported 50+ DeepTech startups, including 24 funded ventures creating real world impact in IoT across agriculture, healthcare, and industrial sectors. The path hasn't been without challenges—DeepTech requires patience, capital, and cross sector coordination. But the greatest lesson has been learning to navigate and harmonize a diverse ecosystem with agility and empathy. As we move forward, strengthening collaboration, accelerating market access, and nurturing talent will be key to unlocking India's full innovation potential.

Shri Kiran Shesh

Chief Executive Officer
TIH Foundation For IOT And IOE
IIT Bombay

Our association with BBF, both as coordinators and project investigators, has been extremely cordial and productive. The foundation has consistently provided strong scientific, technical, and financial support, making it easy to address challenges during the course of our project on resistive sensors for early detection of crop infestation.

One of the most valuable aspects of this collaboration has been BBF's encouragement to prioritise intellectual property protection. With their support, we were able to secure three Indian patents. The entire patenting process—from drafting to submission and even interactions with the patent office—was efficiently handled by the BBF team, making the process seamless for us.

BBF has also actively encouraged the translation of research into practical applications, including startup incubation and technology transfer. Their flexibility in revising project deliverables and providing timely financial support has ensured steady progress. Notably, their empathetic and responsive approach sets them apart from typical funding agencies.

We look forward to continuing this collaboration and contributing further to society through our research outcomes.

Dr Rajeswara Rao M.

Associate Professor
Department of Chemistry
IIT Dharwad

Dr Ruma Ghosh

Associate Professor
EECE Department
IIT Dharwad

Our association with the BITS BioCyTiH Foundation (BBF) began with the approval of our project on developing a point-of-care electrochemical device for measuring glycated hemoglobin (HbA1c) in March 2024. Since then, the experience has been highly positive, particularly due to BBF's efficient administration and active scientific engagement.

The foundation follows a well-structured monitoring system, with timely reminders for progress reporting and quick release of funds upon submission of required documents. This has ensured the uninterrupted progress of our research activities. The technical team has also been highly supportive, offering valuable inputs during discussions on project milestones and future directions. Our visit to BBF provided an opportunity to interact with other researchers and explore well-maintained facilities, fostering collaboration and knowledge exchange.

During the course of the project, we expanded our initial scope after recognising the need to measure total hemoglobin (Hb) alongside HbA1c. This led to the development of an additional point-of-care device for Hb measurement, which can serve as a standalone anemia screening tool. The BBF team was highly receptive to this addition and further guided us to validate our device using clinical samples and benchmark it against NABL-certified laboratory results. Their continued emphasis on meeting regulatory standards has helped strengthen the translational potential of our work.

BBF's support has also extended to intellectual property facilitation. The patent team provided detailed guidance, from initial discussions to assessment of patentability, encouraging us to move forward with filing a patent application. Additionally, their understanding of practical challenges during clinical validation, including timelines and financial requirements, has been crucial. The provision of extensions and additional support for research personnel ensured that scientific quality was maintained without disruption.

Overall, BBF's research-oriented approach, timely funding, and collaborative ecosystem have played a significant role in advancing our project from a lab-scale prototype towards a device ready for regulatory approval and potential technology transfer.

Dr Uma Maheswari K.

Professor & Dean, School of Arts
Sciences, Humanities & Education (SASHE)
SASTRA Deemed University
Thanjavur

COMRADO Aerospace emerged from ARTPARK's innovation ecosystem, evolving from a research initiative into a deep-tech startup focused on unmanned aerial systems. Supported by DST and other government agencies, the startup has developed advanced UAV technologies for both strategic and commercial applications.

Its product portfolio includes microdrones, cargo platforms, and advanced simulators, with the flagship Viraat UAS designed for surveillance and defence applications. The system is capable of long-endurance operations at high altitudes, addressing critical requirements of the Indian Army. The company has also filed multiple Indian and international patents, reflecting strong innovation capabilities.

ARTPARK's role in this journey has been central, providing not only funding but also access to advanced testing facilities, mentorship, and opportunities to engage with end users. This support enabled the startup to scale rapidly and focus on developing indigenous solutions for defence and logistics.

The experience highlights the importance of integrated support systems in nurturing deep-tech startups and demonstrates how initiatives under NM-ICPS are enabling the growth of globally competitive technologies in India.

Shri Ansar H. Lone

Co-founder, CEO & Director
COMRADO Aerospace

IIITB COMET Foundation (TIH), IIIT Bangalore

The IIITB COMET Foundation, established under NM-ICPS, has significantly contributed to strengthening India's capabilities in Advanced Communication Systems. It has developed key indigenous technologies such as an ORAN-based 5G base station and Reconfigurable Intelligent Surfaces (RIS), supporting the vision of Atmanirbhar Bharat.

A major achievement is the development of 5G-Advanced ORAN Massive MIMO subsystems, including the 32TR Radio Unit and O-DU accelerator card, in collaboration with leading academic institutions. These technologies are crucial for enabling scalable, high-capacity connectivity across both rural and urban areas. The TIH has also made notable progress in RIS technology, developing prototypes and testbeds through collaborations with multiple IITs and IIITs, and demonstrating their potential for future 6G networks.

The foundation has actively enabled technology translation through licensing agreements with startups such as WiSig Networks and partnerships with industry players like Tejas Networks. Its strong research output includes over 65 publications and 18 patents. In addition, initiatives such as the 5G Springboard and Entrepreneur-in-Residence programmes have supported startups, while training programmes and workshops have contributed to skill development.

Looking ahead, COMET aims to expand into 6G systems, AI-driven networks, and integrated communication platforms, while strengthening industry collaborations and accelerating commercialization of indigenous technologies.

Since its inception in 2021, IIITB COMET Foundation has worked to bridge academic research and industry applications in advanced communication systems. Through collaborations with leading institutions, it has developed technologies such as 5G-Advanced ORAN systems and RIS, which are expected to play a key role in future 6G networks.

By licensing technologies to startups like WiSig Networks and collaborating with industry partners such as Tejas Networks, COMET is contributing to Atmanirbhar Bharat in telecommunications. Its entrepreneurship programmes have nurtured deep-tech startups, while skill development initiatives continue to equip students and professionals with industry-relevant capabilities.

Prof. Debabrata Das

Project Director
IIITB COMET Foundation (TIH)
IIIT Bangalore

The NM-ICPS framework has enabled strong collaboration between TIHs, academia, and industry, supporting the development of indigenous deep-tech capabilities. At IIT Hyderabad, our project under COMET led to the development of a 32TR Massive MIMO radio aligned with global standards.

The system has progressed beyond a laboratory prototype towards deployment, with technology licensed to WiSig Networks for commercialization. This reflects the effectiveness of the TIH-academia-industry model in translating research into real-world applications. Its showcase at Mobile World Congress 2026 further highlights India's growing capabilities in advanced wireless technologies.

Prof. Kiran Kuchi

IIT Hyderabad

ARTPARK, established at the Indian Institute of Science (IISc) under NM-ICPS, has focused on advancing India's capabilities in AI and robotics by bridging the gap between research and real-world deployment. Its core approach addresses the long-standing challenge of translating early-stage research (TRL 3–4) into field-ready technologies (TRL 6–7) through a deep-touch venture-building model.

This model combines sustained funding, access to a large prototyping and testing facility (ARTgarage), industry collaboration, and continuous mentorship. As a result, ARTPARK has supported 29 deep-tech startups with a combined valuation of around ₹1,300 crore and enabled the development of over 60 technologies, with nearly half reaching commercialization. These solutions are already being deployed across sectors, including defence, manufacturing, construction, and railways, demonstrating strong real-world impact.

Beyond industrial applications, ARTPARK has developed AI-driven platforms for societal benefit. Project VAANI has created a large open-source speech dataset covering over 156,000 speakers across multiple Indian languages, contributing to digital public infrastructure initiatives. Other platforms, such as Dharini, support health and climate intelligence, while solutions for frontline healthcare workers are being scaled across states. Collaborative efforts like MIDAS have also enabled advancements in AI-based healthcare research.

Looking ahead, ARTPARK aims to expand its infrastructure and innovation ecosystem through initiatives such as the proposed Bengaluru Robotics & AI Innovation Zone (BRAINZ) and strengthened partnerships with government and industry. Its journey reflects how mission-driven Technology Innovation Hubs can translate research excellence into scalable, indigenous technologies aligned with the vision of Viksit Bharat 2047.

Shri Raghu Dharmaraju

CEO, ARTPARK
IISc Bengaluru

Our association with I-HUB QTF has been instrumental in supporting QuPrayog's growth. The hub provided seed funding, incubation support, and access to infrastructure, helping strengthen our technology development efforts. The team has been highly supportive in addressing technical, operational, and policy-related challenges.

Training programmes on areas such as logistics, compliance, and business processes have also been valuable for building global capabilities. The leadership and mentorship provided by the hub have played a key role in refining our business strategy and advancing our work in quantum technologies.

Shri Swapnil Wankhede

Head Business & Operations
QuPrayog

Participation in the "Challenge to be Quantum Ready," organised with I-HUB QTF, significantly strengthened our research in quantum cryptanalysis. The initiative enabled us to translate theoretical work into practical quantum implementations, particularly in assessing vulnerabilities in communication systems.

Access to quantum infrastructure and collaborative partnerships enhanced our technical capabilities and provided insights into scaling quantum simulations. The initiative has supported our ongoing efforts in advancing quantum-secure communication research and strengthening national security applications.

Dr Allu Swamy Naidu

Research Scientist
C.R. Rao AIMSCS

I-HUB Quantum Technology Foundation (I-HUB QTF), established under NM-ICPS and anchored at IISER Pune, plays a key role in strengthening India's quantum technology ecosystem. Through a hub-spoke model involving over 13 partner institutions, it promotes collaborative research, innovation, and technology development in quantum science and engineering.

A major focus area has been capacity building. Through initiatives such as Chanakya Fellowships, workshops, and specialised training programmes in quantum computing, materials, and algorithms, the hub has trained over 3,300 students, researchers, and faculty. These efforts have contributed to developing a skilled workforce for India's emerging quantum ecosystem.

The hub has also enabled significant technology development. Key innovations include a Josephson Parametric Amplifier for high-fidelity quantum measurements and an NV-centre-based magnetometer for precision sensing. The iQuantrol Arbitrary Waveform Generator, developed with industry partners, is now commercially available and supports multiple quantum computing platforms. These efforts reflect a strong push towards indigenous technology development and reduced dependence on imports.

In the startup ecosystem, I-HUB QTF has supported several deep-tech ventures. Notable achievements include long-distance quantum key distribution by QNu Labs, a 64-qubit quantum processor by QpiAI, and advanced laser systems by emerging startups. Through funding, mentorship, and infrastructure support, the hub has accelerated the transition from research to commercial applications.

Looking ahead, the hub aims to develop a commercial-grade trapped-ion quantum computer and affordable quantum platforms for educational use, while strengthening collaborations and expanding access to quantum technologies.

Dr Kunj Tandon

Chief Executive Officer
I-HUB Quantum Technology Foundation

Menthosa Solutions Pvt. Ltd. is a deep-tech startup incubated at TiHAN (Technology Innovation Hub on Autonomous Navigation), IIT Hyderabad, under the National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS). Led by Dr Nitish Mahajan (PhD) as CEO, with Anup Ahlawat as Head of Engineering and Kartik Pathak as Head of Systems and AI, the company focuses on developing indigenous autonomous drone platforms and cyber-physical technologies. Through its collaboration with TiHAN, Menthosa has leveraged advanced research infrastructure, incubation support, and innovation funding to design and demonstrate 5G-enabled drone systems, autonomous navigation capabilities, and integrated avionics solutions for applications such as infrastructure monitoring, surveillance, and precision agriculture. The partnership has enabled accelerated prototyping and real-world validation of advanced UAV technologies, contributing to the translation of research into deployable solutions and strengthening India's Cyber-Physical Systems ecosystem in autonomous mobility and intelligent aerial platforms.

Shri Nitish Mahajan

PhD, CEO, Director
Menthosa Solutions Pvt. Ltd

Support from I-HUB QTF under the National Quantum Mission has been crucial for Quanastra's growth. Funding support enabled the development of superconducting nanowire single photon detectors and helped establish early-stage infrastructure.

Beyond funding, being part of the NM-ICPS ecosystem has provided visibility and credibility. The support has strengthened our position for future investments and enabled meaningful progress in deep-tech innovation.

Dr Vidur Raj

(RAMANUJAN FELLOW)
Founder, Quanastra Pvt. Ltd.

Dr Sunnam Venkata Srikanth highlights that the collaboration between C-DAC and TiHAN–IITH has advanced intelligent transportation systems through the development of an indigenous Cellular Vehicle-to-Everything (C-V2X) platform. Field deployments and interoperability testing have demonstrated reliable vehicle communication systems, enabling technology transfer and supporting safer mobility and smart infrastructure development.

Dr Sunnam Venkata Srikanth

Scientist F
C-DAC Hyderabad

RobotoAI Technologies Pvt Ltd acknowledges the pivotal role played by TiHAN–IITH during a critical phase of our journey, when our sales traction was limited but our technological vision was strong. TiHAN–IITH provided early recognition, R&D funding, and sustained technical mentorship that significantly accelerated the development of our autonomous navigation and AMR technologies. This support enabled us to transition from core research to real-world deployments of autonomous mobile robots, contributing to industrial adoption and employment generation. The opportunity to showcase our robots before DST and senior Government of India officials provided valuable national visibility and credibility. More than a funding agency, TiHAN–IITH supported us when we were at a nascent stage, helping us build momentum toward sustainable growth. Today, we are approaching an annual turnover of approximately INR 50 lakhs which is more than 130% growth than last year. We sincerely appreciate the continued support from TiHAN–IITH and the NM-ICPS ecosystem.

Shri Rubesh Thirumani S

Co-Founder & Managing Director
RobotoAI Technologies Pvt Ltd

The IITI DRISHTI CPS Foundation at IIT Indore focuses on building a translational research ecosystem in digital healthcare, integrating cyber-physical systems, artificial intelligence, and data-driven technologies to address real-world clinical needs. Its objective is to enhance healthcare accessibility, efficiency, and diagnostic accuracy through innovative and scalable solutions.

A key area of work is the development of Digital Twin frameworks that create dynamic computational models of patients, medical devices, and healthcare systems. These models enable real-time monitoring, predictive diagnostics, and simulation-based clinical decision-making, supporting personalized and preventive healthcare. The foundation is also exploring immersive technologies such as Augmented Reality (AR) and Virtual Reality (VR) for medical training, surgical simulation, rehabilitation, and remote healthcare delivery, helping extend advanced medical capabilities to underserved regions.

Another important focus is the creation of large-scale, standardized clinical data repositories to support AI and machine learning applications. These datasets will enable improved disease prediction, early diagnosis, and personalized treatment strategies. The foundation is also working towards developing a Clinical Decision Support System (CDSS) that can assist healthcare professionals with evidence-based recommendations and predictive analytics. In addition, efforts are underway in areas such as AI-assisted radiology, genomics, and digital pathology to improve the speed and accuracy of diagnosis.

Prof. I.A. Palani

Project Director
Drishti CPS Foundation
IIT Indore

Dr Deepak Agrawal highlights the importance of collaboration in advancing healthcare innovation. Through the DRISHTI ecosystem and partnerships with multiple AIIMS institutions, efforts are underway to develop AI-driven digital health solutions, particularly a Digital Twin platform for severe traumatic brain injury (TBI).

This approach integrates genomic, clinical, and radiological data to generate patient-specific models, enabling early risk assessment and supporting personalized treatment decisions in neurocritical care. The initiative demonstrates how collaborative platforms can translate advanced research into clinically relevant solutions.

Dr Deepak Agrawal

Professor Department of Neurosurgery
JPN Apex trauma Centre
All India Institute of Medical Science

Noor Fatma, founder of Easiofy Solutions, notes that DRISHTI has provided both funding and ecosystem support, enabling the development and deployment of their AI-powered medical imaging platform, ImagiXAI.

The integration of this solution within the DRISHTI ecosystem has enhanced its visibility, strengthened industry connections, and supported wider adoption across healthcare systems. This collaboration highlights the role of the hub in accelerating the translation of AI-driven innovations into real-world applications.

Ms. Noor Fatma

Founder
Easiofy Solutions Pvt. Ltd

MISSION TARGETS

OVERVIEW

*Driving **Innovation**.*
*Empowering **People**.*
*Creating Global **Impact**.*

S.No.	Mission Targets	Target Area	Achieved Targets
1	TECHNOLOGY DEVELOPMENT	Technologies / Technology Products supported	1800+
		Patents Filed	720+
		Patents Granted	220+
		Publications, IPR and other Intellectual activities	3400+
		Increase in CPS Research Base	2600+
2	HUMAN RESOURCE DEVELOPMENT	Total Fellows	9400+
		Skill Development	230000+ (beneficiaries)
3	ENTREPRENEURSHIP DEVELOPMENT	Start-ups & Spin-off companies	950+
		Jobs created	45000+
4	INTERNATIONAL COLLABORATIONS	International Collaborations	180+

National Mission on Interdisciplinary Cyber-Physical Systems

List of 25 Technology Innovation Hubs (TIHs)

S.No.	Name of the Host Institute	Name of the Technology Innovation Hub	Name of Technology Vertical	State
1	Indian Institute of Technology, Dhanbad	Technology Innovation in Exploration & Mining Foundation	Technologies for Mining	Jharkhand
2	Indian Institute of Science, Bengaluru	I-HUB for Robotics and Autonomous Systems Innovation Foundation	Robotics & Autonomous Systems	Karnataka
3	Indian Institute of Technology, Kanpur	IHUB NTIHAC Foundation	Cyber Security and Cyber Security for Physical Infrastructure	Uttar Pradesh
4	Indian Institute of Technology, Indore	IITI Drishti CPS Foundation	System Simulation, Modelling & Visualization	Madhya Pradesh
5	Indian Institute of Technology, Madras	IIT Madras Pravartak Technologies Foundation	Sensors, Networking, Actuator & controls	Tamil Nadu
6	Indian Institute of Technology, Hyderabad	NMICPS Technology Innovation Hub on Autonomous Navigation Foundation (TiHAN)	Autonomous Navigation and Data Acquisition systems (UAV, RoVetc)	Telangana
7	Indian Institute of Technology, Bombay	TIH Foundation For IOT And IOE	Technologies for Internet of Things & Internet of Everything and BharatGen: A Suite of Generative AI Tech for India	Maharashtra
8	Indian Institute of Technology, Bhilai	IIT Bhilai Innovation and Technology Foundation	Technologies for financial sector (Fintech)	Chhattisgarh
9	Indian Institute of Technology, Ropar	IIT Ropar Technology and Innovation Foundation	Technologies for Agriculture & Water	Punjab
10	International Institute of Information Technology, Hyderabad	IIIT-H Data I-Hub Foundation	Data Banks & Data Services, Data Analysis	Telangana
11	Birla Institute of Technology & Science, Pilani	BITS BioCYTiH Foundation	Bio-CPS	Rajasthan
12	Indian Institute of Technology, Mandi	IIT Mandi IHub and HCI Foundation	Human Computer Interaction	Himachal Pradesh

S.No.	Name of the Host Institute	Name of the Technology Innovation Hub	Name of Technology Vertical	State
13	Indian Institute of Technology, Guwahati	IIT Guwahati Technology Innovation and Development Foundation	Technologies for Under water exploration	Assam
14	Indian Institute of Technology, Palakkad	IIT Palakkad Technology Ihub Foundation	Intelligent Collaborative Systems	Kerala
15	International Institute of Information Technology, Bengaluru	IIITB Comet Foundation	Advanced Communication System	Karnataka
16	Indian Institute of Technology, Delhi	I-Hub Foundation for Cobotics (IHFC)	Cobotics	Delhi
17	Indian Institute of Technology, Jodhpur	IHUB Drishti Foundation	Computer Vision, Augmented and virtual reality	Rajasthan
18	Indraprastha Institute of Information Technology, Delhi	IHUB Anubhuti-IIITD Foundation	Cognitive Computing & Social Censing	Delhi
19	Indian Institute of Science Education and Research, Pune	I-Hub Quantum Technology Foundation	Quantum Technologies	Maharashtra
20	Indian Institute of Technology, Roorkee	Divyasampark IHUB Roorkee for Devices Materials and Technology Foundation	Device Technology and Materials	Uttarakhand
21	Indian Institute of Technology, Tirupati	IIT Tirupati Navavishkar I-Hub Foundation	Positioning and Precision Technologies	Andhra Pradesh
22	Indian Institute of Technology (Banaras Hindu University)	I-DAPT-HUB Foundation	Data Analytics & Predictive Technologies	Uttar Pradesh
23	Indian Institute of Technology, Patna	IIT Patna Vishlesan I-hub Foundation	Speech, Video & Text Analytics	Bihar
24	Indian Institute of Technology, Kharagpur	IIT Kharagpur AI4ICPS I-Hub Foundation	Artificial Intelligence and Machine Learning	West Bengal
25	Indian Statistical Institute, Kolkata	IDEAS- Institute of Data Engineering, Analytics and Science Foundation	Data Science, Big Data Analytics and Data curation etc	West Bengal

Glimpses of National Workshops on Technology Innovation in Cyber-Physical Systems (TIPS) (2022-2025)

TIPS @ IIT Indore

TIPS @ IIT Kanpur

TIPS @ IIT Indore

TIPS @ IIT Delhi

TIPS @ IIT Kanpur

TIPS @ IIT Indore

TIPS @ IIT Kanpur

TIPS @ IIT Bombay

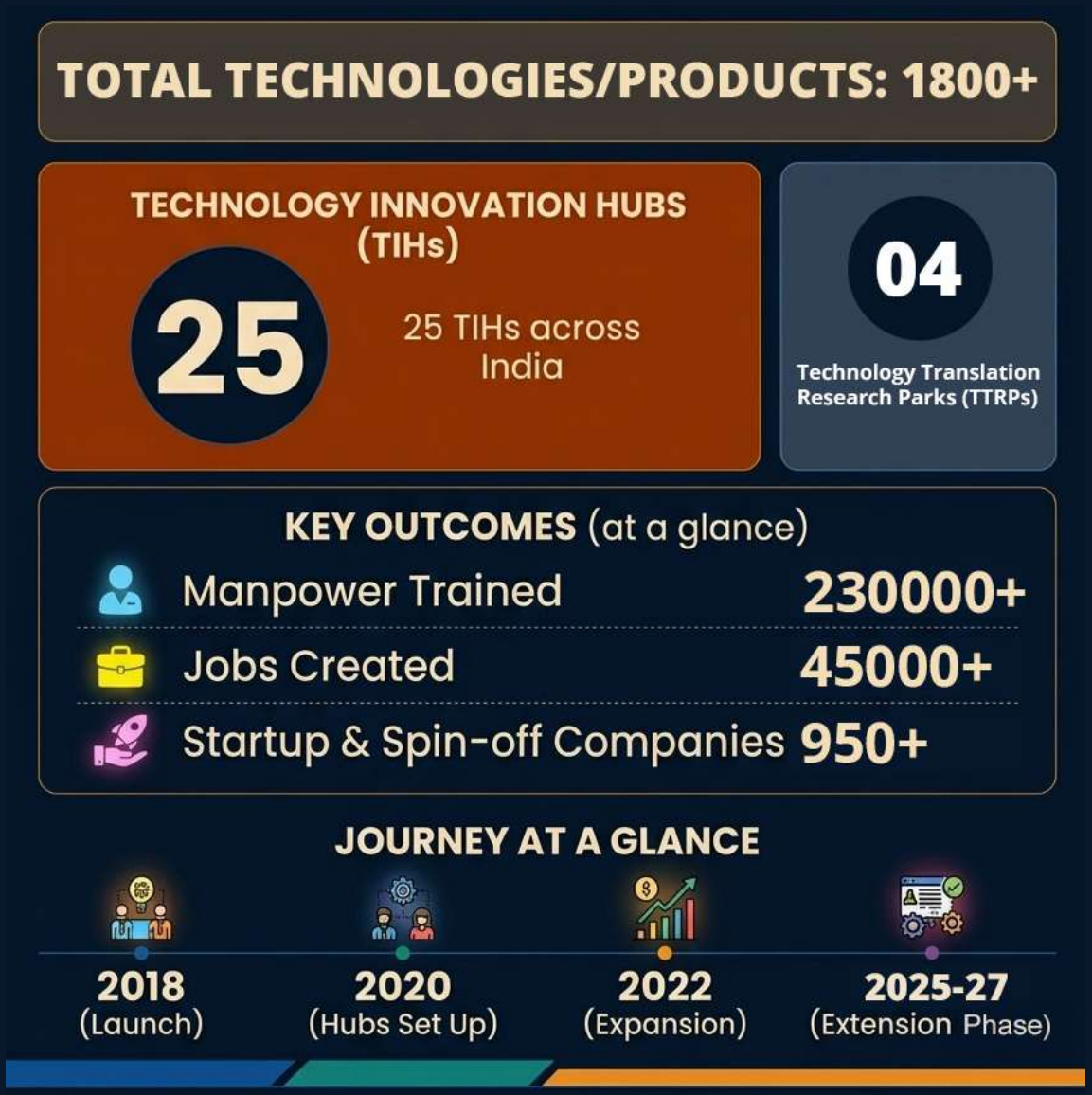
TIPS @ IIT Bombay

Cultural Events at IIT Indore During TIPS

TIPS @ IISc Bengaluru and IIIT Bengaluru

TIPS @ IIT Indore

National Mission on Interdisciplinary Cyber-Physical Systems



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