

Paving the Way for the Future of Mobility: AI, Digital Twins, and Digital Public Infrastructure





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Foreword

I am pleased to offer this foreword to the white paper emerging from the **MInT Mobility Summit 2025**—an initiative that brings together India’s brightest minds and most forward-thinking institutions to address one of the most pressing challenges of our time: sustainable, inclusive, and intelligent mobility.

Though I joined the Summit virtually this year due to official commitments in Delhi, my earlier visit to the newly established MInT facility at IIT Madras’s offered a firsthand appreciation of the collaborative spirit and technical depth that underpin this important initiative. I have long seen MInT as a natural and timely progression of MeitY’s engagement with IIT Madras and its pioneering work in integrated transport systems.

At **MeitY**, our mission has always been to apply technology for public goods—especially across sectors that touch people’s lives daily. Mobility is one such sector. It is not just about transport—it is about access, equity, efficiency, and environmental sustainability. Whether it’s enabling a safer commute, reducing time lost in traffic, cutting emissions, or helping a mother reach the hospital faster, mobility solutions must be citizen centric.

This is where the convergence of Artificial Intelligence, Digital Twins, and Digital Public Infrastructure (DPI) becomes not only transformative but essential. AI is not merely a vertical technology—it is a horizontal enabler, and its application in urban mobility can unlock meaningful societal impact at scale. Digital twins can help us simulate, plan, and manage our systems with a level of accuracy and adaptability previously unavailable. And the development of a **Bharat Multi-Modal Mobility Stack (BM3S)** offers us a pathway to deliver interoperable, cost-effective, and inclusive solutions for all.

The initiatives discussed in this white paper—adaptive traffic control, bus prioritization, multimodal integration, and data-driven urban transport—showcase how India can lead in building low-cost, high-impact systems that can be deployed across cities and towns. We have seen this with Aadhaar and UPI. With the right frameworks and partnerships, mobility can become the next frontier of DPI-driven innovation.

I commend the MInT Collaborative and IIT Madras for spearheading this important dialogue and for laying out a roadmap rooted in research, partnership, and public purpose. The **Government of India, through MeitY**, is keen to engage with and support such platforms that build the next generation of digital infrastructure for India—and the world.

Let us use the momentum of this Summit not just to imagine better mobility—but to *build it together*.

S. Krishnan,
IAS, Secretary, Ministry of Electronics and Information Technology,
Government of India



1. The Evolving Landscape of Mobility and Its Challenges

Mobility is a fundamental enabler of economics and is profoundly important in modern society. However, it also presents significant challenges, particularly in rapidly growing urban environments. **Urban traffic congestion** has become a critical issue, impacting the entire movement of vehicles, especially emergency and priority vehicles. Fixed-time traffic signals exacerbate this problem, hindering the efficient movement of ambulances and other essential services. Recent instances in Chennai have highlighted ambulances being frequently stuck in traffic, sometimes for extended periods.

Beyond emergency services, congestion affects daily life and economic activity. The time taken for public transport journeys has significantly increased over the decades. This is compounded by rapid urbanization and the growth in private vehicles; for instance, one lakh private vehicles are added to Chennai

every month, while road space has not grown at the same pace. The shift towards larger vehicles like SUVs also consumes more road space compared to smaller cars.

Safety is another paramount concern in mobility. Existing safety features in vehicles often primarily protect the occupant and driver, leaving vulnerable

road users like pedestrians and two-wheelers at greater risk. The causes of accidents are complex, stemming from an interplay of factors including driver behavior, vehicle condition, road conditions, and environmental factors. The high cost-to-GDP ratio in the logistics sector in India also suggests significant inefficiencies that could be addressed. Furthermore, transporting





perishable goods rapidly from farm to fork remains a difficult challenge.

The mobility sector is also a **huge contributor to greenhouse gas emissions**. The transition to cleaner forms of energy, such as electric vehicles powered by solar or fuels

from biomass, is crucial, enabled by innovations like bio manufacturing. Efficiency and sustainability are embedded within the concept of affordable mobility. Addressing these multifaceted challenges requires a reimagining of urban and rural living, logistics, safety, and congestion.





2. AI as a Key Enabler for Transformation

Professor Travis Waller, Lighthouse Professor and Chair of Transport Modelling and Simulation at TU Dresden discussed the concept of “**mobility as a resource**,” where complex mobility systems are dissolved into atomic parts and reorganized in real-time to match supply and demand. He highlighted the potential for highly personalized solutions, processing massive data volumes, and complex real-time decision-making.

Professor Srin Parthasarathi, Computer Science and Engineering, The Ohio State University discussed the need to adapt education methods to leverage new tools like AI while maintaining focus on first principles and understanding causal relationships.

To tackle the complex and interrelated challenges in mobility—from congestion and safety to sustainability and inefficiencies—technology must become

smarter and more adaptive. Artificial Intelligence (AI) offers a powerful set of tools to address these issues at scale. By turning raw mobility data into actionable insights, AI enables real-time traffic management, improves emergency response times, enhances safety for all road users, and supports a shift toward cleaner and more efficient transportation systems. It is not just a technological upgrade but a systemic enabler for equitable, responsive, and future-ready mobility.

Artificial Intelligence (AI), viewed potentially as “automated intelligence” to distinguish from merely “fake” applications, is poised to play a significant role in transforming mobility.

AI integrates Machine Learning (ML), Deep Learning, and Data Science. While models are seen as the “glamour component,” **data is the core** and “key” to the entire process.

AI can refine mobility solutions from a “one-size-fits-all” approach to personalized and adaptive systems. It can assist users in making travel decisions, whether driving or maneuvering through traffic. AI is used to analyze historical data and optimize traffic signals to minimize delays. It can also optimize routes for safety and efficiency, minimizing travel distance. AI can contribute to data-driven decision-making for governments by collecting data points from every

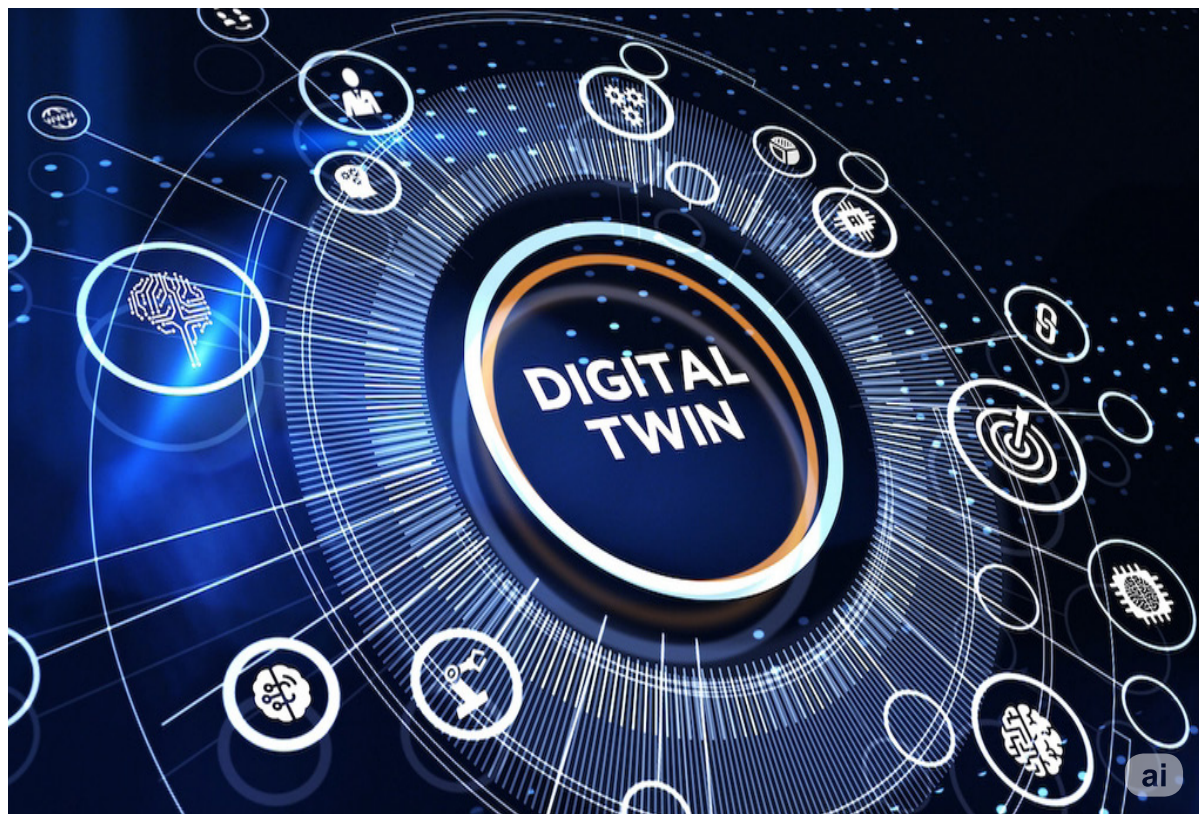




journey. Real-time detection of recklessness could potentially reduce accidents.

AI's capabilities in real-time complex decision-making are crucial for leveraging other technological advancements, such as highly personalized solutions and high-

fidelity observation data. It acts as the integrating and synthesizing layer for these developments. However, applying AI in mobility requires caution, ensuring sufficient testing before widespread deployment. Encoding ethics and social values into algorithms is essential to avoid potential pitfalls.



3. Digital Twins: Virtual Replicas for Planning and Management

Mr. Asit Kadayan, Director General, Department of Telecommunications (DoT) outlined a vision for digital twins in the role of **telecom data** in mobility and the need to solve the problem of **privacy**, ideally through an **incentive framework** where people are willing and excited to share data, not just compliant with regulations.

Mr. Vignesh Tamilvanan, Data Architect, Chennai Unified Metropolitan Transport Authority (CUMTA) shared the vision for a “Digital Chennai,” focusing on seamless data exchange between government departments and the development of an integrated project planning and management tool.

Dr. Ramachandran Balakrishna, Principal Transportation Scientist, Caliper Corporation provided a broad overview of digital twins while highlighting specific dimensions of critical significance to mobility. While narrowly-defined

digital twins are being developed around the world, there is a need for a framework that connects land use, travel demand and infrastructure supply models into a seamless, communicative framework that captures the complexities necessary to solve real-world problems. A well-crafted digital twin can assist with planning for various uncertainties in multi-modal networks, the interactions between human and freight mobility, electrification and autonomous vehicles, to name a few current challenges in the mobility landscape. Given the expansive scope of mobility ecosystems, it is important to build digital twins in phases, taking into account stakeholder inputs about the crucial unanswered questions that can provide short- and medium-term system-level and societal benefits. Managing model complexity,

assembling the appropriate data streams, and the judicious use of ML and AI are keys to a functional and evolving digital twin that will always remain useful as the ecosystem evolves in real-time. Though automatic or semi-automatic updates to the twin are both desirable and necessary, careful validation and sensitivity testing must be conducted periodically to ensure that the twin continues to accurately reflect the human responses and system phenomena it is expected to forecast.

While AI provides the intelligence layer to interpret data and drive decision-making, it needs a dynamic and responsive environment to operate within—this is where digital twins come in. The mobility challenges outlined earlier—congestion, inefficiencies in logistics, delays in emergency response, urban planning mismatches,



and rising emissions—require not just smarter analytics but also real-time, spatially aware systems that mirror the complexity of the real world. Digital twins act as high-fidelity virtual replicas of physical systems, enabling governments and planners to simulate, predict, and respond to mobility issues before they escalate. When combined with AI, these tools unlock a powerful capability: continuously learning, adjusting, and optimizing urban mobility networks in ways that are proactive, not reactive.

These models are built at various levels and layers, potentially accumulating to create a digital twin for a whole city.

Digital twins serve multiple purposes in mobility:

- **Transport Planning:** They can support planning for long horizons (e.g., 20-25 years). Unlike traditional methods relying on infrequent surveys, digital twins can provide real-time feedback for dynamic planning, perhaps monthly or every six months.
- **Strategic Infrastructure Planning:** They help identify optimal locations for infrastructure like depots or multimodal hubs.
- **Day-to-Day Operations:** Digital twins are valuable for managing traffic and congestion in real-time.
- **Simulation and “What If” Scenarios:** Hand-in-hand with simulators, digital twins allow the evaluation of various

scenarios and the impact of different interventions or models.

- **Understanding Problems and Testing Solutions:** They enable stakeholders to understand mobility problems (e.g., origin-destination patterns of trucks in a port city) and test potential solutions rapidly, getting feedback.
- **Monitoring Urbanization:** Digital twins can incorporate data on urbanization, which is tightly coupled with transportation.

Building digital twins requires data – historic, time series (from sensors), and real-time data. Integrating data from diverse sources of varying quality and standards is a challenge. **Standards and open APIs are essential** for interoperability and enabling the platform to integrate new services and vendors. Deriving or using data to inform the units and structure of the digital twin is a key consideration.

Digital twins offer potential benefits, including quantifiable economic gains. From an individual’s perspective, a major benefit is **savings in journey time** due to network-wide visibility and the ability of the system to react to congestion in real-time. Efforts are underway to develop digital twin initiatives, such as DoT’s Sangam Digital Twin Initiative, aiming to make data accessible and available while preserving privacy. Synthetic data is being explored to allow developers to experiment and build models without compromising privacy.



4. The Foundation: Data and Digital Public Infrastructure

Dr. Ajay Gummalla, Co-founder-Vice President, Bedrock Robotics The synergy of data and digital infrastructure will fundamentally reshape mobility, offering users personalized, efficient, and seamless travel experiences. For urban planners, this evolution enables data-driven decision-making, facilitating the design of smarter, more sustainable, and resilient transportation systems. This ultimately creates a continuous feedback loop, refining urban planning strategies in response to real-world dynamics.

Mr. Krishnan Karunganni, Program Delivery, IITM outlines that mobility architecture should enable movement of passengers and freight from source to destination, choosing most suitable modes of mobility, is safe, ensures arrival on time and the cost is optimal. The mobility solution design approach ensures holistic thinking and action that ensures the right balance between 4Es:

Engineering, Economics, Environment and Experience.

To make AI-powered mobility solutions and digital twins truly effective, the underlying foundation of high-quality, standardized, and accessible data must be in place. AI cannot function without reliable inputs, and digital twins are only as accurate as the data that feeds them. Building this data backbone requires a shift toward Digital Public Infrastructure (DPI)—open, interoperable, and secure systems that serve as public goods. The Bharat Multi-Modal Mobility Stack (BM3S) aspires to be such a foundation, enabling the ecosystem of governments, businesses, and citizens to co-create scalable, multimodal, and inclusive mobility solutions. Without this infrastructure, AI and digital twins remain fragmented pilots; with it, they become transformative tools.

Data is not only the “core” but also often the biggest problem in mobility. While AI models are powerful, their effectiveness is limited without sufficient and high-quality data. Data collection and standardization are crucial challenges. Different parts of the country may use different standards, and agreeing on common standards is necessary. Data quality can be poor, hindering analysis and research.

The concept of **Digital Public Infrastructure (DPI)** and Digital Public Goods (DPGs) is seen as a means to revolutionize mobility. DPI involves building foundational digital capabilities for public purposes, fostering an innovative ecosystem. Key principles for DPI include interoperability, trusted and secure design, agility, scalability, and being open source. The ownership of such infrastructure should ideally



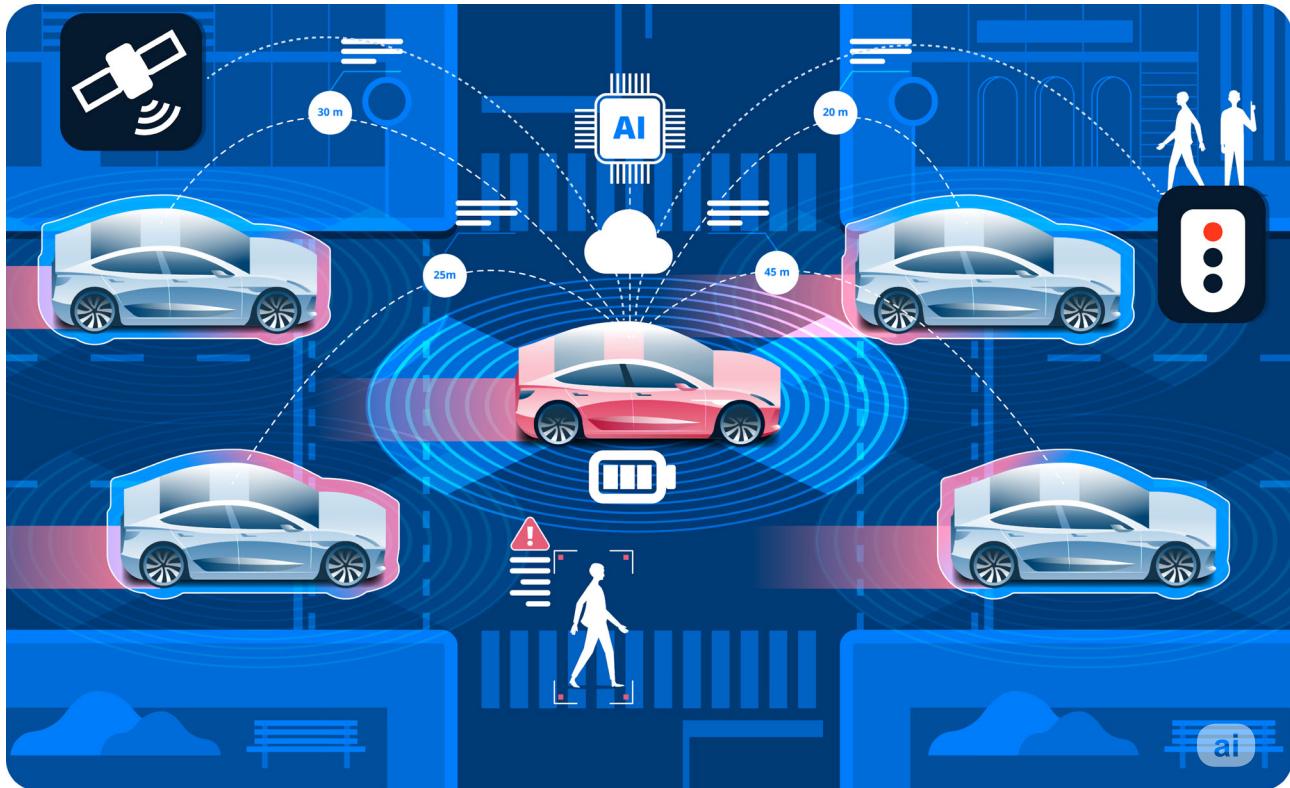


reside with taxpayers. Open data policies are crucial to make public data available for innovation.

The **(BM³S) Bharat Multi-Modal Mobility Stack** is an aspiration that aligns with this DPI approach. It is envisioned as a system-wide stack that supports multimodality and is a multi-stakeholder problem involving governments, businesses, academics, and entrepreneurs. Community-driven efforts are suggested for building

fundamental technical layers. A legal layer is also needed to handle policies and regulations. The aim is to enable the kind of innovation and momentum seen with platforms like UPI.

Integration and adoption of these platforms have been significant challenges. Balancing the long-term goal of building a comprehensive platform with the immediate need to deliver use-case-based solutions and drive uptake is necessary.



5. AI Use Cases in Mobility (Safety, Freight, and Air Mobility)

Dr. Subramani Ramakrishnan, Vice President, UPS shared how they use their own systems' data for operations, providing **real-time visibility** for enhanced customer service. He mentioned exploring use cases like optimizing fuel stops based on real-time fuel prices.

Mr. Krishnan Narayanan, Co-founder and President, itihaasa Research and Digital emphasized AI's rising role in mobility—highlighting global examples, India's logistics challenges, and safety improvements. He steered discussions on AI in driver rating, traffic prediction, autonomous vehicles, and railways, underscoring the need for collaboration, real-world application, and responsible deployment.

Mr. Mahesh Krishnamurthi, Co-Founder, Vayu Robotics shared insights on building AI-powered delivery robots with a focus on inherent safety through

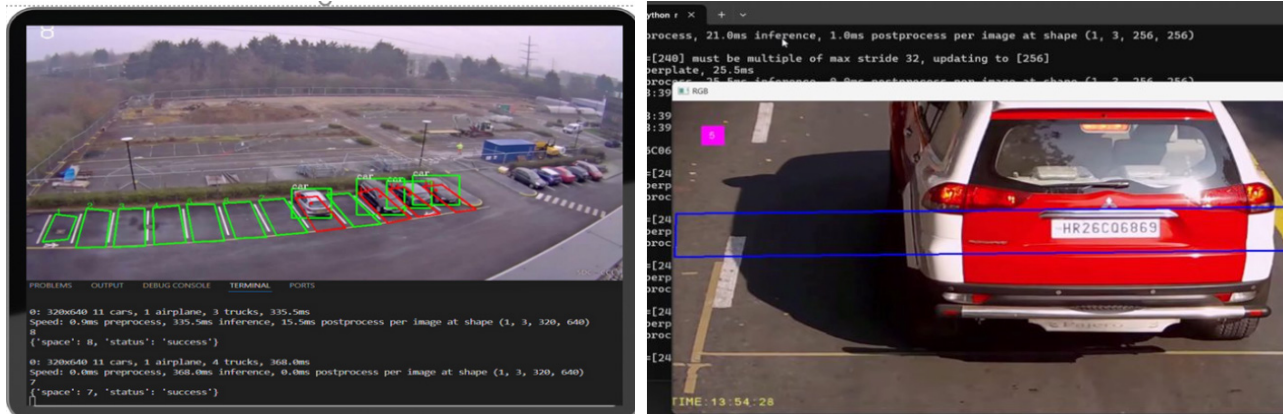
lightweight, low-speed designs. He emphasized the use of simulation for training machine learning models, enabling capital efficiency and exposure to rare, high-impact scenarios. He highlighted platforms like Omniverse, Carla, and Moku, noting that variation in simulation is more important than realism to accelerate learning.

AI is playing a transformative role in the mobility sector, driving advancements across safety, freight, and emerging air mobility systems. In freight and logistics, AI enables real-time operational visibility, dynamic route optimization, and predictive decision-making, such as adjusting fuel stops based on current market conditions. In the realm of safety, AI applications like driver behavior monitoring, wrong-way detection, and rash driving alerts leverage computer vision and deep learning to proactively reduce accidents. Simulation-based

training for AI models is gaining prominence, especially for rare or high-impact scenarios, enhancing the robustness of autonomous and semi-autonomous systems. In rail and public transport, reinforcement learning is being explored to optimize waiting policies and capacity utilization. Across all domains, human-in-the-loop approaches, responsible deployment, and integration with policy frameworks are critical to ensure that AI contributes to safer, more efficient, and inclusive mobility ecosystems.

AI is not just enhancing existing systems – it is redefining the boundaries of what’s possible in mobility. From the warehouse floor to aerial delivery corridors, intelligence is becoming embedded at every node of movement. The shift is no longer about automation alone, but about augmenting human decision-making with foresight, precision, and adaptability.





6. MInT Mobility Hackathon 2024:

Recognizing the challenges posed by the exponential growth in vehicles, the TechUniters team developed ParkSync to address the **need for efficient parking management**.

Addressing a critical urban issue, the Zoneguard project tackles **traffic congestion that severely impacts emergency and priority vehicles**, such as ambulances.

TechUniters (Winner): Real-time Inventory on Cars and Bikes (ParkSync)

Improper parking and vehicles searching for spots contribute significantly to traffic congestion, increased fuel usage, and carbon footprint. ParkSync is presented as a **real-time inventory system for cars and bikes** that aims to improve existing parking infrastructure and space utilization through a streamlined, cost-effective, and scalable process tailored for Indian conditions. This approach allows the system to potentially **eliminate the need for traditional sensor-based systems** while leveraging the benefits of existing surveillance infrastructure.

The solution is integrated with a user-friendly mobile application, the ParkSync app, which enables users to **book, reserve, and manage their parking bookings**. It provides features like real-time availability updates based on the detection model.

Key features demonstrated include real-time availability, reservation workflows (including payment processing triggered by an input validation model), slot number revelation before booking time, navigation assistance, and the ability for users to **extend their booking time**. The system incorporates a **Number Plate Recognition (NPR) system** to control vehicle entry based on bookings.

Importantly, the system is designed to handle potential conflicts, such as booking extensions, by implementing a **reallocation algorithm** to seamlessly assign alternate spots when needed.

A functional prototype has been developed and tested, demonstrating the system's viability. Data collection was acknowledged as a key component, with models being the 'glamour' but **data being the core**.

The project showcased a high level of technical capability and the potential for this parking solution to be scaled and potentially form part of a **digital public infrastructure (DPI)**

Zoneguard (Runner-up): Automated Traffic Management near Schools/ Hospitals

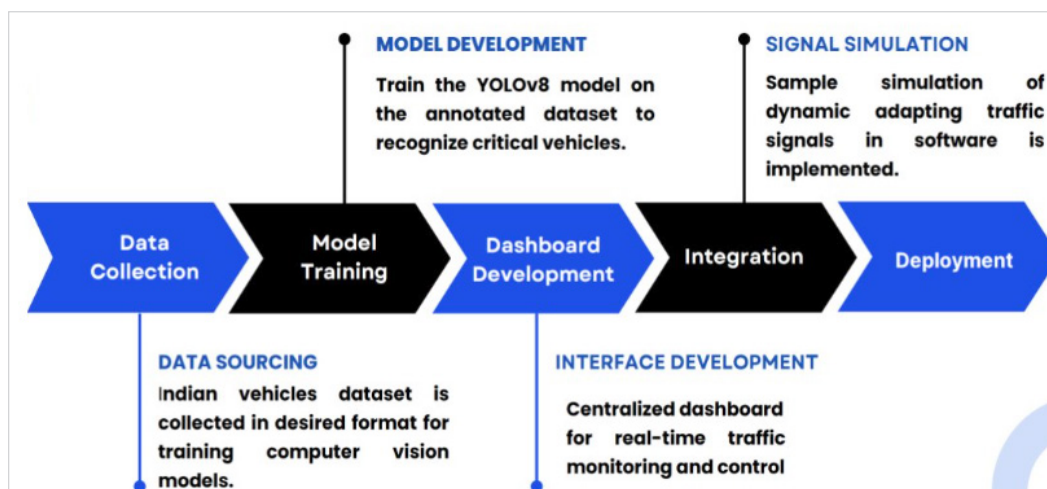
The problem is particularly acute near schools during peak hours and is worsened by fixed-time traffic signals. Real-world examples, like ambulances being stuck in Chennai traffic, underscore the urgency of finding solutions that also ensure public safety. Zoneguard proposes a **smart traffic**

management system designed to ease congestion and streamline the flow of emergency vehicles using real-time analytics. Their solution is an **AI-powered system** that can detect priority vehicles in real-time and dynamically adjust traffic signals.

The system includes a **dynamic control mechanism that simulates how traffic signals would change** to prioritize detected emergency vehicles. A **centralized dashboard** was developed as the front-end, enabling continuous real-time traffic monitoring, vehicle count retrieval, and aiding effective traffic control decisions.

Although currently running in a simulated environment, the system has demonstrated promising results in dynamically changing traffic lights based on ambulance detection.

The project showcased high technical capability and highlights the **potential for such solutions to evolve into small-scale digital public infrastructure (DPI)** that could be replicated across different cities.





7. Future Vision: Laying the Digital Foundation for India's Mobility Future

Dr. Ramakrishna Srinivasan and Prof. Gitakrishnan Ramadurai, who are leading the MIAT Collaborative effort, spoke at the conclusion of the MIAT Summit about the objectives and vision for MIAT in the coming year. Below are key excerpts from their discussion, capturing the direction they envision for India's mobility ecosystem.

Dr. Ramakrishna Srinivasan: This has been an exciting summit, Gita. What do you see as the main takeaways from the discussions? Where should we begin as we move forward?

Prof. Gitakrishnan Ramadurai: What stood out to me was the strong interest from multiple stakeholders—government, industry, academia—all aligned around the importance of AI and big data in enabling future mobility solutions. The use of these technologies was clearly seen as essential, not optional.

Dr. Ramakrishna Srinivasan:

Absolutely. One strong message across sessions was the relevance and urgency of building a digital ecosystem around mobility. The integration of a mobility stack within the broader India Stack narrative was consistently reinforced. Would you agree?

Prof. Gitakrishnan Ramadurai:

Yes, completely. There's been a lot of optimism based on what India Stack has achieved—starting from UPI to ONDC, and even during COVID. It's built credibility in the transformative potential of digital public infrastructure. While ONDC has started touching mobility, we need to recognize that mobility is a much larger canvas—it requires a broader and more inclusive approach.

Dr. Ramakrishna Srinivasan:

Exactly. That's where MIAT is uniquely positioned. Our upcoming projects—especially around the creation of digital twins and setting standards—will help us understand the evolving nature of mobility systems. It's about designing the right protocols and architectures to enable this ecosystem.

Prof. Gitakrishnan Ramadurai:

Yes, and digital twins become the natural next step when we have real-time data streaming in from sensor networks. With the right data infrastructure in place, we can dynamically monitor system health,

congestion, safety, and infrastructure gaps. The tech is ready—it's now about integrating it smartly.

Dr. Ramakrishna Srinivasan: And it won't be a one-dimensional ecosystem. I imagine a multi-layered system, with these digital twins interacting and informing each other through interoperable protocols. One of our core focuses this year will be to architect this digital mobility environment—layer by layer.

Prof. Gitakrishnan Ramadurai: Exactly. And our current projects give us real testbeds to begin shaping this. The insights we gather will directly inform the larger Bharat Multimodal Mobility Stack we're envisioning, in collaboration with our partners.





Dr. Ramakrishna Srinivasan: Another major highlight from the summit was the overwhelming support from government bodies—MeitY, DoT, MoHUA, CUMTA and other stakeholders. Their active participation and alignment with this vision was very encouraging. Our task this year is to convert that intent into institutional mechanisms and governance structures.

Prof. Gitakrishnan Ramadurai: Absolutely. There’s already a great deal

of alignment. Government is a crucial stakeholder in building digital public infrastructure—just as they were for UPI. But equally important is the role of industry. Mobility thrives when public and private sectors work in tandem.

Dr. Ramakrishna Srinivasan: Perhaps an inter-ministerial coordination mechanism could help move this forward. And we should also explore a sustainable institutional model—akin to the National Payments Corporation—for long-term stewardship of the mobility ecosystem.

Prof. Gitakrishnan Ramadurai: That’s a great direction. Honestly, I feel a renewed sense of energy—almost like a student at the start of something big. The potential is huge, and I look forward to working with the MINT team, our government partners, and the broader ecosystem to realize it.

Dr. Ramakrishna Srinivasan: So 2025 becomes the year of building—where aligned intent turns into collaborative action. Build for India, Solve for the World. Let’s see how far we can take this by the next summit in April 2026.

Prof. Gitakrishnan Ramadurai: Looking forward to it, Ramki!

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