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OMI FOUNDATION

Predict, Prevent, Protect:

An AI Roadmap for Safer Roads in Telangana and India

Futures Report

November 2025

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An AI Roadmap for Safer Roads in Telangana and India

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A Futures Report By

ITS India Forum

&

OMI Foundation Trust

President's Message

Akhilesh Srivastava
President,
ITS India Forum

India is at the cusp of an intelligent safety revolution. With over 150,000 lives lost annually to road crashes, the time has come to apply intelligence - not only infrastructure - to **protect every road user**.

Artificial Intelligence (AI) now enables what manual enforcement cannot: the ability to **predict, prevent, and protect in real time**. This Futures Report, ***Predict, Prevent, Protect: An AI Roadmap for Safer Roads in Telangana and India***, lays out how technology, governance, and public purpose can converge to *achieve Vision Zero - no deaths on Indian roads*.

The findings are clear and actionable. First, **AI-based enforcement systems** - using *computer vision, automated number plate recognition, and behavioral analytics* - must move from pilots to full-scale deployment across cities and national highways. Second, **predictive analytics for blackspot and grey-spot management** must become the *backbone of road engineering*, ensuring that no crash is treated as an isolated event. Third, **ADAS and driver monitoring systems across public and freight fleets** can turn every vehicle into a node of intelligence - detecting risk before disaster strikes. Fourth, **dynamic driver scoring and incentive frameworks** can replace fear-based enforcement with *data-driven accountability and reward*.

The report also underscores what the **ITS community** has long emphasized: **intelligent transport is not merely about algorithms; it is about governance**. The proposed institutional model for **AI in road safety**, anchored by a **state lead agency and inter-agency task force**, offers a replicable **blueprint** for other states. The focus on *capacity building, standardization, and assurance frameworks* ensures that India's AI systems remain safe, transparent, and equitable.

Telangana's pioneering initiatives - **Hyderabad's AI-enabled ITMS, the iRASTE project, and the integration of TGSRTC fleets with ADAS** - demonstrate India's readiness to lead globally in AI-driven safety. The challenge now is to scale these innovations through sustained investment, interoperable standards, and institutional continuity.

As President of the ITS India Forum, I am proud to see our collaboration with the **OMI Foundation** yield this forward-looking roadmap. Together, we have combined the insights of practitioners, technologists, and policymakers to chart a national path where intelligence safeguards life.

If implemented with urgency, the vision outlined here will mark a turning point in India's mobility story - *from reactive enforcement to predictive prevention, from individual responsibility to systemic safety.* Every camera, every sensor, every alert must serve a single purpose: saving lives. That is the true measure of intelligent transport, and the future we must build.

Foreword

Dr R.S.Sharma IAS (Retd.)
Former Chairman,
TRAI
Govt. of India

The intersection of artificial intelligence and public safety represents one of the most promising frontiers in India's digital transformation. As the nation advances rapidly toward a connected, data-driven future, we are reminded that technology must ultimately serve people - enhancing safety, trust, and quality of life. Nowhere is this more urgent or impactful than on our roads, where the human and economic costs of accidents weigh heavily on families and the nation.

The report ***Predict, Prevent, Protect: An AI Roadmap for Safer Roads in Telangana and India*** sets out a pragmatic framework for this transformation. It outlines how data analytics, intelligent transport systems, and cross-sector collaboration can enhance decision-making and strengthen institutional capacity. By harnessing AI and intelligent transport systems, India can shift from reactive enforcement to proactive prevention.

Experiences at TRAI, has shown that when technology is supported by robust governance frameworks, it can solve complex societal challenges at scale. The roadmap outlined in this report provides an exemplary case of that philosophy in action. It underscores the importance of ethical data use, interoperability, and inclusion, ensuring that innovation benefits every road user.

I congratulate the ITS India Forum and the OMI Foundation for this forward-looking work that serves as both a blueprint and a call to action. It represents rightly the kind of systemic, multi-stakeholder approach that will define the next decade of India's leadership in technology for good.

Foreword

Shri Giridhar Aramane, IAS (Retd.)
Former Secretary, Defence and Ministry of Road Transport and Highways.
Govt. of India

Road safety is not only a national policy priority, it is a fundamental responsibility towards the citizens of India. As the country urbanizes and digitizes at an unprecedented pace, the adoption of advanced technologies within governance frameworks has become vital to saving lives and enhancing public welfare. Telangana, as one of India's most innovation-driven states, has demonstrated how technology can be effectively leveraged to address complex societal challenges. Through the Telangana AI Mission (T-AIM), the State has established a robust platform for the responsible and inclusive adoption of Artificial Intelligence across sectors.

The Futures report ***Predict, Prevent, Protect: An AI Roadmap for Safer Roads in Telangana and India***, prepared by the ITS India Forum and the OMI Foundation, chart how Artificial Intelligence can redefine enforcement, engineering, and emergency response for safer mobility across Telangana and the nation.

Over the years, the Ministry of Road Transport and Highways (MoRTH) has taken pioneering steps in this direction, from AI-enabled enforcement and crash prediction to black spot identification. Initiatives such as the Integrated Road Accident Database (iRAD) and the Data Sharing Policy under the National Transport Repository have created a unified digital foundation for secure, responsible use of data across Vahan, Sarathi, e-Challan, FASTag, and other platforms. These systems now enable emerging AI applications for enforcement, driver behaviour analysis, and predictive black spot management.

This report offers a clear path from innovation to real impact. It reminds us that technology delivers its true value only when it improves everyday life when roads are safer, travel is predictable, and cities function with dignity and efficiency for all. If government, industry, and research institutions continue to collaborate with purpose, India can build mobility systems that stand as global benchmarks. The measure of our progress will be simple: fewer lives lost, fewer hours wasted, and greater trust in the systems that move our nation.

Foreword

Shri Rohit Kumar Singh IAS (Retd.)
Former Secretary, Ministry of Consumer Affairs; and Member, National Consumer Dispute Redressal Commission Govt. of India

India stands at a pivotal moment in its transportation journey. Over the past decade, we have expanded our road networks and mobility systems at an unprecedented pace. Yet, this progress has come with a tragic and persistent cost - the loss of more than 150,000 lives each year to road crashes. The magnitude of this challenge demands not only stronger laws and safer engineering, but also a paradigm shift in how we understand, predict, and prevent road risks.

This Futures Report, ***Predict, Prevent, Protect: An AI Roadmap for Safer Roads in Telangana and India***, represents precisely that shift. It demonstrates how Artificial Intelligence, data analytics, and intelligent infrastructure can together move us from reactive enforcement to predictive and preventive safety systems. By leveraging continuous data streams from vehicles, sensors, and road networks, AI offers the ability to identify hazards before they claim lives - a transformation long overdue in India's road safety framework.

From a governance standpoint, this approach aligns strongly with India's broader objective of citizen protection and public welfare. AI-driven safety solutions can enhance transparency, strengthen accountability, and ensure that road users - drivers, pedestrians, and vulnerable groups - are better protected. When deployed responsibly, these technologies complement traditional engineering, enforcement, and education frameworks, creating a comprehensive and more effective road safety system.

As India moves towards its commitment to halve road fatalities by 2030 under the UN Decade of Action for Road Safety, we must act with urgency and clarity. I commend the ITS India Forum and OMI Foundation for producing this timely and insightful report. I am confident that its recommendations will inspire policymakers, researchers, and industry leaders alike to harness AI responsibly - to predict risks, prevent crashes, and protect every life on India's roads.

Foreword

Ambassador (Retd.) Gautam Bambawale
Managing Trustee,
OMI Foundation

Harish Abichandani
First Trustee,
OMI Foundation

India stands today at a critical juncture in its mobility journey. While we have made unprecedented strides in expanding road networks, vehicle ownership, and urban connectivity, the human cost of unsafe roads remains unacceptably high. Road crashes claim over 150,000 lives in India each year, with millions more injured - undermining our social fabric and imposing enormous economic burdens. Addressing this challenge requires not only stronger enforcement and safer infrastructure, but also a fundamental rethinking of how technology can be harnessed to protect lives.

This Futures Report, ***Predict, Prevent, Protect,*** prepared by **OMI Foundation in collaboration with ITS India Forum**, presents a pioneering framework for the application of Artificial Intelligence (AI) in road safety enforcement. Drawing on global best practices and India's own pilot initiatives, it demonstrates how **predictive analytics, AI-enabled enforcement, and data-driven governance** can **shift our approach from reactive to preventive**, from fragmented interventions to a coherent Safe Systems model.

The state of **Telangana** provides the backdrop for this analysis. With its early leadership through initiatives such as iRASTE, Hyderabad's ITMS, and collaborations with academic and industry partners, Telangana illustrates what is possible when innovation, governance, and political will converge. At the same time, this report looks beyond the state, **offering a policy roadmap for scaling these solutions nationwide**. **By embedding AI** into enforcement, blackspot management, driver scoring, and institutional accountability, **India can take a decisive step towards halving fatalities by 2030**, in line with our commitments under the **UN Decade of Action for Road Safety**.

We believe this work reflects our commitment to shaping India's mobility and technology transitions with urgency, integrity, and inclusion. It is also a testament to the power of partnerships - between government, industry, academia, and civil society - in advancing systemic change. We hope the report reminds us all that **road safety is not a technical issue alone - it is a matter of human dignity and the right to life. Harnessed wisely, AI can be one of the most powerful tools in fulfilling that responsibility.**

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BIG BOSS
BIGGER & BETTER

Executive Summary

The Road Safety Crisis in India

India faces one of the world's gravest road safety challenges. Every year, between **150,000 and 170,000 people lose their lives** in road accidents - translating into nearly **20 deaths every hour** (Ministry of Road Transport and Highways, 2023). The majority of victims are young adults aged 18-34, cutting short lives in their most productive years and imposing long-term socio-economic costs. According to the World Bank, road accidents cost India an estimated **3-5% of GDP annually**, making them not just a public health crisis but also a development challenge (World Bank & SaveLIFE Foundation, 2021).

In Telangana, the problem is acute. In 2022, the state recorded **21,619 road accidents and 7,559 fatalities**, accounting for nearly **one in every 20 road deaths in India**. Highways, though representing a small fraction of the road network, are disproportionately deadly - responsible for around **40% of the state's road fatalities**. (Ministry of Road Transport and Highways, 2022) Rapid urbanization, rising vehicle ownership, and systemic issues such as overspeeding, poor lane discipline, low helmet use, and distracted driving have compounded the crisis. Despite stricter penalties under the **Motor Vehicles (Amendment) Act 2019** and extensive challan issuance by police, fatalities remain stubbornly high (Ministry of Law and Justice, 2019).

The conclusion is inescapable: **traditional enforcement and reactive measures are not enough**. To achieve the national goal of reducing fatalities by **50% by 2030**, Telangana and India must adopt transformative approaches rooted in technology, prevention, and systemic design (UN General Assembly, 2020).

Why Artificial Intelligence? A Shift from Reactive to Preventive Systems

Artificial Intelligence (AI), big data analytics, and intelligent infrastructure represent a paradigm shift in road safety. Unlike manual policing, which is selective and reactive, AI enables:

1. **24/7 automated enforcement** of traffic rules, reducing human bias.
2. **Real-time driver assistance**, helping avert accidents before they occur.
3. **Predictive analytics** to identify high-risk locations ("grey spots") even before they become blackspots.
4. **Data-driven governance**, linking enforcement, engineering, and education into a unified safety framework.

International examples demonstrate the potential: Sweden's **Vision Zero** reduced fatalities by more than 50% since 1997; New York City cut deaths by 30% in six years through smart enforcement; and the European Union is rolling out **Cooperative Intelligent Transport Systems (C-ITS)** to share real-time safety alerts.

Telangana is already at the forefront. The **iRASTE project** (Intelligent Solutions for Road Safety through Technology and Engineering), in collaboration with IIIT-Hyderabad, INAI, Intel, and TSRTC, has piloted AI-enabled Advanced Driver Assistance Systems (ADAS) on 200 buses, reducing accidents by **40%** and identifying over **60 "grey spots"** on highways. Hyderabad has deployed **AI-enabled ITMS** under the Smart Cities Mission, with millions of challans issued through automated detection. These initiatives provide a strong foundation to scale up.

The Framework: Three Pillars of AI-Based Road Safety

Pillar 1: AI-Enabled Enforcement

1. Deployment of **CCTV, ANPR, RLVD, and behavioral analytics** to detect speeding, red-light violations, helmet non-use, distracted driving, and lane indiscipline.
2. Automated e-challans linked to vehicle databases for swift, fair, and consistent enforcement.
3. Expansion from Hyderabad's ITMS to state highways and tier-II cities.

Pillar 2: Predictive Risk Identification (Blackspots and Grey Spots)

1. Use of **iRAD accident data, ADAS telematics, and crowdsourced reports** to map accident-prone areas.
2. Identification of "grey spots" based on near-miss data before they escalate into blackspots.
3. At these high-risk locations, predictive insights must be paired with **physical countermeasures such as crash-rated barriers, cable barriers with energy absorption, raised pedestrian walkways, and protective bollards** to ensure that design improvements complement AI-driven enforcement.
4. Integration of predictive analytics into **routine planning** of roads and buildings (R&B) Department and NHAI.
5. Publication of a **Dynamic Road Safety Map** tracking blackspot remediation.

Pillar 3: Real-Time Risk Detection and Driver Scoring

1. Scaling ADAS and Driver Monitoring Systems (DMS) in public and freight fleets.
2. Real-time driver alerts for collision risk, drowsiness, overspeeding, and lane departures.
3. Introduction of a **driver scoring and rewards system**, incentivizing safe driving behavior.
4. Integration with insurance (usage-based discounts), fleet bonuses, and state-led recognition programs.

Technical and Governance Foundations

Infrastructure and Data Platforms

1. A **layered architecture** of cameras, in-vehicle sensors, communication networks (fiber, 4G/5G, C-V2X), and AI analytics platforms.
2. A unified **Road Safety Data Platform** integrating iRAD, ITMS, ADAS telemetry, and citizen reports.
3. Open APIs to enable startups, researchers, and private players to innovate.
4. Public Dashboards: high-level statistics for transparency and awareness.
5. Infrastructure foundations should also include **crash-tested safety barriers and bollards in both highways and dense urban areas**. These must be installed to global standards (MASH/EN1317/ASTM F3016) and maintained regularly, ensuring that digital enforcement is reinforced by physical protections for vulnerable road users.

Governance and Stakeholders

1. Strengthening the **State Road Safety Cell** as the lead coordinating agency.
2. Clear roles for **traffic police (enforcement), R&B/NHAI (engineering fixes), GHMC (urban roads), and TGSRTC (fleet pilots)**.
3. Academic and industry partners (IIIT-H, IIT-H, INAI, Intel) for R&D, model training, and audits.
4. Consideration of a **dedicated Road Safety Authority** for long-term institutionalization.

Monitoring and Evaluation

1. KPIs covering accident reduction, driver behavior change, enforcement accuracy, and system uptime.
2. Independent audits by academic institutions.
3. Annual "**Road Safety Report Cards**" for transparency and citizen trust.
4. Adaptive learning loops to refine AI models and intervention strategies.

Roadmap: Telangana and India

For Telangana

1. Scale AI enforcement to all cities and highways.
2. Mandate ADAS in TGSRTC buses and incentivize freight fleets.
3. Institutionalize predictive blackspot/grey spot management.
4. Establish an integrated road safety data platform.
5. Launch a statewide driver scoring and rewards program.

For India

1. Develop **national standards for AI enforcement, ADAS, and driver scoring**.
2. Mandate AI-enabled electronic enforcement on all high-fatality corridors.
3. Ring-fence and expand financing from Road Safety Funds and insurance partnerships.

4. Create a **National Centre for AI in Road Safety** for R&D and training.
5. Position India as a **global leader in Vision Zero**, using Telangana as a demonstration state.

The Promise of AI for Road Safety

If implemented with urgency and discipline, Telangana can reduce fatalities by **50% by 2030**, directly contributing to India's international commitments under the UN Decade of Action for Road Safety. The state's success can provide a **replicable blueprint** for other states, showing how AI can transform enforcement, predict risks, and protect citizens.

More broadly, AI-based road safety systems align with India's vision of **smart mobility and digital governance**. The same technologies that improve traffic efficiency and urban management can save lives, reduce economic losses, and build public trust in digital governance. Furthermore, AI and data systems will be most effective when combined with **globally benchmarked crash barriers, medians, and pedestrian protection**, creating a Safe Systems approach that is predictive, preventive, and protective.

The Road Ahead

Road safety is no longer a peripheral issue of enforcement - it is central to public health, economic productivity, and citizen well-being. Telangana's early pilots prove that **AI works**: it saves lives, reduces crashes, and creates a culture of safe driving.

The challenge now is to **scale with speed and sustain with commitment**. By embedding AI into its road safety framework, Telangana can become a **national leader** and a **global example** of how emerging economies can leapfrog to Vision Zero. For India, adopting and replicating this model is not just a policy option - it is a moral imperative to save tens of thousands of lives each year.

1. Introduction

1.1. Road Safety as a Public Health Crisis

Road traffic injuries have reached epidemic proportions in India, making road safety one of the country's most urgent public policy and public health challenges. Each year, **150,000-170,000 people die in road accidents**, equivalent to nearly **20 deaths every hour** - one of the highest tolls in the world (Ministry of Road Transport and Highways, 2023).

In Telangana, the situation mirrors the national crisis. In **2022 alone**, the state recorded **21,619 accidents and 7,559 fatalities**, accounting for nearly **5% of India's road deaths** (Ministry of Road Transport and Highways, 2022). This translates to **over 60 accidents and 20 deaths every day**, disproportionately affecting young adults aged **18-34 years**, who represent nearly 60% of all victims. The loss is not only human but economic - robbing families, communities, and the state of their most productive members.

1.2. Persistent Risky Behaviors

Despite incremental improvements in enforcement, the overall accident burden remains stubbornly high.

In Telangana, enforcement is extensive - Hyderabad police issued **15 million challans in 2024**, collecting over **₹535 crore in fines** (Telangana Today, 2025). Yet violations remain rampant:

- Overspeeding and red-light jumping
- Riding two-wheelers without helmets
- Drunk driving
- Driving while using mobile phones
- Poor lane discipline and unsafe parking of heavy vehicles

These behaviors reveal systemic issues that **cannot be solved by manual policing alone**.

1.3. Urbanization and Highway Risks

Rapid motorization and urban growth have compounded the challenge. The **Hyderabad Metropolitan Area** has seen an explosion of private vehicles and two-wheelers, while **national highways crisscrossing Telangana** carry dense flows of buses, cars, and heavy trucks.

Highways are especially dangerous: in 2022, Telangana recorded **7,505 highway accidents and 3,010 deaths**, meaning **40% of fatalities occurred on a small fraction of the road network** (Ministry of Road Transport and Highways, 2023). Traditional remedial actions - such as fixing spots only after repeated crashes - have proven too slow to save lives.

1.4. Policy Commitment at National and State Levels

India is a signatory to the **UN Decade of Action for Road Safety** and has pledged to reduce road fatalities by **50% by 2030**, aligning with the long-term **Vision Zero** framework. Telangana has taken steps in this direction:

- Establishing a **State Road Safety Council** and Lead Agency (2015)
- Identifying **175 blackspots** on highways and initiating remedial works
- Enforcing tougher penalties under the **Motor Vehicles (Amendment) Act, 2019**
- Suspending **15,000+ licenses** for drunk driving and overspeeding since 2015

While these measures are important, they remain insufficient in scale and speed given the magnitude of the crisis.

1.5. The Case for Technology and AI

Manual enforcement has inherent limits: it is **selective, reactive, and resource-intensive**. By contrast, **AI and data-driven systems** offer three major advantages:

1. **Scale**: AI-enabled cameras and sensors can monitor thousands of vehicles simultaneously.
2. **Predictive capability**: Data analytics can identify risky zones ("blackspots" and "grey spots") before fatal accidents occur.
3. **Real-time intervention**: Advanced Driver Assistance Systems (ADAS) can issue immediate alerts to avert crashes.

These solutions allow a shift from **reactive enforcement** to a **preventive and predictive system**.

1.6. Lessons from Global Leaders

Global experiences validate this transition:

- **Sweden's Vision Zero**: Halved fatalities since 1997 through systemic, technology-driven safety design.
- **New York City**: Achieved a **30% reduction** in traffic deaths in six years with smart enforcement.
- **European Union C-ITS**: Vehicles and infrastructure continuously exchange safety warnings, preventing accidents in real time.

The common lesson: **integrating technology with enforcement, engineering, education, and emergency response** creates lasting safety gains.

1.7. Telangana's Emerging Innovation Ecosystem

Telangana is uniquely positioned to lead India's transition to **AI-enabled road safety**. Initiatives already underway include:

- **iRASTE project** with IIIT-Hyderabad, INAI, Intel, and TSRTC: deploying AI-powered devices in buses, reducing accidents by 40%, and identifying predictive "grey spots."
- **Hyderabad Smart Cities ITMS**: thousands of CCTVs enforcing traffic rules in real time.
- **AI innovation challenges** (e.g., GHMC's pothole detection competition) that mobilize local startups and academia.

These create a **strong foundation** to build a statewide AI-based enforcement framework.

1.8. The Urgency to Act

The human and economic costs of inaction are staggering. The World Bank estimates road crashes cost India **3-5% of GDP annually** through lost productivity, healthcare, and congestion. (World Bank & SaveLIFE Foundation, 2021) Each accident prevented represents **lives saved and livelihoods protected**.

With strong political will, inter-agency coordination, and a bold adoption of AI-driven enforcement, **Telangana can become a national model**, demonstrating that technology, governance, and citizen engagement together can save thousands of lives and bring Vision Zero within reach.

Figure 1: A busy traffic junction well poised for AI-enabled Road Safety integration.

2. AI-Based Enforcement Framework

2.1. Rationale for AI Enforcement

A cornerstone of Telangana's road safety strategy is the transition from **manual, selective policing** to **AI-based enforcement**. Traditional enforcement is constrained by manpower, subjectivity, and post-facto interventions. By contrast, AI systems offer:

1. **24/7, unbiased monitoring** across the network.
2. **Real-time detection and deterrence** of violations.
3. **Automated, evidence-based penalties** that strengthen rule compliance.

This aligns with Section 136A of the Motor Vehicles (Amendment) Act, 2019, which mandates states to deploy **electronic enforcement devices** on high-risk corridors (Ministry of Law and Justice, 2019; Ministry of Road Transport & Highways, 2022).

2.2. Core Enforcement Technologies

Telangana can leverage a layered enforcement system comprising cameras, sensors, and AI analytics:

1. **Closed-Circuit Television (CCTV) Network:** High-resolution cameras at intersections, highways, and accident-prone stretches form the surveillance backbone. Hyderabad's Command and Control Center already integrates thousands of feeds.
2. **Automated Number Plate Recognition (ANPR):** Reads license plates and links violations to vehicle owners, generating **e-challans** instantly. Already operational on Hyderabad's Outer Ring Road for speed enforcement.
3. **Red Light Violation Detection (RLVD):** Cameras at junctions automatically detect signal-jumping, paired with ANPR for ticketing.
4. **Speed Enforcement Systems:** Fixed cameras, radar guns, and point-to-point average speed detection, especially critical on highways where overspeeding is a leading cause of fatalities.
5. **Computer Vision Analytics:** Deep learning models can detect:
    a. Helmet and seatbelt non-compliance (≥98% accuracy in pilot models). (Deshpande et al., 2025)
    b. Mobile phone use and driver distraction.
    c. Lane indiscipline, wrong-way driving, and illegal parking.
    d. Stopped vehicles on highways that pose accident hazards.
6. **Emerging Tools**
    a. **Drones** for aerial monitoring during peak hours or events.
    b. **Mobile surveillance units** in police vehicles with AI-enabled feeds.

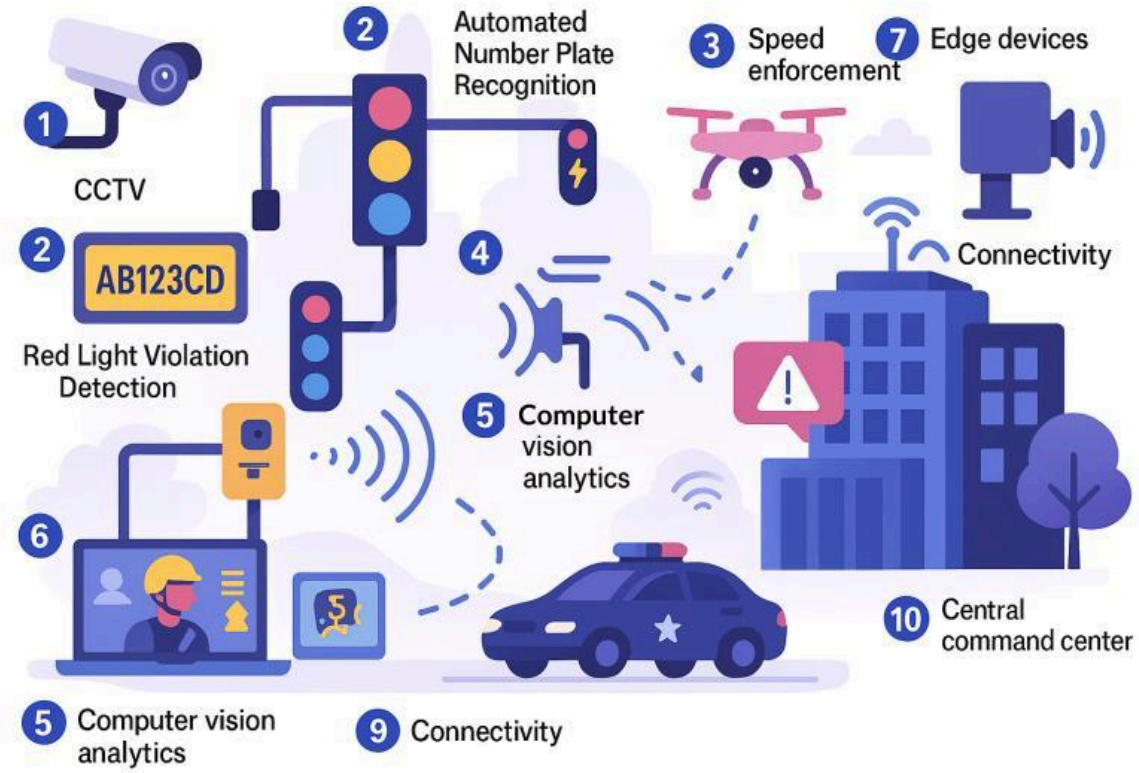
2.3. System Architecture and Workflow

AI enforcement follows a **multi-layer architecture**:

1. **Edge Devices**: Cameras and sensors capture and process raw video/images locally.
2. **Connectivity Layer**: Optical fiber in cities, 4G/5G on highways transmit processed events.
3. **Central Command Center**: Aggregates data, verifies offenses, issues e-challans.
4. **Data Analytics Platform**: Stores violations, identifies repeat offenders, and generates risk heatmaps.

Importantly, **automation reduces human bias**, ensures quicker challan delivery (often within minutes), and increases the **certainty of punishment**, a proven deterrent.

Figure 2: Diagram illustrating technologies and architecture of AI-based road safety enforcement



Source: Authors; AI-generated image.

2.4. Evidence of Impact in Telangana

In 2024, the Hyderabad Traffic Police issued an average of **154,338 traffic challans per day** through a combination of manual surveillance, CCTV monitoring, and automated enforcement systems to enforce traffic rules and enhance commuter safety. Of these, nearly **2,000 challans per day** were generated using Automatic Number Plate Recognition (ANPR)

cameras, underscoring the growing adoption of smart technologies for traffic regulation, which have demonstrated both scalability and effectiveness (Murthy, 2025).

2.5. Policy and Equity Considerations

While AI enforcement promises safer roads, its success depends on addressing social and legal dimensions:

1. **Accuracy and Fairness:** Each e-challan must include photographic evidence to minimize disputes. AI models should undergo independent validation (e.g., accuracy audits by IIIT-H/IIT-H).
2. **Data Privacy and Security:**
    a. Compliance with emerging **Digital Personal Data Protection Act** norms (Ministry of Law and Justice, 2023).
    b. Clear data retention policies (e.g., delete footage after X months unless linked to an active case).
    c. Strong cybersecurity protocols against misuse or tampering.
3. **Equity in Enforcement**
    a. Fines disproportionately affect low-income road users, especially two-wheeler riders. Options include **graduated penalties** or **safety incentive schemes** (linking driver scoring with rewards).
    b. Ensure enforcement is not concentrated only in urban zones; rural and peri-urban roads also require coverage.
4. **Public Awareness and Acceptance:** Transparent communication - “Smart cameras save lives, not just issue fines” - is critical to build public trust.

2.6. The Shift from Reactive to Proactive

AI enforcement creates an environment of **consistent, round-the-clock deterrence**, fostering a culture of compliance. Over time, this shift:

- Reduces dangerous driving behaviors.
- Protects vulnerable groups like pedestrians and two-wheeler riders.
- Frees up police personnel for **on-ground safety tasks** rather than routine monitoring.

3. Identification of Accident-Prone Zones

3.1. Why Blackspot Identification Matters

A relatively small share of road segments accounts for a disproportionate number of serious crashes. These **accident blackspots** - locations with abnormally high accident frequency or severity - are among the most effective targets for road safety interventions.

MoRTH defines a blackspot on National Highways as:

- A **500-meter stretch** with ≥**5 accidents involving fatalities/serious injuries**, or
- ≥**10 fatalities** over the past **3 years**.

In Telangana, over **175 blackspots** have already been identified on national and state highways. However, the current system is **reactive** - it requires accidents to accumulate before action is taken.

3.2. Limitations of Traditional Approaches

1. **Time lag**: Remedial action occurs only after multiple crashes.
2. **Manual data challenges**: Reliance on police FIRs and field inspections slows analysis.
3. **Fragmented accountability**: Multiple agencies (police, highways, R&B, urban bodies) often act in silos.

This approach results in delayed interventions and missed opportunities to **prevent accidents before they happen**.

3.3. AI-Enabled Predictive Analytics

AI and data-driven methods can transform blackspot management by shifting from **reactive** to **predictive and preventive**:

a) Data-Driven Identification

1. **Integrated Road Accident Database (iRAD)**: Digitized police FIRs with GPS tagging provide granular accident data.
2. **Hotspot Clustering**: AI algorithms (e.g., DBSCAN) identify statistically significant clusters of crashes normalized for traffic exposure.
3. **Multivariable Analysis**: Machine learning incorporates road geometry, lighting, traffic mix, roadside hazards, and temporal factors to highlight risk-prone stretches.

b) Grey Spot Detection (Preventive Action)

Pioneered by Telangana's **iRASTE project**, **grey spots** are **locations not yet officially blackspots but showing early warning signals**:

1. Near-misses detected by in-vehicle ADAS sensors (e.g., sudden braking, lane deviation, collision warnings).

2. Crowdsourced inputs from navigation apps or citizen reporting.
3. AI-based road condition analysis (e.g., detecting potholes or poor signage from video feeds).

In 2022-23, iRASTE used TSRTC bus data to identify **60 grey spots** across three highway corridors, enabling preventive interventions before fatalities escalated (Government of Telangana et al., 2024).

Figure 3: A snapshot of iRASTE making roads safer using AI

Source: Department of Science and Technology, n.d.

3.4. Diagnosis and Virtual Testing

Once high-risk sites are flagged:

1. **Pattern Analysis**: E.g., sharp curves + overspeeding = high rollover risk.
2. **AI Simulation Tools**: Micro-simulations test potential solutions virtually (e.g., impact of adding signals, rumble strips, or roundabouts).
3. **Evidence-based Remedies**: Engineering fixes such as speed calming, improved signage, lighting, or re-engineered curves. In addition to signage and geometric fixes, highway interventions should include **crash-rated barriers (MASH or EN1317 compliant), high-tension cable barriers for energy absorption, and raised pedestrian walkways/ foot overbridges** at unavoidable pedestrian crossings. **Wide clear zones** with protective fencing and **bollards at highway access points** can further reduce conflicts between high-speed traffic and pedestrians.

3.5. Continuous Monitoring and Dynamic Index

Blackspot management should not be one-off. AI allows:

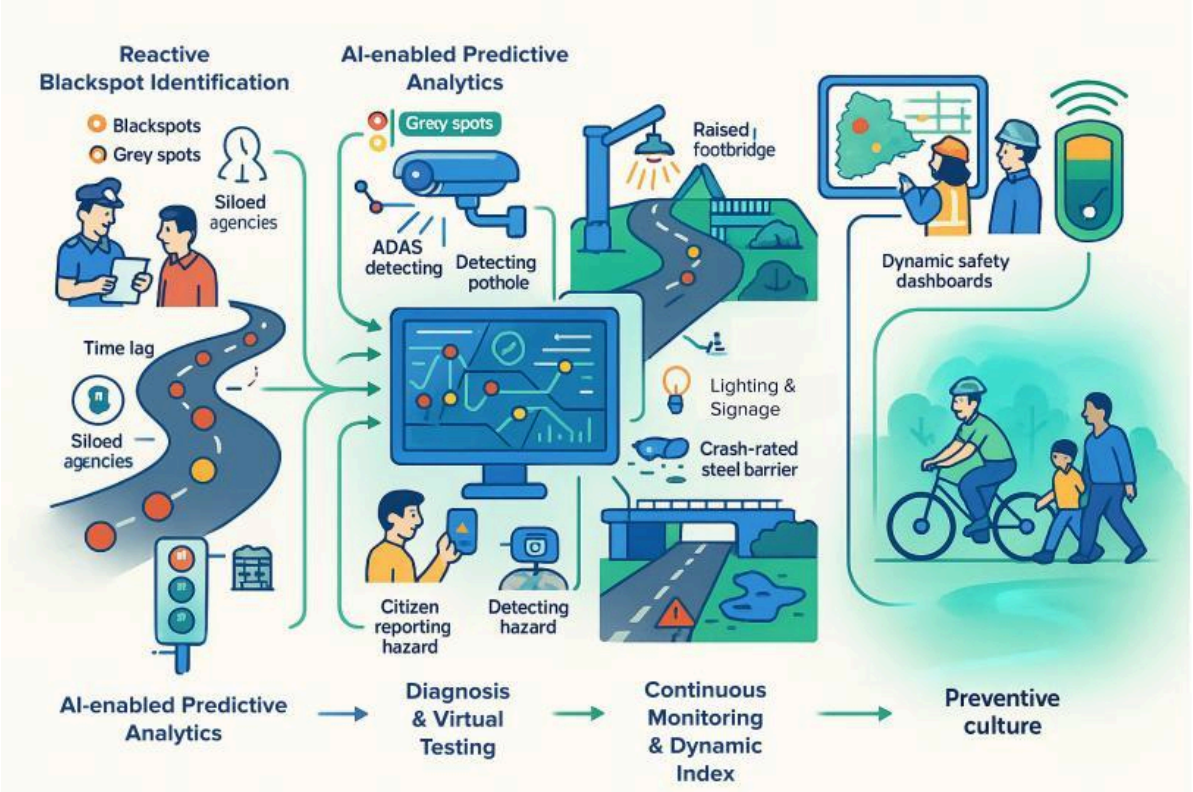
1. **Before-after evaluation**: Measure whether accidents and near-misses reduce after interventions.
2. **Dynamic Road Safety Index**: Update blackspot and grey spot lists in real time, integrating accident data, driver behavior analytics, and road condition mapping.
3. **Public dashboards**: Publishing high-risk corridors builds awareness and transparency.

3.6. Institutional Responsibilities

Effective blackspot management requires **coordinated, multi-agency action**:

1. **Traffic Police/ Transport Dept.**: Collect accident/enforcement data, feed into iRAD, share with analytics teams.
2. **Road Owning Agencies** (NHAI, R&B, GHMC): Implement engineering remedies and integrate AI insights into routine maintenance.
3. **Lead Agency/ Road Safety Cell**: Track rectification progress, publish safety maps, ensure accountability.
4. **Academic Partners** (IIT-H, IIIT-H, CRRI): Conduct technical audits, validate AI models, assist with diagnostics.
5. **Local Communities and NGOs**: Provide citizen feedback on hazardous stretches and monitor rectification efforts.

Figure 4: AI-Enabled Blackspot Management Framework



Source: Authors; AI-generated image.

3.7. Moving from Reactive to Preventive

Through AI-enhanced blackspot and grey spot programs, Telangana can:

1. Identify hazards **before lives are lost**.
2. Implement quick fixes backed by predictive data.
3. Reduce systemic risks even if human error occurs - core to the **Safe Systems approach**.

Every grey spot treated represents **potential lives saved** and a shift towards a **proactive culture of prevention** rather than post-accident reaction.

Preventive measures should also extend to **infrastructure hardening**, ensuring that both highways and urban arterials are equipped with **crash-tested barriers, bollards, and protected pedestrian zones**, prioritized using blackspot/ grey spot analytics.

4. Real-Time Risk Detection and Driver Scoring

4.1. The Human Factor in Road Safety

While infrastructure and enforcement shape safer environments, **human error and risky behavior** account for 84% of crashes in India. (ITS India Forum, 2025). Addressing this requires both **real-time corrective systems** and **long-term behavioral incentives**.

This section proposes a **two-pronged approach**:

1. **Real-time risk detection and driver assistance** to prevent immediate crashes.
2. **Dynamic driver scoring with incentive systems** to promote sustained safe driving habits.

4.2. Real-Time Risk Detection and Alerts (ADAS)

Advanced Driver Assistance Systems (ADAS) act as a co-pilot, monitoring both the road and the driver. For Telangana, initial deployment should prioritize **commercial fleets and public transport**, where the safety payoff is greatest.

Figure 5: An illustration of the Advanced Driver Assistance System (ADAS) in a car.

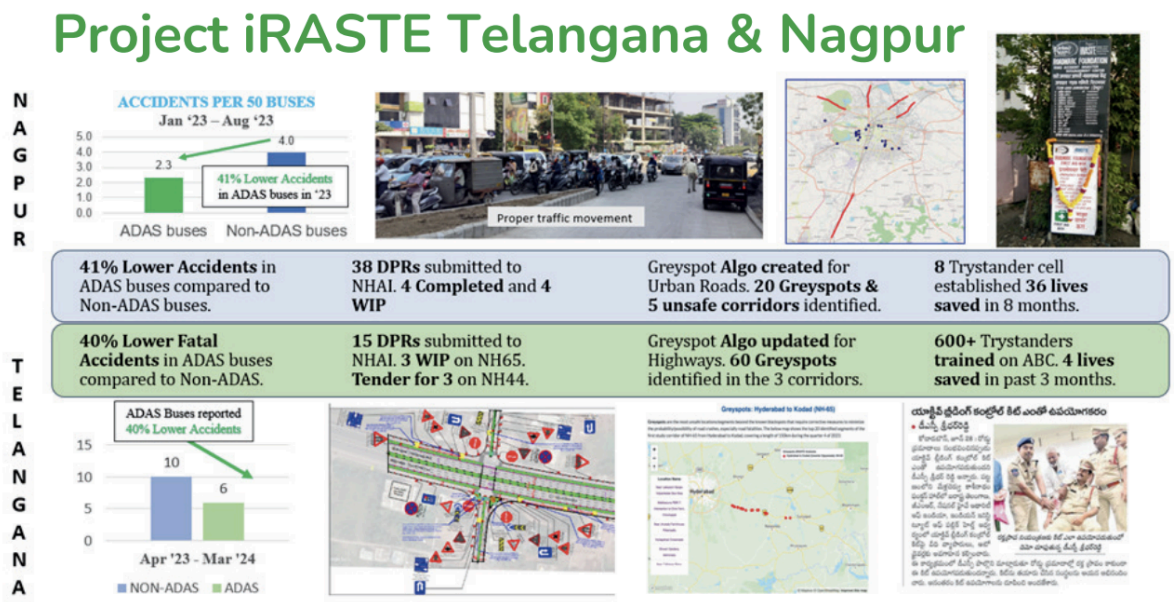
Key features include:

1. **Forward Collision Warning & Automatic Emergency Braking**: Alerts drivers of imminent collisions; auto-brakes if necessary.
2. **Lane Departure Warning / Lane Keep Assist**: Warns of unintentional drifts, reducing run-off-road and side-swipe crashes.
3. **Overspeeding Alerts**: Uses GPS/speed-limit databases to warn drivers; can integrate with intelligent speed governors.
4. **Headway Monitoring**: Prompts drivers to maintain safe following distances, particularly for heavy vehicles.
5. **Driver Monitoring Systems (DMS)**: Detects fatigue, distraction, or mobile phone use through facial recognition and eye-tracking.
6. **Blind Spot Detection**: Protects vulnerable road users (two-wheelers, pedestrians) from large vehicle blind spots.
7. **Real-Time Coaching**: Provides gentle feedback on harsh acceleration, braking, or cornering, encouraging smoother, safer driving.

Evidence from Telangana (iRASTE 2022-23)

In the **iRASTE-TGSRTC pilot** (2022-23), **200 buses equipped with ADAS** recorded a **40% reduction in accidents** compared to control groups. Alerts were issued ~2 seconds before potential collisions - often enough to prevent or mitigate crashes (Government of Telangana et al., 2024).

Figure 6: Outcomes of Project iRASTE in Telangana and Nagpur



Source: Government of Telangana, TSRTC, IIIT-Hyderabad, INAI, Uber, & Intel. (n.d.).

Additional Case Evidence: ADAS Pilot Deployment

1. Zoomcar-Netradyne Study (Bangalore, 2022-23):

In partnership with Netradyne, Zoomcar equipped 500 rental cars with ADAS-enabled driver monitoring systems. Across 52,000 trips covering 10.6 million miles, the technology tracked driver behavior and provided real-time voice alerts for speeding, tailgating, and harsh braking. Results showed a 51% reduction in speeding, a 14% drop in accident rates, and a 27% decline in unsafe driving behaviors, demonstrating the effectiveness of real-time feedback in reshaping driving habits at scale.

2. Mahindra XUV700 ADAS Deployment (Highways, 2021-22):

The Mahindra XUV700 became India's first mass-market SUV with Level 2 ADAS features, including adaptive cruise control, lane-keep assist, and blind-spot monitoring. Field data and customer feedback indicated 30-40% fewer lane-departure and blind-spot incidents, significantly reducing highway fatigue and making long-distance driving safer. This marked a key milestone in democratizing ADAS for Indian consumers.

3. Tata Motors' ADAS Pilot (National Highways, 2022):

Tata Motors tested ADAS features such as automatic emergency braking and lane departure warnings in mixed Indian traffic conditions, where road markings are often faded and traffic behavior is highly unpredictable. Despite these challenges, pilots reported a significant reduction in rear-end collisions and measurable improvements in lane discipline, showing that ADAS can be effectively localized to Indian driving realities.

4. Volvo Trucks' Active Driver Assist (Commercial Fleets, 2022-23):

Volvo introduced ADAS-enabled Active Driver Assist systems for heavy commercial trucks operating on highways and industrial corridors. Logistics companies reported a substantial decline in rear-end collisions and noted that drivers felt more confident during long-haul journeys. The pilot highlighted how ADAS can deliver both safety gains and productivity improvements in commercial freight operations.

Additional Case Evidence: Scaling ADAS Across Vehicle Categories

1. Two- & Three-Wheeler Pilots

1. **Honda Motorcycle Assist Tech:** Integrated ADAS for balance and stability, reducing low-speed accidents and improving rider confidence in congested city traffic.
2. **Bosch ARAS for Two-Wheelers:** Adapted car-based ADAS features (collision warnings, adaptive cruise) to motorcycles, achieving a 30% reduction in high-speed collision risks.
3. **TVS ADAS (Bengaluru trials):** Piloted ADAS features tailored for two-wheelers in Indian urban traffic, resulting in a 25% improvement in accident prevention during trials.

4. **Hero MotoCorp V2X for Three-Wheelers:** Developed AI-based Vehicle-to-Everything communication for shared autos, producing a 20% drop in fleet accident rates, especially in crowded urban corridors.
5. **Ola Electric - S1 Pro Sport (ADAS scooter):** Ola's S1 Pro Sport is claimed to be India's first two-wheeler to come equipped with ADAS (collision warnings, blind-spot alerts, adaptive cruise). The firm is developing MoveOS 6, which is said to integrate AI and ADAS capabilities (Financial Express, 2025).
6. **Ather Energy - Advanced Safety Features:** Ather has introduced "advanced safety features" for its scooters, described as "redefining two-wheeler safety with its updatable electric scooters" (Financial Express, 2024)

2. Fleet & Corporate Pilots

1. **Writer Safeguard (Hitachi Group cash vans):** Deployed ADAS and driver monitoring in cash transport vans operating long, fatigue-prone routes. Outcomes included a 50% reduction in accidents, 74% fewer drowsiness incidents, and 38% less distracted driving, proving ADAS' value for high-risk operations.
2. **IndianOil Skytanking & Shell (fleet safety):** Integrated ADAS with centralized fleet management systems to automate driver coaching and track safety metrics in hazardous fuel transport. The adoption of global safety standards and real-time analytics enabled systematic improvement in fleet safety performance.

Future Directions and Global Evidence

1. **Tesla Autopilot:** Semi-autonomous features piloted on Indian roads showcased potential to reduce driver fatigue and prevent lane-departure and rear-end crashes.
2. **International studies (NHTSA):** International evidence shows Vehicle-to-Everything (V2X) communication could prevent up to 80% of crashes involving unimpaired drivers, underlining the transformative potential of connected vehicle technologies.

4.3. Driver Scoring: Building a Culture of Safe Driving

Technology can correct momentary lapses, but **sustained improvement** depends on reshaping driving culture. A **Safe Driving Score (SDS) system objectively measures driver behavior using AI and creates continuous awareness and accountability**.

Core Parameters:

1. Speed compliance.
2. Smooth driving behavior (frequency of harsh braking, sharp cornering, overspeeding).
3. Adherence to signals and designated routes.
4. Helmet/ seatbelt compliance (where trackable).
5. Frequency of ADAS alerts triggered (fewer alerts = safer driving).

Scores are updated in real time, visible to drivers through apps or in-vehicle displays.

4.4. Incentive Framework

Instead of relying only on penalties, Telangana can encourage safe driving with **positive reinforcement**:

1. **Points-Based Rewards**: Drivers earn redeemable points for safe driving streaks (gift cards, bonuses, extra leave) (Teletrac Navman, 2023).
2. **Performance-Based Pay**: Fleets can tie part of compensation to safety scores.
3. **Recognition**: Publicly honor top drivers (leaderboards within TGSRTC or statewide "Safe Driver of the Year" awards).
4. **Insurance Discounts**: Partner with insurers to link telematics-based safe driving scores with lower premiums.
5. **License/Regulatory Incentives**: Consider waivers (e.g., reduced fines, demerit point removal) for consistently high-scoring drivers.

This "gamification" of safety turns compliance into a **personal challenge**, motivating drivers to continuously improve.

4.5. Integration with Enforcement and Training

1. **Link with e-Challans**: Violations automatically reduce scores.
2. **Training Pathways**: Drivers with persistently low scores undergo refresher training, while high scorers are rewarded.
3. **Institutional Adoption**: TGSRTC and private fleets can embed scoring into HR systems, using it for promotions, incentives, or corrective action.

4.6. Privacy, Fairness, and Acceptance

Driver scoring must be seen as **fair, transparent, and supportive**:

- **Transparency**: Drivers can view their own scores, violation history, and how points are calculated.
- **Privacy**: Personal data must be anonymized outside of necessary operational use.
- **Equity**: Avoid systems that disproportionately penalize drivers of older vehicles or low-income segments; consider state subsidies for retrofitted ADAS kits.
- **Awareness Campaigns**: Position scoring as a **reward system** rather than a surveillance tool.

4.7. The Combined Impact

- **Short-term**: Real-time alerts reduce crashes immediately (as shown in TGSRTC's 40% drop).
- **Long-term**: Incentives and feedback cultivate safer habits, lowering systemic risk.
- **Cultural Shift**: Over time, safe driving becomes the norm, reinforced by peer pressure, institutional rewards, and social recognition.

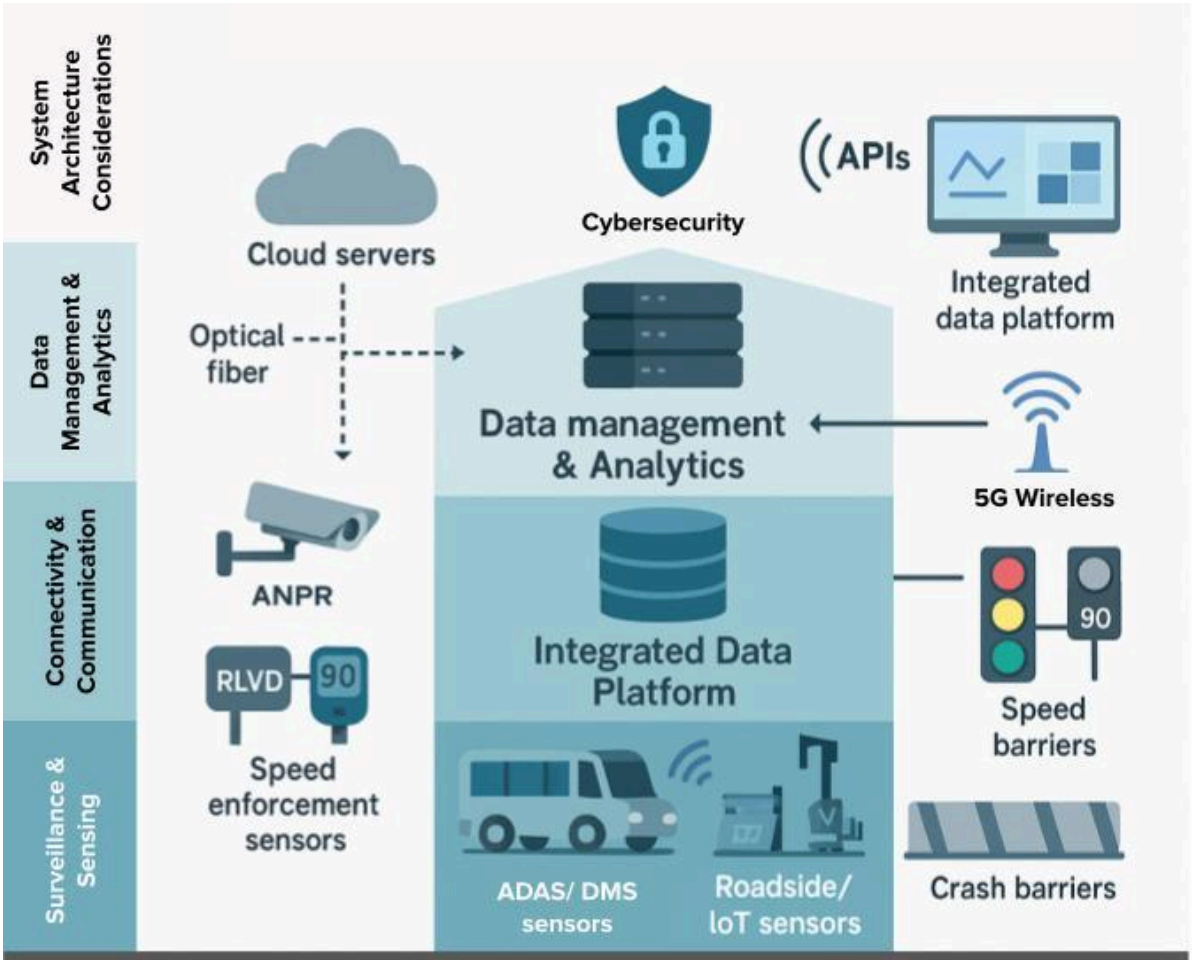
Figure 7: A crowd standing by the side of the road facing oncoming traffic - A situation ideal for AI-enabled Road Safety

5. Technical Infrastructure and System Architecture

5.1. Why Infrastructure Matters

The success of AI-based road safety enforcement depends on a **robust, scalable, and secure technical backbone**. Telangana must integrate field devices, connectivity networks, and analytics platforms into a unified ecosystem capable of real-time monitoring, predictive analysis, and long-term sustainability.

Figure 8: Layered Architecture for AI-Enabled Road Safety



Source: Authors; AI-generated image.

This diagram illustrates the four-layer architecture that underpins Telangana's AI-based road safety system: edge-level sensing devices, connectivity and communication networks, integrated data platforms with advanced analytics, and overarching governance and system safeguards. The layered approach highlights how field-level monitoring, real-time connectivity, predictive analytics, and institutional coordination converge to create a secure and scalable safety backbone.

5.2. Layer 1: Surveillance and Sensing (Edge Devices)

The **first layer** consists of devices that collect real-world data:

1. **CCTV Camera Network:** High-resolution, weatherproof, and night-vision-enabled cameras at intersections, highways, and high-risk corridors.
2. **Enforcement-Specific Devices**
    a. **ANPR cameras** (gantry- or pole-mounted) for license plate recognition.
    b. **Red Light Violation Detection (RLVD) systems** at intersections.
    c. **Fixed and average-speed detection cameras** on highways.
3. **In-Vehicle Systems**
    a. **ADAS and Driver Monitoring Systems (DMS)** retrofitted on buses, trucks, and taxis.
    b. Integrated forward-facing and driver-facing cameras, radar/lidar (where affordable), and GPS modules.
4. **IoT and Roadside Sensors**
    a. **Weigh-in-motion sensors** for trucks to detect overloading.
    b. **Road weather sensors** (fog, rain, visibility, wind).
    c. **Variable Message Signs (VMS)** for real-time warnings to drivers.
5. **Crash-rated physical safety infrastructure** (barriers, bollards, medians) should be digitally mapped and monitored alongside electronic enforcement devices, creating a comprehensive picture of both behavioral and physical safety measures.

5.3. Layer 2: Connectivity and Communication

Reliable communication links ensure **data flows seamlessly** between devices and central systems:

1. **Optical Fiber Networks**: Urban Hyderabad already has extensive fiber; expansion along highways should be prioritized under BharatNet and the state's fiber grid.
2. **Wireless Networks (4G/5G)**: Enable vehicle telemetry and mobile surveillance where fiber is absent. 5G's low latency supports near real-time video streaming.
3. **Edge Computing**: Local processing (e.g., ANPR at junctions) minimizes bandwidth use and speeds up response.
4. **Future-Ready Modules**: Design flexibility for **C-V2X or DSRC** to enable vehicle-to-infrastructure (V2I) alerts (e.g., broadcasting accident or hazard warnings to nearby vehicles).

5.4. Layer 3: Data Management and Analytics

The **analytics core** integrates, processes, and interprets all incoming data:

1. **Integrated Data Platform**
    a. Accident databases (iRAD, e-DAR).
    b. Violation data (e-challans).
    c. Telematics/ADAS feeds from fleet vehicles.
    d. External data (maps, weather, citizen reports).

2. **AI Analytics Modules**
    a. **Computer Vision AI**: helmet/seatbelt detection, signal jumping, driver distraction.
    b. **Violation Automation**: workflow from detection to challan and payment.
    c. **Geo-spatial Analytics**: hotspot mapping, blackspot/grey spot clustering.
    d. **Predictive Models**: accident likelihood scoring by road segment.
    e. **Driver Scoring Engine**: dynamic computation of safe driving scores.
3. **Real-Time Alerting Systems**
    a. Notify police patrols of reckless driving or stranded vehicles.
    b. Push alerts to drivers via VMS boards or in-vehicle devices.
    c. Interface with **emergency services (Dial 100 / 108 ambulances)** for rapid crash response.
4. **User Dashboards**
    a. **Traffic Police Command Center**: violations, live feeds, incident response.
    b. **Transport/Road Safety Cell**: blackspot maps, KPIs, intervention tracking.
    c. **Driver/Passenger Apps**: safe driving scores, safety feedback.
    d. **Public Dashboards**: high-level statistics for transparency and awareness.

5.5. Layer 4: System Architecture Considerations

For credibility and long-term use, the system must be **resilient, interoperable, and secure**:

1. **Scalability**: Modular design to expand from pilot corridors to statewide coverage. Cloud-based infrastructure (NIC or GovCloud) allows elastic scaling.
2. **Reliability & Redundancy**: Backup power for field devices, dual communication links (fiber + wireless), disaster recovery setups at data centers.
3. **Latency**: Instant in-vehicle alerts (ADAS/DMS) handled locally; enforcement workflows tolerate short delays.
4. **Cybersecurity**: Encrypted data transfer, strong authentication for system access, routine audits to prevent tampering with violation records or driver scores.
5. **Interoperability & Standards**: Adopt national/international standards (e.g., DATEX II for traffic data, open APIs) to enable integration with Smart Cities, connected vehicle pilots, and third-party innovations.
6. **Operations & Maintenance (O&M)**:
    a. Annual Maintenance Contracts (AMCs) for cameras and sensors.
    b. Device health dashboards to flag outages.
    c. Zonal maintenance units to ensure timely servicing.

5.6. Institutional Ecosystem for Deployment

Telangana can leverage its existing ecosystem:

1. **Hyderabad ITMS & State Fiber Grid**: ready backbones for camera and network integration.
2. **Emerging Technologies Wing & Telangana AI Mission (T-AIM)**: orchestrate partnerships with industry (hardware/software vendors) and academia.

3. **IIIT-H & IIT-H (TiHAN)**: support AI model development, connected vehicle simulations, and system validation.

5.7. Building a Digital Highway for Safety

This layered architecture effectively creates a **"digital highway" for safety** - a backbone of sensors, networks, and analytics that enables continuous monitoring, rapid intervention, and predictive prevention.

With the right governance and sustained O&M, Telangana can not only reduce fatalities but also lay the foundation for **next-generation smart mobility systems**, including connected and autonomous vehicles.

Figure 9: Concept of a Digital Highway for Safety

Source: Authors; AI-generated image.

This conceptual illustration portrays the vision of a "digital highway" where vehicles, cameras, roadside sensors, and connected infrastructure continuously feed into command centers and cloud systems. The digital overlay symbolizes real-time monitoring, predictive alerts, and preventive interventions, showing how physical infrastructure and AI-enabled analytics combine to protect road users and enable safer mobility.

6. Pilot Strategy: Telangana/ TGSRTC as Initial Deployment Case

6.1. Why Start with a Pilot?

Full-scale AI-based enforcement across Telangana is ambitious and resource-intensive. A **phased pilot** allows the state to:

1. Test technologies in a controlled environment.
2. Measure real-world impact on accidents and driver behavior.
3. Refine protocols, training, and maintenance processes.
4. Build a strong cost-benefit case before scaling statewide.

6.2. Pilot Design and Objectives

The **Telangana State Road Transport Corporation (TGSRTC)** is the ideal starting point because of its large fleet, operational scale, and public accountability.

Pilot Objectives:

1. Demonstrate accident reduction through **ADAS and DMS deployment**.
2. Test **AI-based enforcement cameras** in select urban junctions and highway corridors.
3. Develop training and operational protocols for drivers and enforcement staff.
4. Generate **evidence on cost-effectiveness**, building a financial case for scale-up.

Figure 10: TGSRTC as the Lead Agency for piloting AI-enabled road safety at scale.

Source: The NewsMinute, 2025.

6.3. Phased Rollout Plan

1. **Phase 1: Vehicle-Centric Pilot (Year 1)**
    a. Equip 200-300 TGSRTC buses with ADAS/DMS.
    b. Select 2-3 high-risk highway corridors and fit with speed cameras + ANPR.
    c. Conduct baseline surveys on accidents, violations, and driver behavior.
2. **Phase 2: Integrated Enforcement Pilot (Year 2)**
    a. Extend ADAS to 1,000+ buses and introduce pilot schemes for private fleets (trucks, taxis).
    b. Deploy full AI camera suites (ANPR, RLVD, lane-discipline detection) at 10 high-violation junctions in Hyderabad.
    c. Begin predictive **grey spot identification** using iRASTE data.
3. **Phase 3: Scaling and Policy Integration (Year 3-5)**
    a. Expand to all TGSRTC buses and major state highways.
    b. Formalize a **driver scoring and incentive system** for public transport and logistics fleets.
    c. Embed AI enforcement within the **State Road Safety Action Plan**.

6.4. Role of TGSRTC in Scaling

1. **Proof of Concept**: Demonstrate measurable accident reduction and behavioral change.
2. **Data Sharing**: Provide telemetry and incident data for analytics.
3. **Institutional Champion**: Lead by example, encouraging private fleets to adopt similar practices.
4. **Partnership Leverage**: Collaborate with insurers to explore premium discounts linked to reduced accident claims.

6.5. Evaluation Metrics and Monitoring

Evaluation must be rigorous, independent, and transparent.

Key Metrics:

1. Reduction in accidents, fatalities, and injuries involving pilot vehicles.
2. Change in driver behaviors (speeding, harsh braking, tailgating).
3. Number of violations detected and compliance improvements (e.g., helmet use).
4. Cost savings (repairs, compensation, insurance payouts).
5. User satisfaction (drivers, passengers, enforcement staff).

Methodology:

1. Baseline vs. post-intervention comparisons.
2. Control groups (similar buses/roads without AI systems).
3. Independent audits by IIIT-H/IIT-H to validate results.

6.6. Financing and Sustainability

1. **Seed Funding**: State Road Safety Fund, corporate CSR, or central schemes (MoRTH, NITI Aayog).
2. **Public-Private Partnerships**: Vendors could provide equipment under build-operate-maintain models.
3. **Insurance Tie-ins**: Explore co-funding with insurers who benefit from reduced claims.
4. **Reinvestment of Fines**: Revenue from e-challans can partially fund system expansion.

6.7. Public Communication and Acceptance

Enforcement technologies can face public pushback if perceived as "fine-collection tools". Telangana must frame the pilot as a **life-saving initiative**:

1. Awareness campaigns explaining how ADAS alerts save lives.
2. Transparent dashboards showing reduction in crashes.
3. Recognition of safe drivers to highlight positive outcomes.

6.8. Anticipated Challenges and Mitigation

1. **Driver Over-Reliance on ADAS**: Training to stress that technology assists, not replaces, human judgment.
2. **Technical Failures** (dust, heat, hardware wear): Robust equipment and strong maintenance contracts.
3. **Data Overload**: Prioritize actionable insights through dashboards.
4. **Public Resistance to Fines**: Pair enforcement with awareness and incentive schemes.

6.9. Building Towards Statewide Scale

The pilot is not an end but a **launchpad**. By starting with TGSRTC and select corridors, Telangana can:

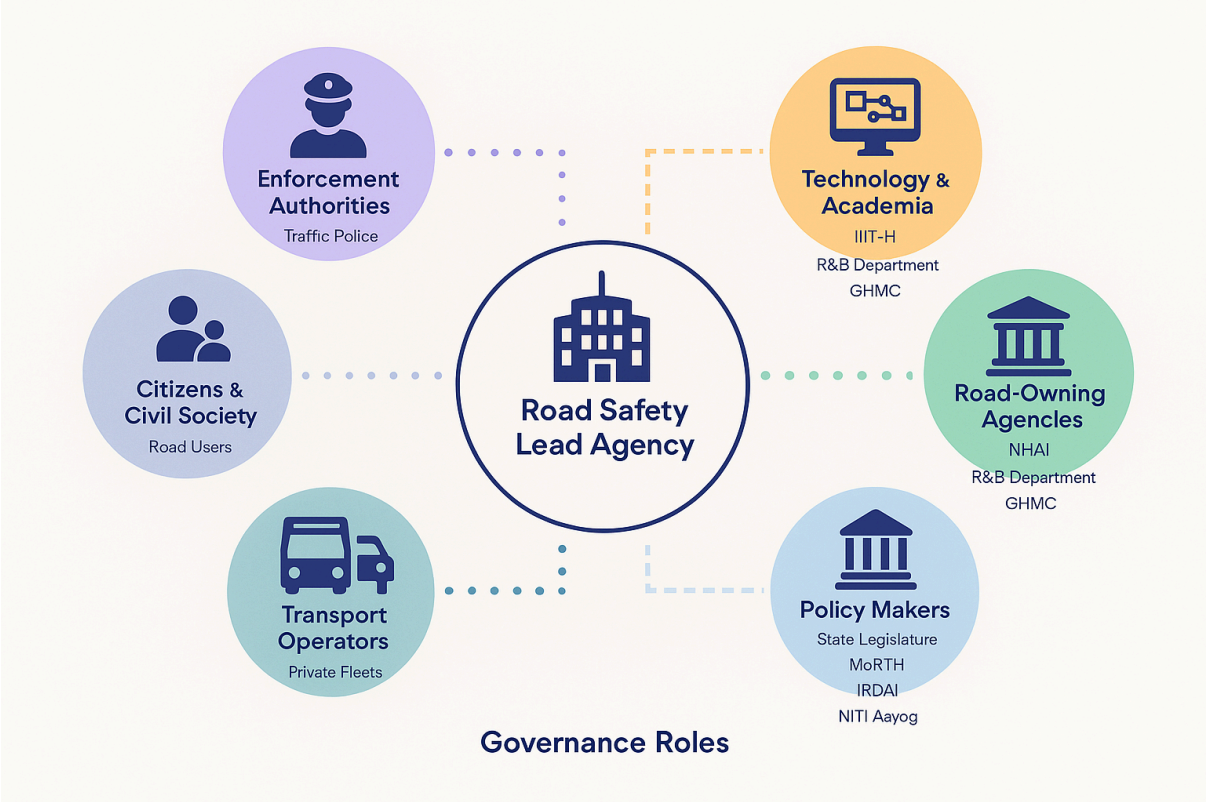
1. Generate hard evidence of accident reduction.
2. Build institutional capacity and inter-agency coordination.
3. Develop replicable protocols for urban and rural contexts.
4. Create momentum for phased expansion across all districts.

7. Governance and Stakeholder Roles

7.1. Why Governance Matters

Technology alone cannot reduce road deaths. Success depends on **clear accountability, inter-agency coordination, and stakeholder buy-in**. Telangana's governance model must bring together transport, police, road authorities, municipalities, operators, and citizens under a unified framework led by the state's **Road Safety Lead Agency**.

Figure 11: Governance Ecosystem for AI-Enabled Road Safety in Telangana



Source: Authors; AI-generated image.

7.2. State-Level Anchor: Road Safety Lead Agency

1. **Nodal Authority**: The Telangana Road Safety Cell (Transport Department) serves as the **anchor institution**.
2. **Core Functions**:
    a. Formulate the state's AI-based road safety strategy.
    b. Coordinate between police, R&B, GHMC, TGSRTC, and private fleets.
    c. Manage the **State Road Safety Fund** and allocate resources.
    d. Commission pilots and independent evaluations.
    e. Report progress to the **State Road Safety Council** and the **Supreme Court Committee on Road Safety**.

7.3. Enforcement Authorities: Traffic Police

1. Operate the **Integrated Traffic Management Center (ITMC)**.
2. Validate and issue **e-challans** from AI-detected violations.
3. Conduct complementary on-ground enforcement at high-risk zones.
4. Share FIR and accident data with iRAD and analytics teams.
5. Lead **public awareness campaigns** on AI-based enforcement.
6. Coordinate emergency response with Dial-100/108 services.

7.4. Road-Owning Agencies

1. **NHAI/MoRTH**: National Highways, blackspot rectification, and highway ATMS deployment.
2. **R&B Department**: State highways and district roads - integrate AI analytics into engineering upgrades.
3. **Urban Local Bodies (e.g., GHMC)**:
    a. Urban traffic signals, junction redesign, **pedestrian infrastructure such as raised walkways/FOBs, anti-ram bollards at metro exits/markets, planter barriers, and continuous medians** to physically protect vulnerable road users.
    b. Fix road infrastructure issues identified via AI (potholes, poor signage).
    c. Support smart city initiatives linked to ITMS.

7.5. Transport Operators

1. **TGSRTC (Public Buses)**:
    a. Implement ADAS and driver scoring pilots.
    b. Train drivers and act on low safety scores.
    c. Share telemetry and incident data with the Road Safety Cell.
2. **Private Fleet Operators (Trucking, Taxi, Ride-Hailing)**:
    a. Adopt ADAS/telematics voluntarily or under state policy.
    b. Participate in safe driving incentive schemes.
    c. Share best practices with the state and industry associations.

7.6. Technology and Academic Partners

1. **IIIT-Hyderabad & INAI**: Develop and validate AI vision models (helmet detection, grey spot prediction).
2. **IIT-Hyderabad (TiHAN Testbed)**: Support connected vehicle simulations and V2X trials.
3. **CSIR-CRRI and Engineering Colleges**: Provide technical audits and support blackspot diagnostics.
4. **Private Tech Vendors and Startups**:
    a. Supply and maintain cameras, sensors, and software platforms.
    b. Participate in **innovation challenges** for AI road safety solutions (e.g., drowsiness detection, pothole mapping).

5. **Industry Partners (e.g., Intel, Capgemini)**: Bring advanced hardware/software expertise and global best practices.

7.7. Policy Makers and Regulators

1. **State Legislature & Road Safety Council**: Provide political backing and legislative support (e.g., state-level mandates for ADAS in fleets).
2. **MoRTH & National Road Safety Board**: Align state efforts with national electronic enforcement and safety standards.
3. **Insurance Regulator (IRDAI)**: Enable usage-based insurance linked to driver scoring.
4. **NITI Aayog, and Multilateral Agencies**: Funding, knowledge support, and visibility for Telangana as a model state.

7.8. Citizens and Civil Society

1. **Road Users**: Must be informed participants, complying with rules and embracing safe driving.
2. **NGOs & Advocacy Groups**: Conduct awareness campaigns, community monitoring of blackspots, and driver training workshops.
3. **Public Feedback Channels**: Apps or helplines for reporting hazards, near-misses, or faulty infrastructure.

7.9. Governance Mechanisms for Coordination

1. **AI for Road Safety Task Force**: A dedicated inter-agency task force under the Lead Agency with nodal officers from transport, police, R&B, GHMC, TGSRTC, and academic partners.
2. **Data-Sharing Agreements (MoUs)**: Define protocols for accident data, vehicle telemetry, and enforcement records.
3. **Capacity Building**:
    a. Training traffic police on AI tools.
    b. Upskilling engineers on GIS/analytics dashboards.
    c. Creating a **Traffic Analytics Unit** within government staffed by data scientists (with academic support).
4. **Judicial Sensitization**: Familiarize traffic courts with digital evidence workflows under MVA 2019.

7.10. Collaborative Leadership

The essence of governance is **joint accountability**. Fatality reduction targets must be shared across agencies, with credit for progress and responsibility for lapses distributed collectively. Regular task force reviews and public reporting will ensure momentum and transparency.

8. Monitoring, Evaluation, and Scalability

8.1. Why Monitoring and Evaluation (M&E) Matter

For AI-based road safety initiatives to succeed, Telangana must demonstrate **credible impact**. Without clear evidence of accident reduction and cost-effectiveness, public trust and long-term financing will be at risk. Monitoring and evaluation ensure:

1. **Accountability** across stakeholders.
2. **Learning** to refine interventions.
3. **Transparency** to build citizen acceptance.
4. **Evidence** for scaling within Telangana and elsewhere.

8.2. Key Performance Indicators (KPIs)

M&E should track both **outcomes** (lives saved, accidents reduced) and **processes** (adoption, compliance, system uptime).

Infrastructure Safety

1. % of blackspot/grey spot corridors retrofitted with crash-rated barriers.
2. Number of bollards/planter barriers installed at high-risk pedestrian zones.
3. % of highways with clear zones maintained.

Safety Outcomes

1. Reduction in road crashes, fatalities, and serious injuries.
2. % decrease in accidents at identified blackspots/grey spots.
3. Reduction in high-risk behaviors (overspeeding, red-light jumping, helmet non-use).

Behavioral Change

1. % improvement in driver scores across fleets.
2. Reduction in ADAS alerts triggered per 1,000 km driven.
3. Increased compliance with helmet/seatbelt norms.

System Efficiency

1. % of violations accurately detected and successfully challaned.
2. Average time from violation to challan issuance.
3. System uptime of cameras, sensors, and analytics dashboards.

Institutional Capacity

1. Number of officers/engineers trained on AI systems.

2. Inter-agency data-sharing MoUs signed and operational.

Equity and Public Acceptance

1. Distribution of enforcement across urban/rural roads.
2. Feedback from drivers and citizens (satisfaction surveys).
3. Grievance redressal rate for disputed challans.

8.3. Evaluation Methods

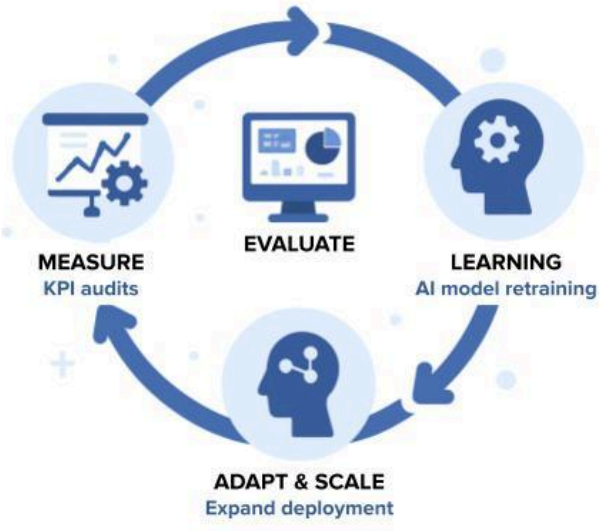
A robust evaluation framework must combine **quantitative analysis, independent audits, and qualitative feedback**.

1. **Baseline vs. Post-Intervention Comparisons**: Track crashes, fatalities, and violations before and after AI system rollout.
2. **Control Groups**: Compare pilot corridors/fleets with similar untreated corridors/fleets.
3. **Independent Technical Audits**: Validation of AI accuracy (false positives/negatives) by academic partners like IIIT-H/IIT-H.
4. **Cost-Benefit Analysis**: Quantify savings from fewer accidents (medical costs, insurance claims, vehicle repairs) relative to system costs.
5. **User Surveys and Focus Groups**: Capture driver, passenger, and citizen experiences with enforcement fairness and system usability.

8.4. Adaptive Learning and Feedback Loops

AI-enabled enforcement systems must continuously **learn and adapt**:

1. Fine-tune computer vision models with new datasets (e.g., rural helmets, diverse vehicle types).
2. Update grey spot predictions as new near-miss data emerges.
3. Regularly recalibrate driver scoring algorithms for fairness across vehicle categories.
4. Publish **annual "Road Safety Report Cards"** showing progress and areas needing action.



8.5. Transparency and Citizen Trust

Public acceptance hinges on making systems **visible, fair, and accountable**:

1. **Open Dashboards**: Publish high-level statistics on accidents prevented, blackspots treated, and violations detected.
2. **Evidence-Based Challans**: All challans must carry photographic/video proof.
3. **Redressal Mechanisms**: Quick dispute resolution via traffic courts or online platforms.

4. **Awareness Campaigns**: Reinforce that AI is used for **saving lives, not collecting fines**.

8.6. Pathways for Scalability

Scaling requires a **phased, evidence-driven roadmap**:

1. **Within Telangana**
    a. Expand from TGSRTC and select corridors ➔ all buses, trucks, and highways.
    b. Integrate AI enforcement into district-level action plans.
    c. Standardize procurement, training, and O&M protocols statewide.
2. **Across India**
    a. Share learnings with MoRTH, National Road Safety Board, and other states.
    b. Position Telangana as a **demonstration state** under India's Vision Zero commitment.
    c. Explore replication through **central funding schemes** and multilateral loans (World Bank, AIIB).

8.7. Risk Management and Sustainability

1. Physical barriers require **regular audits and maintenance** to ensure crashworthiness and anchoring integrity. Failure to maintain could compromise safety despite initial installation.
2. **Technical Risks**: Hardware failures ➔ mitigated via strong AMCs and zonal maintenance units.
3. **Financial Risks**: Over-reliance on fines ➔ diversify funding (insurance partnerships, Road Safety Fund).
4. **Equity Risks**: Over-penalizing low-income road users ➔ balance with incentives and safety subsidies.
5. **Institutional Risks**: Weak inter-agency coordination ➔ enforce accountability through the AI Task Force (see Chapter 7).

8.8. Towards a Model for India

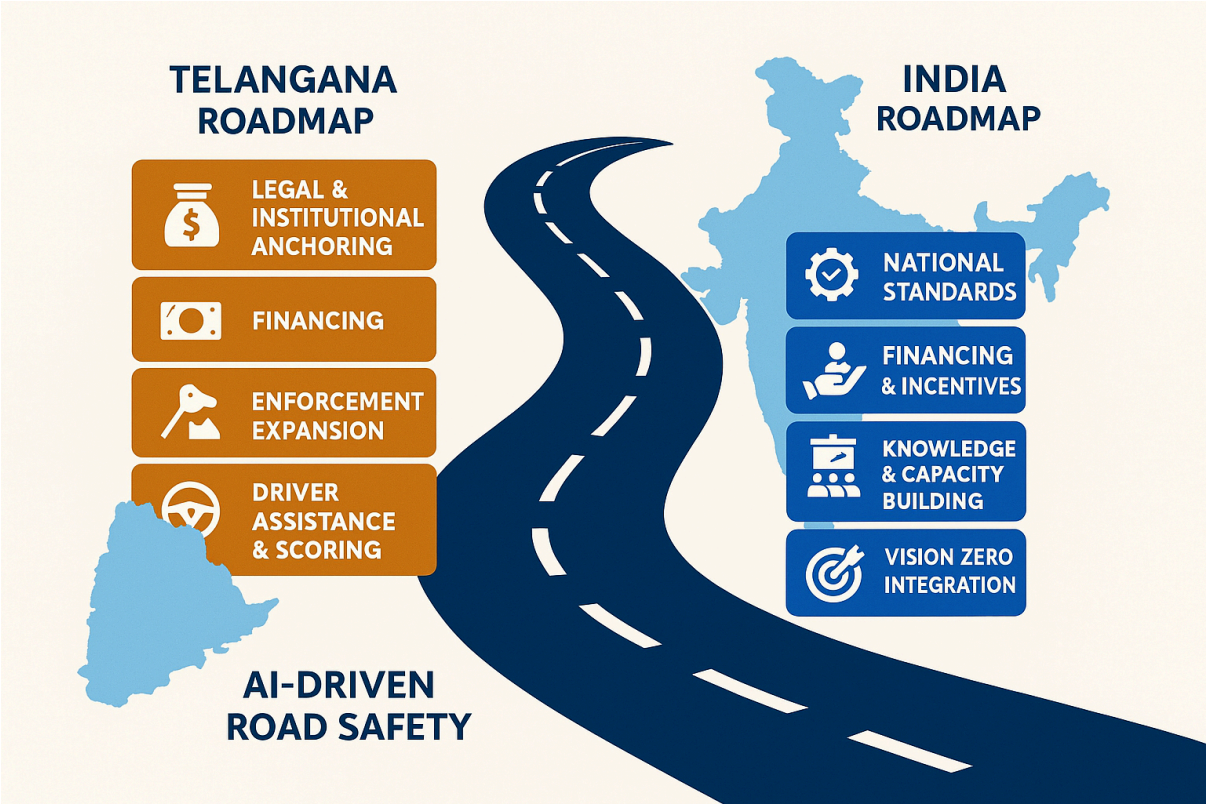
If rigorously monitored, transparently reported, and sustainably scaled, Telangana's AI-based enforcement system can achieve:

- **50% reduction in fatalities by 2030**, in line with UN goals.
- A replicable governance and technical model for other states.
- A foundation for **next-generation smart mobility systems**, including connected and autonomous vehicles.

9. From Telangana to India: A Policy Roadmap for AI-Driven Road Safety

Telangana has laid the foundation for a transformative leap in road safety through its pioneering AI-enabled initiatives. Yet, to maximize impact, the state must embed these interventions in policy and governance systems while simultaneously offering a blueprint for India. This chapter therefore presents a **two-tier roadmap**: (a) immediate next steps for Telangana and (b) national-level directions for replication across India.

Figure 12: Telangana-to-India Dual Policy Roadmap



Source: Authors; AI-generated image.

9.1. Telangana Roadmap: Scaling Statewide

1. Legal and Institutional Anchoring

1. Enforce Section 136A of the Motor Vehicles Act across all high-risk corridors in Telangana.
2. Empower the State Road Safety Cell as the nodal body to lead AI adoption, with authority to coordinate across police, R&B, GHMC, and TGSRTC.
3. Issue state-level rules to validate AI-generated digital evidence in traffic adjudication.

2. Sustainable Financing

1. Dedicate the State Road Safety Fund to cover capital and recurring O&M costs for AI enforcement.
2. Explore public-private partnerships with insurers and fleet operators to co-finance ADAS retrofitting and data platforms.
3. Seek central and multilateral funding (e.g., World Bank road safety program loans) for rapid expansion.

3. Statewide Enforcement Expansion

1. Scale Hyderabad's ITMS to all tier-II and tier-III cities.
2. Deploy speed, ANPR, and behavioral analytics cameras along all high-fatality highways.
3. Mandate open APIs for interoperability between existing and new enforcement systems.

4. Blackspot and Grey Spot Management

1. Institutionalize predictive analytics from iRASTE in R&B and NHAI planning.
2. Mandate road safety audits for all new road and highway projects.
3. Publish an annual "Dynamic Road Safety Map" showing progress on blackspot and grey spot remediation.

5. Driver Assistance and Scoring

1. Equip all TGSRTC buses with ADAS and Driver Monitoring Systems within three years.
2. Provide targeted subsidies for ADAS in freight vehicles.
3. Launch a statewide driver scoring and rewards program, starting with TGSRTC and expanding to private fleets.

9.2. India Roadmap: Scaling Nationally

1. National Standards and Guidelines

1. MoRTH and the National Road Safety Board should set technical standards for AI enforcement, driver scoring, and ADAS integration.
2. Standardize data formats (ANPR, ADAS telemetry, grey spot reporting) for cross-state sharing.
3. MoRTH should adopt **uniform crash-tested standards (MASH, EN1317, ASTM F3016)** for all roadside barriers, bollards, and pedestrian protection elements, making them mandatory for new highway and urban transport projects.

2. Financing and Incentives

1. Expand central funding schemes (under MoRTH's electronic enforcement and blackspot rectification programs) to explicitly support AI deployments.

2. Introduce insurance-linked incentives for safe driving, backed by telematics and scoring data.
3. Encourage state governments to earmark a fixed % of their Road Safety Funds for AI-enabled enforcement and analytics.

3. Knowledge-Sharing and Capacity Building

1. Establish a **National Centre for AI in Road Safety** as a hub for R&D, training, and audits.
2. Develop design handbooks and training for state engineers on **integrating barriers with urban design** (e.g., planters, benches, bike racks) to balance functionality and aesthetics
3. Develop training curricula for transport officers, police, and engineers on AI-enabled enforcement.
4. Institutionalize peer-learning platforms where states like Telangana share lessons with others.

4. National Vision Zero Integration

1. Embed AI-based enforcement into India's National Road Safety Plan.
2. Use Telangana as a **model state pilot** for demonstrating UN Decade of Action commitments.
3. Encourage all states to adopt annual "Road Safety Report Cards" with AI-based metrics.

9.3. Conclusion

Telangana has the opportunity to demonstrate that **AI is not just a tool for efficiency, but a catalyst for saving lives**. By embedding AI-based enforcement, predictive analytics, and driver scoring into its policy framework, the state can halve fatalities by 2030 and set an example for India.

For the nation, Telangana's journey illustrates a replicable model: combining **technology, governance, incentives, and citizen engagement** into a single coherent system. If scaled across India, such an approach could save tens of thousands of lives annually, reduce economic losses of 3-5% of GDP, and move the country decisively toward its Vision Zero commitment.

By acting with urgency and clarity, Telangana can lead India's transition from reactive enforcement to **predictive, preventive, and people-centered road safety** - a legacy that safeguards its citizens today and inspires national progress tomorrow.

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Credits

About ITS India Forum

The **ITS India Forum** is a leading not-for-profit think tank dedicated to advancing Intelligent Transportation Systems (ITS) in India. ITS India Forum promotes safety, affordability, and inclusivity in transportation in alignment with the Viksit Bharat Vision 2047. The Forum serves as a collaborative platform for industry professionals, government agencies, and academic institutions working together to shape the future of transportation in the country.

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OMI Foundation Trust is a new-age policy research and social innovation think tank operating at the intersection of mobility innovation, governance, and public good. Mobility is a cornerstone of inclusive growth providing the necessary medium and opportunities for every citizen to unlock their true potential. OMI Foundation endeavours to play a small but impactful role in ushering meaningful change as cities move towards sustainable, resilient, and equitable mobility systems, which meet the needs of not just today or tomorrow, but the day after.

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