

Report on the NCAER–NHAI Centre Inauguration and Inception Workshop

20 July 2026

The NHAI Centre for the Economics of Transport, Mobility and Logistics was inaugurated by the National Highways Authority of India (NHAI) Chairman, Shri Santosh Kumar Yadav, at NCAER on 20 July 2026, marking the establishment of India's first applied economics research Centre dedicated to this sector. The Centre is the outcome of a Memorandum of Understanding (MoU) signed between NHAI and NCAER, with NHAI as its founding anchor. The launch was followed by an inception workshop bringing together senior NHAI officials, transport economists, infrastructure developers, and investors to deliberate on and help shape the Centre's research agenda.

The workshop comprised different sessions presenting insights on the economics and research on Transport, Mobility and Logistics. Details of the proceedings of these sessions are delineated below.

Address by Shri Santosh Kumar Yadav, Chairman, National Highways Authority of India (NHAI): *Perspective of NHAI on the Partnership and Directions for the Collaboration and Viksit Bharat Vision 2047*

The Chief Guest, Shri Santosh Kumar Yadav, Chairman, NHAI, delivered the inaugural address at the event, outlining the vision behind the establishment of the NHAI–NCAER Centre for Economics of Transport, Mobility and Logistics. He congratulated NHAI and NCAER on creating a dedicated platform for evidence-based research in shaping India's transport infrastructure and policy ecosystem.

Shri Yadav observed that while the country had made remarkable progress in expanding its highway network in the recent past, the next phase of development would require research-driven decision-making not merely based on engineering judgement or administrative experience, but increasingly guided by rigorous analysis, reliable data, and empirical evidence. This is especially important to enable policymakers to address complex questions related to highway planning, travel time, congestion, safety, tolling, logistics efficiency, and investment outcomes. In this context, one of the principal objectives of the newly established Centre should be to generate credible research to inform infrastructure planning and management while directly supporting policymaking within NHAI.

He also stressed the importance of developing robust scientific traffic forecasting models, supported by large-scale datasets to accurately capture evolving travel patterns, economic activity, transport demand, and regional connectivity.

Another major theme of his address was road safety. He observed that accident reduction requires a stronger analytical foundation, combining engineering interventions with behavioural research to help develop predictive approaches for preventing accidents through improved planning and operational management. He also highlighted the enormous potential of data generated through FASTag and other intelligent transport systems, which provide valuable information on traffic volumes, travel behaviour, toll operations, and corridor performance. Further, research on

congestion patterns, bottlenecks, freight movement and multimodal connectivity would help optimise infrastructure utilisation while reducing logistics costs.

Continuous investment in multimodal logistics parks, ports, rail connectivity and economic corridors across India necessitates coordinated planning across transport modes. Research undertaken by the Centre could thus play a significant role in identifying opportunities for improving multimodal integration and enhancing overall network efficiency.

Shri Yadav concluded his address by expressing confidence that the NHAI–NCAER Centre would emerge as a premier institution for transport policy research in India and serve as a collaborative platform for generating practical solutions to contemporary challenges in transport, mobility and logistics. He expressed hope that the deliberations during the workshop would help define a focused research agenda aligned with the aspirations of Viksit Bharat 2047 and contribute meaningfully to the future development of India's transport sector.

Address by Shri N.R.V.V.M.K. Rajendra Kumar Member (Finance), National Highways Authority of India (NHAI): *Research Priorities and Policy Mandate of NHAI*

Shri N.R.V.V.M.K. Rajendra Kumar outlined the strategic rationale behind establishing the NHAI–NCAER Centre and emphasised the growing importance of research in supporting evidence-based policymaking within NHAI. He stressed that decisions relating to traffic forecasting, project prioritisation, financing, tolling, logistics efficiency, multimodal connectivity, road safety, and asset monetisation require analytical frameworks supported by reliable data and rigorous research. The establishment of the Centre, therefore, represents an important institutional mechanism for bridging the gap between policy requirements and academic expertise. He argued that NHAI is no longer solely responsible for constructing highways but is increasingly engaged in managing a diverse portfolio of transport assets, digital infrastructure, and innovative financing mechanisms. Consequently, research priorities must evolve to address emerging challenges associated with network optimisation, operational efficiency, financial sustainability, and long-term asset management.

A significant area identified for future research was traffic demand forecasting and network planning as infrastructure planning should be supported by dynamic forecasting models capable of capturing changes in economic activity, freight movement, urbanisation patterns, and travel behaviour. Shri Rajendra Kumar further suggested that beyond improvements in physical connectivity, research should examine how highway infrastructure influences industrial development, regional competitiveness, employment generation, logistics efficiency and overall economic productivity.

On the issue of financial sustainability, Shri Rajendra Kumar observed that innovative financing models have become an integral component of India's highway development strategy. Research on asset monetisation, investment structures, Infrastructure Investment Trusts (InvITs), public-private partnerships, and alternative financing mechanisms would contribute to improving resource mobilisation while ensuring the long-term sustainability of highway infrastructure.

He also underlined the importance of strengthening multimodal integration within India's transport ecosystem. As investments continue across highways, railways, ports, airports, and logistics parks, research should support coordinated planning across transport modes to improve connectivity, reduce logistics costs, and enhance supply chain efficiency, contributing to making India a globally

competitive logistics hub. Further, improvements in infrastructure must be complemented by research into user behaviour, engineering design, operational management, and technological interventions. Evidence-based approaches towards accident prevention, corridor safety, and emergency response systems would help improve safety outcomes while supporting national road safety objectives.

Concluding his address, Shri Rajendra Kumar expressed confidence that the NHAI–NCAER Centre would emerge as an important national platform for transport research. By combining academic excellence with practical policy engagement, the Centre would contribute to strengthening institutional capacity, supporting evidence-based governance and advancing India's long-term transport and infrastructure objectives under the vision of Viksit Bharat 2047.

Address by Mr Suresh Goyal, Director General, NCAER: National Priorities in Transport, Mobility, and Logistics Research, NHAI-NCAER MoU

Mr Goyal explained that the idea of establishing the Centre emerged from recognition of the need for an institution that could bridge academic research, industry expertise, and public. The Centre was, therefore, conceived not merely as an academic initiative but as a collaborative platform that would connect government agencies, industry stakeholders, and researchers to address real-world policy challenges.

He acknowledged the support received from the NHAI leadership in approving the Centre within a remarkably short period, wherein NHAI committed financial assistance over a ten-year period, demonstrating its confidence in the importance of evidence-based transport research. He also highlighted the encouraging response received from industry partners, including infrastructure investors and developers, who had agreed to support the initiative financially. According to him, this broad-based support reflected a shared recognition that India required an independent research institution dedicated to transport, mobility and logistics.

He identified several priority research themes that could shape the Centre's work programme, including logistics cost measurement, multimodal logistics parks, port connectivity, highway traffic demand modelling, congestion analysis, highway design, data-driven policymaking, and asset monetisation. Since NHAI possesses vast datasets generated through FASTag and other digital systems, these could be responsibly leveraged for research while respecting data privacy and governance principles. The intelligent use of such datasets could significantly improve decision-making in areas such as toll operations, traffic forecasting, investment planning, and highway monetisation, thereby generating substantial economic gains for the country.

In conclusion, Mr Goyal expressed confidence that the Centre would become an important national institution for transport research and thanked NHAI, industry partners, and the Advisory Council for their support in transforming the idea into reality within a short span of time.

Dr G. Raghuram, Chairman, Advisory Council, NHAI Centre, and Former Director, IIM Bangalore; Former Dean, IIM Ahmedabad; Professor Emeritus, GMU: Defining the Research Agenda and Institutional Architecture of the NHAI Centre Governance, Engagement, and Next Steps: Data-Sharing Principles; Workstream Championship

Congratulating NHAI and NCAER for establishing the NHAI–NCAER Centre for Economics of Transport, Mobility and Logistics, Dr Raghuram described the initiative as a timely and significant institutional intervention that would strengthen the interface between research, policymaking, and industry, while generating evidence to support India's rapidly evolving transport sector. He noted that transport infrastructure cannot be viewed in isolation, as highways form part of a broader mobility ecosystem comprising railways, ports, airports, inland waterways, logistics facilities, and urban transport systems. Consequently, research undertaken by the Centre should adopt a systems perspective, recognising the interdependence between different transport modes and the wider economic environment within which they operate.

He suggested that the Centre should proactively anticipate emerging challenges associated with freight movement, logistics efficiency, digital technologies, climate resilience, sustainable mobility and infrastructure financing. He also underscored the need for multidisciplinary collaboration, as many contemporary transport challenges extend beyond engineering, thereby requiring insights from economics, public policy, finance, operations research, data science, behavioural sciences, and environmental studies.

An equally important priority would be the development of strong institutional partnerships connecting government agencies, academic institutions, industry participants, multilateral organisations and independent researchers, which would facilitate research on key national issues and improve access to specialised expertise. Further, instead of pursuing isolated studies, the Centre should develop a structured research agenda organised around thematic workstreams. These workstreams could evolve in response to changing policy requirements, technological developments, and emerging transport challenges.

The primary objective of the Centre should be to generate impact on policy and management excellence by continually asking who the Centre's users are, how its outputs can be continuously improved, and how its inputs can be sourced and optimised. Research should begin with a clear understanding of transport users as well as the profile of goods used for building using roads, such as raw materials, industrial intermediaries, finished goods, durables, fast-moving goods, perishable goods, and time-vulnerable goods. He also highlighted the importance of studying the profile of passengers using roads, the nature of multimodality, vehicle characteristics including motorised and non-motorised vehicles, weight, size, maximum speed and acceleration, as well as driver characteristics such as ownership, age, experience, driving time, and rest behaviour.

He observed that nearly 60 per cent of the road traffic moves on non-National Highways, while 35–40 per cent of freight traffic moves through rail, water, and pipelines, and about 15 per cent of passenger traffic moves through rail and air. In this context, there is a need to review the macro road vision and road development plans, develop a feeder–backbone hierarchy of roads, adopt user-based road classification, learn from different authority and management models, and improve traffic estimation while reducing forecasting error margins.

The Centre should thus continually improve its delivery outcomes by focusing on speed, safety, security, stresslessness, and sustainability. Research should examine the average speed of different vehicle segments, determinants of safety and security, approaches for streamlining traffic flow and reducing stress, and issues relating to sustainability and climate impacts.

Recognising the increasing availability of digital information, Dr Raghuram underlined that the Centre should work closely with NHAI and other partner institutions to facilitate secure access to transport datasets while maintaining appropriate standards of privacy, confidentiality and ethical

use. The research process should include sourcing research ideas, executing projects with intermediate timelines, obtaining project-specific Advisory Group feedback, and disseminating outcomes. The success of the Centre would ultimately depend not only on producing research but also on ensuring that its research findings are translated into actionable policy recommendations.

Looking ahead, Dr Raghuram expressed confidence that the Centre could emerge as India's leading institution for transport policy research. By combining academic excellence, institutional collaboration and policy engagement, it would contribute to improving infrastructure planning, strengthening transport governance and supporting the country's long-term development objectives. He encouraged participants to view the workshop as the beginning of a sustained collaborative process rather than a one-time consultation. The deliberations across the thematic sessions would help define the Centre's initial research agenda, establish priority workstreams and create a roadmap for future engagement between government, academia and industry to operationalise the vision of a modern, efficient, and integrated transport system for India.

TECHNICAL SESSION 1: *Research Needs: Highway Planning, Traffic Demand and Logistics*

The first technical session focused on identifying research priorities in highway planning, traffic demand estimation and logistics. The discussion recognised that India's highway sector has entered a new phase of development where future investments must increasingly be guided by robust analytical frameworks, empirical evidence and data-driven decision-making. Following the remarks of the speakers, the discussion was opened to participants from academia, industry and government, who contributed perspectives on transport modelling, freight movement, corridor planning, and the role of digital technologies in improving highway planning.

Dr Hari Reddy, Chairman, Cube Highways:

Commencing the technical discussions, Dr Hari Reddy emphasised that traffic demand estimation remains the foundation of every successful highway investment. Recalling his early experience in highway traffic surveys during the initial phases of India's highway modernisation programme, Dr Reddy observed that transport planning has traditionally relied on origin–destination surveys, traffic counts, and conventional forecasting techniques. While these approaches have served an important purpose, the complexity of India's rapidly changing transport system now requires more dynamic and data-intensive modelling frameworks.

He noted that one of the foremost priorities for the NHAI–NCAER Centre should be the development of a national framework for traffic demand estimation that integrates multiple sources of information. Rather than relying solely on periodic field surveys, researchers should increasingly utilise digital datasets, vehicle movement records, and emerging mobility data to improve forecasting accuracy. Research should examine not only demand for highways but also the changing distribution of freight and passenger traffic across the transport network. He observed that technological change is rapidly altering travel patterns and logistics systems. The advent of electric vehicles, digital freight platforms, intelligent transport systems, and improved logistics infrastructure are likely to reshape transport demand over the coming decades.

A major concern he highlighted was the need to improve access to high-quality transport data, especially since India now possesses enormous quantities of operational data generated through FASTag systems, traffic monitoring technologies, and digital transport platforms. When made

available under appropriate governance frameworks, these datasets could substantially improve traffic modelling, corridor analysis, and infrastructure planning.

He also emphasised the importance of understanding user behaviour in transport planning. Infrastructure utilisation is influenced not only by engineering design but also by behavioural choices relating to route selection, travel time, cost, convenience, and modal preferences. Future research should, therefore, incorporate behavioural analysis alongside traditional engineering and economic models in order to produce more realistic demand forecasts.

He also observed that freight movement patterns are changing rapidly due to industrial development, e-commerce expansion, supply chain restructuring, and improvements in logistics infrastructure. It is thus important to examine how freight corridors evolve over time and how investments in highways interact with rail, ports, and multimodal logistics facilities to support economic growth. Once projects become operational, researchers should undertake continuous assessment of traffic redistribution, corridor utilisation, travel time savings, and logistics efficiency. Transport demand forecasting should therefore be an ongoing analytical process rather than a one-time exercise undertaken during project preparation. Continuous monitoring of traffic flows, supported by modern data analytics and digital technologies, would enable policymakers to respond more effectively to changing economic conditions and emerging mobility patterns.

Dr Reddy reiterated that the establishment of the NHAI–NCAER Centre provides a unique opportunity to modernise India's transport research ecosystem. By combining rich transport datasets with advanced analytical methods and multidisciplinary research, the Centre can play a pivotal role in developing more accurate demand forecasting models, strengthening multimodal planning, and supporting evidence-based transport policy for the coming decades.

Dr P.K. Sikdar, Advisor, International Road Federation (IRF) – India Chapter; Former Professor, IIT Bombay; and Former Director, CSIR:

Dr P.K. Sikdar discussed the changing nature of transport planning in India and emphasised the need to adopt integrated, multimodal and data-driven approaches to infrastructure development. He noted that the pace of highway construction in recent years has been unprecedented, significantly improving connectivity between cities, industrial centres, and rural regions. However, future investments should increasingly be guided by systematic planning frameworks that evaluate transport demand within the context of broader economic development, regional growth patterns, and multimodal transport systems.

A central theme of his address was the importance of integrating transport planning across different modes of travel, as the efficient movement of passengers and freight depends upon seamless connectivity between highways, railways, ports, airports, and inland waterways. Research should therefore focus on understanding the complementarities among these modes rather than treating them independently, to help improve network efficiency, reduce logistics costs, and support more sustainable patterns of transport development.

Alluding to the Government of India's PM Gati Shakti National Master Plan, he highlighted the importance of coordinated infrastructure planning across ministries and sectors. The availability of integrated geospatial information and digital planning tools provides new opportunities for researchers to examine infrastructure needs from a systems perspective. The NHAI–NCAER Centre, he suggested, could contribute significantly by developing analytical methodologies that support integrated planning under this framework.

Dr Sikdar emphasised that traffic demand forecasting should evolve alongside changes in India's economy and transport sector. Future research should, therefore, incorporate dynamic models capable of reflecting changing travel behaviour, economic activity and infrastructure utilisation over time. India's ambition to become a global manufacturing and logistics hub necessitates the development of transport systems that facilitate efficient movement of goods across production centres, logistics parks, ports, and export gateways. Research should therefore examine freight corridors, commodity flows, logistics performance and last-mile connectivity to identify opportunities for improving supply chain efficiency.

Another important issue discussed was the role of emerging technologies in transport planning. Dr Sikdar observed that digital tolling systems, intelligent transportation technologies, satellite imagery and geospatial analytics have transformed the availability of transport-related information. These technologies provide researchers with opportunities to develop more accurate traffic models, monitor corridor performance in real time, and evaluate infrastructure utilisation with greater precision than was previously possible.

Dr Sikdar also emphasised the need for regular post-project evaluation. Systematic evaluation of travel time savings, traffic redistribution, economic impacts and logistics improvements would generate valuable lessons for future infrastructure planning and investment decisions.

Also focusing on the issue of environmental sustainability, he pointed out that as India's transport sector continues to expand, infrastructure planning should incorporate considerations relating to environmental impacts, energy efficiency, and climate resilience. Research should, therefore, explore approaches that balance economic growth with environmental sustainability while ensuring that transport infrastructure remains resilient to future climatic and ecological challenges.

The establishment of the NHAI–NCAER Centre provides an institutional platform capable of fostering collaboration among government agencies, academic institutions, private sector organisations, and international experts. While encouraging multidisciplinary research across engineering, economics, logistics, environmental studies and public policy. Dr Sikdar expressed confidence that the Centre could become a national repository of knowledge on transport planning and infrastructure policy.

TECHNICAL SESSION 2: Regional and Zonal Economic Impact of Highway Investments

The second technical session examined the wider economic implications of highway infrastructure beyond improvements in transportation. The discussion focused on how investments in highways influence regional development, industrial growth, urbanisation, employment generation, and the spatial distribution of economic activity. The participants emphasised that highways should be viewed not merely as transportation assets but as catalysts for economic transformation capable of reshaping production networks, investment decisions, and regional competitiveness.

Dr Shriniwas S. Arkatkar, Professor, SVNIT

Opening the session, Dr Shriniwas Arkatkar emphasised that the success of highway investments should not be assessed solely through engineering indicators such as road length, pavement quality, or construction costs. Instead, transport infrastructure must be evaluated in terms of its broader contribution to economic development, regional connectivity, and improvements in the quality of life. Highways influence a wide range of economic and social outcomes whose impacts extend well beyond the transport sector.

He noted that transportation infrastructure serves as an important enabler of economic activity by reducing travel time, lowering transportation costs, and improving market accessibility. These improvements strengthen the movement of goods, services, and people, encouraging investment, increasing productivity and expanding economic opportunities across regions. Future evaluations should also consider broader development outcomes, including regional GDP growth, employment generation, logistics efficiency, industrial growth, investment attraction, agricultural market access, tourism development, export enhancement, and urban and regional development.

He raised several key questions that should guide highway investment decisions, including which regions will benefit, which industries will grow, how much employment will be generated, how logistics costs will be reduced, whether investments will attract additional private investment, which industrial clusters may emerge, how land use will change, the expected impact on regional GDP growth, and whether benefits will be equitably distributed across districts. He observed that one of the major challenges in transport economics is establishing a clear causal relationship between highway development and economic growth. While regions experiencing rapid economic expansion often attract greater infrastructure investment, improved infrastructure itself also contributes to higher levels of economic activity. Disentangling these relationships requires careful empirical research using appropriate econometric methods and longitudinal data. Research should also develop indicators that measure changes in accessibility and examine how these improvements affect regional development outcomes.

Dr Arkatkar also highlighted the role of highways in supporting industrial and logistics development. Improved road connectivity reduces transportation costs, enhances supply chain reliability, and increases the attractiveness of regions for private investment. Industrial clusters, logistics parks and manufacturing centres frequently emerge along major transport corridors, generating employment opportunities and stimulating local economic growth. Understanding these spatial dynamics should constitute an important area of future research for the Centre.

He also discussed the importance of evaluating distributive impacts. While highway investments often generate substantial aggregate economic benefits, these gains may not be distributed uniformly across regions or population groups. Some districts experience rapid economic expansion, whereas others derive comparatively limited benefits. Research should, therefore, examine issues of regional equity, balanced development, and inclusive growth when assessing infrastructure investments. He encouraged researchers to integrate spatial analysis into transport research. Geographic Information Systems (GIS), satellite imagery, and location-based data can significantly improve understanding of changes in land use, urban growth, and economic activity associated with new transport infrastructure. Combining these tools with socio-economic datasets would provide richer insights into the long-term impacts of highway investments.

He further highlighted the need to develop an integrated regional economic database by bringing together data from sources such as the Ministry of Road Transport and Highways (MoRTH), NHAI, the Census of India, Ministry of Statistics and Programme Implementation (MoSPI), Department for Promotion of Industry and Internal Trade (DPIIT), Indian Space Research Organisation (ISRO), Indian Railways, PM Gati Shakti, FASTag, the Ministry of Agriculture, State governments, and remote sensing and satellite imagery. Such an integrated database would support GIS-enabled spatial analytics, advanced modelling, real-time dashboards and evidence-based decision-making.

He outlined a framework for assessing the regional economic impacts of highway infrastructure, which includes baseline assessment of transport networks, population, economic profile, land use and baseline economic indicators; accessibility analysis covering connectivity improvements, travel time reduction, market accessibility and network efficiency; economic modelling to estimate economic impacts, employment and income effects, and sectoral multipliers; spatial analysis using GIS and remote sensing to evaluate urban growth, industrial clusters and regional spillover effects; and policy evaluation focusing on investment prioritisation, economic corridor planning, regional development strategies and policy recommendations.

Dr Arkatkar highlighted several challenges associated with regional economic assessment, including missing and fragmented datasets, limited freight and logistics information, inconsistent socio-economic and employment data, low-resolution spatial and land-use information, and issues relating to data quality and timeliness. The modelling challenges pertain to capturing regional spillover effects, analysing multi-sector interactions, evaluating long-term impacts, addressing uncertainty in assumptions and improving model calibration and validation. In addition, policy challenges relate to weak transport and regional planning integration, limited policy coordination, insufficient attention to regional disparities, short-term decision-making, weak performance monitoring and limited institutional capacity.

He emphasised the use of a range of analytical techniques for regional economic impact assessment, including HDM-4, Cost-Benefit Analysis, Accessibility Index, Gravity Model, Input-Output Analysis, Computable General Equilibrium (CGE) Model, Spatial Econometrics, Land Use–Transport Interaction (LUTI) Model, GIS analysis, Remote Sensing, Machine Learning and Artificial Intelligence.

He also discussed the role of emerging technologies in future infrastructure research, including Artificial Intelligence, Machine Learning, Big Data, Cloud Computing, FASTag analytics, IoT sensors, remote sensing satellites, drone surveys, GIS dashboards, economic forecasting, smart mobility and climate resilience. These technologies can support research on regional mobility, regional economic performance, freight and logistics performance, regional accessibility and environmental sustainability, contributing to stronger regional growth, better connectivity, industrial and logistics development, employment generation, sustainable development, and long-term resilience.

Dr Arkatkar emphasised the importance of continuous monitoring rather than one-time evaluation. Economic impacts often emerge gradually over several years as businesses respond to improved connectivity and investment patterns evolve. Longitudinal studies tracking economic indicators before and after highway development would therefore provide more reliable evidence than cross-sectional analyses conducted immediately after project completion. He concluded that India's continued investment in transport infrastructure presents an important opportunity for advancing knowledge on infrastructure economics. Through collaboration between economists, engineers and policymakers, can play a leading role in developing rigorous methodologies for measuring the economic impacts of highways. Such evidence would strengthen investment appraisal, improve policy design and contribute to more efficient allocation of public resources in the years ahead.

Dr Reenu Aneja, Senior Transport Specialist, World Bank:

Dr Reenu Aneja highlighted the importance of developing rigorous analytical frameworks to evaluate how highway infrastructure influences economic activity across different regions. She emphasised that transport investments generate effects that extend well beyond improvements in mobility, shaping patterns of production, investment, employment and regional competitiveness over both the short and long term.

She observed that India's continued expansion of the national highway network provides a unique opportunity to examine the relationship between infrastructure and economic development. While improved connectivity undoubtedly reduces travel time and transportation costs, policymakers increasingly require evidence on the broader developmental outcomes of highway investments. Such evidence is essential for ensuring that infrastructure investments deliver sustained economic returns and contribute to balanced regional growth. Measuring these impacts presents significant methodological challenges. Economic development is influenced by multiple factors operating simultaneously, including industrial policy, demographic change, technological progress, and private investment. Consequently, attributing changes in regional economic performance solely to highway construction requires carefully designed empirical studies that distinguish the effects of transport infrastructure from other concurrent developments.

Another key theme of her presentation was the spatial dimension of economic development. Highways influence not only the regions through which they pass but also neighbouring districts and wider economic corridors. Improved connectivity often alters trade patterns, labour mobility, industrial location, and urban expansion, generating spillover effects that extend beyond immediate project boundaries. Research should, therefore, adopt regional perspectives capable of capturing these broader economic interactions.

Dr Aneja highlighted the importance of examining sector-specific impacts. Different industries respond differently to improvements in transport infrastructure depending on their dependence on logistics, supply chains and market accessibility. Manufacturing, agriculture, tourism, and service industries may experience varying degrees of benefit from improved connectivity. Understanding these sectoral differences would enable policymakers to better align infrastructure planning with regional economic development strategies.

She also discussed the role of transport infrastructure in reducing regional disparities. Well-designed highway networks improve market access for relatively less developed regions, facilitating greater participation in national supply chains and creating opportunities for private investment. However, infrastructure alone cannot eliminate regional inequalities and should be complemented by supportive policies relating to industrial development, skills, urban planning and institutional capacity.

The availability of increasingly detailed administrative and digital datasets, she observed, offers new possibilities for infrastructure research. Combining transport data with information on economic output, employment, enterprise activity, land use, and demographic change would enable researchers to present comprehensive evidence on the long-term developmental impacts of highway investments. Advances in geospatial analysis, remote sensing and big data analytics further expand the scope for understanding spatial patterns of economic transformation.

Dr Aneja also emphasised the need to evaluate the distribution of benefits across different population groups. Infrastructure investments should not be assessed solely in terms of aggregate

economic gains but also with respect to their contribution to inclusive development. It is important to examine whether improved connectivity enhances access to employment, education, healthcare and public services across rural and urban communities while identifying groups that may remain under-served.

She argued that the NHAI–NCAER Centre is well positioned to establish a long-term research programme dedicated to infrastructure impact assessment. By bringing together economists, transport planners, data scientists, and policymakers, the Centre can develop standardised methodologies for evaluating transport investments and generate evidence capable of informing future infrastructure policy at both the national and state levels. In conclusion, Dr Aneja reiterated that India's investment in transport infrastructure should be accompanied by an equally strong investment in research. Systematic evidence on the economic, social and regional impacts of highway development would strengthen project appraisal, improve policy formulation and ensure that future infrastructure investments contribute effectively to the objectives of sustainable and inclusive economic growth.

TECHNICAL SESSION 3: *Research on the Efficacy Analysis of FASTag Deployment (including MLFF)*

The third technical session explored the transformative role of digital technologies in highway management, with particular emphasis on the deployment of FASTag and its implications for transport planning, operational efficiency and evidence-based policymaking. The discussion recognised that digital tolling systems have generated unprecedented volumes of traffic data, creating new opportunities for understanding travel behaviour, corridor performance and freight movement across India's national highway network.

Shri Mudit Agarwal, CEO, IHMCL:

Shri Mudit Agarwal discussed the evolution of FASTag from a cashless toll collection mechanism into one of the most significant sources of transport data available in India. He observed that while the initial objective of FASTag was to improve toll collection efficiency and reduce congestion at toll plazas, the system has subsequently evolved into a valuable digital platform capable of supporting research, policy analysis and operational management across the national highway network.

He explained that the nationwide implementation of FASTag has fundamentally transformed toll operations by replacing manual cash transactions with seamless electronic toll collection. This transition has reduced waiting times at toll plazas, improved traffic flow, and enhanced user convenience while simultaneously increasing operational transparency and efficiency. Beyond its operational benefits, FASTag generates continuous, large-scale information on vehicle movement across the highway network. Unlike conventional traffic surveys, which provide only periodic snapshots of traffic conditions, FASTag records enable researchers and policymakers to observe traffic patterns over extended periods with far greater temporal and spatial coverage. This shift represents a significant advancement in the availability of transport data for analytical purposes.

He noted that the data generated through FASTag has considerable potential to improve traffic demand estimation and infrastructure planning. Information on vehicle volumes, travel corridors, seasonal variation, travel times and vehicle categories can strengthen forecasting models and support more accurate assessments of future infrastructure requirements. Such evidence enables

policymakers to make better-informed decisions regarding capacity expansion, new corridor development and investment prioritisation.

Shri Agarwal highlighted the role of FASTag data in improving operational management of the highway network. Continuous monitoring of traffic flows enables the identification of congestion hotspots, recurring bottlenecks and variations in corridor performance. These insights support timely operational interventions and contribute to improving travel efficiency for highway users.

Commercial vehicle transactions recorded through FASTag also provide valuable information on freight flows across different economic corridors. Analysing these patterns can improve understanding of logistics networks, support freight corridor planning and assist policymakers in identifying emerging transport demands associated with industrial growth and changing supply chains.

Shri Agarwal further emphasised the value of digital data in evaluating infrastructure performance after projects become operational. Rather than relying solely on projected traffic estimates prepared during project appraisal, policymakers can now compare expected outcomes with observed traffic behaviour. Such post-implementation evaluations strengthen future forecasting methodologies and improve the quality of investment planning.

He stressed that the use of FASTag data must be supported by robust institutional frameworks governing privacy, security, and responsible data management. Appropriate safeguards are essential to ensure that operational data is utilised for research and policymaking while protecting user confidentiality and maintaining public trust.

He also highlighted the potential for integrating FASTag information with other digital transport datasets. Combining toll transaction data with GIS, traffic sensors, weather information, freight databases, and satellite imagery would enable researchers to develop richer analytical models capable of supporting more comprehensive transport planning and corridor management. He observed that the NHAI–NCAER Centre provides an ideal institutional platform for undertaking advanced research using these datasets and for developing innovative analytical tools that can directly inform infrastructure policy.

Concluding his presentation, Shri Agarwal observed that India's investment in digital highway infrastructure has created opportunities extending far beyond electronic toll collection. FASTag should be viewed not merely as a technological innovation but as a strategic data asset capable of transforming transport research, improving infrastructure governance and supporting evidence-based policymaking. Harnessing this potential through collaborative research would strengthen planning, enhance operational efficiency, and contribute to the development of a smarter, more integrated national highway system.

Mr Viren Mehta, Director of Growth, Akara Research & Technologies Pvt Ltd.:

Mr Viren Mehta examined how digital technologies and advanced data analytics are reshaping highway planning and operations. He emphasised that the transport sector is undergoing a transition from infrastructure-led decision-making to information-led decision-making, where continuous streams of digital data enable authorities to monitor, evaluate, and optimise highway networks in real time.

He observed that the widespread deployment of electronic toll collection systems, intelligent transportation infrastructure, and connected digital platforms has significantly expanded the availability of transport data. These developments present an unprecedented opportunity to understand traffic dynamics, travel behaviour and freight movement at a scale that was previously impossible. However, the value of these datasets lies not merely in their volume but in the ability to transform raw information into actionable insights for policymakers and infrastructure managers.

A key theme of his presentation was the application of advanced analytics in transport planning. Rather than relying exclusively on historical traffic trends, future planning should increasingly incorporate predictive models capable of identifying emerging travel patterns, forecasting demand and anticipating operational challenges. Such analytical approaches would support more proactive infrastructure management and enable authorities to respond more effectively to changing mobility needs.

Mr Mehta highlighted the growing role of Artificial Intelligence (AI) and machine learning in analysing transport datasets. These technologies can process large volumes of information generated through digital tolling systems, traffic sensors and connected infrastructure to identify recurring congestion patterns, detect anomalies and estimate future network performance. Integrating such tools into highway management systems would improve operational efficiency while supporting evidence-based decision-making.

He further observed that digital highways can evolve into intelligent highways through the application of artificial intelligence for congestion management, toll demand estimation, maintenance cycles, incident risk assessment, seasonal traffic analysis and revenue forecasting. He discussed the importance of real-time monitoring in highway operations. Continuous observation of traffic conditions allows authorities to respond promptly to incidents, manage congestion, improve emergency response and optimise the utilisation of existing infrastructure. Digital monitoring systems, therefore, represent an important complement to traditional infrastructure investments by improving the efficiency of network operations.

Mr Mehta noted that digital transaction records provide valuable insights into commercial vehicle movement across economic corridors. Analysing freight flows can help policymakers identify emerging logistics hubs, understand supply chain dynamics and evaluate the performance of freight corridors. Such information would support more effective logistics planning and contribute to national efforts aimed at reducing logistics costs.

He also observed that continuous mobility data has the potential to provide earlier signals of economic change than conventional economic indicators. FASTag data may reveal industrial corridor activity, freight movement patterns, seasonal economic cycles, regional demand shifts, and supply-chain disruptions.

Mr Mehta stressed the importance of integrating multiple data sources. FASTag data, while highly valuable, should be analysed alongside information obtained from GIS, satellite imagery, vehicle telematics, weather databases and land-use records. Combining these datasets would enable researchers to develop comprehensive analytical models capable of capturing the complex interactions between infrastructure, travel behaviour and regional economic activity.

He further observed that the value of FASTag multiplies when integrated with datasets such as GST, E-Way Bills, industrial output, port cargo, rail freight, banking credit, weather information

and satellite data, creating the opportunity for a national infrastructure-intelligence platform through the NHAI–NCAER Centre.

He highlighted the need for robust data governance frameworks. Issues relating to data quality, interoperability, cybersecurity, and privacy must be addressed to ensure the effective utilisation of digital information. Standardised protocols for data sharing and institutional collaboration would thus play a critical role in supporting future transport research.

He also emphasised the importance of strengthening analytical capacity within public institutions. As digital technologies become increasingly central to transport management, infrastructure agencies require specialised expertise in data science, predictive analytics, and digital systems alongside traditional engineering capabilities. Building such capacity through collaboration with research institutions and academic organisations would strengthen evidence-based governance across the transport sector.

The research frontiers for digital highway intelligence include the use of FASTag as an economic indicator, smarter highway planning through continuous mobility data, strengthening infrastructure finance through traffic intelligence, improving asset monetisation using historical mobility patterns, and applying artificial intelligence to predictive highway management.

He noted that continuous digital data enables proactive planning for capacity augmentation, lane expansion, bypass planning, corridor prioritisation, and demand forecasting. Traffic intelligence can also support project appraisal, lending decisions, asset valuation, risk assessment and credit monitoring for banks, infrastructure funds, InvITs, insurance companies and rating agencies.

Mr Mehta observed that every corridor has its own economic signature and that traffic behaviour is not uniform across India. Corridors serve distinct economic functions, and future capital expenditure will be driven by these characteristics. Traffic volume alone does not explain corridor performance, as the underlying economic function of a corridor is equally important. He noted that revenue density matters more than network length, since longer highway networks do not necessarily generate proportionately higher revenue. Revenue concentration depends upon traffic composition and economic activity, making revenue density an important indicator of the economic weight of a corridor. Further, traffic stability is as important as traffic volume. Corridors with lower volatility, better seasonal balance, and more predictable freight movement present a stronger risk profile for investors, lenders, InvITs, and infrastructure funds.

Mr Mehta observed that India's asset monetisation journey has evolved through multiple models, including Toll-Operate-Transfer (ToT), InvITs, trust structures, and other emerging approaches. Comparative analysis of these models presents opportunities for developing better valuation frameworks. He argued that the opportunity presented by digital infrastructure cannot be realised by any one organisation alone, and requires collaboration among NHAI, IHMCL, academia, research institutions, infrastructure developers, and financial institutions. He noted that the value of digital infrastructure grows when data becomes knowledge and knowledge informs better decisions.

He also highlighted the development of India's structured highway-intelligence platform, covering national highway projects, toll plazas, toll traffic, toll revenue, trusts, and InvITs, ToT bundles, asset monetisation, highway developers and corridor-level analytics.

Looking ahead, Mr Mehta observed that India's digital infrastructure provides a strong foundation for the development of intelligent transportation systems. The integration of connected vehicles,

automated traffic management, predictive maintenance technologies, and real-time monitoring platforms has the potential to transform highway operations over the coming decades. Research undertaken by the NHAI–NCAER Centre can play an important role in evaluating these technologies, identifying best practices, and supporting their effective implementation. He further suggested opportunities for collaborative national research through the development of a National Highway Mobility Index, Freight Movement Index, Corridor Performance Index, Highway Demand Index, Asset Monetisation Index and Highway Economic Activity Index.

In conclusion, he remarked that digital technologies should be viewed not simply as operational tools but as strategic assets for improving transport policy and infrastructure governance. By harnessing advanced analytics and fostering collaboration between government, academia and industry, India can build a transport system that is more efficient, resilient, and responsive to the evolving needs of its economy and society. The future of highways will be defined not only by the roads that are built, but also by the intelligence built around them.

TECHNICAL SESSION 4: *Road Safety, Mobility, and Socio-economic Research Priorities*

The fourth technical session focused on one of the most pressing challenges confronting India's transport sector—road safety. While the expansion of the national highway network has significantly improved connectivity and mobility, reducing fatalities and serious injuries remains a critical public policy priority. The speakers observed that India's road safety challenge cannot be addressed solely through infrastructure improvements; it requires a comprehensive, evidence-based approach encompassing road engineering, vehicle safety, user behaviour, enforcement, emergency response and institutional coordination.

Dr Geetam Tiwari, Emeritus Professor, TRIP Centre, IIT Delhi:

Dr Geetam Tiwari began her presentation by emphasising that road safety should be viewed as a fundamental component of transport planning rather than an issue addressed only after infrastructure has been developed. She observed that despite significant investments in highway construction and improvements in road connectivity, India continues to experience an unacceptably high number of road traffic fatalities and serious injuries each year. Reducing these losses requires a systematic shift in the way transport systems are planned, designed, and managed.

She explained that the traditional approach to road safety has often focused on correcting individual 'black spots' or responding to crashes after they occur. While such interventions remain important, they are insufficient to address the underlying causes of road traffic injuries. Instead, she advocated adopting the internationally recognised Safe System approach, which assumes that human error is inevitable and therefore seeks to design transport systems that minimise the likelihood of fatal or serious outcomes when mistakes occur.

Dr Tiwari noted that the responsibility for road safety should not rest solely with road users. Engineers, planners, policymakers, vehicle manufacturers, enforcement agencies, and emergency medical services all contribute to creating a safer transport system. Effective road safety policy, therefore, requires coordinated action across multiple institutions rather than isolated interventions by individual agencies.

A major theme of her presentation was the importance of incorporating road safety considerations at every stage of infrastructure development. Safety should be integrated into planning, design, construction, operation, and maintenance rather than treated as an afterthought. Road design

decisions—including lane widths, intersection layouts, access control, pedestrian facilities, median treatments and roadside protection—have a direct influence on crash risks and injury severity.

She further emphasised the need to recognise the diversity of road users in India. Unlike many developed countries, Indian roads accommodate pedestrians, cyclists, motorcyclists, public transport vehicles, freight traffic, and non-motorised transport simultaneously. Road designs thus need to account for the varying levels of vulnerability among these users. In particular, pedestrians and two-wheeler users face disproportionately high risks and require dedicated infrastructure that protects them from high-speed traffic.

Dr Tiwari highlighted the critical role of high-quality crash data in developing effective safety interventions. Reliable and detailed information on crash locations, contributing factors, vehicle types, road conditions and injury outcomes is essential for identifying risk patterns and evaluating the effectiveness of safety measures. She observed that improvements in crash data collection, integration and analysis would significantly strengthen evidence-based policymaking.

She also highlighted the use of new data sources for road safety research. These include exposure data derived from satellite images, physical inventory through street views and Mapillary, and user behaviour data collected using videos, drones and cameras employing vision-based techniques for compliance monitoring and surrogate safety measures.

She discussed the value of road safety audits as a preventive tool. Conducting independent safety audits during the planning and design stages allows potential hazards to be identified before infrastructure becomes operational. Such audits are considerably more cost-effective than undertaking corrective measures after crashes have already occurred and contribute to embedding safety within the infrastructure development process.

Behavioural research, she argued, should complement engineering interventions. Understanding why road users engage in risky behaviour, including speeding, distracted driving, non-use of helmets and seatbelts, and unsafe pedestrian crossings, would enable policymakers to design more effective education campaigns, enforcement strategies, and behavioural interventions. Evidence from behavioural sciences should also play a greater role in shaping road safety programmes.

She also discussed several limitations of the existing interventions. Helmet compliance remains low despite surveillance and penalties. The use of powered two-wheelers (PTWs) continues to increase despite their high risk, reflecting the trade-off between convenience and personal risk. Exclusive lanes for pedestrians and bicycles are often used by PTWs in urban areas, highlighting the need for PTW deterrents and pedestrian- and bicycle-friendly designs of non-motorised vehicle lanes. She also observed that safer modes such as public transport must compete with the convenience and affordability of PTWs, underscoring the need for bus priority lanes, pedestrian-priority at-grade crossings, and dedicated pedestrian and bicycle paths.

Dr Tiwari highlighted several risk factors affecting motorised two-wheeler (MTW) safety. These include the influence of urban and transport planning on mode choice behaviour, mixed traffic and lane sharing, the design of road infrastructure, roadside hazards such as trees, signposts and gantry columns within clear zones, guard rails without motorcycle protection systems, and the lack of public transport.

She noted that motorised two-wheelers are exposed to high risk and also impose risks on other vulnerable road users. Approximately 25 per cent of MTWs are involved in single-vehicle crashes such as overturning or colliding with fixed objects or parked vehicles, while approximately 65 per

cent are involved in head-on and rear-end collisions in multi-vehicle crashes. Helmet use in rural areas remains below 10 per cent, and the correct use of helmets in urban areas is less than 50 per cent in India.

Dr Tiwari identified several current challenges in improving road safety outcomes. She questioned why earlier successful approaches are no longer producing the desired results on the ground and highlighted the need for continuous monitoring and evaluation of processes, and strategies to address emerging risks within the transport system. She also referred to the need for further research on high medians on access-controlled roads in India, noting concerns regarding tyre bursts and rollover crashes and observing that their impact has not yet been quantified.

She further highlighted the importance of post-crash care. Improvements in emergency response systems, trauma care, communication networks, and hospital accessibility can substantially reduce fatalities even when crashes occur. Consequently, research should examine the complete continuum of road safety, extending beyond crash prevention to include emergency response and rehabilitation.

Looking ahead, Dr Tiwari encouraged the NHAI–NCAER Centre to establish road safety as a long-term interdisciplinary research programme. Collaboration among engineers, economists, public health specialists, behavioural scientists, urban planners, and policymakers would facilitate a deeper understanding of crash causation and support the development of comprehensive, evidence-based safety strategies. She also observed that the realisation of Vision Zero requires the generation of new knowledge and the establishment of processes that enable continuous knowledge creation to ensure safe highways in India. Given the complexity of traffic safety science and its implementation in the field, she emphasised that continuous experimentation is required to develop safe highways based on the principles of the Safe System Approach.

Finally, she observed that India's aspiration to build world-class transport infrastructure must be matched by an equally strong commitment to protecting human life. Investments in highways should ultimately be evaluated not only by their contribution to mobility and economic growth but also by their ability to create transport systems that are inherently safer for all road users. She expressed confidence that the newly established NHAI–NCAER Centre would play a pivotal role in advancing research, informing policy, and promoting a culture of safety across India's transport sector.

Dr Venkatesh Balasubramanian G. Narayanan

Dr Venkatesh Balasubramanian examined road safety from the perspective of human factors, injury prevention, and scientific investigation. He emphasised that road crashes should not be regarded as unavoidable consequences of mobility but as preventable public health events that can be substantially reduced through evidence-based planning, engineering innovation and institutional collaboration.

He observed that India has made considerable progress in expanding its highway network and improving transport connectivity. However, infrastructure development alone cannot ensure safer roads unless equal attention is devoted to understanding how people interact with transport systems. Road users differ significantly in their physical capabilities, behavioural patterns, and vulnerability to injury. Consequently, highway design and transport policy must be centred around human needs rather than solely around vehicle movement or traffic capacity.

A central theme of his presentation was the concept of human-centred road design. Traditional engineering approaches often assume ideal driver behaviour, whereas real-world transport systems must account for human limitations such as delayed reaction times, fatigue, distraction, and errors in judgement. Designing infrastructure that accommodates these limitations significantly reduces the likelihood that ordinary mistakes will result in fatal or serious injuries.

Dr Balasubramanian highlighted the importance of adopting a scientific approach to crash investigation. Every serious road crash contains valuable information about the interaction between road design, vehicle characteristics, human behaviour, and environmental conditions. Systematic crash investigation enables researchers to identify recurring risk factors, understand injury mechanisms, and recommend targeted interventions that address the root causes of crashes rather than merely their consequences.

He emphasised that curation of high-quality crash data is fundamental to effective road safety policy. While aggregate statistics provide an overview of accident trends, they often fail to capture the detailed circumstances that contribute to individual crashes. Research thus ought to focus on collecting comprehensive information relating to vehicle dynamics, occupant injuries, road geometry, traffic conditions, environmental factors, and emergency response. Such detailed investigations provide the scientific foundation for designing safer roads and vehicles.

Dr Balasubramanian also discussed the role of biomechanics in understanding road traffic injuries. Examining how the human body responds to different types of collisions helps engineers improve vehicle safety features, roadside infrastructure, and protective equipment. Advances in biomechanics have contributed to the development of safer vehicle designs, improved crash barriers, and more effective occupant protection systems, all of which play an important role in reducing the severity of injury in road accidents.

Particular attention was given to vulnerable road users, including pedestrians, cyclists, and motorcyclists, who account for a substantial proportion of road traffic fatalities in India. He emphasised that transport infrastructure should be designed with these users in mind by incorporating safe pedestrian crossings, dedicated cycling facilities, speed-calming measures, and appropriate separation from high-speed vehicular traffic. Protecting vulnerable users should remain a central objective of transport planning rather than an auxiliary consideration.

Dr Balasubramanian further stressed the importance of vehicle safety standards and technological innovation. Improvements in braking systems, crash protection technologies, intelligent driver assistance systems, and vehicle design have significantly enhanced safety outcomes in many countries. Continued research into vehicle technologies, along with stronger regulatory frameworks, would contribute to reducing both the frequency and severity of road crashes in India.

Recognising the rapid growth of digital technologies, Dr Balasubramanian noted that emerging tools such as connected vehicles, AI, computer vision, and intelligent transport systems offer significant opportunities for improving road safety. Real-time monitoring, automated incident detection, and predictive safety analytics can help identify hazardous conditions before crashes occur and enable authorities to implement timely interventions.

He also stressed the need for multidisciplinary collaboration in road safety research. Engineers, medical professionals, behavioural scientists, economists, law enforcement agencies, and policymakers each contribute unique perspectives on crash prevention and injury reduction. In

order to deal with the complex road safety challenges, these disciplines need to work together in developing comprehensive solutions supported by rigorous scientific evidence.

He also emphasised the importance of strengthening institutional capacity for road safety research. Dedicated research centres, long-term data collection programmes, and sustained collaboration between government agencies and academic institutions are essential for building robust evidence capable of informing national road safety policy. The establishment of the NHAI–NCAER Centre, therefore, provides an important opportunity to integrate engineering research with economic analysis and public policy.

Dr Balasubramanian also presented estimates of the socio-economic cost of road crashes in Tamil Nadu for 2019. He noted that the total cost of road crashes was estimated to range between ₹21,078.83 crore and ₹56,543.29 crore, accounting for 0.94–2.5 per cent of the State Gross Domestic Product (SGDP). The economic cost of each road fatality was estimated at ₹87,45,154.79, while the cost associated with each grievous injury was ₹1,69,544.82. The estimated cost of a simple injury was ₹8,486.76 per victim, and production losses to the economy were estimated at ₹12,057.84 crore.

Concluding his presentation, Dr Balasubramanian observed that achieving substantial reductions in road traffic fatalities requires a sustained commitment to scientific inquiry, technological innovation, and institutional cooperation. Investments in safer infrastructure, better vehicles, improved data systems, and human-centred design must be viewed as complementary components of a comprehensive road safety strategy. In this context, the NHAI–NCAER Centre could play a significant role in advancing interdisciplinary research and supporting India's long-term objective of creating a transport system wherein mobility and safety progress together.

TECHNICAL SESSION 5: *Discussion on Various Models of Highway Development and the Way Forward*

The fifth technical session examined the evolution of highway development models in India, with particular emphasis on financing mechanisms, project delivery frameworks, and long-term asset management. As India's highway sector has expanded in scale and complexity, financing and implementation models have undergone significant transformation to balance public investment with private sector participation while ensuring the timely delivery and sustainable operation of highway infrastructure.

Dr S. Velmurugan, Senior Advisor, NHAI Centre:

Dr S. Velmurugan commenced his presentation by observing that India's highway sector has evolved considerably over the past three decades. Early efforts focused primarily on expanding road connectivity to meet growing transport demand, whereas the current phase increasingly emphasises improving network quality, operational efficiency, resilience, and long-term sustainability. As infrastructure programmes become larger and more sophisticated, development models must also evolve to address changing economic, technological and institutional requirements.

He noted that highway development today extends well beyond the construction of physical assets. Modern infrastructure projects require integrated planning, scientific design, efficient project implementation, continuous maintenance, and systematic performance evaluation throughout the

asset lifecycle. Consequently, future development models should adopt a lifecycle perspective rather than focusing exclusively on project construction.

Dr Velmurugan highlighted the importance of selecting appropriate project delivery mechanisms based on project characteristics, financial viability, and expected traffic demand. India has adopted a variety of implementation models, including Engineering, Procurement and Construction (EPC), Build-Operate-Transfer (BOT), Hybrid Annuity Model (HAM) and other public-private partnership arrangements, to address differing investment requirements and risk profiles. Each model presents distinct advantages and challenges, making careful project selection and risk allocation essential for successful implementation.

A key theme of his presentation was the need to strengthen asset management practices after infrastructure becomes operational. He observed that maintaining highways in good condition is often more cost-effective than undertaking major rehabilitation after deterioration has occurred. Research should, therefore, support the development of predictive maintenance strategies that use engineering data, traffic information, and pavement performance indicators to optimise maintenance schedules and reduce lifecycle costs.

Dr Velmurugan also asserted the growing role of technology in highway development. Advances in pavement materials, construction technologies, digital monitoring systems, and intelligent transportation infrastructure have significantly improved the efficiency and durability of highway assets. Research institutions should continue evaluating new technologies under Indian conditions to ensure that innovations deliver measurable improvements in performance, safety, and cost-effectiveness.

Environmental sustainability formed another important component of his address. Highway development should increasingly incorporate climate resilience, resource efficiency, and environmentally sustainable construction practices. Research on recycled materials, low-carbon construction technologies, energy-efficient infrastructure, and resilient pavement systems would contribute to reducing the environmental footprint of future transport investments while improving infrastructure durability.

Dr Velmurugan also noted that infrastructure projects should be evaluated not only during construction but throughout their operational life. Indicators relating to pavement quality, travel time reliability, safety performance, maintenance efficiency, and user satisfaction provide valuable information for improving future project planning and management. Multidisciplinary collaboration is essential for improving highway development models. Engineers, economists, environmental scientists, financial experts, and policymakers each contribute important perspectives on infrastructure planning and management. The NHAI–NCAER Centre provides an opportunity to integrate these disciplines within a common research framework capable of addressing the complex challenges associated with modern transport infrastructure.

Another area identified for future research was resilience. India's highway network increasingly faces risks associated with extreme weather events, climate variability, natural disasters, and rapidly changing traffic patterns. Infrastructure planning should thus incorporate resilience assessments that enhance the ability of transport systems to withstand and recover from disruptions while maintaining essential connectivity.

Dr Velmurugan concluded by expressing confidence that the NHAI–NCAER Centre would become an important platform for advancing research on highway development models. By

combining scientific research, engineering innovation, and policy analysis, the Centre can contribute to improving infrastructure quality, reducing lifecycle costs, and supporting the development of an efficient, resilient, and sustainable transport system over the long term.

Shri Jitender Kumar Chauhan, Whole Time Director and CEO IRB Infrastructure Developers Ltd.:

Shri Jitender Kumar Chauhan focused on the practical dimensions of highway development and the institutional mechanisms required for successful project implementation. While financing models and engineering innovations have expanded the scale of India's highway programme, he emphasised that effective project delivery ultimately depends upon efficient planning, timely execution, strong institutional coordination and continuous performance monitoring.

He observed that India's highway sector has witnessed remarkable growth over the past decade, supported by sustained public investment, improved policy frameworks, and greater participation from the private sector. However, as projects become larger and increasingly complex, infrastructure delivery faces new challenges relating to land acquisition, environmental clearances, utility relocation, contractual management, and coordination among multiple implementing agencies. Addressing these challenges requires not only administrative reforms but also research capable of identifying best practices in project management and institutional design.

A central theme of his presentation was the importance of comprehensive project preparation. Successful implementation begins long before construction starts and depends upon careful planning, realistic traffic forecasts, sound engineering design, and timely statutory approvals. Strengthening project preparation processes reduces implementation risks, minimises delays, and improves the overall quality of infrastructure delivery.

Shri Chauhan further emphasised the importance of effective contract management throughout the project lifecycle. Large infrastructure projects involve multiple stakeholders, including government agencies, concessionaires, contractors, consultants, and financial institutions. Hence, clear contractual arrangements, transparent communication, and timely dispute resolution mechanisms are essential for maintaining project momentum and ensuring accountability among all participants.

He highlighted the role of risk management in improving project outcomes. Highway projects are exposed to a wide range of uncertainties, including fluctuations in construction costs, changes in traffic demand, financing constraints, legal disputes, and unforeseen environmental conditions. Systematic identification and allocation of risks among project stakeholders contribute to more resilient implementation models and improve investor confidence in the sector.

Another important area discussed was the adoption of digital technologies for project monitoring and management. Modern infrastructure programmes increasingly utilise satellite imagery, GIS, Building Information Modelling (BIM), drone surveys, and digital project management platforms to monitor construction progress and improve decision-making. These technologies enhance transparency, enable early identification of implementation challenges, and facilitate more efficient project supervision.

Shri Chauhan also stressed the need to strengthen institutional capacity within implementing agencies. As highway projects become more technically sophisticated, government institutions require specialised expertise in project management, contract administration, financial analysis,

environmental assessment, and digital technologies. Continuous capacity building and knowledge sharing are, therefore, essential for sustaining improvements in infrastructure delivery.

The presentation also highlighted the importance of learning systematically from completed projects. Post-project evaluations should examine not only construction outcomes but also operational performance, maintenance requirements, user satisfaction, and economic impacts. Lessons derived from completed projects can inform future project design, improve institutional practices, and strengthen policy frameworks governing highway development.

Recognising the diversity of India's transport network, Shri Chauhan observed that a single implementation model may not be appropriate for every project. Factors such as traffic demand, geographical conditions, financial viability, and regional development objectives should guide the selection of suitable development models. Flexible policy frameworks that allow different implementation approaches under varying circumstances are, therefore, likely to produce more efficient and sustainable outcomes.

He further opined that collaboration between policymakers, researchers, industry practitioners, and academic institutions is essential for addressing the evolving challenges of infrastructure development. The establishment of the NHAI–NCAER Centre provides an institutional platform through which research findings can be translated into practical recommendations for improving project delivery, institutional governance, and infrastructure management.

Concluding his presentation, Shri Chauhan observed that India's continued investment in transport infrastructure offers an opportunity not only to expand physical connectivity but also to strengthen the institutions responsible for planning, financing, and managing these assets. By combining sound policy, rigorous research, technological innovation, and effective project management, the country can build an efficient and resilient highway network capable of supporting long-term economic growth. The NHAI–NCAER Centre would, therefore, play an important role in documenting best practices, fostering policy dialogue, and supporting continuous improvements in highway development across the country.

TECHNICAL SESSION 6: *NHAI Asset Monetisation*

The sixth technical session focused on asset monetisation as an important component of India's highway financing strategy. As the national highway network expands, sustainable financing increasingly requires innovative approaches that extend beyond traditional budgetary allocations. The speakers discussed how operational highway assets can be leveraged to mobilise capital for future infrastructure investment while ensuring efficient asset management and continued service quality.

Mr Sujit Kumar, Chief Economist, National Bank for Financing Infrastructure and Development (NaBFID):

Mr Sujit Kumar observed that India's highway development programme has entered a stage wherein financing future infrastructure expansion requires innovative approaches to capital mobilisation. While public investment has played a central role in developing the national highway network, the growing scale of infrastructure requirements necessitates complementary financing mechanisms capable of unlocking value from operational assets.

He explained that asset monetisation differs fundamentally from asset privatisation. Under monetisation models, ownership of public infrastructure remains with the government while private investors are granted the rights to operate and maintain assets for a specified period in return for an upfront financial consideration or periodic payments. The proceeds generated through such arrangements can then be re-invested in developing new infrastructure, thereby creating a self-sustaining investment cycle.

Shri Kumar highlighted the success of NHAI in pioneering innovative monetisation models, including the Toll-Operate-Transfer (TOT) programme and InvITs. These initiatives have demonstrated that mature highway assets with stable revenue streams can attract long-term institutional investors while enabling NHAI to recycle capital into new projects without compromising public ownership of strategic infrastructure.

A key theme of his presentation was the importance of selecting appropriate assets for monetisation. He noted that factors such as traffic stability, revenue predictability, operational performance, maintenance requirements, and contractual risk significantly influence investor interest. Careful asset selection and transparent valuation processes are thus essential for ensuring successful monetisation programmes.

He emphasised that robust traffic forecasting and revenue estimation remain fundamental to infrastructure valuation. Reliable projections enhance investor confidence, reduce uncertainty, and contribute to fair asset pricing. Improved data availability, including information generated through digital tolling systems, can strengthen valuation methodologies and support more informed investment decisions.

Mr Kumar observed that infrastructure investors increasingly seek stable, long-term assets capable of generating predictable returns. Well-maintained highway assets with transparent regulatory frameworks and reliable operational performance are attractive investment opportunities for pension funds, sovereign wealth funds, insurance companies, and other institutional investors. Establishing confidence through sound governance and consistent policy implementation is essential for sustaining investor participation.

Mr Kumar also highlighted the importance of maintaining service quality post monetisation. He stressed that financial objectives should not overshadow operational performance or user experience. Clearly defined contractual obligations, measurable performance standards, and effective monitoring mechanisms are necessary to ensure that private operators maintain infrastructure to agreed standards throughout the concession period.

Another important aspect of his presentation concerned the role of research in strengthening asset monetisation policies. Empirical studies examining traffic risk, revenue performance, contract design, maintenance outcomes, and investor behaviour can provide valuable evidence for refining future monetisation models. Comparative analysis of international experiences may also offer insights on best practices that can be adapted to Indian conditions.

Mr Kumar also pointed out that long-term infrastructure investments depend upon predictable regulatory environments, transparent procurement processes, and efficient dispute resolution mechanisms. Continued improvements in these areas would strengthen India's reputation as an attractive destination for infrastructure investment while reducing financing costs for future projects.

Looking ahead, Mr Kumar observed that asset monetisation should be viewed as one component of a broader infrastructure financing strategy rather than as a standalone policy instrument. When integrated with public investment, public-private partnerships, and innovative financial instruments, monetisation can support sustainable expansion of India's transport infrastructure while improving capital efficiency.

In conclusion, Mr Kumar expressed confidence that the NHAI–NCAER Centre could make significant contributions to the evolving field of infrastructure finance by undertaking rigorous research on asset valuation, concession design, investment risk, and financing innovation. Such evidence would support the continued refinement of monetisation policies and strengthen the long-term financial sustainability of India's highway development programme.

Mr Pawan Kant, CEO, Interise Trust:

Mr Pawan Kant examined the institutional and policy dimensions of highway asset monetisation. He emphasised that monetisation should be viewed not merely as a financing mechanism for raising capital, but as part of a broader strategy for improving the efficiency, sustainability, and long-term management of public infrastructure assets.

He observed that the focus in India's highway sector has gradually shifted from expanding physical infrastructure alone to optimising the performance of existing assets and ensuring that investments generate sustained economic value over their lifecycle. Asset monetisation, he argued, enables governments to recycle capital from mature operational assets for the development of new infrastructure, thereby supporting continued expansion without placing excessive pressure on public finances.

A key theme of his presentation was the importance of establishing strong institutional frameworks to support successful monetisation programmes. Investor confidence depends not only on the quality of infrastructure assets but also on the transparency, predictability, and credibility of the institutions responsible for managing them. Clearly defined contractual arrangements, stable regulatory policies, and efficient governance mechanisms are essential for attracting long-term investment into public infrastructure.

Mr Kant highlighted the need for rigorous asset valuation methodologies. Infrastructure assets should be evaluated using transparent and scientifically robust approaches that account for traffic demand, revenue potential, maintenance requirements, operational performance, and long-term investment risks. Accurate valuation protects public interest while ensuring that investors receive realistic assessments of future returns.

He further emphasised the importance of balancing commercial objectives with public service obligations. Although private participation can improve operational efficiency and introduce managerial innovation, highway infrastructure continues to serve broader social and economic objectives. Monetisation frameworks should ensure service quality, safety standards, affordability, and accessibility throughout the concession period.

Another important issue discussed during the presentation was risk allocation. Successful infrastructure contracts require an appropriate distribution of risks between public authorities and private investors. Construction risk, traffic risk, operational risk, regulatory uncertainty, and force majeure events should each be allocated to the party best positioned to manage them.

Shri Kant highlighted the role of institutional learning in strengthening future monetisation initiatives. India's experience with programmes such as Toll-Operate-Transfer (TOT) concessions

and InvITs has generated valuable practical insights into investor behaviour, concession design, and operational management, enabling improvement in subsequent monetisation transactions.

Recognising the growing importance of digital technologies, Shri Kant observed that advances in traffic monitoring, electronic toll collection, and asset management systems have significantly improved the availability of operational data. These datasets allow for more accurate assessment of infrastructure performance, strengthen financial modelling, and enhance transparency for both policymakers and investors.

He asserted that successful asset monetisation depends upon close collaboration among government agencies, financial institutions, infrastructure operators, and research organisations. Independent research can provide valuable evidence on contract performance, investor confidence, maintenance outcomes, and user satisfaction, thereby supporting continuous improvements in policy design. In this context, the NHAI–NCAER Centre is well-positioned to contribute to this evidence base by undertaking rigorous research on infrastructure finance and asset management.

Concluding his presentation, Shri Kant observed that India's evolving experience with asset monetisation offers important lessons for infrastructure policy, both domestically and internationally. Sustained success will depend upon transparent institutions, robust regulatory frameworks, sound financial practices, and continued policy innovation. Accordingly, the NHAI–NCAER Centre could play an important role in supporting research on infrastructure finance, evaluating emerging monetisation models, and contributing to the development of evidence-based policies for strengthening the long-term sustainability of India's transport sector.

TECHNICAL SESSION 7: *Multi-modal Framework and the Immediate Next Steps in Research Agenda Curation*

The final technical session examined the transition from a highway-centric approach to a multimodal transport framework. The speakers observed that the country's future transport strategy must move beyond the expansion of individual transport modes towards the development of an integrated network that seamlessly connects highways, railways, ports, airports, inland waterways, and urban transport systems. Such integration is essential for improving logistics efficiency, reducing transportation costs, and supporting sustainable economic growth.

The discussions during this session highlighted the importance of institutional coordination, digital technologies and integrated planning frameworks in building a resilient and efficient transport ecosystem.

Mr Gaurav Chandna, Vertis:

Mr Gaurav Chandna stressed that India's transport sector is entering a phase wherein future improvements in efficiency will depend less on expanding individual modes of transport and more on strengthening multi-modal integration. He observed that transport infrastructure should be considered as a connected system rather than as a collection of independent assets. Highways provide first- and last-mile connectivity, railways facilitate cost-effective long-distance freight movement, ports connect domestic markets with international trade, and airports support high-value and time-sensitive cargo. The efficiency of the overall transport system, therefore, depends on how effectively these different modes interact with one another.

A major focus of the presentation was the need to reduce logistics costs through integrated planning. Mr Chandna noted that high logistics costs reduce the competitiveness of Indian industry by increasing the cost of production, distribution, and exports. Thus, improvements in multimodal connectivity, supported by efficient logistics hubs and coordinated infrastructure planning, can reduce transportation costs while improving supply chain reliability.

Mr Chandna highlighted the importance of logistics parks and freight terminals in facilitating multimodal integration. These facilities serve as critical interfaces between highways, railways, and other transport modes, enabling smoother cargo transfers and reducing delays caused by fragmented logistics systems. Research should, therefore, examine the optimal location, design, and operational performance of logistics hubs to maximise network efficiency.

Mr Chandna explained that digital tools are becoming increasingly important in enabling integrated transport management. Real-time freight tracking, digital documentation, electronic tolling, intelligent transport systems, and integrated logistics platforms allow different components of the transport network to communicate more effectively. These technologies improve operational efficiency, reduce transaction costs, and generate valuable transport data that can be used to analyse freight movement and identify infrastructure bottlenecks.

Another important issue highlighted during the presentation was institutional coordination. Mr Chandna observed that infrastructure planning involves multiple ministries, government agencies, and private stakeholders with different responsibilities and objectives. Hence, effective multimodal planning requires stronger coordination mechanisms that facilitate joint decision-making, data sharing, and integrated investment planning across sectors.

Mr Chandna emphasised the strategic importance of the PM Gati Shakti National Master Plan in promoting multimodal infrastructure development. By integrating geospatial information and infrastructure planning across sectors, the initiative provides a common platform for identifying connectivity gaps, improving project coordination, and enhancing the efficiency of public investment. He noted that research undertaken by the NHAI–NCAER Centre can help in evaluating both the implementation and the long-term impacts of this integrated planning framework. He observed that freight movement patterns are evolving rapidly due to industrial expansion, the growth of e-commerce, and changes in global supply chains. Infrastructure planning should remain flexible and responsive to these emerging trends. Continuous monitoring of freight corridors, logistics performance, and regional economic activity would enable policymakers to adapt infrastructure strategies to the changing transport demand.

The presentation also highlighted the importance of sustainability within multimodal transport planning. Mr Chandna argued that better integration between transport modes can reduce fuel consumption and congestion, and mitigate environmental impacts by encouraging more efficient movement of goods and passengers. He suggested that research should examine how multimodal investments contribute towards reducing emissions while supporting national economic objectives.

In conclusion, Mr Chandna emphasised that multimodal integration is not merely an infrastructure challenge but also an institutional and policy challenge requiring collaboration across government, industry, and academia. The NHAI–NCAER Centre could play an important role in developing analytical frameworks, evaluating multimodal policies, and supporting evidence-based decision-making to strengthen India's transport and logistics ecosystem.

Mr Akhilesh Tilotia, Thurro:

Mr Akhilesh Tilotia concluded the technical sessions by placing the workshop discussions within the broader context of India's economic transformation and infrastructure ambitions. He observed that transport infrastructure should be viewed not merely as a facilitator of mobility but as a strategic driver of economic growth, productivity, and national competitiveness. As India advances towards the vision of *Viksit Bharat 2047*, research must play a central role in ensuring efficient and resilient transport investments that are responsive to emerging economic challenges.

Mr Tilotia noted that the discussions throughout the workshop had consistently highlighted the need to strengthen the connection between academic research and public policymaking. India has accumulated significant experience in planning, financing, and operating transport infrastructure, yet considerable opportunities remain to transform this experience into systematic knowledge that can guide future decision-making. The establishment of the NHAI–NCAER Centre represents an important institutional step towards embedding evidence within the transport policy process.

A central theme of Mr Tilotia's address was the need to move beyond isolated sectoral analysis towards a systems-based understanding of transport. Roads, railways, ports, airports, and logistics infrastructure together constitute a single economic network that supports production, trade and regional development. Research should therefore examine the interactions among roads, railways, ports, airports, and logistics infrastructure rather than evaluating each mode independently. Such an integrated perspective would enable policymakers to identify investments that maximise overall network efficiency rather than optimising individual sectors in isolation.

Mr Tilotia further noted that infrastructure should ultimately be evaluated in terms of its contribution to economic outcomes. Improvements in transport connectivity influence productivity, labour mobility, industrial development, investment decisions, and access to markets. Measuring these broader economic effects requires analytical frameworks that combine transport planning with economics, finance, regional development, and public policy. The NHAI–NCAER Centre should encourage multidisciplinary research capable of capturing the full range of impacts associated with transport infrastructure.

Another important aspect of Mr Tilotia's presentation concerned the use of data in policymaking. The rapid digitisation of India's transport sector has generated large volumes of information on traffic movement, freight flows, toll transactions, and infrastructure utilisation. However, data alone does not automatically improve decision-making. Its value depends upon the ability to analyse, interpret, and translate information into practical policy recommendations. Building analytical capacity should become one of the Centre's long-term priorities.

Mr Tilotia also stressed the importance of establishing a structured and forward-looking research programme. The NHAI–NCAER Centre should identify emerging issues likely to influence India's transport sector over the coming decades. These include climate resilience, technological disruption, artificial intelligence, autonomous mobility, digital logistics, changing freight patterns, and the evolving relationship between transport infrastructure and regional economic development.

Mr Tilotia observed that high-quality research requires sustained collaboration between government, academia, industry and international institutions. Public agencies possess valuable operational experience and administrative data, academic institutions contribute methodological rigour, while industry provides practical insights into infrastructure implementation and logistics

operations. Bringing these stakeholders together through the NHAI–NCAER Centre would strengthen the quality, relevance, and impact of transport research in India.

He also highlighted the importance of effective communication of research findings. Analytical studies should be translated into practical recommendations accessible to policymakers, infrastructure practitioners, and the wider public. Policy briefs, technical reports, workshops, training programmes, and stakeholder consultations would play an important role in ensuring that research informs real-world decision-making.

Looking ahead, Mr Tilotia suggested that the NHAI–NCAER Centre should establish long-term thematic research programmes in the key areas of transport economics, logistics competitiveness, infrastructure finance, road safety, digital mobility, climate adaptation, and multimodal integration, supported by longitudinal datasets and regular policy engagement.

He suggested that the NHAI–NCAER Centre has the potential to become India's premier institution for transport policy research. By combining analytical excellence with practical policy engagement, the Centre can contribute to more efficient infrastructure planning, stronger institutional capacity, and evidence-based governance across the transport sector. The success of the Centre should ultimately be measured not only by the number of studies it produces but by the extent to which its research influences policy decisions, improves infrastructure outcomes, and contributes to India's long-term economic development.

Concluding Observations and Takeaways

The workshop concluded with a shared recognition that India's transport sector is entering a new phase of development in which research, data, and institutional collaboration will play an increasingly important role. Across the inaugural addresses and the seven thematic sessions, the participants consistently emphasised the need to strengthen evidence-based policymaking, promote multidisciplinary research, and build institutional mechanisms that bridge academia, government, and industry.

The establishment of the NHAI–NCAER Centre for Economics of Transport, Mobility and Logistics was widely welcomed as a significant institutional initiative capable of supporting these objectives. The Centre is expected to serve as a national platform for generating high-quality research on transport economics, infrastructure finance, logistics, road safety, digital mobility, multimodal planning, and regional development. The speakers also expressed confidence that through sustained collaboration and rigorous analytical work, the Centre would contribute meaningfully to improving transport policy and advancing India's vision of a modern, efficient, and integrated transport system under Viksit Bharat 2047.