KAUTILYA
SCHOOL OF
PUBLIC POLICY

Issue **Brief** Series

Integration of AI In Multi Modal Public Transportation Systems

Issue Brief Number: IB-2025-07

Submitted by: Mr. Subhash Gottumukkala (MPP Cohort 2023-25)

Under the Guidance of: Dr. Vishnu S. Pillai, Assistant Professor at Kautilya School of Public Policy

Cite this Article as *Gottumukkala, S.(2025). Integration of AI In Multi Modal Public Transportation Systems. Kautilya School of Public Policy [online]. Available at: https://kspp.edu.in//issue-brief/integration-of-ai-in-multi-modal-public-transportation-systems*

Integration of AI in Multi-Modal Public Transportation Systems

Executive Summary

The lack of efficient integration between metro rails, buses and local trains presents significant public transportation issues for Indian cities. These inefficiencies lead to more private vehicle use, and dispersed commuter routes, exacerbating the negative environmental effects such as air pollution. To tackle these issues, augmenting transport planning through predictive maintenance, route optimization, dynamic scheduling, multimodal integration, and real-time passenger information systems can significantly improve last-mile connectivity, lower traffic congestion, and improve service quality, facilitating efficient multi-modal transport systems. Such integration of algorithms falls into the categories of assisted/augmented intelligence when this comes to mapping them to the bigger construct of adoption of AI technologies.

While these are potential arenas of AI integration in public transportation, they increase the system's complexity and coupling, and according to Perrow's (2011) *Normal Accidents Theory*, the systems become more vulnerable to accidents. While commuters, transportation authorities, and technology suppliers benefit from increased accessibility and operational efficiency, there are challenges, including high implementation costs, ethical concerns, data security risks, and unequal access to AI-driven services.

1. Overview of Multi-Modal Public Transportation in Indian Cities

Public transportation is an essential service for urban mobility for all city citizens. The primary modes of public transport in Indian cities include metro rail, state-owned city bus services, surface rail systems (local trains), and others in some cities. With the rapid urbanization, these systems are facing significant challenges with the lack of integration between the different modes, and it has been one of the significant factors for the present inefficiencies in public transportation, leading to other factors like lack of last mile connectivity, making commuters move towards private vehicles in urban India. (Dawda, 2024)

Metro rail systems are traditionally seen as a solution to the inefficiencies of urban public transportation in India. "21 Indian cities to date compared to five in 2014" (Mishra, 2024) have invested capital to develop a metro rail system. However, the actual ridership of metro rail is lesser than the forecasted ones in four southern cities – Hyderabad, Bengaluru, Chennai, and Kochi (Oommen, 2022). This adds to the discussions on the lack of last-mile connectivity as one among the many concerns along with other factors such as inadequate parking space.

State-owned city bus services are the most widely used public transportation mode in Indian cities. "Decrease in the fleet size, Aging fleets" (Jose, 2022), lack of reliability and quality in services have limited their "effectiveness" (MoHUA, 2019) for an efficient urban commute. A survey by Banerjee (2023) says that approximately 85% of commuters find public transport buses inadequate, adding overcrowding and unreliable service as significant concerns.

Surface rail or the local trains in some cities in India, like Mumbai, form the backbone of urban commute. These systems are often overcrowded in certain cities and underutilized in others. "In 2010-11, in the three megacities of Mumbai, Kolkata, and Chennai, and on the ring rail in New Delhi, surface rail carried 4.06 billion passengers – a daily average of 11.1 million passengers" (Indian Railways 2011: 112 as cited in Ravibabu & Phani, 2014).

Though these systems are individually significant depending on the city, the lack of integration of these modes leads to fragmented journeys for the commuters, multiple ticketing, unaligned schedules, and increased trip times, eventually leading to citizens commuting through their private vehicles. Safety for women due to lack of last-mile connectivity and unreliable service due to the absence of proper integration between travel modes also exacerbates the inefficiencies in service delivery (Sahu et al., 2023).

2. Potential for Artificial Intelligence (AI) Application in Public Transportation

AI has the potential to significantly improve public transportation systems in Indian cities by addressing the various challenges mentioned above. As mentioned before, the integration of AI in this sector comes under the bracket of both assisted and augmented intelligence with its potential for real-time data collection and analysis to improve operational efficiency, reducing travel time, and satisfaction for commuters.

- **Predictive Maintenance of the fleet**: AI algorithms can anticipate potential issues in the vehicles. Analyzing sensor data, transit authorities can address maintenance needs, minimize downtime, and ensure more reliable services (Vemuri et al., 2024).
- **Route Optimization**: AI can use historical and real-time data to recommend efficient transit routes by considering traffic patterns, weather conditions, and passenger demand, which helps reduce passenger travel time and improves system efficiency (George et al., 2024).

- **Dynamic Scheduling**: AI-driven algorithms adapt transit schedules in real-time based on changing passenger needs and external factors such as traffic congestion. This dynamic approach reduces wait time and improves user satisfaction (Vemuri et al., 2024).
- **Multimodal Integration**: AI can help facilitate the integration of different transportation modes, such as metro, buses, and auto rickshaws, and create seamless journeys for passengers. It becomes crucial for improving last-mile connectivity and overall system efficiency (George et al. 2024).
- **Passenger Information Systems**: AI enhances passenger experience by providing real-time updates through mobile apps and digital displays, allowing them to make informed travel decisions (George et al. 2024).

3. Systems Perspective with AI Integration

However, integrating AI systems into the existing public transportation system will alter the system characteristics with respect to its interactions, changing system complexity and coupling. Complex systems have subsystems and system parts interacting in unanticipated ways creating

Without AI, the multimodal public transportation systems in Indian cities are moderately complex and loosely coupled. The different modes of transport, such as buses, metro, and local trains, operate independently without coordination, reducing the impact of failures of one mode on others.

The integration of AI increases the complexity of the public transportation system due to the presence of advanced algorithms, real-time data processing, and the need for continuous updates. These complexities arise from integrating various data sources, the need for adaptive algorithms, and the coordination required across multiple transportation network components.

Coupling: The implementation of AI creates a more tightly coupled system because various components of the transportation network—buses, metro trains, traffic signals, and passenger information systems—become increasingly interdependent. Real-time data and AI-driven decisions require continuous communication and synchronization among these components, enhancing

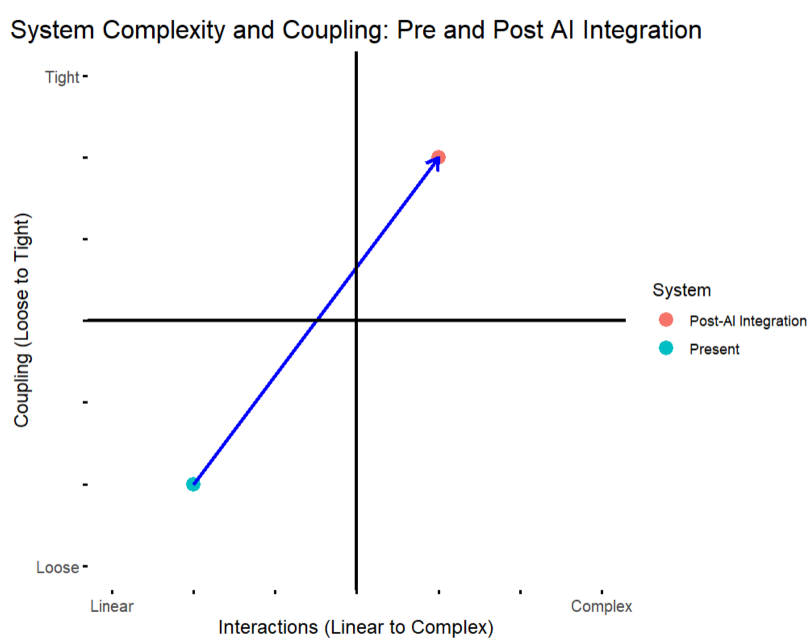

Figure 1. Complexity and Coupling Pre and Post AI integration in Multi Modal Public Transportation

operational efficiency and increasing the system's vulnerability to disruptions in any part of the network. This tighter coupling means that a failure in one component can have more immediate and widespread impacts across the entire system.

Impact Groups:

Integrating artificial intelligence (AI) into public transportation systems significantly affects various impact groups/ victim groups (Perrow (2011), (Sivarudran Pillai & Matus, 2020)). Identifying the impact groups and their challenges aids in formulating tailor-driven policies that are risk-based over umbrella regulations potential to hamper innovation.

Impact Group -1: Technology Developers and Providers

Impacts:

- **Increased Demand**: AI in public transit creates substantial opportunities for technology developers and providers specializing in AI solutions, leading to business growth and innovation (Shah, 2024).
- **Collaboration with Transit Authorities**: Technology providers collaborate closely with public transit agencies to customize AI applications (Vujadinovic et al., 2024), making the data available for technology providers at cheaper costs. The rapid advancements in AI technology necessitate ongoing investment in research and development by technology providers with the availability of more data. This

commitment is essential for maintaining competitive and practical solutions in a fast-evolving market (Pasha, 2024).

Risks:

- **Data Security**: AI systems heavily rely on data, making robust cybersecurity measures critical. Providers face significant reputational and legal risks if data breaches occur (Vujadinovic et al., 2024).
- **Regulatory Compliance**: As data privacy and AI usage regulations evolve, technology providers must adapt continuously, which can incur additional costs and operational challenges (Vujadinovic et al., 2024).

Impact Group -2: Transit Authorities, Government Agencies, and City Planners

Impacts:

- **Operational Efficiency**: AI enhances route planning, scheduling, and maintenance for transit authorities. This optimization leads to improved resource allocation and service reliability (Shah, 2024).
- **Data Management Challenges**: Implementing AI requires robust data infrastructure to handle large volumes of information effectively, presenting a challenge for agencies that must upgrade their systems accordingly (Ionescu, 2024).
- **Training and Adaptation**: Staff training is crucial for effectively utilizing AI tools. Additionally, organizational processes may need adjustments to integrate AI-driven insights seamlessly into existing workflows (Impact of AI in the Public Sector, 2022).

Risks (Impact of AI in the Public Sector, 2022):

- **Financial Burden**: The initial investment required for implementing AI systems is significant, with a risk of budget overrun if projects exceed planned costs.
- **Technology Dependence**: Over-reliance on AI technologies can lead to operational disruptions because of an inbuilt complex and tight coupling system, i.e. if components of systems fail or malfunction, it impacts service delivery.
- **Public Backlash**: Poor implementation or misuse of AI can lead to public backlash concerning privacy issues related to data usage.
- **Pacing Problem**: Rapid technological advancements may outpace the development of adequate policies and regulations, which leads to governance gaps complicating implementation (Pande & Taeihagh, 2023; Thierer, 2018).
- **Ethical Concerns**: Policymakers should address ethical considerations with the AI use, including algorithmic bias and ensuring equitable access to its benefits across different socio-economic groups.

Impact Group -3: Commuters (Users) (Both IG2 and IG3)

Impacts:

- **Improved Service Quality**: AI applications improve travel experience by providing more accurate arrival predictions, reducing wait times, and personalizing services based on user preferences.
- **Privacy Concerns**: The data collection for AI applications raises significant concerns about the privacy and security of personal information of users (Vujadinovic et al., 2024).

- **Accessibility Improvements**: AI integration enhances accessibility features within public transportation systems, making them more user-friendly for individuals with disabilities. For example, initiatives like Project Luna provide real-time information in formats accessible to users with hearing impairments (AI in improving public transportation, 2024).

Risks (Chakrabarti, 2024)**:**

- **Digital Divide**: Not everyone has equal access to or even comfort with digital tools, Thus potentially marginalizing less tech-savvy individuals from the benefits of AI-enhanced services.
- **Service Disruptions**: During the transition to AI-driven systems, people might experience temporary service inefficiency that could impact their trust in public transportation options.
- **Social Inequity**: Without proper planning, the introduction of AI may increase social inequities if the benefits are not equitably distributed across socio-economic groups.

References

AI in improving public transportation (2024, December 18). *Global Tech Council.* https://www.globaltechcouncil.org/ai/ai-in-improving-public-transportation/

Banerjee, A. (2023, October 19). 85 percent commuters think Indian public transport is inadequate: Overcrowding, maintenance among major issues. *The Times of India*. https://timesofindia.indiatimes.com/auto/news/85-percent-commuters-think-indian-public-transport-is-inadequate-overcrowding-maintenance-among-major-issues/articleshow/104553408.cms

Chakrabarti, K. (2024, July 31). AI's role in public transportation: Optimizing routes and reducing delays. *iTMunch.* https://itmunch.com/ais-role-in-public-transportation-optimizing-routes-and-reducing-delays/

Dawda, N. "Towards A Comprehensive Framework for Public Transport System Planning in India," ORF Occasional Paper No. 455, November 2024, Observer Research Foundation. https://www.orfonline.org/public/uploads/posts/pdf/20241123112003.pdf

Desai, D., & Dawda, N. (2024). "New Approaches for Integrated Multimodal Transport Systems," GP-ORF Series. December 2024, Observer Research Foundation. https://www.orfonline.org/public/uploads/posts/pdf/20241228102901.pdf

George, A., Harsh, RG., Girijamma, HA., Hemanth, S. (2024). AI and ML-Based Optimization of MultiModal Transportation. *International Journal of Novel Research and Development*, *9*(8), 479–487.

Shah, H. (2024, October 9). *AI in transportation: Applications, examples, and future trends. Prismetric.* https://www.prismetric.com/ai-in-transportation/

Impact of AI in the public sector. (2022, November 22). *T-Systems.* https://www.t-systems.com/id/en/insights/newsroom/news/impact-of-ai-in-the-public-sector-562062

Ionescu, D. (2024, October 12). How AI can improve public transit. *Planetizen.* https://www.planetizen.com/news/2024/10/132205-how-ai-can-improve-public-transit

Jose, D. (2022, August 18). Hyderabad needs 6,000 buses, only 3,100 in Telangana State Road Transport Corporation fleet. *The Times of India*. https://timesofindia.indiatimes.com/city/hyderabad/hyderabad-needs-6000-buses-only-3100-in-telangana-state-road-transport-corporation-fleet/articleshow/93648452.cms

Ministry of Housing and Urban Affairs (MoHUA) (2019). Developing Options & Recommendations for Resolving Regulatory, Institutional and Fiscal Constraints in Providing Efficient and Sustainable City Bus

Services.https://mohua.gov.in/upload/uploadfiles/files/PC1_ESCBS_Domestic_Review_Report_(09_Jun_19).pdf

Mishra, T. (2024, August 16). Cabinet approves metro rail projects worth Rs 30,000 crore in Bengaluru, Thane, and Pune. *The Economic Times*. https://economictimes.indiatimes.com/news/economy/infrastructure/cabinet-approves-metro-rail-projects-worth-rs-30000-crore-in-bengaluru-thane-and-pune/articleshow/112574039.cms

Pande, D., & Taeihagh, A. (2023). Navigating the governance challenges of disruptive technologies: insights from regulation of autonomous systems in Singapore. Journal of Economic Policy Reform, 26(3), 298–319.

Pasha, S. M. (2024, October 14). Transforming public transit with AI and machine learning. *RTInsights.* https://www.rtinsights.com/transforming-public-transit-with-ai-and-machine-learning/

Paul Oommen. (2022, July 22). *Metro rails in Chennai, Bengaluru, Hyd & Kochi struggle with low revenues*. The News Minute. https://www.thenewsminute.com/news/metro-rails-chennai-bengaluru-hyd-kochi-struggle-low-revenues-166097

Perrow, C. (2011). Normal Accidents: Living with High-Risk Technologies-Updated Edition. Princeton University Press. https://www.jstor.org/stable/j.ctt7srgf

Ravibabu, M., & Phani Sree, V. (2014). Public transport for Indian urban agglomerations: A strong case for surface rail. *Economic and Political Weekly*, *xlix* (23), 105–116.

Sahu, S., Shanker, S., Kamat, A., & Barve, A. (2023). India's public transportation system: the repercussions of COVID-19. *Public Transport*, *15*(2), 435–478. https://doi.org/10.1007/s12469-023-00320-z

Sivarudran Pillai, V., & Matus, K. J. M. (2020). Towards a responsible integration of artificial intelligence technology in the construction sector. Science and Public Policy, 47(5), 689–704. https://doi.org/10.1093/scipol/scaa073

Thierer, A. (2018). The pacing problem and the future of technology regulation. The Bridge.

Vemuri, N., Manoj Tatikonda, V., & Thaneeru, N. (2024). Enhancing Public Transit System Through AI and IoT. *International Journal of Scientific Research and Management (IJSRM)*, *12*(02), 1057–1071. https://doi.org/10.18535/ijsrm/v12i02.ec07

Vujadinovic, V. L., Damnjanovic, A., Cakic, A., Petkovic, D. R., Prelevic, M., Pantovic, V., Stojanovic, M., Vidojevic, D., Vranjes, D., & Bodolo, I. (2024). AI-driven approach for enhancing sustainability in urban public transportation. *Sustainability, 16*(17), 7763. https://doi.org/10.3390/su16177763