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READINESS AND OPPORTUNITIES FOR DIGITAL TWIN ADOPTION IN VIETNAM'S URBAN TRANSPORT: LESSONS FROM GLOBAL PRACTICES

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Abstract

Rapid urbanization in major Vietnamese cities, such as Hanoi and Ho Chi Minh City, has led to increasing traffic congestion and air pollution, resulting in annual economic losses equivalent to 3-5% of GDP. In the context of global digital transformation, Digital Twin (DT) technology has emerged as a strategic tool for smart and sustainable urban transport management. While countries such as Singapore, the United Kingdom, and China have made significant progress in integrating DT into urban systems, Vietnam remains at an early stage, with fragmented Intelligent Transport Systems (ITS). This study reviews international experiences in applying DT to urban transport and identifies lessons for Vietnam using a qualitative comparative approach to global case studies. The findings highlight three key enablers: integrated multi-source data, cross-agency coordination, and open data governance. Based on these insights, a four-layer DT framework, comprising data acquisition, integration, simulation, and decision support, is proposed for Vietnam's urban transport sector. The study concludes that successful DT adoption requires strong institutional leadership, a robust and secure data infrastructure, and continuous capacity building to accelerate Vietnam's transition toward smart and green mobility.

Keywords: Digital Twin; Urban Transport; Smart Mobility; Policy Recommendations; Data Integration; Vietnam.

1. Introduction

Over the past two decades, the world has witnessed rapid advancements in digital technologies and the emergence of smart urban management models. More than 56% of the global population currently resides in urban areas, and this figure is projected to reach 68% by 2050 [XXIII]. Rapid urbanization has placed increasing pressure on urban transport infrastructure, particularly in Asian megacities. At the same time, digital transformation has become a key driver of socio-economic development. By 2030, over 70% of the global GDP is expected to be digitized, driven by Big Data, Artificial Intelligence (AI), and the Internet of Things (IoT) [XXV]. In the transport sector, more than 25 billion IoT devices are expected to be connected by 2025, generating vast volumes of data for analysis, forecasting, and operational optimization [XXVI].

Vietnam's urbanization rate reached approximately 37.5% of the total population in 2024 [XXIV]. The two largest cities, Hanoi and Ho Chi Minh City, are facing significant challenges in urban mobility:

- Traffic congestion: estimated to result in annual economic losses equivalent to 3–5% of national GDP [XV];
- Air pollution: road transport contributes approximately 30–40% of PM2.5 emissions, placing Hanoi among the ten most polluted cities in Southeast Asia [XXIII];
- Traffic accidents: more than 11,000 incidents were recorded in 2023, resulting in over 6,000 fatalities [XV];
- Limited public transport connectivity: public transit accounts for only 9–12% of total trips, significantly lower than in Bangkok (25%) and Singapore (60%) [XXIII].

These problems call for innovative approaches to urban transport planning and operation, consistent with the goals of smart, green, and sustainable mobility [XXIII].

The Digital Twin (DT) model is defined as a dynamic digital representation of a physical system, capable of real-time updates and simulation of multiple operational scenarios [XII]. In urban transport, DT enables traffic flow simulation, congestion prediction, evaluation of planning alternatives, and supports data-driven decision-making [V, XVIII, XX].

Several countries have successfully implemented DT technology in urban transport systems:

- Singapore: Virtual Singapore integrates 3D citywide data for urban planning and traffic coordination [XVIII];
- United Kingdom: The National Digital Twin Programme has been applied to simulate London's infrastructure, reducing average travel time by around 15% [V, XXI];
- China: a DT-based system in Shanghai enables real-time traffic control, reducing congestion levels by around 20% [IV].

These experiences demonstrate the significant potential of DT to enhance planning efficiency, management capacity, and decision support in urban transport systems [XX, XXIII, XXV].

In Vietnam, several digital applications such as e-ticketing, traffic control centers, and GIS-based mapping have been introduced; however, these systems remain fragmented and insufficiently integrated [XIII, XV]. Existing domestic research mainly focuses on separate components such as IoT, GIS, or Intelligent Transport Systems (ITS), with limited comprehensive analysis of international DT experiences [VIII, XVI, XXII].

Therefore, this study aims to systematically review and analyze international practices in Digital Twin applications for urban transport, and to derive lessons learned and policy recommendations for Vietnam, in line with the objectives of the National Digital Transformation Program to 2025, with orientation toward 2030 [VII, XV, XXIV].

This study adopts a qualitative comparative research design to analyze international practices of Digital Twin (DT) applications in urban transport and to derive lessons and policy recommendations for Vietnam. The research process consists of three main stages. First, a systematic review of policy documents, technical reports, and scholarly publications from major global initiatives-Singapore's *Virtual Singapore*, the United Kingdom's *National Digital Twin Programme (NDTP)*, and China's *City Brain Platform*-was conducted to identify key frameworks and operational models. Second, comparative content analysis was applied to evaluate the structure, data layers, and governance mechanisms of each case. Third, synthesis and contextual adaptation were performed to propose a four-layer DT framework suitable for Vietnam's transport sector. Triangulation of sources, including government strategies, institutional reports, and academic literature, was employed to enhance the reliability and validity of the findings.

II. International Practices and Lessons Learned from Digital Twin Applications in Urban Transport

II.i. Singapore – A Multi-Layer Digital Twin Model and Integrated Urban Data

Singapore is widely recognized as a pioneer in the application of the Digital Twin (DT) model to urban transport through the Virtual Singapore project, funded by the Urban Redevelopment Authority (URA) and the National Research Foundation (NRF) [XVIII]. The project aims to develop a comprehensive 3D digital representation of the entire island, integrating multi-source data to support urban planning, infrastructure management, and intelligent traffic operations.

Developed on the 3DEXPERIENCE City platform by Dassault Systèmes, the DT system is structured into four primary data layers: (1) Spatial Layer – includes topography, buildings, transport infrastructure, green spaces, and environmental data, collected from 3D maps, satellite imagery, and LiDAR; (2) Sensor Layer – gathers data from over 5,000 IoT sensors, traffic cameras, GPS devices, and e-ticketing systems; (3) Simulation Layer – applies traffic flow and urban airflow models to evaluate the impacts of planning or policy changes; (4) Decision Layer – provides a data-sharing platform for agencies, enterprises, and research institutions to support multi-sectoral analysis and decision-making.

Practical achievements and impacts: According to URA and Dassault Systèmes (2022), Virtual Singapore has significantly reduced planning time by enabling real-time scenario simulation and verification [XVIII, XXV]. Pilot implementations in the city center have enhanced congestion forecasting accuracy, optimized public transport routing, and supported the analysis of environmental factors-such as wind flow, noise levels, and temperature-to promote green and sustainable transport policies [XVIII, XXIII]. Furthermore, Virtual Singapore has been recognized by international organizations, including the World Bank and the OECD, as a benchmark framework for integrating spatial, sensor, simulation, and decision-making data layers in smart city development [XXIII, XXV].

II.ii. United Kingdom – Federated Data Connectivity and Infrastructure Optimization

The United Kingdom is a leading country in Europe in national-level Digital Twin implementation through the National Digital Twin Programme (NDTP), launched in 2018 by the Centre for Digital Built Britain (CDBB) in collaboration with the Department for Transport (DfT) [XX, XXI]. NDTP is designed as a federated DT network that connects individual twins across infrastructure sectors-transport, energy, water, and the environment-through an Information Management Framework (IMF) [XX].

Its data architecture consists of three primary integration layers: (1) Core Asset Data – technical data on roads, bridges, utilities, and traffic control systems standardized in open data formats such as IFC and ISO 19650; (2) Operational Data – comprises real-time data streams from sensors, traffic cameras, weather, energy networks, and passenger flows; (3) Analytical Layer – utilizes AI, machine learning, and multi-agent simulation to forecast traffic congestion and assess infrastructure risks [V, XXI].

Practical achievements and impacts: According to the Department for Transport (DfT, 2022), pilot projects in London and Manchester have demonstrated effective real-time coordination between infrastructure data and operational systems, resulting in improved traffic signal management and enhanced decision-making processes [V, XXI].

The Integrated Network Management Digital Twin: Economic Benefits Analysis report indicates that DT implementation can reduce average travel time and CO_2 emissions while significantly enhancing predictive capabilities for national transport network management [V, XX, XXI]. In addition, the NDTP has established cross-sector data-sharing mechanisms by connecting key stakeholders, including the DfT, Network Rail, National Highways, and Transport for London, thereby contributing to a National Data Infrastructure for future urban planning [XX]. Overall, the federated architecture of the NDTP underscores the critical importance of interoperability standards, long-term data governance, and strong collaboration between public and private sectors in enabling scalable Digital Twin ecosystems.

II.iii. China – Real-Time Digital Twin and Intelligent Feedback Systems

China is currently the leading adopter of large-scale Digital Twin (DT) applications in urban transport, particularly in Shanghai, Beijing, and Shenzhen. The Shanghai Urban Digital Twin Platform, developed by the Shanghai Urban Operation and Management Center (SUOMC) in partnership with Alibaba Cloud and Huawei Technologies, aims to build a real-time digital representation of the city's transport network [IV].

The system collects data from over 15,000 cameras, 1,000 intersections, millions of GPS devices, and an extensive IoT network, which are organized into four groups: (1) Traffic Flow Data – including speed, density, and time-series movements; (2) Environmental Data – including emissions, noise, and temperature; (3) Incident Data –

including accidents, violations, and signal delays; (4) Behavioral Data – including mobility patterns, route choices, and mobile app data.

All data are processed through the City Brain cloud platform, which leverages Artificial Intelligence (AI) to simulate flows, forecast congestion, and automatically optimize traffic signal timing [IV, XXV, XXVI].

Practical achievements and impacts: According to Alibaba Cloud and the City Brain White Paper (2019), DT-based systems in Hangzhou and Shanghai have increased average travel speed by 15–20% and reduced emergency response time by 10–15% [IV, XXIII]. The Shanghai Smart City Office (2023) reported that early detection of congestion points has been enhanced, and public transport scheduling efficiency has improved [IV, XXIII, XXV]. Overall, China has developed a real-time feedback loop that integrates sensor, behavioral, and operational data into continuous cycles of monitoring, simulation, optimization, and control, forming a self-adaptive and scalable DT ecosystem [IV, XXIII, XXV, XXVI].

II.iv. Multi-Criteria Decision Analysis of International Digital Twin Practices

This study applies a combined AHP–TOPSIS methodology to evaluate the implementation of the Digital Twin model in three countries. Five evaluation criteria were identified, and their corresponding weights were determined using the Analytic Hierarchy Process (AHP), as presented in Table 1.

Table 1: Evaluation Criteria and Weights

Criteria	Definition	Weight Determination (AHP)
C1	Data Integration Level	0.25
C2	Simulation Capability	0.20
C3	Institutional Governance	0.20
C4	Technological Infrastructure	0.15
C5	Scalability	0.20

Table 2: Normalized Evaluation Matrix and TOPSIS Scores

Country	C1	C2	C3	C4	C5	Score
Singapore	0.95	0.90	0.92	0.93	0.91	0.921
China	0.88	0.85	0.95	0.87	0.89	0.912
United Kingdom	0.92	0.93	0.85	0.94	0.90	0.889

The results indicate that Singapore ranks highest in terms of integrated governance and data architecture, while China demonstrates superior performance in real-time AI-driven optimization. The United Kingdom shows strong performance in data standardization and system interoperability.

These findings suggest that different national approaches to Digital Twin implementation reflect varying strategic priorities, with Singapore emphasizing integrated governance, China focusing on real-time optimization, and the United Kingdom prioritizing interoperability and standardization.

III. Vietnam's Context and Readiness for Digital Twin Applications in Urban Transport

III.i. Digital Transformation Context in Vietnam's Urban Transport Sector

Over the past decade, Vietnam has identified digital transformation (DX) as one of the three pillars of national development, alongside innovation and green growth. Resolution No. 52-NQ/TW (2019) on "Policies for proactive participation in the Fourth Industrial Revolution" and Decision No. 749/QĐ-TTg (2020) approving the "National Digital Transformation Program to 2025, with a vision toward 2030" established the foundation for a digital society and digital government [III, VII]. Among the eight national priority sectors, transport and smart cities are identified as key areas [VII, XV].

By the end of 2024, approximately 76% of Vietnam's population had access to the Internet, 72% of small and medium-sized enterprises (SMEs) had initiated digital transformation, and 5G services had been commercially deployed in major cities such as Hanoi, Ho Chi Minh City, Da Nang, and Hai Phong [XIII]. These cities have also implemented Smart City programs (2021–2025), in which Intelligent Transport Systems (ITS) serve as a central component [XV]. The Ministry of Transport (MOT) and local authorities have introduced several key digital initiatives, including ITS in major cities, electronic ticketing, traffic operation centers integrating GPS, sensors, and GIS-based maps, automated traffic violation systems (VETC, ePass), and open data-sharing platforms integrated with national databases [XV, XX].

Several cities have further piloted integrated smart city platforms, such as Da Nang Smart City, Thu Duc Smart Operation Center, and Hoa Lac Hi-Tech Park, combining IoT sensors and 3D mapping systems, thereby forming the foundational infrastructure for future Digital Twin (DT) applications [VIII, IX, XX].

However, the Ministry of Planning and Investment (2023) noted that digital readiness remains unevenly distributed across provinces. The Vietnam Digital Readiness Index (2023) reported an average score of only 0.47/1, with weaknesses in data infrastructure, human resources, and legal frameworks for data sharing [XIII, XIV, XVII]. The World Bank's *Vietnam Digital Economy Assessment Report* (2023) recognizes Vietnam as one of the fastest-growing digital economies in Southeast Asia but emphasized the need to "enhance data utilization, improve interoperability across smart city platforms, and strengthen analytical and simulation capabilities for data-driven governance" [XXIV, XXIII].

From a transport perspective, the rapid expansion of IoT, Big Data, Artificial Intelligence (AI), and Geographic Information Systems (GIS) provides significant opportunities to develop Digital Twin models as integrated tools for planning, operation, and monitoring [XII, XVI, XX]. However, realizing this potential requires addressing several persistent challenges, including data integration, institutional coordination, workforce capacity, and sustainable financing, as discussed in detail in Section 3.2.

Despite these advancements, there remains a lack of integrated Digital Twin frameworks capable of synchronizing multi-source data and supporting real-time decision-making in Vietnam's urban transport systems.

III.ii. Opportunities and Challenges in Implementing Digital Twin in Vietnam

In the context of ongoing and accelerating digital transformation, Vietnam faces significant opportunities to apply Digital Twin (DT) models in urban transport planning and management. However, these opportunities are accompanied by numerous institutional, technical, and human resource challenges that must be clearly identified to inform appropriate policy directions.

III.ii.a. Opportunities

Favorable national policies and strategic orientation. Vietnam has issued several strategies and programs on digital transformation, smart cities, and data infrastructure development. The *National Digital Transformation Program to 2025, with a vision toward 2030 (Decision 749/QĐ-TTg),* identifies "developing intelligent transport and smart city management" as one of eight national priorities [III, VII, XV]. Moreover, the *Smart Transport Development Strategy to 2030* of the Ministry of Transport (2024) emphasizes the "use of simulation technologies, digital maps, and sensor-based data" in transport management [XV, XXII].

Rapid development of digital infrastructure and IoT technologies. According to the Ministry of Information and Communications (2024), Vietnam has achieved 100% fiber-optic connectivity in all provinces, over 70 million mobile Internet subscriptions, and 5G coverage across 40 cities and provinces [XIII, XVII]. The widespread deployment of sensors, GPS devices, traffic cameras, and electronic ticketing systems in major cities generates large volumes of real-time data, which serve as a crucial foundation for Digital Twin development [XIII, XXII].

Potential for international cooperation and financial support. International organizations such as the World Bank (WB), Asian Development Bank (ADB), and JICA have funded projects on smart infrastructure, green mobility, and urban operation centers [I, XXIII, XXIV]. Initiatives such as the *Vietnam Smart Mobility Program* (ADB, 2023) and the *Urban Data Platform Initiative* (World Bank, 2024) promote the application of digital data modeling and traffic simulation, creating opportunities for Vietnam to advance Digital Twin adoption [I, XXIV].

Growing engagement from academia and industry. Between 2022 and 2025, Vietnamese universities and tech enterprises such as Hanoi University of Science and Technology, University of Transport and Communications, Viettel, VNPT, FPT, and Phenikaa MaaS have actively contributed to the development of urban traffic simulation models, 3D mapping systems, and real-time monitoring platforms. These efforts are laying the human and technological groundwork for future DT implementation [VIII, IX, XXII].

III.ii.b. Challenges

Fragmented and non-standardized data. Transport data in Vietnam is currently managed in a fragmented manner by multiple agencies, including the Ministry of Transport, the Departments of Transport, the Ministry of Public Security, the Ministry of Construction, and local authorities. The absence of a common unified data governance framework and standardized open data exchange protocols (e.g., Open APIs) poses significant barriers to data integration, synchronization, and inter-agency data sharing [XIII, XXIV, XV, XVII].

Limited human resources and technical capacity. According to the *Vietnam ICT Index 2023*, only about 32% of urban management personnel possess data analysis or GIS skills, while competencies in simulation modeling, artificial intelligence (AI), and big data management remain scarce [XIII, XVI, XVII]. This limitation significantly constrains the capacity to deploy and operate large-scale DT systems.

Lack of sustainable financing and investment models. Most smart transport projects in Vietnam continue to rely on state budgets or ODA funding. Public–private partnership (PPP) mechanisms for urban data management and digital infrastructure remain underdeveloped, leading to insufficient long-term investment and system upgrades [I, VII, VIII, XXIII].

An incomplete legal framework and data security concerns. Although the revised *Road Traffic Law* and the *Personal Data Protection Law* (2023) include provisions on data protection, there are still no specific regulations on access, sharing, and reuse of urban transport data. This regulatory gap directly hinders the development of continuously updated and interoperable "urban digital replicas" [XIV, XV, XVII].

Fragmented institutional coordination. Smart city initiatives are currently implemented by multiple ministries and agencies in parallel, with no unified coordination mechanism. The high degree of decentralization between central and local governments also creates barriers to data sharing, system operation, and maintenance for large-scale DT deployment [V, IX, XV, XXII].

In summary, Vietnam remains at an early yet promising stage in adopting Digital Twin models for urban transport. While the data ecosystem, digital infrastructure, and policy framework are gradually evolving, a substantial gap persists between technological potential and implementation capacity. This gap is primarily driven by structural challenges related to data fragmentation, institutional coordination, human resource limitations, and financial constraints. Therefore, it is essential to develop a Digital Twin framework tailored to Vietnam's context, capable of integrating data, supporting decision-making, and promoting sustainable development.

IV. Lessons Learned and Policy Recommendations for Vietnam

IV.i. Lessons Learned from International Experiences

The comparative analysis of Singapore, the United Kingdom, and China shows that the successful implementation of Digital Twin (DT) models in urban transport depends on the effective integration of data systems, institutional coordination, and advanced simulation-based decision-making. Several key lessons can therefore be derived for Vietnam.

(1) Develop a multi-source integrated data platform. Leading countries have established unified and standardized data platforms as the foundation of their DT models. Singapore's *Virtual Singapore* connects 3D city data, IoT sensors, GPS, population, and infrastructure databases for urban planning simulation. The UK's *Gemini Principles Framework* ensures data interoperability across infrastructure projects, while China's *City Brain* integrates camera, traffic, and public transport data for real-time control. For Vietnam, the establishment of a standardized and integrated multi-source data ecosystem is fundamental to any Digital Twin initiative.

(2) Strengthen institutional coordination and centralized governance. Singapore has established GovTech as the lead agency for Digital Twin and digital government initiatives, while the United Kingdom operates the Centre for Digital Built Britain (CDBB) at the University of Cambridge to standardize national DT practices. The presence of a centralized coordinating body ensures consistency, transparency, and public–private collaboration. Vietnam should adopt a similar governance model to address the current fragmentation among the Ministry of Transport, the Ministry of Information and Communications, the Ministry of Construction, and local authorities.

(3) Develop dynamic simulation and predictive modeling capacity. Cities such as London and Shanghai utilize DT models to simulate traffic scenarios, forecast congestion, manage emissions, and evaluate public transport policies. These simulation capabilities support real-time decision-making and enable authorities to respond more effectively to dynamic urban conditions. Vietnam should prioritize investment in Urban Mobility Simulation Centers to model traffic dynamics in major cities like Hanoi, Ho Chi Minh City, and Da Nang.

(4) Ensure data security and governance ethics. Leading countries have established clear legal frameworks for public data use and privacy. Singapore's *Public Sector Data Governance Framework* and the UK's *Data Ethics Framework* ensure accountability and trust in data-driven operations. Vietnam should develop a comprehensive Urban Data Governance Framework that balances data security, accessibility, and public trust to enable reliable Digital Twin deployment.

(5) Align Digital Twin development with sustainability goals. DT is not only a technical innovation but also serves as a strategic policy instrument for sustainable urban development. By optimizing transport networks, reducing emissions, and improving energy efficiency, Digital Twin systems contribute to green and low-carbon mobility. Vietnam's Digital Twin strategy should be aligned with its National Green Growth Strategy (2021–2050) and Net Zero 2050 commitment to ensure long-term sustainability.

Collectively, these lessons highlight that successful Digital Twin implementation requires not only technological advancement but also institutional alignment, standardized data ecosystems, and a long-term strategic vision.

Building upon these lessons, the following section proposes a structured Digital Twin framework tailored to Vietnam's urban transport context.

IV.ii. Recommendations for Vietnam: A Four-Layer Digital Twin Framework

Based on international experiences and Vietnam's current context, this study proposes a Four-Layer Digital Twin Framework for urban transport management and planning.

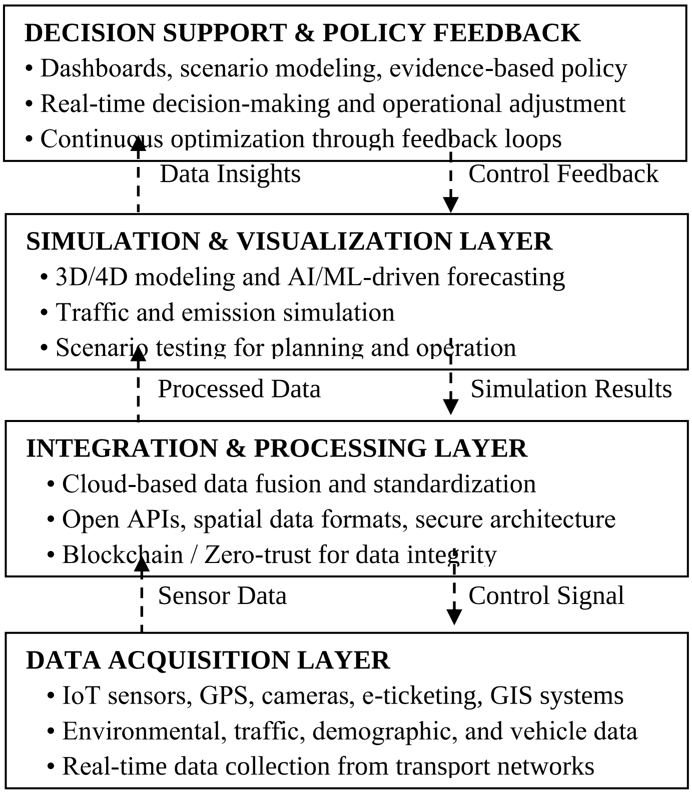

Fig. 1. Four-Layer Digital Twin Framework for Urban Transport in Vietnam

Figure 1. The proposed Four-Layer Digital Twin Framework for Vietnam's urban transport integrates data collection, processing, simulation, and decision-making into a continuous feedback loop, supporting real-time governance and sustainable mobility.

IV.iii. Interoperability Standards for Digital Twin Architecture

To enable seamless interoperability across heterogeneous and multi-source systems, the following interoperability standards are recommended:

Layer 1 – Data Acquisition

- IoT protocols: MQTT, CoAP.
- Positioning systems: GPS (NMEA standard).
- Video streaming protocols: RTSP (Real-Time Streaming Protocol).

Layer 2 – Integration & Processing

- Application Programming Interfaces (APIs): RESTful APIs and GraphQL.

- Spatial standards: OGC WMS/WFS, CityGML, GeoJSON.
- Transport standards: GTFS / GTFS-RT, DATEX II.

Layer 3 – Simulation

- Functional Mock-up Interface (FMI) for model interoperability and co-simulation.
- Traffic simulation platforms such as SUMO and MATSim.

Layer 4 – Decision Support

- Data exchange formats: JSON, XML.
- Visualization and analytics platforms such as Power BI and Grafana.

The adoption of these interoperability standards is critical for ensuring data consistency, system scalability, and real-time information exchange across the Digital Twin ecosystem, thereby enabling effective data-driven decision-making.

IV.iv. Implementation Roadmap and Policy Actions

To effectively operationalize the proposed Digital Twin framework, Vietnam should adopt a structured three-phase implementation roadmap:

Phase 1 (2025–2027): Pilot implementation and legal framework development.

- Implement pilot DT projects in major corridors (e.g., Hanoi Ring Road 3, Ho Chi Minh City urban core).
- Develop and promulgate technical and regulatory standards for transport data access, sharing, and security.
- Establish an inter-ministerial task force on urban digital twins, jointly coordinated by the Ministry of Transport (MOT) and the Ministry of Information and Communications (MIC).

Phase 2 (2027–2030): Data integration and model expansion.

- Develop an integrated National Transport Data Platform connecting IoT, GPS, GIS, and citizen databases.
- Integrate DT systems into urban Intelligent Transport System (ITS) operation centers.
- Strengthen and promote public–private partnerships (PPPs) in digital infrastructure development and simulation-based investment.

Phase 3 (Post - 2030): Expansion and international cooperation.

- Expand DT applications to related domains such as energy, environment, and urban planning.
- Participate in ASEAN Smart City and Digital Twin initiatives to support regional data standardization and interoperability.

- Strengthen human resource development in AI, IoT, simulation technologies, and urban data analytics through academic–industry partnerships.

The development of a Digital Twin model for Vietnam's urban transport should not be viewed merely as a technological initiative but rather as a strategic instrument to enhance urban governance, reduce congestion, and achieve sustainability. The proposed four-layer DT framework provides a robust and scalable foundation for data-driven planning, system operation, and evidence-based decision-making, thereby supporting the transition toward a smart, resilient, and sustainable urban transport ecosystem.

This phased implementation roadmap ensures a gradual yet scalable transition from pilot deployment to nationwide integration, aligning technological innovation with institutional readiness and policy reform.

V. Conclusion

This study systematically analyzed international experiences from Singapore, the United Kingdom, and China in applying Digital Twin (DT) models to urban transport and assessed Vietnam's readiness in the digital transformation era. The study identified key lessons, opportunities, and challenges, and proposes a four-layer DT framework, covering data collection, integration, simulation, and decision support, specifically tailored to Vietnam's urban transport context.

The findings provide a scientific and practical foundation for developing DT-based solutions to improve urban transport governance, optimize planning, and support the transition toward smart, green, and sustainable mobility. Future research should further focus on pilot implementations in major urban areas, quantitative impact assessments using real-time data, and the refinement of legal and institutional frameworks to ensure the scalability and long-term sustainability of Digital Twin applications at the national level.

Overall, this study contributes to the growing body of knowledge on Digital Twin applications in emerging economies by providing an integrated analytical and policy-oriented framework for data-driven urban transport management.

Conflict of Interest:

The authors declare that there is no conflict of interest regarding this article.

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