International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 10 Issue: 02 | Feb – 2026 SJIF Rating: 8.659 ISSN: 2582-3930

Smart Multimodal Transit Hub

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Abstract - Rapid urbanization and increasing dependence on private vehicles have put immense pressure on urban transportation systems. Challenges in rapid urbanization range from congestion and pollution to inefficient public transport and poor last-mile connectivity. Multimodal transit hubs have emerged as critical urban infrastructure that integrates varied modes of traveling on a single, efficient system. With the advancement of digital technologies, the concept has grown to smart multimodal transit hubs using intelligent systems to enhance user experience, operational efficiency, and sustainability.

This paper examines the concept of smart multimodal transit hubs from the point of view of architectural and urban design. It explores how spatial organization, functional integration, technological interventions, and sustainability strategies are defining features of smart transit hubs. Following the case studies selected for this purpose, the paper points to how smart multimodal hubs offer seamless mobility with reduced carbon footprint and livability in urban situations.

Keywords: Smart Transit Hub, Multimodal Transportation, Urban Mobility, Sustainable Infrastructure, Intelligent Transport Systems

1. INTRODUCTION

A Multimodal Transit Hub refers to a central transport facility where two or more modes of transport, including metro, rail, bus, BRT, taxi, ride share, bicycles, and pedestrian networks, are integrated physically and functionally to allow smooth and efficient movement of persons.

In a smart multimodal transit hub, this is enhanced through the use of digital technologies, which include but are not limited to the use of real-time passenger information systems, integrated ticketing systems, intelligent traffic management systems, and data-driven systems.

KEY FEATURES :

Mode Integration: Efficient movement between rail, bus, non-motorized modes, and last-mile services

Spatial Integration: the integration of modes in a vertical or horizontal stacking pattern based on the minimum walking distance

Operational Coordination: Synchronized Schedules & Ticketing Systems

User-Centric Design: Barrier-free accessibility, easy navigation, safety, and comfort.

Smart Technology: IoT Sensors, Digital Displays, Mobile Apps, Automated Systems

Urban Interface: Serves as a catalyst for Transit Oriented Development (TOD) and public spaces

2. Literature review

Studies in urban mobility stress the significance of integrated transportation systems in reducing the dependency on private motorization. The studies propose that a connected, multidimensional system would make urban areas more accessible, save time, and increase the efficiency of the connected public systems. The literature on TOD also spotlights the significance of transit hubs in forming compact urban spaces.

Recent research on smart cities focuses on integrating technology into transportation infrastructure. Intelligent Transport Systems, data analytics, and automation are highlighted as integral aspects to enhance transportation experiences. Architectural studies focus on human factors, emphasizing the human experience and comfort in spatial experiences and transportation settings.

These projects create the theoretic groundwork for discerning the notion of smart multimodal transportation hubs as both infrastructure and public architectural space.

3. Research Methodology

This research will be qualitatively and analytically conducted, based on the following:
Literature review on multimodal shift and smart mobility
Architectural analysis of spatial organization and functional zoning
Study of selected national and international examples of transit hubs
The main emphasis is still on architectural planning, user movement, and the integration into the urban framework, without focusing on engineering details.

4. Concept Of Intelligent Multimodal Transit Hub

A smart, multimodal transit hub is an integrated transportation facility, incorporating multiple modes of transit with digital intelligence to ensure seamless mobility. Unlike conventional terminals, these hubs prioritize passenger experience, efficiency, and sustainability.

Key characteristics include:

4.1 Seamless transition between transport modes

4.2 Real-time information systems

4.3 Smart ticketing and access control

4.4 Accessibility for all

4.5 Integration with surrounding urban fabric

4.6 Architecturally, such hubs function more like public spaces and urban landmarks rather than pure transit points.

5. Architectural Planning And Spat

A. Functional Zoning

The different functional zones within smart transit hubs include arrival and departure areas, areas for ticket purchases, waiting areas, retail areas, and service areas. Proper and efficient zones enable minimal conflict to exist between pedestrians and vehicles.

B. Circulation & Wayfinding

Clear circulation paths and good way-finding systems are necessary to provide for the smooth movement of passengers between points within the airport. Planning of vertical and horizontal circulation minimizes the distance between modes of transportation, while digital signage helps in facilitating the passenger's way-finding process.

C. Public and Semi-Public Spaces

Public spaces inside transit hubs may now include items such as plazas, food courts, co-working spaces, and gardens. Such spaces create active urban hubs beyond just peak travel hours.

6. Role Of Smart Technologies

Smart technologies feature prominently in the operations of modern hubs and include the following:

6.1 Information on arrival and departure time

6.2 Integrated ticketing and payments systems

6.3 Crowd Management using Sensors and Data Analytics

6.4 Smart security and surveillance systems

These technologies increase efficiency in operations while improving comfort and safety.

7. Sustainability in Smart Transit Hub Design

Sustainability is one of the major goals in the concept of smart multimodal hubs. The strategies include:

7.1 Promotion of public transport and non-motorized mobility

7.1 Energy-efficient building systems

7.3 Use of Renewable Energy Sources

7.4 Renewable energy

7.5 Rainwater harvesting and waste management

The hubs thereby reduce the overall carbon footprint of cities by promoting modal shift and discouraging the use of personal vehicles.

8. Challenges Smart Multimodal Transit Hub

Although smart transit hubs have their own advantages, there are challenges like investment costs, technical integration complications, land acquisition problems, and coordination with various entities. Ensuring the reliability of such infrastructures and their intra-inclusivity are major concerns.

9. Case Studies

Case Study 1: King's Cross Station Redevelopment, London:

The King's Cross re-development combines the facilities of the national rail network, metro, bus, and cycling in one area. The smart systems assist and make the systems more enjoyable for the passengers. The re-development was architecturally impressive in revitalizing the city area, showing how transport hubs can positively affect urban renewal.

Case Study 2: Delhi Metro Kashmere Gate Interchange, India

Kashmere Gate is an important hub that incorporates the metro network, intercity bus service terminals, and other modes of transport. This enhances the operational efficiency of the system. It is essential in minimizing the problems of traffic congestion in the capital city.

10. CONCLUSION

Smart multimodal transport centers form an important new paradigm in how cities deliver transport infrastructure. They are efficient, sustainable, and inclusive in the way they deliver transport, and in an architectural sense, they are important as a public place that improves connectivity in a city and boosts economic growth.

As cities continue to expand, smart multimodal transit hubs will also play a vital role in developing coherent and sustainable urban ecosystems. Architects and urban planners must therefore embrace a holistic approach to urban planning and try to integrate technology, function, and human experience.

ACKNOWLEDMENT

I would like to express my sincere gratitude to my guide and faculty members for their valuable guidance, constructive suggestions, and continuous support throughout the development of this research paper. Their academic input played a significant role in shaping the direction and quality of this study.

I am also thankful to my institution for providing the necessary academic resources and learning environment that facilitated this research. I would like to acknowledge the authors and researchers whose work in the field of urban mobility, transit-oriented development, and smart infrastructure formed the theoretical foundation of this paper.

Finally, I extend my appreciation to my peers and family for their encouragement and support during the completion of this research.

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