**Optimizing Public Transportation in Järfälla Municipality Through AI-Driven and Multimodal Transport Solutions**

# Introduction

Several market reports predict an increase in demand for public transport (PT) services during the coming years (Market Research Future 2021) Some of the main reasons mentioned for this are the growing population resulting in increased demand and the environmental effects of car travel, pressuring people to change their traveling behaviors (Jevinger et al., 2024).

Transport infrastructure is now failing to function properly; we are often faced with issues such as insufficient capacity, dependability, contamination of the environment, and inefficiency of operation. The employment of diverse Artificial Intelligence (AI) approaches may, however, help establish new, intelligent modes of operation for infrastructures already in place and improve efficiency in reducing delays at bus stops and overcrowding in trams (Ushakov, Dudukalov, Shmatko & Shatila, 2022).

The aim of this study is to extend the general understanding of the PT system and its travellers, or to make PT more efficient, leading to, e.g., cost savings and a reduced environmental impact. The intended users of the AI technology differ depending on these aims, from governmental PT authorities, via planners and operators, to individual travellers. (Jevinger et al., 2024)

**1.1 Problem Statement**

According to research, a change to AI-enhanced transportation infrastructure could significantly enhance efficiency by optimizing scheduling, real-time monitoring, and adaptive routing, aligning with environmental sustainability goals (Nikitas et al., 2020; Vidojevic et al., 2024). Inefficiencies in public transportation arise from a lack of multimodal options and an overreliance on cars. The lack of integrated, technology-driven transportation systems that use real-time data and artificial intelligence (AI) contributes to the inefficiencies, resulting in higher carbon emissions, congested services, and insufficient transit during peak hours.

## **Why Is Artificial Intelligence in Transportation Important**

AI is crucial in transportation because it enhances efficiency, safety, and sustainability across various modes, from public transit to freight logistics (Maity, Roy & Verdegay, 2020). By analyzing large datasets and predicting patterns, AI can optimize routes, reduce fuel consumption, and decrease congestion (Dhanasekaran et al., 2024). This leads to lower emissions, cost savings, and faster, more reliable transit times. Additionally, AI-driven systems improve traffic management and public safety through real-time monitoring, autonomous vehicle technology, and predictive maintenance, ultimately making transport systems more resilient and accessible (Maity, Roy & Verdegay, 2020; Dhanasekaran et al., 2024).

## **1.3 Scope and Objectives**

The scope of this study is to explore and evaluate innovative AI-driven and multimodal transport solutions and how it can be tailored to Järfälla’s needs, focusing on enhancing the efficiency, accessibility, and sustainability of its public transport system. By integrating AI technologies such as real-time data analytics with flexible multimodal options like call-based buses. This study aims to reduce the municipality’s dependence on private cars, contributing to environmental sustainability goals(Bagloee et al., 2016). This project will help us to answer the research question: *How can AI-driven real-time data analytics enhance resource allocation in Järfälla’s public transport systems during peak and off-peak hours?* Through this inquiry, the study seeks to demonstrate how smart resource management and demand-responsive transport can drive efficiency and reduce emissions, supporting Järfälla’s vision for a cleaner, more accessible transport network.

# Relation to Sustainable Development Goals

This research aligns with two key Sustainable Development Goals (SDGs), focusing on enhancing public transportation in Järfälla Municipality through AI-driven and multimodal solutions to promote sustainability, efficiency, and climate action.

* **SDG 11 Sustainable Cities and Communities:** SDG 11 advocates for making cities inclusive, safe, resilient, accessible and sustainable. SpringerLink. (2024). Cities like New York have successfully implemented AI to decrease congestion and emissions, providing a valuable example for Järfälla (Nikitas et al., 2020). Furthermore, introducing on-demand, call-based buses targets low-demand areas, reducing operational costs and emissions while ensuring all residents have reliable transport access (International Association of Public Transport, 2020). By optimizing Järfälla’s public transportation system, this project seeks to improve accessibility, reliability, and user-centered service.
* SDG 13: Climate Action: The application of AI in the transport field is aimed at overcoming the challenges of an increasing travel demand, CO₂ emissions, safety concerns, and environmental degradation. (Alkheder & Shan, 2019). This further calls for urgent efforts to combat climate change, and this research addresses this goal by leveraging AI-driven tools to minimize emissions in public transit. By optimizing routes and timetables based on demand, AI can reduce fuel consumption and lower carbon footprints, directly supporting climate mitigation. Additionally, incorporating multimodal options such as biking and walking promotes eco-friendly transit choices, further reducing the environmental impact of urban transport systems (IEEE, 2024). Integrating these sustainable, multimodal options allows Järfälla to contribute to global climate action while meeting its local mobility needs in a more sustainable way.

# Methodology

This study followed a structured, systematic approach for finding, selecting, analyzing, and synthesizing relevant literature on AI-driven and multimodal transport solutions.

## **Literature Search**

To gather relevant information for my literature review, I conducted comprehensive searches using Google Scholar and Scopus. Initially, I accessed Google Scholar by searching for it on Google, which directed me to its search engine. I employed search terms such as "Artificial Intelligence in Public Transportation" and "How AI Affects Public Transportation," yielding numerous journals and books. I reviewed abstracts to assess relevance to my focus on optimizing transportation with AI. For pertinent sources, I examined sections like the introduction, methodology, and other relevant parts to extract valuable information.

Additionally, I utilized Scopus by visiting its website and using the search bar with various filters, including language preferences like English. While I concentrated on studies from Sweden and Europe, I also considered information from broader sources that contributed valuable insights to my research like the USA that would help me to contrast and compare my findings.

* 1. **Selection Criteria**

The selection criteria for this literature review were meticulously designed to ensure the inclusion of high-quality and relevant sources. The process involved the following steps:

**3.2.1 Inclusion Criteria**

* **Relevance to Research Objectives:** Selected studies were required to directly address the integration of artificial intelligence (AI) in public transportation systems, with a focus on areas such as scheduling optimization, real-time monitoring, adaptive routing, and multimodal transport solutions.
* **Geographical Focus:** Priority was given to research conducted within Sweden and Europe to ensure contextual applicability. However, studies from other regions were considered if they offered valuable insights or innovative approaches relevant to the research objectives.
* **Publication Date:** Sources published within the last decade were preferred to capture the most recent advancements and trends in AI applications in public transportation.
* **Language:** Only publications available in English were included to maintain consistency and comprehensibility.
* **Publication Type:** Peer-reviewed journal articles, conference papers, official reports, and reputable books were considered to ensure the credibility and reliability of the information.
  1. **Analysis Framework**

To systematically evaluate the integration of artificial intelligence (AI) in public transportation systems, an analysis framework was established to guide the literature review process. This framework included the following components:

**3.3.1 Literature Collection**

A total of 10 research articles were collected and selected to aid in my in-depth analysis. The distribution of these sources were: 4 articles from Google Scholar, 3 articles from Scopus and 3 from web of science. These databases were chosen for their comprehensive coverage of scholarly publications and relevance to the research objectives.

**3.3.3 Synthesis Approach**

The analysis involved a comparative synthesis of the findings from the selected articles. This approach facilitated the identification of common themes, divergences, and gaps in the current research landscape. By systematically categorizing and cross-referencing information, the framework aimed to provide a comprehensive understanding of the potential and challenges associated with AI-driven public transportation solutions. This structured analysis framework ensured a methodical evaluation of the literature, aligning with the research objectives and providing a solid foundation for subsequent discussions and conclusions.

**3.4 Synthesis of Findings**

Most studies agree that integration of artificial intelligence (AI) into public transportation systems has been extensively studied, revealing several key insights as follows:

**AI Techniques Employed**

The review shows that the primary aims of using AI are to improve the service quality or to better understand traveller behavior. (Davidsson et al., 2023). These AI methodologies are applied to optimize scheduling, enable real-time monitoring, and facilitate adaptive routing, thereby improving operational efficiency and service reliability (Olawoyin & Chen, 2020).

**Functional Applications**

Firstly, **scheduling optimization** utilizes AI algorithms to analyze both historical and real-time data, allowing for the creation of efficient schedules that reduce passenger wait times and improve resource utilization. This aspect is really valuable in high-demand urban environments where resources must be allocated dynamically to meet fluctuating travel patterns (Davidsson et al., 2023).

In addition, **real-time monitoring** leverages AI systems to process live data feeds, continuously tracking vehicle locations, traffic conditions, and passenger loads. This enables transit operators to make dynamic adjustments to operations, which enhances the reliability and responsiveness of public transit services (Olawoyin & Chen, 2020).

**4.0 Analysis of Literature**

**4.1 Overview of Research Fields**

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| City | Main Features | Source |
| USA (New York and Chicago) | The "Via" system uses a mobile application to offer on-demand, shared rides powered by AI algorithms. This system matches passengers heading in the same direction, reducing reliance on personal cars and improving public transport accessibility. | Via Transportation, Inc. (2023) |
| Singapore | The "Smart Nation" initiative uses AI to monitor traffic and manage public transport routes. Real-time analytics allow call-based buses to dynamically adjust routes based on commuter demand, reducing emissions and improving service efficiency. | Debnath et al. (2011) |
| London | AI optimizes train frequencies and manages congestion in the rail network. Predictive algorithms adjust train routes in real-time, reducing delays and enhancing urban transport flow. | Government Digital Service (2019); Quest Global (2023) |
| Gothenburg | Self-driving buses tested in Lindholmen Science Park provide a sustainable transit solution, connecting with other public transport options. These AI-enhanced shuttles are designed for various weather conditions and seamless connectivity. | Keolis (2021) |
| Västtrafik (Västra Götaland) | Västtrafik has integrated multimodal options like buses, trams, and regional trains. However, the system lacks advanced AI applications for real-time flexibility, highlighting the potential for AI-driven improvements in resource allocation and reliability. | Drive Sweden (2021) |

* 1. **Chosen Perspective**

The chosen perspective is a solution-based approach that will aid in solving Järfälla's transportation inefficiencies by incorporating AI, call-based bus services, and improving multimodal choices. AI-powered real-time data analytics can dynamically change schedules depending on demand patterns, optimizing resource allocation and boosting reliability—a approach that is successfully employed in places such as New York to manage congestion and minimize energy consumption (Nikitas et al., 2020; IEEE, 2024). Call-based bus services in low-demand areas, led by predictive analytics, can operate only when needed, reducing fuel consumption and emissions. Combining these AI-enhanced tactics with multimodal options has the potential to considerably reduce car dependency, helping Järfälla achieve its environmental goals (IEEE, 2024).

**5.0 Discussion**

AI technologies, such as real-time data analytics, can optimize resource allocation during peak and off-peak hours, reducing overcrowding and wait times while minimizing environmental impact (Maity, Roy & Verdegay, 2020; Dhanasekaran et al., 2024). The integration of artificial intelligence (AI) and multimodal transport solutions can offer significant potential to enhance Järfälla's public transportation system by improving efficiency through cost reduction and carbon emission and saves time that people have to wait in stops, accessibility, and sustainability.

International experiences are proven evidence that this is actually feasible: for instance, the "Via" system in New York and Chicago employs AI algorithms to provide on-demand, shared rides, decreasing reliance on personal cars and enhancing accessibility (Via Transportation, Inc., 2023). Similarly, Singapore's "Smart Nation" initiative utilizes AI for real-time traffic monitoring and dynamic route adjustments based on commuter demand, leading to reduced emissions and improved service efficiency (Debnath et al., 2011). These examples illustrate how AI-driven solutions can address inefficiencies in public transport and support environmental sustainability goals, aligning with Sustainable Development Goals 11 and 13 by promoting inclusive, safe, and sustainable urban environments and urgent climate action (SpringerLink, 2024; Alkheder & Shan, 2019).

Transferring these international models to the Swedish context is possible, although it presents both opportunities and challenges. One significant opportunity lies in integrating AI solutions into train stations and metros, which can substantially improve the efficiency of public transport. Enhanced efficiency may encourage people to reconsider their transportation choices and opt for public transportation, as it will save time and be more cost-effective. This shift can reduce dependency on private cars, thereby decreasing carbon emissions and contributing positively to environmental sustainability.

However, implementing these solutions may also present significant challenges. These include data privacy concerns under regulations like the General Data Protection Regulation (GDPR), scalability limitations due to initial investment costs, and the necessity for community engagement to ensure public acceptance (European Commission, 2018; Nikitas et al., 2020). By addressing these challenges through pilot programs, stakeholder collaboration, and policy development, Järfälla can tailor AI-driven solutions to its specific needs. This approach not only enhances operational efficiency and reduces emissions but also contributes to global climate action efforts, supporting Järfälla's vision for a cleaner, more accessible transport network.

**6.0 Conclusion**

**6.1 Important Lessons that I have Learned in this Study**

The key takeaway from this research is that artificial intelligence (AI) will not replace humans; rather, individuals or nations equipped with AI tools will dramatically enhance productivity. Specifically, integrating AI and multimodal transport solutions could significantly benefit Järfälla's public transportation system. By employing real-time scheduling and predictive analytics, AI technology can optimize the existing transport network, transforming buses into highly efficient modes of transit. This optimization reduces passenger wait times, conserves fuel, and decreases pollution levels.

Furthermore, in low-demand areas, implementing call-based buses that operate only when needed can maintain low emissions while satisfying local transportation needs. While data privacy is a critical concern particularly under regulations like the General Data Protection Regulation (GDPR). These challenges can be addressed through robust data management strategies and community engagement. By getting all stakeholders on board, Järfälla has the potential to become a model for sustainable suburban transit, effectively aligning with Sustainable Development Goals 11 and 13. This approach promotes inclusive, safe, resilient, and sustainable urban environments and contributes to urgent climate action efforts, supporting Järfälla's vision for a cleaner, more accessible transport network.

**6.1 Recommendations for Further Research**

Future research should focus on optimizing AI and multimodal transport solutions for suburban areas like Järfälla. Key recommendations include implementing real-time AI monitoring to dynamically adjust public transport based on demand, especially during peak hours. Small-scale pilot programs for call-based buses can help evaluate the impact on car dependency and emissions while assessing scalability. Addressing data privacy through anonymization and encryption within AI systems is crucial to ensure GDPR compliance. Additionally, public awareness campaigns could help overcome resistance to AI by highlighting its benefits in efficiency and environmental impact.

**References**

Alkheder, S. and Shan, J. (2019) 'Applications of Artificial Intelligence in Transport: An Overview', Sustainability, 11(1), p. 189. doi:10.3390/su11010189.

Bagloee, S.A., Tavana, M., Asadi, M., and Oliver, T. (2016) ‘Autonomous vehicles: challenges, opportunities, and future implications for transportation policies’, Journal of Modern Transportation, 24(4), pp. 284-303.

Davidsson, P., Hajinasab, B., Holmgren, J., et al. (2023) 'Artificial intelligence for improving public transport: a review', Public Transport, 15(1), pp. 3-25. doi:10.1007/s12469-023-00334-7.

Debnath, A.K., Haque, M.M., Chin, H.C., and Yuen, B. (2011) 'Sustainable urban transport: Smart technology initiatives in Singapore', Transportation Research Record, 2243(1), pp. 38-45.

Dhanasekaran, S., Gopal, D., Logeshwaran, J., Ramya, N., and Salau, A.O. (2024) 'Multi-Model Traffic Forecasting in Smart Cities using Graph Neural Networks and Transformer-based Multi-Source Visual Fusion for Intelligent Transportation Management', International Journal of Intelligent Transportation Systems Research. doi:10.1007/s13177-024-00413-4.

IEEE Xplore. (2024) 'Urban mobility: Leveraging AI, machine learning, and data analytics for smart transportation planning - A case study on New York City'. Available at: https://ieeexplore.ieee.org/document/10307632 (Accessed: 28 October 2024).

International Association of Public Transport (UITP) (2020) 'Moving forward with artificial intelligence in public transport'. Available at: https://cms.uitp.org (Accessed: 28 October 2024).

Jevinger, Å., Zhao, C., Persson, J.A., et al. (2024) 'Artificial intelligence for improving public transport: a mapping study', Public Transport, 16(1), pp. 99–158. doi:10.1007/s12469-023-00334-7.

Maity, G., Roy, S.K., and Verdegay, J.L. (2020) 'Analyzing multimodal transportation problem and its application to artificial intelligence', Neural Computing and Applications, 32, pp. 2243–2256. doi:10.1007/s00521-019-04393-5.

Market Research Future (2021) Public Transport Market Research Report: Information by Type (Bus, Light Rail, Regional Taxi, Metro and Tram), Application (City and Rural) and Region - Forecast till 2027, Report ID: MRFR/AM/7205-CR.

Nikitas, A., Michalakopoulou, K., Njoya, E.T., and Karampatzakis, D. (2020) 'Artificial intelligence, transport, and the smart city: Definitions and dimensions of a new mobility era', Sustainability, 12(7), p. 2789. doi:10.3390/su12072789.

Olawoyin, L.A. and Chen, S. (2020) 'An intelligent machine learning-based real-time public transportation information system', Advances in Intelligent Systems and Computing, 1208, pp. 547-556. doi:10.1007/978-3-030-58817-5\_47.

Quest Global (2023) 'Future of Rail Signaling: Innovations for Safer, Smarter Railways'. Available at: https://www.quest-global.com/resources/future-of-signaling-embracing-innovation-for-safer-smarter-railways/ (Accessed: 13 November 2024).

SpringerLink (2024) 'SDG 11 - Make cities and human settlements inclusive, safe, resilient and sustainable'. Available at: https://link.springer.com/collections/eighbddcdb (Accessed: 11 November 2024).

Transport for London (2024) 'Underground services performance'. Available at: https://tfl.gov.uk/corporate/publications-and-reports/underground-services-performance (Accessed: 13 November 2024).

Ushakov, D., Dudukalov, E., Shmatko, L., and Shatila, K. (2022) 'Artificial Intelligence as a factor of public transportation system development', Transportation Research Procedia, 63, pp. 2401-2408. doi:10.1016/j.trpro.2022.06.276.

Via Transportation (2023) 'Via acquires Citymapper to expand its end-to-end TransitTech solution'. Available at: https://ridewithvia.com/news/via-acquires-citymapper-to-expand-its-end-to-end-transittech-solution (Accessed: 13 November 2024).