International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 11 Issue: 1 | Jan 2024 www.irjet.net p-ISSN: 2395-0072

A Review Paper on Travel Time Reliability in Public Transportation

Sonali Bharti[1], Tarun Narnaure [2]

[1] M. Tech Student, Department of Civil Engineering and Applied Mechanics, Shri G.S. Institute of Technology and Science, Indore (M.P.), Pincode-452003
[2] Assistant Professor2, Department of Civil Engineering and Applied Mechanics, Shri G.S. Institute of Technology and Science, Indore (M.P.), Pincode-452003

Abstract - *The challenges and dynamics associated with public transportation reliability in India, considering the complexities of diversified metropolitan traffic patterns and the increasing demand for automobiles. The study focuses on the urbanization trends in major Indian cities, emphasizing the crucial role of public transit in connecting both urban and rural areas. Travel time variability is identified as a significant factor affecting public transportation reliability, influenced by dynamic elements such as weather conditions, traffic fluctuations, and delays. Passengers' experiences and perceptions, including waiting and transfer times, are recognized as key contributors to transit network connectivity and system performance. The term travel time reliability is defined as a measure of the expected range in travel time, providing a quantitative indicator of predictability. Various methods, including the 90th percentile time, planning time index, buffer index, buffer time, total travel time, and statistical calculations such as delay and journey time, are discussed as crucial metrics for assessing reliability in heterogeneous traffic. The analysis of travel time data collected from diverse cities; a suggested methodology is proposed for improving travel time reliability in public transportation. The importance of Intelligent Transportation System data, such as GPS data and ticketing data, is highlighted, emphasizing the necessity of incorporating user feedback for Travel Time Reliability (TTR) improvement. Factors influencing public transportation reliability were explored, with recommendations made for improving efficiency, reducing delays, and enhancing overall reliability. Models for predicting travel times in bus networks were developed, often based on regression analysis and machine learning techniques, to provide accurate predictions and insights for optimizing bus movements, resource allocation, and service planning. The research papers collectively contribute to advancing the understanding of travel time reliability in public transportation.*

Key Words: Travel time reliability, Variability, Route level attributes, heterogenous traffic, Public transit

1.INTRODUCTION

India's urban population is growing at a pace of 3% annually, with an emphasis mostly on key political centers. [18]. Transportation is essential for efficient and socially equitable transit, and assessing citizens' accessibility to public transportation services is crucial for identifying population disparities and developing policies to improve passenger service quality [20]. Public transportation in India has considerable hurdles as a result of the country's diversified metropolitan traffic patterns and rising automobile demand. City buses are crucial in public transport, serving as the backbones of connectivity in some cities. India ranks 8th in total vehicle usage across 192 countries, with 44.9 million vehicles, followed by the USA and China. The nation currently holds the third position globally in terms of the fleet strength of buses and motor coaches, trailing behind Indonesia and China. The sustained growth of the economy has led to an expansion of the transportation sector; however, there has been a notable decrease in its percentage share in India's Gross Domestic Product (GDP), declining from 49.9% in the fiscal year 2015-16 to 4.59% in the fiscal year 2019-20. Specifically, the road transport segment singularly contributes 3.06% to the Gross Value Added (GVA), while the entire transport sector collectively contributes 4.59% at the national level during the fiscal year 2019-20. As of March 31, 2020, vehicles newly registered in India were categorized, revealing that 8.4% fell within specific categories. [19]. Reliability in public transportation is a crucial factor in both public and private sectors, connecting different neighborhood's, rural areas, or key locations. City buses' utility and desirability are influenced by their regular arrival times, but passengers often worry about their dependability due to unexpected travel times, weather conditions, traffic congestion, and driver and passenger behavior. Weather conditions, such as rain or snow, can also affect travel times, while city buses operating on urban roads contribute to traffic difficulties due to their size and the responsibility of traveler [15].

1.1. Travel Time Reliability

The reliability of the public transportation system is often defined as one minus the probability of failure. [2][3]. USDOT's definition of reliability, which defines it as "The transportation system's certainty and predictability in travel times is a crucial aspect to consider" [1], According to the agency, reliability is linked to the consistency of bus service performance. [21]. Travel time reliability refers to the consistency and dependability of the duration required for a journey or the time taken to traverse a specific road section, experienced across various times of the day and days of the

week. This metric is quantified by the extra time, known as time cushion or buffer, that drivers must allocate to account for unforeseen delays. Commuters, transit riders, shippers, and other road users find travel time reliability crucial as it enables them to make informed decisions about managing their time effectively.[1].

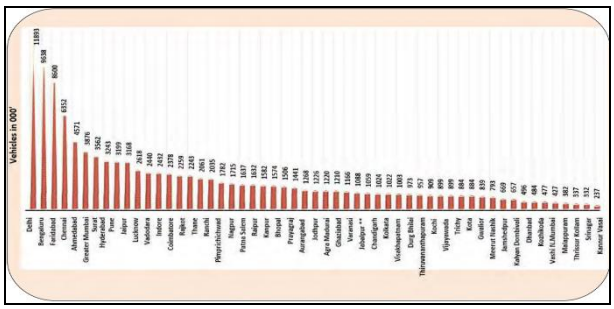

Figure 1: Aggregate Motor Vehicle Registrations in million Plus Cities as on 31st March,2020(in million)

Sources: RTYB_Publication_2019_20. (n.d.).

1.2. Travel Time Reliability Measures

There are four measures used to determine the reliability of public transport: Frequency Consistency Measures, Wait Duration Measures, Transfer Duration Measures, and Trip Duration Measures. In which travel time metrics are considered to analyses the reliability. The four recommended measures are outlined below: 90th or 95th percentile travel time, BTI, PTI, BT, PT and TTT the frequency with which congestion surpasses several predicted thresholds.

1.2.1 90th Percentile Time (PT)

Planning time, also referred to as the 95th percentile of travel time, indicates the potential severity of a transit travel delay. Utilized as a metric, planning time serves as valuable information for passengers. The drawback of this measure is that it is difficult to compare between journeys because most trips will vary in length. It is likewise challenging to average out route or trip travel times for an entire city or subarea. [2], [3],[9].

Planning Time = Planning Time Index × Average Travel Time ...(i)

1.2.2 Planning Time Index (PTI)

The entire duration a road user needs to allocate to ensure on-time arrival for 95 percent of trips. [1]. In other terms, we can articulate the overall time a traveler must strategize to guarantee punctual arrival, encompassing buffer time and the mean travel duration. Ultimately, the delay incurred by utilizing public transportation serves as an illustration of reliability. As the delay lengthens, so does the dependability [18],[9] [4],[27].

Planning time index= (90th or 95th Percentile of mean travel time/ Mean Travel Time)*100 ...(ii)

1.2.3 Buffer Index (BI)

Road users must allocate additional time to assure on-time arrival in 95 percent of trips, which is equivalent to being late for work once a month. The buffer index is calculated as a proportion of the average trip time. [1],[14],[18],[27],[28],[4].

Planning time index= (90th or 95th Percentile of mean Journey time/ Mean Journey Time)*100 ...(iii)

1.2.4 Buffer Time (BT)

Buffer time measures the extra time that a traveler must add to the average travel time when planning for a trip [9],[28].

Buffer Time = Buffer Index × Average Travel Time ...(iv)

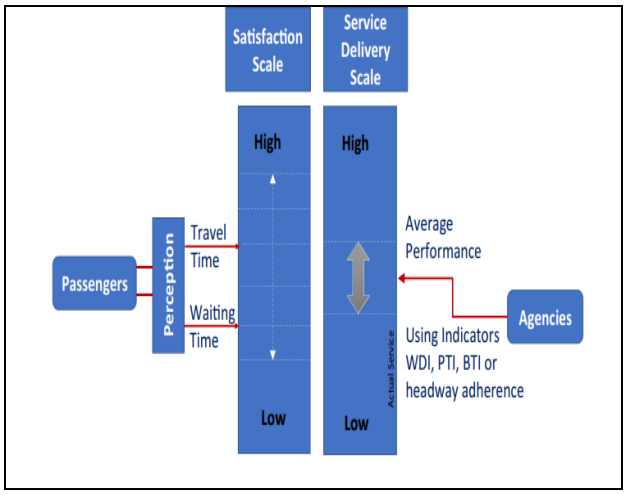

Figure 2: Represent the viewpoints of passengers and agencies regarding travel time reliability

Source: https://doi.org/10.1007/s13177-019-00195-0.

1.3. Total Travel Time (TTT)

The total travel time encompasses the maximum durations that a traveler might spend to complete a trip. These durations are determined by factors such, as waiting in queues to purchase tickets waiting for buses at stations or terminals the time taken by buses at stops (including traffic lights and pedestrian crossings), between terminals, stations and terminals well as the time spent onboarding and off-boarding passengers. These equation presents a representation that describes this phenomenon under study [9].

TTT=TQ+TW+TI*(NS-1) +TS*NI+TO*(NS-1) ...(v)

The following are the definitions of the imbedded parameters and variables in equation

TTT = Total Travel time,

TQ = Waiting time for ticketing in a queue

TW = Bus station/terminal waiting time

TI = Inter-node transit time

TS = Stoppage duration at intersections.

TO = Passenger boarding and alighting time

NS = Station counts along a designated route

NI = Intersection count along a designated route

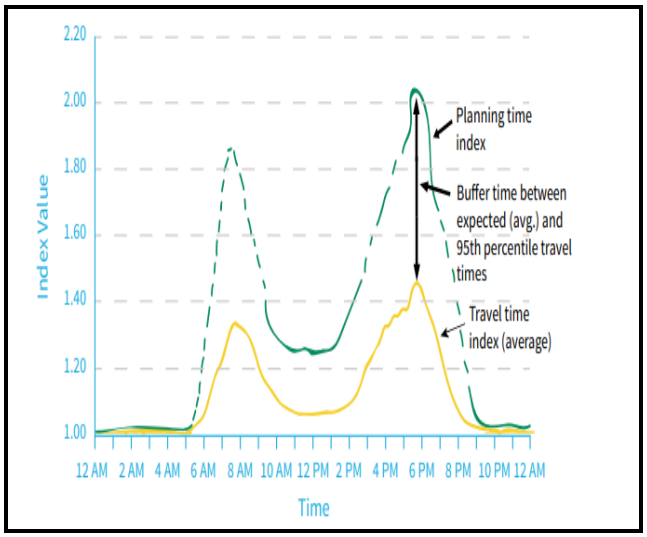

Figure 3: Relationship Between Total travel time index, Buffer time index and Planning time Index

Sources:
https://ops.fhwa.dot.gov/publications/tt_reliability.com

2. Literature Review

Numerous studies have explored travel time reliability and variability of public transit for heterogeneous traffic, using methods like GEV distribution, Burr distribution, and k-s test. Several studies focus on reliability metrics such as the Time cushion indicator, Timetable adherence, and cumulative travel time in order to assess the dependability of public transportation.

Balkrishan Panwar et al (2018). emphasize the growing role of advanced technologies in transportation engineering. They underscore the potential for information systems, automation, and telecommunications to revolutionize transportation systems, enhancing efficiency, safety, and service reliability. The adoption of these technologies is crucial for the future growth and development of transportation networks. Engin Pekel et al (2017). use crash databases to predict travel time reliability and its impact on crash injury severity. Their research identifies significant factors contributing to the severity of accidents, such as alcohol and drug impairment and work-zone presence. These findings can inform safety measures and traffic management strategies. Joanna Rymarz et al (2015). conduct a comparative analysis of the reliability of different bus systems, shedding light on the reliability of specific bus brands and their various structural systems. This type of analysis can guide transportation agencies in selecting and maintaining their bus fleets. Krystine Birr et al (2014). emphasize that the average speed of public transport vehicles is influenced by various external factors. Their research underscores the complexity of estimating public transport speed and travel time due to a multitude of contributing factors. They advocate for the need to characterize network sections in terms of infrastructure and traffic organization to build detailed models and improve transportation efficiency. Lingxiang Zhu et al (2022). propose a travel time prediction algorithm that achieves high accuracy, particularly in the context of a specific bus line in Guangzhou. While the model shows promise, there is room for further research to improve its generalizability by considering more diverse bus lines and routes. M.M. Harsha et al (2022). shed light on the variability in public transit travel times. Their use of probability distributions, especially the GEV distribution, proves to be a valuable tool for modeling transit travel time variability across different temporal and spatial scales. This provides insights for transportation planning and management. Many of these studies highlight the importance of utilizing advanced data sources, such as GPS data, smart card data, and real-time tracking, to enhance the accuracy and reliability of travel time estimates and reliability measures. This emphasis on data-driven decision-making is critical for modern transportation planning and management. Mukta Ranjan Singha et al (2013). explore the potential of mobile phone networks for urban traffic management and data collection, particularly for optimizing bus movements and alleviating congestion. This approach, with its minimal infrastructure development costs, offers a cost-effective means for traffic management and data analysis in urban areas. Li-Minh et al (2014). introduce the concept of Public Transport Travel Time (PTTV) and outline a comprehensive approach for modeling and monitoring PTTV. Their study identifies the lognormal distribution as a suitable descriptor for PTTV, providing insights for optimizing recovery time and reliability in public transportation. It also calls for future research to delve deeper into factors influencing PTTV. Punam Baral et al(2015)., explore the factors affecting operational efficiency and travel time variation in public transportation routes. They identify issues such as intersection delays, fare collection, and bus stop placement as crucial determinants of reliability and efficiency. Pagidimarry Gopi et al. examine travel time reliability in urban corridors in New Delhi, demonstrating the significant variability in

travel times during working and non-working hours. Their study highlights the importance of measuring and understanding travel time reliability to aid travelers in planning for on-time arrival, and it demonstrates the application of reliability indices like PTI and BTI in transportation studies [18]. These insights can guide operational improvements in public transit Renzo Massobrio (2022), Luping Zhi (2022), and Zhuang Dai (2019) present various models and methodologies for estimating travel times in public transportation networks. These models leverage a wide range of data sources, including infrastructure, schedules, and GPS data. They offer valuable tools for transportation planners and policymakers to enhance the accuracy of travel time predictions, which can lead to better service planning and resource allocation. Spela Verovsek et al. (2022) highlights the importance of integrating travel time indicators into National Safety Administration standards. This integration is crucial for addressing congestion and sustainability concerns in transportation systems. Proper observation periods and robust statistical methods are necessary for obtaining reliable estimates of traffic situations on strategic routes. Several studies, such as those by Sakdirat Kaewunruen (2021), Justine Kira (2022), and Ankit Kathuria (2022), emphasize the significance of identifying factors that contribute to travel time delays in public transportation. These factors include station dwell times, ticketing processes, and variations in demand levels during different times of the day and week. Understanding these factors is crucial for improving the efficiency and reliability of public transportation systems. Several articles, including Mahmoud Owais (2021), Akhilesh Cherapunji (2020), and Ankit Kathuria (2020), delve into the concept of reliability in public transportation systems. They introduce measures like PTI, BI, and RBI to assess travel time reliability, and these measures can help in evaluating performance and making improvements. The results indicate that reliability can vary with factors such as route length, day of the week, and peak/off-peak hours. Several studies, such as Zhen Chen et al. (2020), F. Zheng, Xiaobo Liu, et al.(2017), and Zhen-Liang Ma et al.(2019), concentrate on developing models to assess travel time reliability and variability. They employ statistical distributions, network-level models, and recurrent congestion indices to characterize and analyze the variability in travel times along transportation corridors. This understanding is fundamental for improving service planning and resource allocation. Saikat Deb et al (2018). analyze the factors affecting users' perceptions of public transportation services, revealing variations across different groups based on income, gender, employment status, and vehicle ownership. Understanding these variations can help transit agencies tailor their services to better meet the needs of specific user groups, improving overall satisfaction and reliability systems. Tanzina Afrin's (2020) study addresses the global challenge of traffic congestion. While there is no one-size-fits-all solution to this issue, the paper emphasizes the importance of categorizing congestion and implementing a combination of strategies tailored to specific contexts. Effective congestion mitigation measures involve a comprehensive understanding of the problem and the use of real-time traffic data for evaluation and decision-making [24]. Yaser Hawas et al. contribute to the field by focusing on bus network operations and introducing models for predicting travel times. These models, while promising, require real-life validation through data collection and comparison with actual bus trip times. The research lays the groundwork for more accurate modeling and prediction of travel times within bus networks. Zixu Zhuang et al. (2022) introduce a novel metric for assessing bus travel time reliability, which accounts for dwell time and on-board travel time. The study underlines the impact of factors like weather conditions and service frequency on travel time reliability, emphasizing the importance of efficient service scheduling in improving the passenger experience.

3. Discussion

The studies collectively contribute to the advancement of transportation engineering and management by addressing various aspects of travel time reliability, safety, and efficiency in public transportation systems. Panwar et al. (2015) highlight the transformative role of advanced technologies, emphasizing information systems, automation, and telecommunications, with significant implications for enhancing transportation network efficiency and safety. Engin Pekel et al. (2017) utilize crash databases to predict travel time reliability's impact on crash injury severity, identifying crucial factors such as alcohol and drug impairment and work-zone presence, providing insights for safety measures and traffic management strategies. Rymarz et al.'s comparative analysis of bus system reliability offers valuable information on the performance of different bus brands and structural systems, aiding transportation agencies in fleet selection and maintenance decisions. Birr et al. emphasize the complexity of estimating public transport speed and travel time due to various external factors, advocating for the characterization of network sections to enhance detailed modeling and transportation efficiency. Zhu et al.'s travel time prediction algorithm showcases promise, particularly in a specific bus line in Guangzhou, prompting the need for further research to enhance its generalizability across diverse bus lines and routes. Harsha et al.'s use of probability distributions, specifically the GEV distribution, proves valuable for modeling transit travel time variability, providing insights into temporal and spatial variations essential for transportation planning and management Singha et al.'s exploration of mobile phone networks for urban traffic management highlights a cost-effective approach for optimizing bus movements and alleviating congestion, showcasing the potential of minimal infrastructure development for effective traffic management in urban areas . Li-Minh et al.'s introduction of Public Transport Travel Time (PTTV) and its comprehensive approach for modeling and monitoring, using the lognormal

distribution as a descriptor, provides valuable insights for optimizing recovery time and reliability in public transportation. Baral et al.'s examination of factors affecting operational efficiency and travel time variation in public transportation routes underscores the importance of addressing issues such as intersection delays, fare collection, and bus stop placement for improved reliability and efficiency. Gopi et al.'s examination of travel time reliability in New Delhi urban corridors demonstrates the significant variability during working and non-working hours, emphasizing the importance of measuring and understanding travel time reliability, applying reliability indices like PTI and BTI. Overall, these studies underscore the critical role of advanced data sources, such as GPS data and real-time tracking, in enhancing the accuracy and reliability of travel time estimates and reliability measures, emphasizing the importance of data-driven decision-making in modern transportation planning and management.

4. Conclusion

The study provides important new perspectives on the study and forecasting of journey times under various transportation conditions. The investigation recognized the importance of incorporating travel time reliability measurements into the evaluation of urban road performance, highlighting a departure from traditional metrics. The following conclusions are drawn from existing literature.

1. To increase the accuracy and reliability of journey time models, they underline the necessity for precise data gathering, reliable statistical techniques, and more study. Planning, establishing policies, and improving operational aspects of both private automobiles and public transportation systems can benefit from these findings.

2. The studies underline the need for data-driven, context-specific strategies and draw attention to the complexity of travel time challenges. With an emphasis on reliability, unpredictability, and user perceptions, they provide a complete examination of travel times in public transportation networks.

3. By offering several techniques and models to address these crucial aspects of transportation planning and administration, they help to increase the efficacy, safety, and quality of public transportation systems. They also provide approaches and strategies for dealing with various facets of transportation planning and administration, adding to ongoing initiatives to raise the effectiveness, security, and caliber of public transportation systems.

4. This will aid in the identification of different factors influencing travel time reliability at the route, segment, and corridor levels.

5. After studying Travel Time Reliability measure and statistical formulation and model, we can easily find journey time, delay on route, dwell time, mean duration time for heterogenous traffic condition.

6. A comprehensive awareness of the factors that influence the quality of public transit services, offering a variety of transportation outcomes such as safety, comfort, accessibility, and dependability (Saiket Deb,2018).

7. The study focuses on characterizing travel time distribution and reliability, providing critical insights into understanding and managing variability in transportation systems, thereby contributing to improved service planning and operational efficiency (Zhen Chen,2020).

8. This emphasis bus route travel times and network travel times enhances our comprehension of transit system dynamics, facilitating the development of models and strategies for optimizing travel times within bus networks (Yaser Hawas,2013).

9. Pre-journey waiting times, journey durations, and measures related to public transportation travel times, offering valuable data for enhancing the passenger experience and optimizing transit planning.

REFERENCES

[1] Ankit Kathuria, Parida, M., & Sekhar, C. R. (2020). A Review of Service Reliability Measures for Public Transportation Systems. International Journal of Intelligent Transportation Systems Research, 18(2), 243–255. https://doi.org/10.1007/s13177-019-00195-0.

[2] Ankit Kathuria, Parida, M., & Chalumuri, R. S. (2020). Travel-Time Variability Analysis of Bus Rapid Transit System Using GPS Data. Journal of Transportation Engineering, Part A: Systems, 146(6). https://doi.org/10.1061/jtepbs.0000357.

[3] Akhilesh Chepuri, Joshi, S., Arkatkar, S., Joshi, G., & Bhaskar, A. (2020). Development of new reliability measure for bus routes using trajectory data. Transportation Letters, 12(6), 363–374. https://doi.org/10.1080/19427867.2019.1595356.

[4] Balkrishan Panwar, M., & Gill, S. (2018). IJCRTRIETS003| International Journal of Creative Research Thoughts (IJCRT) www.ijcrt.org |Page 13 Advanced Technologies Use in Transportation Engineering. www.ijcrt.org.

[5] Does Travel Time Reliability Matter? https://ops.fhwa.dot.gov/publications/tt_reliability.com.

[6] Engine Pekel, & Soner Kara, S. (2017). Review Paper / Derleme Makalesi A Comprehensive Review for Artificial

Neural Network Application to Public Transportation. In Nat Sci (Vol. 35, Issue 1)

[7] Fangfang Zheng, Liu, X., Zuylen, H. Van, Li, J., & Lu, C. (2017). Travel Time Reliability for Urban Networks: Modelling and Empirics. Journal of Advanced Transportation, 2017. https://doi.org/10.1155/2017/9147356.

[8] Joanna Rymarz, Niewczas, A., & Stoklosa, J. (2015). Reliability evaluation of the city transport buses under actual conditions. Transport and Telecommunication, 16(4), 259–266. https://doi.org/10.1515/ttj-2015-0023.

[9] Justine Kira, J., & Mohamed, S. (2022). Modeling Travel Time with Travelers' Experience. https://doi.org/10.7176/MTM.

[10] Kyrstine Birr, Jamroz, K., & Kustra, W. (2014). Travel time of public transport vehicles estimation. Transportation Research Procedia, 3, 359–365. https://doi.org/10.1016/j.trpro.2014.10.016.

[11] Li-Minh Kieu, Bhaskar, A., & Chung, E. (2014). Public Transport Travel-Time Variability Definitions and Monitoring. https://doi.org/10.1061/(ASCE)TE.1943.

[12] Lingxiang Zhu, Shu, S., & Zou, L. (2022). XGBoost-Based Travel Time Prediction between Bus Stations and Analysis of Influencing Factors. Wireless Communications and Mobile Computing, 2022. https://doi.org/10.1155/2022/3504704.

[13] Luping Zhi, Zhou, X., & Zhao, J. (2020). Vehicle routing for dynamic road network based on travel time reliability. IEEE Access, 8, 190596–190604. https://doi.org/10.1109/ACCESS.2020.3030654.

[14] M. M Harsha, & Mulangi, R. H. (2022). Probability distributions analysis of travel time variability for the public transit system. International Journal of Transportation Science and Technology, 11(4), 790–803. https://doi.org/10.1016/j.ijtst.2021.10.006.

[15] Mukta Ranjan Singha, & Kalita, B. (2013). Estimation of City Bus Travelers Using GSM Network... × Congestion Control of Guwahati City View project. In International Journal of Innovative Technology and Exploring Engineering (IJITEE) (Issue 2). https://www.researchgate.net/publication/267403153.

[16] Mahmud Owais, Ahmed, A. S., Moussa, G. S., & Khalil, A. A. (2021). Integrating underground line design with existing public transportation systems to increase transit network connectivity: Case study in Greater Cairo. Expert Systems with Applications, 167. https://doi.org/10.1016/j.eswa.2020.114183.

[17] Punam Bural Shahi, Devkota, B., Baral, P., & Devkota, B. P. (2015). Variation in Travel Time of Public Transportation-Case Study of Micro Bus Routes in Kathmandu Road Accident Information Management System View project Construction industry research View project Variation in Travel Time of Public Transportation-Case Study of Micro Bus Routes in Kathmandu. https://www.researchgate.net/publication/351945230_Variation_in_Travel_Time_of_Public_Transportation_-_Case_Study_of_Micro_Bus_Routes_in_Kathmandu https://www.researchgate.net/publication/351945230.

[18] Pagidimarry Gopi, P., Sachdeva, S. N., Bharati, A. K., & Professor, E.-A. (2014). Evaluation of Travel Time Reliability on Urban Arterial. https://www.ijert.org/evaluation-of-travel-time-reliability-on-urban-arterial.

[19] RTYB_Publication_2019_20.(n.d.).https://morth.nic.in/sites/default/files/RTYB_Publication_2019_20%20(1).pdf.

[20] Renzo Massobrio, Hernández, D., & Hansz, M. (2022). Travel time estimation for public transportation systems. https://doi.org/10.1007/978-3-030-96753-6_14.

[21] Sakdirat Kaewunruen, Sresakoolchai, J., & Sun, H. (2021). Causal analysis of bus travel time reliability in Birmingham, UK. Results in Engineering, 12 https://doi.org/10.1016/j.rineng.2021.100280.

[22] Saiket Deb, & Ahmed, M. A. (2018). Variability of the Perception about Safety, Comfort, Accessibility and Reliability of City Bus Service across Different Users' Groups. International Journal of Civil Engineering and Technology (IJCIET, 9(2), 188–204. http://www.iaeme.com/IJCIET/index.asp188http://http://www.iaeme.com/ijciet/issues.asp?JType=IJCIET&VType=9&IType=2http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=9&IType=2.

[23] Špela Verovšek, Juvančič, M., Petrovčič, S., Zupančič, T., Svetina, M., Janež, M., Pušnik, Ž., Velikajne, N., & Moškon, M. (2022). An integrative approach to neighborhoods sustainability assessments using publicly available traffic data. Computers, Environment and Urban Systems,95. https://doi.org/10.1016/j.compenvurbsys.2022.101805.

[24] Tanzina Afrin, & Yodo, N. (2020). A survey of road traffic congestion measures towards a sustainable and resilient transportation system. In Sustainability (Switzerland) (Vol. 12, Issue 11). MDPI. https://doi.org/10.3390/su12114660.

[25] Yaser Hawas, E. (2013). Simulation-Based Regression Models to Estimate Bus Routes and Network Travel Times. https://doi.org/10.5038/2375-0901.16.4.6.

[26] Zixu Zhuang, Cheng, Z., Yao, J., Wang, J., & An, S. (2022). Bus travel time reliability incorporating stop waiting time and in-vehicle travel time with AVL data. International Journal of Coal Science and Technology, 9(1). https://doi.org/10.1007/s40789-022-00544-7.

[27] Zhen Chen, Fan, W. D. (2020). Analyzing travel time distribution based on different travel time reliability patterns using probe vehicle data. International Journal of Transportation Science and Technology, 9(1), 64–75. https://doi.org/10.1016/j.ijtst.2019.10.001.

[28] Zhen-Liang Ma, Luis Ferreira, Mahmoud Mesbah, and Ahmad Tavassoli Hojati (2019), Bus travel time modelling using GPS probe and smart card data: A probabilistic approach considering link travel time and station dwell time. Journal of Intelligent Transportation Systems: Technology, Planning, and Operations, 23(2), 175–190. https://doi.org/10.1080/15472450.2018.1470932.