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# PASSENGERS' PERCEPTIONS OF THE SERVICE QUALITY AND OPERATION OF A BUS RAPID TRANSIT SYSTEM (TRANS SEMARANG) IN SEMARANG, INDONESIA

**Summary.** The increasing population in urban areas has expanded the role of the transportation system to meet people's mobility needs in developing countries. Since the demand for transportation services is proliferating, bus rapid transit (BRT) offers the opportunity to create a high-quality mass transit system in developing countries. The presence of BRT Trans Semarang, however, has not yet become a solution to city traffic problems since the transit system and its operation are not yet implemented. This study aims to explore the service quality and operation of BRT based on observations and passengers' viewpoints at the BRT shelter, which is located in the central business district. The method of the research is a statistical descriptive and qualitative analysis using variables from passengers' perspectives and observations on bus operation. The result shows that the capacity of the transit shelter, the interval between bus arrivals, bus dwell times, and BRT infrastructures (door size) are the most influential variables on passengers' satisfaction. Furthermore, from the operation point of view, users' trip destinations and maximum delay times are considered important for the improvement of BRT service.

## 1. INTRODUCTION

City centers are currently experiencing a significant surge in daily commutes, which can cause traffic jams that spread across the urban road network and requires a good mobility system, smart transportation, and efficient design. Furthermore, the allocation of limited urban roads must be effectively adjusted to capacity in an integrated transit system transportation environment [1]. The increasing population level in urban areas has expanded the role of the transportation system to meet people's mobility needs [2]. As a city develops, planners must have long-term land use and transportation plans [3]. Improving service quality is critical to increasing the use of public transport systems [2, 4-6]. Rapid urban population growth has increased the demand for transportation services, and the presence of public transit modes can help to fulfill the rising demand [7-9].

Public transport systems provide the most efficient means of moving large numbers of people, especially in densely populated urban centers [10]. The importance of public transit has become an

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interesting topic of examination, especially in the context of densely populated areas [8]. Public transit has been considered an effective way to reduce urban traffic congestion and pollution emissions [11]. Bus rapid transit (BRT) is a public transit mode that offers the opportunity for developing cities to create high-quality bus-based mass transit systems at affordable costs [12]. The BRT system is a transportation mode that has gained popularity worldwide as a cost-effective alternative to public transportation modes (e.g., trains) in urban areas that are much more expensive [13]. High-quality bus-based transportation systems can also serve low-density settlement patterns in suburbs and small to medium-sized cities. The main advantages of implementing a bus-based transportation system are its flexibility and punctuality.

Punctuality is an essential component in the service quality for passenger, road transport, and freight transport on railways [14]. A study revealed that riders are willing to pay more for their transport costs in exchange for reduced travel time variability (TTV) [15, 16]. TTV is a significant variable to consider when assessing the service quality of a bus transit system. A researcher stated that the importance of TTV can be discerned from the viewpoint of operators and riders [16]. From the travelers' perspective, they expect that the travel time of a transport system will not exceed the average time of travel or the scheduled time with some proper level of extra time. Meanwhile, based on the operators' standpoint, high TTV represents the poor performance of the transport system, which reduces the number of passengers and the income of transport operators [16].

Based on a previous study, a transit stop plays an important role in evaluating the on-time performance of public buses [17]. Delays in BRT stops, however, are very common since the bus stop is located in the central business district, where the number of passengers is high. Bus delays at stops are affected by stop characteristics (amenities and the arrival rate), bus characteristics (bus service, bus size, and the number of seats), traffic conditions (traffic lights), passenger volume, and signalization parameters [18]. Based on the study of the BRT planning guide, all transit systems take more passengers if they have larger vehicles with multiple doors with a size of 1 m or greater. By optimizing the transit system that is integrated into BRT corridor options, transportation planners can maximize the number of potential passengers. The public transportation system does not end at the entrance or exit of the station but covers the entire potential area of public transport users. If transportation users cannot reach their destination comfortably and safely, then they will stop using public transportation. Moreover, integrated transit-oriented transport systems should be more focused on people's mobility, and they have to contend with other transport modes [2, 19-21]. BRT is expected to reduce road congestion, which is still a major challenge in Semarang, especially during morning and evening peak hours and the rainy season.

The location of the BRT stop, which is close to the municipality (Balai Kota), needs to be improved for the sake of transportation safety since the stop is located in an area with increased passenger loads and high traffic density. Moreover, diverse features of the built environment significantly affect how frequently people walk along the BRT Trans Semarang route [22]. Nevertheless, there is a lack of infrastructure that integrates into transit services; thus, the presence of deficiencies in a transport system can result in minimum productivity [23]. Some experts observed that BRT Trans Semarang can hardly solve traffic jam problems with its current design and operation. Consequently, passengers were waiting too long because there was no reliable time schedule at the stop. Moreover, the bus took quite a long time to transfer passengers in transit during peak hours because of the low frequency of bus arrivals at the stop. Further, passengers were often reluctant to take crowded buses due to comfort and safety reasons. They would prefer to wait at the stop for the next bus to get and keep a comfortable seat. The high volume of passengers who were waiting at the stop caused an inconvenient situation that can influence ridership satisfaction and the willingness to use BRT.

There are clear knowledge gaps between policy, science, and sustainable development. Therefore, this study aims to explore the service quality and operation of BRT in Semarang based on riders' perspectives and observations. Since the bus and its stop are critical elements of the BRT system, this research identified the general characteristics of BRT users at the BRT stop, as well as transit patterns, transit time management services, average transit time, and the average number of passengers at the stop. Furthermore, statistical analysis was used to determine which variables affect users' transit movement at the BRT stop, combined with the analysis of the integration services of all BRT Trans Semarang corridor routes. The results of this study are expected to provide input for the improvement

of BRT Trans Semarang in terms of infrastructure and transit services. Furthermore, research on this topic is expected to contribute to the scientific literature at the conceptual and application levels. First, the paper adds to the relatively small amount of transportation research that investigates the factors influencing passengers' satisfaction with rapid transit modes. Second, the results of the study provide a better understanding of the planning of rapid transit systems in growing cities.

## 2. MATERIALS AND METHODS

In this paper, several variables were selected from the viewpoint of passengers and bus operators. The researchers examined passengers to assess their expectations, perceptions, and movements; the integration of BRT corridors; the BRT service providers; and the services of the BRT Trans Semarang. The researchers considered the customer's view as the most relevant factor for evaluating transit performance [24,25]. On the other hand, in evaluating the operator's perspective, past studies have reported the use of productivity measures. These measures focus on evaluating the effectiveness of the system using a set of efficiency indicators. Such measures usually consider cost-effectiveness and cost-efficiency [8]. The categories of attributes examined in this study are described in Tab. 1.

Table 1

Category Features

| Category | Attribute | Examined aspect |
|---|---|---|
| Passengers' perceptions of BRT Trans Semarang's transit services | 1. Passengers' comfort based on the type of passenger<br>2. Boarding and alighting passengers<br>3. Passengers' behavior while using BRT<br>4. Passengers' willingness to use BRT<br>5. Passengers' experiences with the BRT service | • Physical condition of the transit vehicle<br>• Frequency of transit passengers<br>• Sitting and standing passengers<br>• Type of passenger<br>• Trip destination |
| Analysis of BRT Trans Semarang's transit services at a certain stop (Balai Kota transit point) | 1. Boarding situation at the BRT shelter<br>2. Frequency of transit passengers<br>3. BRT arrival time<br>4. Load factor of BRT Trans Semarang<br>5. Time reliability of BRT Trans Semarang<br>6. Passengers' ideal waiting time<br>7. Maximum delay time at the BRT point. | • BRT schedule<br>• BRT waiting time<br>• Origin of BRT corridor<br>• Frequency of transit passengers<br>• BRT arrival time<br>• Passenger boarding time |

The BRT main shelter in the central business district (i.e., the Balai Kota shelter) was selected as a case study. This shelter provides transit services for nine BRT corridors with a pass frequency of eight to nine times per corridor. During the 30-day data-collection period, we intensively observed passengers' behaviors while waiting for the bus (both on weekends and weekdays) and interviewed 350 respondents (BRT passengers) for 10 minutes. The questionnaire was used to determine the profile of passengers, their destinations, the routes they take, their opinions about the in-vehicle situation, their reasons for using BRT, the frequency with which they use BRT, and the boarding/alighting duration. Moreover, we counted the number of arrival/departure buses to identify the bus frequency, bus arrival time, and headway time. We used a scoring system to define passengers' satisfaction and assess the quality of the service since a well-designed and efficiently operated bus system fosters satisfaction among riders and, in turn, high scores [26].

### 2.1. Passengers' Perceptions of the BRT Trans Semarang Service

Improving the quality of BRT services is critical to increasing the use of these public transport systems [2, 4, 27], especially concerning their speed, convenience, and security [2]. BRT users often

consider the operational management of public buses (e.g., departure and arrival times) [28]. BRT service quality can be assessed by using the SERVQUAL instrument, which considers the expectations and perceptions of passengers [29]. This instrument consists of five elements: assurance, empathy, reliability, responsiveness, and physical tangibles. The aspect of tangibles is defined as the appearance of bus facilities, equipment, personnel, and communication substances [29]. A transit system with a good level of service is easily accessible, has a short waiting time, provides acceptable space (e.g., low access distance), is reliable, requires a minimum number of transfers for travel, provides affordable and safe travel, is fast and convenient, and has a minimal environmental impact. BRT can provide maximum benefits for passengers if they have a dedicated bus lane, which enables BRT to be more punctual in serving passengers [30.31]. In this research, passengers, who are linked to the independent mobility and accessibility of public transportation, were categorized based on their characteristics as normal passengers, students, disabled people, older adults, and women. Passengers were asked questions regarding the physical condition of the BRT vehicles (door features, availability of bus seats, and bus size), how often passengers use BRT for transit and trip destinations.

### 2.2. Transit Services of BRT Trans Semarang

BRT systems began operating in 2004 in Indonesia, which is a pioneer of public transportation in southeast Asia. The success of BRT in Greater Jakarta in transforming the urban area into a less car-reliant city was followed by other growing cities in Indonesia. In this research, a case study is performed in Semarang as it is depicted in Fig.1, a medium-sized city located six hours (by road transportation) from the capital city of Indonesia (Jakarta); its population is 1.65 million.

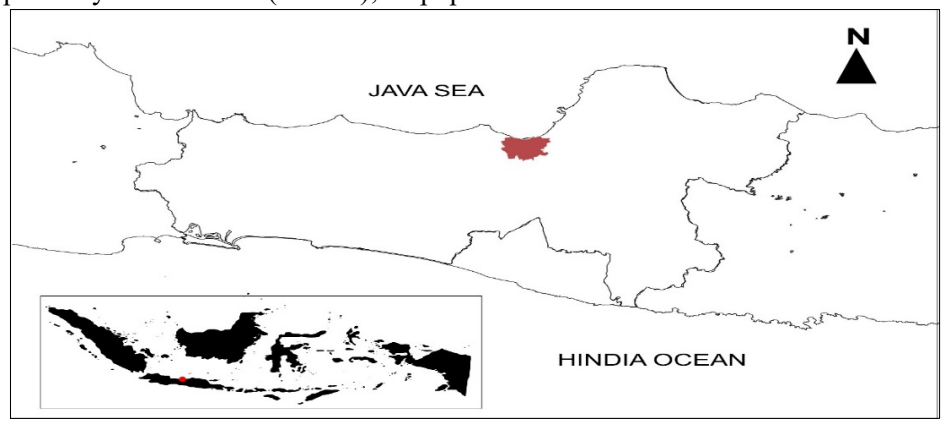


Fig. 1. The case study area: The city of Semarang, Indonesia

In this research, the quality of BRT service was assessed based on the transit schedule, waiting time, the origin of the BRT Trans Semarang corridor, the frequency of transit passengers, bus arrival times, and passenger boarding times. BRT is a public transportation system that has flexible transit time management, fast transit services connected to transportation nodes, convenient service, and the use of intelligent transport systems technology with dedicated lanes [32]. It is also integrated with feeder vehicles to collect passengers at every bus stop and distribute customers along local roads [33]. Passengers are attracted to BRT because it provides transit services with more reliable time management than other transportation modes [34]. Transit time services at stops have rapidly grown and are urgently needed since the demand for reliable public transport is proliferating. BRT time management should be designed and implemented in an integrated manner and not separately. Separately designing public transportation systems can shift individuals' interest to private transportation. The BRT system is based on good design characteristics regarding the integration of bus corridors and other modes of transportation [35]. A public transport system that is accessible on foot is critical in developing countries [36].

The operation of BRT Trans Semarang started on 18 September 2009 with corridor I, and then the local government kept adding new routes and expansions to cover all areas in Semarang. It now has nine main corridors and seven additional routes, which can be seen in Fig. 2. In the current situation of BRT

Trans Semarang, however, around 235 buses (including feeder buses) are operated with no dedicated bus lanes. Consequently, buses often get stuck in traffic, making travel for passengers slow and unreliable in several critical areas, such as in the central business district, where this research was conducted.

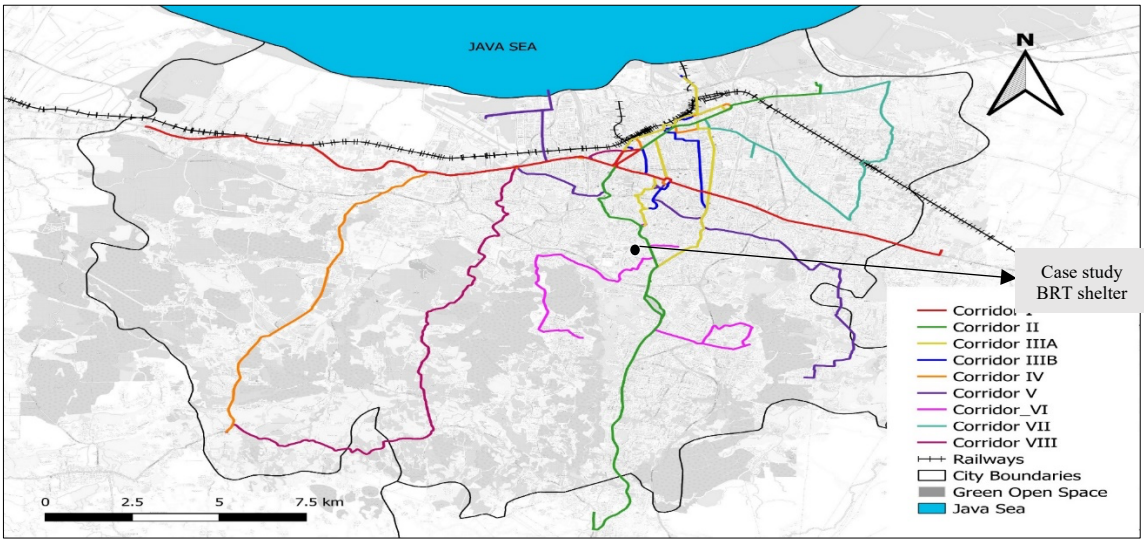


Fig. 2. Map of the BRT Trans Semarang network

## 3. RESULTS AND DISCUSSION

### Passengers' Perceptions of the BRT Trans Semarang Service and Operation

#### *Passengers' Perceptions of BRT Trans Semarang Service Based on Door Size*

Based on Tab. 2, the door size of BRT vehicles influences most passengers' perceptions. During the interviews, we scored the level of influence from 1 (no influence) to 5 (strong influence). The average value obtained was 3.5, which means that passengers feel safe and comfortable with the current door size, and there was no risk of being bumped or squeezed in the gap between the BRT vehicle's door and the bus stop. The feature of BRT doors has a significant influence on passengers with luggage since it was sometimes challenging to bring objects onto the bus due to limited space while making sure these objects do not interfere with other passengers. Likewise, parents with children, elderly people, and students were identified as vulnerable BRT users, as they often felt pressure on board, especially during crucial times when normal passengers[6] were rashly boarding the bus and overcrowded it. For disabled people, the door size has an important influence on their transit travel, especially when they arrive at Balai Kota BRT stops with a high volume of riders during peak hours. Bus boarding/alighting are crucial activities that impact the service quality of BRT systems. Passengers contended that the bus infrastructure could influence the level of safety and the likelihood of boarding and alighting incidents occurring.

Based on the observations, the door size of BRT vehicles for Corridor 1, Corridor 5 and Corridor 7 is larger than the door size of vehicles in other bus corridors since these buses carry many passengers and provide long-distance trips within the city. The wider distance between the bus and the curbside shelter does not allow for free movement when boarding and exiting the bus. Passengers had to jump to get to the stop while exiting the bus, which could cause accidents. Although the result shows that the average value obtained was 3.3 out of 5, it is necessary to improve the capacity and service quality to increase safety and comfort.

[6] Normal passengers were workers or people who frequently use BRT as their daily transport mode.

Table 2

Passengers' Perceptions of the Physical Condition of BRT Trans Semarang Vehicles

| | | Characteristic | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **Normal Passengers** | **People with Disabilities** | **Elderly People** | **Parents with Children** | **Students** | **Passengers With Luggage** | **Total** |
| Passengers' Perceptions Based on Door Size | No influence | 1.4% | 0.0% | 0.0% | 0% | 2.3% | 0% | **3.7%** |
| | Slight influence | 2.9% | 0.0% | 0.0% | 0.3% | 0.0% | 0.3% | **3.4%** |
| | Influence | 1.7% | 0.0% | 0.9% | 0.3% | 2.6% | 2.9% | **8.3%** |
| | Enough influence | 17.1% | 0.3% | 2.9% | 2.9% | 11.7% | 9.1% | **44%** |
| | Strong influence | 15.4% | 0.30% | 2.0% | 2.3% | 11.1% | 9.4% | **40.6%** |
| | **Total** | **38.6%** | **0.60%** | **5.7%** | **5.7%** | **27.7%** | **21.7%** | **100%** |

### *Passengers' Comfort Perceptions Based on BRT Services and Trip Destinations*

Based on the observations, passengers mostly used BRT in the morning (rush hour), and they had to jostle with other passengers to enter the bus. Passengers often used BRT Trans Semarang as their main transportation mode to workplaces (18%) and schools (17.7%), as well as for city sightseeing (11.4%) and visiting families (7.7%). BRT was less crowded during relaxed times (weekends) when people only used BRT for city sightseeing or recreation purposes (6%). People usually use their weekends to stay at home, or they travel in private vehicles. We also found that there were many domestic and international tourists using BRT for traveling or sightseeing.

Table 3

Passengers' Comfort Perceptions Based on BRT Trans Semarang Service and Trip Destination

| | | Trip Destination | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **School** | **Work** | **Only for Transit** | **Visiting Family** | **Recreation/ Sightseeing** | **Public Offices** | **Travel with Family/ Friends** | **Other** | **Total** |
| Passenger convenience while using BRT Trans Semarang | Crowded | 17.7% | 18% | 6% | 7.7% | 11.4% | 1.4% | 1.7% | 3.4% | **67.4%** |
| | Less crowded | 3.4% | 4.9% | 0.9% | 1.4% | 6% | 1.1% | 0.6% | 3.1% | **21.4%** |
| | Waiting for staff to help during boarding | 1.7% | 2% | 1.7% | 1.4% | 2.3% | 1.1% | 0.3% | 0.6% | **11.1%** |
| **Total** | | **22.9%** | **24.9%** | **8.6%** | **10.6%** | **19.7%** | **3.7%** | **2.6%** | **7.1%** | **100%** |

Moreover, passengers with disabilities, parents with children, and tourists need assistance from BRT staff to help them board the BRT vehicle. Public transportation that does not meet female passengers' needs for safety makes most women face difficulties, and they depend on men when traveling [37]. The average value obtained was 2.8 out of 5, meaning that riders feel uncomfortable with the high flow of passengers on the bus. Current studies highlighted that in-vehicle crowding has affected travelers' stress, health, and subjective well-being [38], which causes dissatisfaction.

### *Passengers' Perceptions Based on the Condition of BRT Vehicles and Bus Time Schedule*

Based on Tab. 4, about 94.3% of passengers used BRT to go to schools and majority of them were experienced in-vehicle crowding. It is clearly seen that buses were crowded on weekdays, when passengers were predominantly students going to school. Students are required to attend school before 7:00 a.m. Therefore, the bus was full of passengers (students) from 6:00 to 6:30 a.m. Meanwhile, approximately 5.7% of work-related commuters use BRT.

Table 4

Passengers' Perceptions Based on the Condition of BRT and Bus Time Schedule

| | | Destination | | Total |
|---|---|---|---|---|
| | | **School** | **Work** | |
| Situation of the passenger when getting off the BRT Trans Semarang | Crowded | 63.1% | 1.4% | **64.6%** |
| | Less crowded | 16.9% | 2.3% | **19.1%** |
| | Waiting for staff to help during boarding/alighting | 14.3% | 2% | **16.3%** |
| **Total** | | **94.3%** | **5.7%** | **100%** |

Some demographic groups, including students and female riders, are at a higher risk of transport safety than others. However, students in Semarang are still loyal BRT customers, and schools are the main trip destinations of passengers. The average value obtained was 2.8 out of 5, which means that passengers felt uncomfortable when exiting the BRT Trans Semarang at the stop because there was no clear information about departure and arrival times on the bus. Passengers had to get off in a rush to catch the next bus at the shelter, even if doing so was unsafe. A time schedule would also reduce the risk of jostling at the shelter during peak hours.

### *Passengers' Perceptions Based on Passenger Conditions in BRT Trans Semarang*

According to Tab. 5, many riders (46.9%) were sitting on the BRT public chair. Meanwhile, 44.9% stood. This balanced proportion shows that the BRT corridor has a high volume of passengers. Very few passengers used priority seats, and they were usually disabled people, pregnant women, and parents with children (kindergarten or elementary students).

Table 5

The Correlation between the Passengers' Locations on BRT and their Characteristics

| | | Characteristic of Passengers | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **Normal Passengers** | **People with Disabilities** | **Elderly People** | **Parents with Children** | **Students** | **Passengers With Luggage** | **Total** |
| Passenger location on BRT Trans Semarang | Sit on a public seat | 19.7% | 0.3% | 2.9% | 4.0% | 11.4% | 8.6% | **46.9%** |
| | Sit on a priority seat | 3.7% | 0.3% | 1.4% | 0.9% | 0.9% | 1.1% | **8.3%** |
| | Stand and hold the pull handle | 15.1% | 0.0% | 1.4% | 0.9% | 15.4% | 12% | **44.9%** |
| **Total** | | **38.5%** | **0.6%** | **5.7%** | **5.7%** | **27.7%** | **21.7%** | **100%** |

Normal passengers (38.55%), who regularly sat on bus seats when the bus was not too crowded, made up the largest group of passengers, followed by students (27.7%) and people with luggage (21.7%). Moreover, passengers sitting on BRT seats were physically fit and not carrying heavy items. Women often waited at stops for less-crowded buses because they prefer sitting and avoid standing close to others. On the one hand, standing passengers, especially elderly and disabled people, are susceptible to falls and injuries. Thus, disabled people, elderly people, and parents with children often felt uncomfortable in overcrowded vehicles. The passengers followed etiquette and obeyed BRT rules when they were using BRT.

### *The Relationship between Passengers' Reasons for Using BRT and the Frequency of Transit Use*

Tab. 6 shows that people mostly use BRT for one transit (77.7%), while 16% of passengers had a one-way trip to their destinations, and very few passengers (2.9%) had multiple transits. Factors related

to bus punctuality are considered important from the passengers' standpoint since BRT Trans Semarang is integrated with other multimodal modes and feeder transportation systems that provide a well-connected system for reaching residential areas in suburban regions. Moreover, customers enjoy air-conditioned public vehicles, and they can use multiple transit services with integrated systems at very affordable prices. The BRT service fare is affordable for all people in Semarang; a one-way ticket costs IDR 3,500.00 ($0.22) per person. Meanwhile, the fare for children under six years and students is IDR 1,000.00 ($0.06). The low price is the main reason people use BRT Trans Semarang.

Table 6

The Relationship between the Passengers' Reasons for Using BRT and Transit Frequency

| | | Transit Frequency | | | | Total |
|---|---|---|---|---|---|---|
| | | 0 Transit | 1 Transit | 2 Transits | >3 Transits | |
| Users' reasons for using BRT Trans Semarang | Headway time | 0.3% | 0.3% | 0% | 0% | **0.6%** |
| | Safety | 1.7% | 6.6% | 0.3% | 0% | **8.6%** |
| | Low price | 9.1% | 32% | 2% | 0% | **43.1%** |
| | Convenience | 3.1% | 28.3% | 1.1% | 1.4% | **34%** |
| | Integrated | 1.7% | 10.6% | 0% | 1.4% | **13.7%** |
| **Total** | | **16%** | **77.7%** | **3.4%** | **2.9%** | **100%** |

Contrarily, BRT users are unsatisfied with inconsistent headway time. People experienced inefficient boarding/alighting and longer waiting times for the bus at the BRT shelter. It was observed that there was no real-time information screen on the bus, and passengers depended solely on the BRT staff. There were two staff members on each bus: a driver and a ticketing staff person. The bus operation was manually undertaken by these staff members. Regarding arrival information, the staff usually announced the route number and destination names to passengers before the door opened. Hence, passengers should pay attention to the staff; otherwise, they could miss their stop or exit the bus late.

### *The Relationship between Boarding and the Characteristics of Passengers*

The average value obtained was 3.4 out of 5. Based on Tab.7, the analysis of transit service based on the ideal downtime of the BRT Trans Semarang for boarding passengers shows that 30 seconds (39.4%) is enough time to carry all type of passengers. The boarding time has an influence on passenger satisfaction. Normal passengers expected to take 10–20 seconds to board, while others, such as elderly people, parents with children, and passengers with luggage, perceived that 30 seconds was the maximum proper time for entering the bus. During the analysis, we transformed the result of riders' satisfaction into ratings as follows: 1 (very unsatisfied), 2 (unsatisfied), 3 (neutral), 4 (satisfied), and 5 (very satisfied). The results show that the average value was 3.9 out of 5, which means that passengers were satisfied with the 30-second disembarkation times. The interval between boarding and disembarking is very important to avoiding disturbances at the transit shelter, especially during rush hour.

It is worth mentioning that passengers were satisfied with the transit service if it provided high punctuality, short waiting times, availability of seats, and sufficient and functional in-vehicle infrastructures (automatic doors, adequate door size, air conditioning, and the provision of straphangers for standing passengers). The previous study in Chile showed that young, male, and high-income riders are more sensitive to travel time but not to in-vehicle crowding compared with other types of passengers [39]. On contrary, the study in Paris revealed that high-income passengers are more sensitive to in-vehicle crowding, which affects their satisfaction [40].

### *The Influence of BRT Speed towards Transit Frequency in each corridor*

The majority of BRT users considered that the time it takes the bus to reach the transit shelter has a significant influence on passengers. Transit passengers are very concerned about bus punctuality and

availability. In the observed BRT shelter located in the city center close to the municipality, the BRT vehicles often had to decrease their speed due to traffic congestion. In this research, however, people expected that BRT would be more punctual and provide acceptable waiting times, and passengers expressed wanting to arrive at their destinations as soon as possible. The average value obtained was 3.5 out of 5, which means passengers are satisfied with the time it takes buses to reach the transit stop and waiting times, especially during rush hour.

Table 7

The Relationship between Boarding Time and Characteristics of Passengers

| | | **Characteristic of Passengers** | | | | | | **Total** |
|---|---|---|---|---|---|---|---|---|
| | | **Normal Passengers** | **People with Disabilities** | **Elderly People** | **Parents with Children** | **Students** | **Passengers With Luggage** | |
| Boarding time | 10 seconds | 12.5% | 0% | 0.6% | 1.7% | 5.4% | 2% | **22.3%** |
| | 20 seconds | 11.7% | 0% | 1.7% | 1.4% | 8% | 4.6% | **27.4%** |
| | 30 seconds | 12% | 0% | 2.6% | 2.6% | 13.4% | 8.9% | **39.4%** |
| | 40 seconds | 0.3% | 0% | 0% | 0% | 0% | 0.6% | **0.9%** |
| | 50 seconds | 0% | 0% | 0.3% | 0% | 0% | 0.6% | **0.9%** |
| | 60 seconds | 2% | 0.6% | 0.6% | 0% | 0.9% | 5.10% | **9.1%** |
| | **Total** | **38.6%** | **0.6%** | **5.7%** | **5.7%** | **27.7%** | **21.7%** | **100%** |

Table 8

The Influence of BRT Speed towards Transit Frequency in each corridor

| **BRT corridor** | | **Transit Frequency** | | | | | | | | | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3A** | **3B** | **4** | **5** | **7** | **Stop at the Airport** | **Non-Transit** | |
| Service speed of BRT Trans Semarang | No influence | 0% | 0.3% | 0.9% | 0% | 0% | 0.3% | 0% | 0% | 0% | **1.4%** |
| | Slight influence | 0% | 0.3% | 0.3% | 0.3% | 0% | 0% | 0% | 0% | 0% | **.9%** |
| | Influence | 1.7% | 3.1% | 0.9% | 0.9% | 1.4% | 1.7% | 0.3% | 1.1% | 0% | **10.9%** |
| | Enough influence | 3.4% | 10% | 0.9% | 0.9% | 5.4% | 9.7% | 3.7% | 3.4% | 0.3% | **39.4%** |
| | Strong influence | 5.4% | 12% | 1.1% | 1.1% | 4.9% | 6.3% | 4.9% | 8.6% | 0.3% | **47.4%** |
| | **Total** | **10.6%** | **25.7%** | **3.1%** | **3.1%** | **11.7%** | **18%** | **8.9%** | **13.1%** | **0.6%** | **100%** |

According to Tab.8, the Balai Kota transit shelter provides transit services in Corridors 1, 2, 3A, 3B, 4, and 5. There were high volumes of passengers in Corridors 2 and 5 since these routes operate from the northern to the southern part of Semarang (residential areas – city center – residential areas in suburban regions) and have high trip generation.

### *The Relationship between the Service Load Factor of BRT and Waiting Time*

The results revealed that the load factor of BRT Trans Semarang affects passenger comfort. The low level of load factor in BRT refers to bus availability on which passengers can comfortably use public seats without standing on the bus. The average value obtained is 4.1 out of 5, which means passengers are satisfied with the load factor in BRT. The load factor of BRT Trans Semarang does not interfere with passengers' comfort or safety, as presented in Tab. 9.

The load factor of BRT Trans Semarang (approximately 25%), however, is below the standard of the World Bank (70%), which may be caused by traffic congestion (where private vehicles often use the

BRT lane). The presence of online transportation services such as Grab and Gojek[7] may influence people's willingness to use BRT. The lack of BRT facilities also causes high variability in bus dwell times. When delays are inevitable, unreliable travel times are likely to arise, which will have negative effects on bus operators and users. The bus operator is expected to adjust the length of recovery times at bus shelters [41,42]. Moreover, poor capacity bus stops may force buses to queue on the road, and the waiting time may be relatively inefficient. Consequently, BRT passengers perceived longer waiting times than predicted. Not surprisingly, the average value obtained was 2.7 out of 5, which indicates passenger dissatisfaction. Unreliable transit times, therefore, create a disadvantage for bus operators in terms of cost and reputation and BRT customers in terms of time, satisfaction, and loyalty since it is a crucial determinant of transit system performance in urban public transportation [43].

Table 9

The Relationship between Service Load Factor and BRT Waiting Time

| | | **BRT Waiting Time** | | | | | | **Total** |
|---|---|---|---|---|---|---|---|---|
| | | **<3 Minutes** | **3 Minutes** | **5 Minutes** | **7 Minutes** | **10 Minutes** | **>10 Minutes** | |
| Service load Factor of BRT Trans Semarang | <25% | 16.3% | 11.1% | 9.4% | 0.9% | 1.4% | 0.3% | **39.4%** |
| | 25% | 15.4% | 10.3% | 16% | 0.9% | 1.1% | 0.3% | **44%** |
| | 50% | 1.1% | 3.4% | 5.4% | 0.6% | 2% | 0% | **12.6%** |
| | 75% | 0.6% | 0% | 0.9% | 0% | 1.1% | 0.3% | **2.9%** |
| | Others | 0.3% | 0.3% | 0.6% | 0% | 0% | 0% | **1.1%** |
| **Total** | | **33.7%** | **25.1%** | **32.3%** | **2.3%** | **5.7%** | **0.9%** | **100%** |

Table 10

The Relationship between Service Reliability and the Level of Speed to Arrive at the BRT Stop

| | | **BRT Waiting Time** | | | | | **Total** |
|---|---|---|---|---|---|---|---|
| | | **No Influence** | **Slight Influence** | **Influence** | **Enough Influence** | **Strong Influence** | |
| Service reliability of the BRT Trans Semarang | On time | 0.3% | 0% | 1.1% | 3.7% | 0.9% | **6%** |
| | Smooth boarding/alighting | 0.6% | 0% | 1.4% | 7.1% | 6.9% | **16%** |
| | Several buses are queuing | 0.6% | 0.9% | 6.9% | 24.6% | 31.7% | **64.6%** |
| | Traffic jam | 0% | 0% | 1.1% | 4% | 8% | **13.1%** |
| | Other | 0% | 0% | 0.3% | 0% | 0% | **0.3%** |
| **Total** | | **1.4%** | **0.9%** | **10.9%** | **39.4%** | **47.4%** | **100%** |

The results in Tab.10 show that there are several buses waiting in line (64.6%) to get to the transit shelter, which has a strong influence on passengers' waiting times. Although external factors influence the service reliability of BRT, such as traffic congestion and bus queueing, BRT users often consider the bus operational management, such as departure and arrival times [28].

### *The Relationship between Arrival Time Service of BRT and Passengers' Alighting Time*

The average value of bus punctuality was 4.1 out of 5, which means passengers are satisfied with bus arrival times. As shown in Tab. 11, the bus arrival time was 30 seconds (40.3%), and many passengers were waiting for next empty bus at the stop to be seated. These passengers were looking forward to empty buses and spent 30 seconds waiting due to safety reasons. Studies on passengers by age and gender reported that safety perceptions are significantly influenced by bus shelter characteristics, natural surveillance, and reliable real-time information [44]. In this research, however, bus arrival time is subjective and depends on the passenger's individual interest. The bus arrival time of 50 seconds to one minute is commonly influenced by passenger disembarkation. Based on the interview, the bus arrival time and the waiting times are very valuable for students and workers who are constantly

[7] Gojek is a multi-service tech application providing access to a wide range of services including transport and payments, which people can use on their smartphones.

using BRT as their daily transport modes. Choice riders who use BRT once have no problems with delays or the inaccuracy of the BRT schedule.

Table 11

The Relationship between Arrival Times of BRT Vehicles and Passengers' Alighting Times

| | | BRT Arrival Time at the Stop | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | | 10 seconds | 20 seconds | 30 seconds | 40 seconds | 50 seconds | 60 seconds | |
| BRT arrival service at the Balai Kota Semarang transit point | On time | 2% | 1.1% | 2.6% | 0% | 0% | 0.3% | **6%** |
| | Not on time due to traffic congestion | 3.7% | 3.4% | 6.9% | 0.3% | 0% | 0 | **14.3%** |
| | Bus came late | 12% | 8.3% | 7.1% | 0% | 0% | 1.4% | **28.9%** |
| | I am waiting for the next bus at the stop (for an empty bus) | 8.6% | 8.6% | 19.7% | 0.3% | 0.3% | 6% | **43.4%** |
| | On time, must be in a rush | 1.1% | 0.3% | 2.6% | 0% | 0.3% | 1.4% | **5.7%** |
| | Not on time, several buses are queuing | 0% | 0% | 1.4% | 0% | 0.3% | 0% | **1.7%** |
| **Total** | | **27.4%** | **21.7%** | **40.3%** | **0.6%** | **0.9%** | **9.10%** | **100%** |

Moreover, many BRT Trans Semarang users (43%) were expecting the ideal waiting time for BRT to be around three minutes. The average value obtained was 3.4 out of 5, indicating that passengers felt that it is acceptable to wait for three minutes and avoid the accumulation of passengers at the transit shelter of Balai Kota. It is observed that bus queueing on the road, traffic congestion, and the number of buses available to carry passengers can be seen as the main factors causing delays.

Based on Tab. 12, the waiting time at BRT stops is normally less than three minutes (33.7%), depending on the location of the BRT stop. On the contrary, there was a long waiting time of around five minutes to more than seven minutes when the volumes of riders were high during peak hours. Very few riders (0.3%-0.6%) waited more than 10 minutes at the BRT stop. Individuals usually waited for around three to five minutes since there were many available buses stopped at the shelter. Irregular bus arrival times at stops were commonly caused by the inaccurate estimation of bus dwell time. Consequently, the interaction between buses and passengers can restrict the discharge flows of buses [43, 45].

Table 12

The Relationship between Arrival Time Service of BRT and Passengers' Alighting Times

| | | The Frequency of Transits at the BRT stop | | | | Total |
|---|---|---|---|---|---|---|
| | | Non-Transit/0 Transits at the stop | 1 Transit at the stop | 2 Transits at the stop | 3 Transits at the atop | |
| Waiting time at the Balai Kota Semarang transit shelter | < 3 Minutes | 6.3% | 10.6% | 16.9% | 0.0% | **33.7%** |
| | 3 Minutes | 3.7% | 2.3% | 18.9% | 0.3% | **25.1%** |
| | 5 Minutes | 4.6% | 4.6% | 23.1% | 0% | **32.3%** |
| | 7 Minutes | 0.3% | 0.3% | 1.7% | 0% | **2.3%** |
| | 10 Minutes | 0.3% | 0% | 5.4% | 0% | **5.7%** |
| | >10 Minutes | 0.3% | 0.6% | 0% | 0% | **0.9%** |
| **Total** | | **15.4%** | **18.3%** | **66%** | **0.3%** | **100%** |

## 4. CONCLUSIONS

BRT is a fundamental element in the city infrastructure to carry millions of people who are commuting to work and enjoying their leisure time. It can be concluded that the capacity of the transit shelter, the interval of bus arrivals, bus dwell times, and BRT infrastructures are the most influential variables on passengers' satisfaction. The Balai Kota transit shelter needs improvements in terms of time management and infrastructure since it is located in the central business district of Semarang, which

has a high volume of passengers and many routes. Door size has a significant influence on people's movement during boarding. Larger doors enable more people to enter the bus and reduce boarding and alighting times. The results also reveal that passengers were mostly unsatisfied with in-vehicle crowding on public transportation because they perceived travel discomfort and insecurity due to risks of sexual harassment, especially for women. People were also expecting that the bus operation will add more available buses to minimize the time between bus arrivals at the transit stop.

There are two significant variables (the reason for using BRT and the maximum delay time) that bus operators need to consider. Normal passengers (workers and students) are the main users of BRT Trans Semarang for commuting to work and school. Bus operations should consider the existing design of BRT to make it a better ergonomic fit for commuters since the shelter provides transit services with multiple corridors and routes from suburban areas to the city center of Semarang. On the one hand, the amount of space available within the vehicle determines the circulation speed of passengers [46]. The shelter for transit services should be equipped with greater circulation and different exit and entrance gates to accommodate more passengers since BRT features also have an influence on riders' comfort and safety. In contrast, the poor infrastructure of BRT might produce chances for a potential boarding and alighting incident for vulnerable riders such as disabled people, elderly people, children, and pregnant women. It is interesting to note that unreliable transit times can be disadvantageous for bus operators (cost and reputation) and BRT customers (time, satisfaction, and loyalty). A real-time information system is considerably important for transit passengers to provide predictable departure and arrival times because passengers are satisfied with the shorter waiting times at stops and trustworthy bus schedules. The maximum acceptable waiting time at a BRT shelter is three minutes, but bus operators should care about the headway time and speed to avoid the disturbance of transit activities, especially during rush hour. Furthermore, since there are shortcomings and a few gaps in the current knowledge, it would be beneficial if the present findings could be used for further research—specifically, more methodological works to capture the service performance of transit-based transportation, comparative analyses between the concept of BRT and current transport policy in the city, and analyses of BRT infrastructure to support the transit-oriented system.

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## References

1. Zhang, F. & Zheng, N. & Yang, H. & Geroliminis, N. A systematic analysis of multimodal transport systems with road space distribution and responsive bus service. *Transportation Research Part C: Emerging Technologies*. 2018. Vol. 96. P. 208-230.
2. Rizelioğlu, M. & Arslan, T. A comparison of LRT with an imaginary BRT system in performance: Bursa example. *Case Studies on Transport Policy*. 2020. Vol. 8(1). P. 135-142.
3. Zahraei, S.M. & Cheah, L. & Cheema, W. & Kurniawan, J. A foresight study on urban mobility: Singapore in 2040. *Foresight*. Emerald Publishing Limited 2020. Vol. 22. No. 1. P. 37-52. ISSN 1463-6689.
4. Prioni, P. & Hensher, D.A. Measuring service quality in scheduled bus services. *Journal of Public Transportation.* 2000. Vol. 3(3). P. 1-24.
5. Hensher, D.A. & Stanley, J. Performance-based quality contracts in bus service provision. *Transportation Research Part A: Policy and Practice*. 2003. Vol. 37(6). P. 519-538.
6. Said, HA. Evaluation method of service quality parameters in transport networks. In: *Proceedings of the 5th Biannual World Automation Congress.* IEEE. 2002 Jun 9. Vol. 14. P. 21-26.
7. Schmöcker, J.D. & Bell, M.G.H. & Lam, W.H.K. Special issue: Importance of public transport. *Journal of Advanced Transportation*. 2004. Vol. 38(1). P. 1-4.

8. Ahasan, R. & Kabir, A. *Performance Evaluation of Public Transportation System: Analyzing the Case of Dhaka, Bangladesh.* Planning Forum 18. 2021. Available at: https://sites.utexas.edu/planningforum/article-3-performance-evaluation-of-public-transportation-system-analyzing-the-case-of-dhaka-ban
9. Berg, J. & Ihlström, J. The importance of public transport for mobility and everyday activities among rural residents. *Social Sciences*. 2019. Vol. 8(2). No. 58. P. 1-13.
10. Eboli, L. & Mazzulla, G. Structural equation modelling for analysing passengers' perceptions about railway services. *Procedia - Social and Behavioral Sciences*. 2012. Vol. 54. P. 96-106.
11. He, L. & Yang, D. & Li, J. Improving the service quality of public transit with exclusive bus lanes: a perspective from passenger satisfaction. *Journal of Advanced Transportation*. 2021. Article ID 8599256.
12. Wright, L. *Module 3b: Bus Rapid Transit. Sustainable Urban Transport Project (SUTP*). 2003.
13. Cervero R. *Bus rapid transit (BRT): An efficient and competitive mode of public transport*. *Working paper.* 2013.
14. Økland, A. & Olsson, N.O. Punctuality development and delay explanation factors on Norwegian railways in the period 2005-2014. *Public Transport*. 2021. Vol. 13(1). P. 127-161.
15. Li, L. & Zhang, H. & Wang, X. & Lu, W. & Mu, Z. Urban transit coordination using an artificial transportation system. *IEEE Transactions on Intelligent Transportation Systems*. 2010. Vol. 12(2). P. 374-83.
16. Low, V.J.M. & Khoo, H.L. & Khoo, W.C. Quantifying bus travel time variability and identifying spatial and temporal factors using Burr distribution model. *International Journal of Transportation Science and Technology.* 2021. Vol. 11(3). P. 563-577.
17. Norhisham, S. & Katman, H.Y. & Ismail, N. & Abd Halim, S.N.N. & Ismail, A. & Borhan, M.N. Evaluation on time performance for public bus service in West Klang Valley. *Fuel*. 2018. Vol. 8(9).
18. Huo, Y. & Li, W. & Zhao, J. & Zhu, S. Modelling bus delay at bus stop. *Transport*. 2018. Vol. 33(1). P. 12-21.
19. Beirão, G. & Sarsfield Cabral, J.A. Understanding attitudes towards public transport and private car: A qualitative study. *Transport Policy*. 2007. Vol. 14(6). P. 478-489.
20. Lai, W.T., & Chen, C.F. Behavioral intentions of public transit passengers – The roles of service quality, perceived value, satisfaction, and involvement. *Transport Policy*. 2011. Vol. 18(2). P. 318-325.
21. Machado-León, J.L. & de Oña, R. & de Oña, J. The role of involvement in regard to public transit riders' perceptions of the service. *Transport Policy*. 2016. Vol. 48. P. 34-44.
22. Rakhmatulloh, A.R. The built environment and its impact transit based transportation users walking activity in Semarang, Indonesia. *Pertanika Journal of Science and Technology*. 2021. Vol. 29(2). P. 771-789.
23. Aziz, A. & Nawaz, M.S. & Nadeem, M. & Afzal, L. Examining suitability of the integrated public transport system: A case study of Lahore. *Transportation Research Part A: Policy and Practice.* 2018. Vol. 117. P. 13-25.
24. Cruz, L. & Barata, E. & Ferreira, J.P. Performance in urban public transport systems: a critical analysis of the Portuguese case. *International Journal of Productivity and Performance Management.* 2012. Vol. 61(7). P. 730-751.
25. Friman, M. & Lättman, K. & Olsson, L.E. Public transport quality, safety, and perceived accessibility. *Sustainability*. 2020. Vol. 12(9). No. 3563. P. 1-14.
26. Nadeem, M. & Azam, M. & Asim, M. & Al-Rashid, M.A. & Puan, O.C. & Campisi, T. Does bus rapid transit system (BRTS) meet the citizens' mobility needs? *Evaluating Performance for the Case of Multan.* Pakistan. *Sustainability*. 2021. Vol. 13(13). No. 7314. P. 1-18.
27. Hensher, D. & Stopher, P. & & Bullock, P. Service quality- developing a service quality index (SQI) in the provision of commercial bus contracts. *Transportation Research Part A: Policy and Practice*. 2003. Vol. 37. P. 499-517.
28. Elhajj, M. & Ochieng, W.Y. Urban bus positioning: Location based services and high-level system architecture. *Case Studies on Transport Policy*. 2020. Vol. 8(1). P. 12-21.

29. Ulkhaq, M.M. & Ardiani, A.J. &, Farhan, M. & Bagja, R.P. & Hanif, R.Z. Service quality analysis of bus rapid transit: a case in Semarang, Indonesia. *4th International Conference on Intelligent Transportation Engineering (ICITE*). 2019. P. 6-10.
30. Iswalt, M. & Wong, C. & Connolly, K. Innovative operating solutions for bus rapid transit through a congested segment of San Jose, California. *Journal of the Transportation Research Board*. 2011. No. 2218. P. 27-38.
31. Wirasinghe, S.C. & Kattan, L. & Rahman, M. & Hubbell, J. & Thilakaratne, R.S., & Anowar, S. Bus Rapid Transit (BRT) - a review. In: *International Journal of Urban Sciences*. 2013. Vol. 17. P. 1-38.
32. Zimmerman, S. & Levinson, H. Vehicle selection for BRT: issues and options. *Journal of Public Transportation*. 2004. Vol. 7. No. 1. P. 83-103.
33. Deng, T. & D. Nelson, J. Recent Developments in Bus Rapid Transit: A Review of the Literature. *Transport Reviews - TRANSP REV*. 2011. Vol. 31. P. 69-96.
34. Currie G. The demand performance of bus rapid transit. *Journal of public transportation*. 2005. Vol. 8(1). P. 41-55.
35. Carrigan, A. & King, R. & Velásquez, Miguel, J. & Raifman, M. & Nicolae, D. Social, *Environmental and Economic Impacts of Bus Rapid Transit.* EMBARQ. World Resources Institute. 2013.
36. Gahlot, V. & Swami, B.L & Parida, M. & Kalla, P. User oriented planning of bus rapid transit corridor in GIS environment. *International Journal of Sustainable Built Environment*. 2012. Vol. 1(1). P. 102-109.
37. Harumain, Y.A.S. & Nordin, N.A. & Zaid, S.M. & Goh, H.C. & Woodcock, A. & Mcdonagh, D. & Faiz, K. Understanding factors of using public transportation among women in Kuala Lumpur. *J. Pengemb. Kota*. 2020. Vol. 8. P. 109-115.
38. Kumagai, J. & Wakamatsu, M. & Managi, S. Do commuters adapt to in-vehicle crowding on trains? *Transportation*. 2021. Vol. 48(5). P. 2357-2399.
39. Tirachini Hernández, A. & Hurtubia, R. & Dekker, T. & Daziano, R.A. Estimation of crowding. discomfort in public transport: results from Santiago de Chile. *Transportation Research Part A: Policy and Practice*. 2017. Vol. 103. P. 311-326.
40. Haywood, L. & Koning, M. & Monchambert, G. Crowding in public transport: Who cares and why? *Transportation Research Part A: Policy and Practice*. 2017. Vol. 100. P. 215-227.
41. Furth, P.G. & Muller, T.H. Conditional bus priority at signalized intersections: better service with less traffic disruption. *Transportation research record*. 2000. Vol. 1731(1). P. 23-30.
42. Sun, L. & Tirachini, A. & Axhausen, K.W. & Erath, A. & Lee, D.H. Models of bus boarding and alighting dynamics. *Transportation Research Part A: Policy and Practice*. 2014. Vol. 69. P. 447-460.
43. Bie, Y. & Wang, Y. & Zhang, L. Impact of carriage crowding level on bus dwell time: modelling and analysis. *Journal of Advanced Transportation*. 2020. Article ID 6530530.
44. Abenoza, R.F. & Ceccato, V. & Susilo, Y.O. & Cats, O. Individual, travel, and bus stop characteristics influencing travelers' safety perceptions. *Transportation Research Record*. 2018. Vol. 2672(8). P. 19-28.
45. Ojo, T.K. Quality of public transport service: An integrative review and research agenda. *Transportation Letters*. 2019. Vol. 11(2). P. 104-116.
46. Bie, Y. & Xiong, X. & Yan, Y. & Qu, X. Dynamic headway control for high-frequency bus line based on speed guidance and intersection signal adjustment. *Computer-Aided Civil and Infrastructure Engineering*. 2020. Vol. 35(1). P. 4-25.

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