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ORIGINAL RESEARCH

PUBLIC TRANSPORT INTEGRATION CHALLENGES OF WIRA WIRI SUROBOYO AS A COMMUTER TRAIN FEEDER

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Abstract

Congestion is a problem in most big cities, including Surabaya. One alternative to reduce congestion is to create city transportation with excellent service. Surabaya has had city transportation, city buses and also commuter trains for a long time. However, it is considered that travelers do not have excellent service. In 2023, a new city transportation will be created with the name Wira Wiri Suroboyo (WWS) with the aim of diverting some private vehicle users to WWS. However, until now, WWS has not been able to attract the interest of the public who use private vehicles. So it is necessary to research the operational performance of the WWS and analyze integration opportunities with commuter trains. The research method used was conducting field surveys and interviews with WWS passengers. The results of the survey show that load factor, headway, departure frequency, number of vehicles in operation are still not optimal to divert private vehicle users to WWS and at the same time integrate with commuter trains. Therefore, other efforts are needed to limit private vehicles in order to provide cross-subsidies for public transportation. So that it does not burden operational costs which have been borne by the Government.

KEYWORDS:

performance, operations, city transportation, integration, commuter trains.

1 | INTRODUCTION

Research into traffic jams in Surabaya has been identified since 2006 and continues to this day. The number of vehicles in Surabaya in 2010 reached 3,723,885 units. Meanwhile, the number of city transportation was only 22,261 vehicles or only reached 5.95%. The addition of private vehicles reached 15,000 units per month. There are 7 road sections that have a degree of saturation of more than 1 and 33 roads that have a degree of saturation of more than 0.5 [1]. Congestion in Surabaya is generally caused by the increasing number of private vehicles which is not balanced with road capacity. Public awareness of using public transportation and the quality of public transportation services are also still low. Some of these things result in people using private vehicles [2] [3].

The increasing volume of vehicles results in road capacity becoming smaller if it is not balanced with an increase in the road network and capacity, indicating that the majority of the road network system is no longer able to keep up with the growth in vehicle volume. Traffic jams occur in every big city such as Jakarta, Surabaya, Medan , Makassar and others. Surabaya, as one of the big cities in Indonesia, through the Surabaya City Transportation Department, always solves the problem of traffic jams in Surabaya so that it does not get worse in the future, which will be very detrimental to the residents of the city of Surabaya [4]. Until now, the problem of traffic jams in the city of Surabaya is increasing even though the city government has issued several strategies and policies related to solving the problem of traffic jams. In overcoming congestion, the strategy used is to improve the quality and increase the number of public transportation such as city buses with the aim of encouraging people to switch from private vehicles to public transportation.

However, in fact, the number of private vehicles continues to increase by 10% every year, even the number of private vehicles in Surabaya reached 4.5 million in 2016 [5].

The phenomenon of growth in the number of vehicles in Surabaya which is not balanced with the growth in road length causes congestion on Surabaya roads. Congestion in Surabaya causes a decrease in vehicle speed. The decrease in average vehicle speed due to traffic jams causes wasteful use of fuel oil. The impact of fuel wastage due to traffic jams in Surabaya is IDR. 631.75 billion per year [6]. So it is clear that traffic jams in the city of Surabaya cause many further problems. The city of Surabaya has long operated public transportation facilities (city buses, city transportation and commuter trains). City transportation is the most common mode of public transportation because it has 57 routes throughout the city of Surabaya and acts as a feeder for city buses and commuter trains [1] [2].

However, it is very unfortunate that public transportation services are less popular with the public due to long waiting times and travel times, less comfort, less safety, low levels of accessibility, too many transits, tickets and other modes of public transportation are not integrated optimally. So the cost of traveling using public transportation becomes uneconomical and many people end up using private vehicles [1].

The shortage of city transportation is trying to be overcome by launching a precisely scheduled city transportation, namely Wira Wiri Suroboyo (WWS), which has 7 routes. WWS has advantages compared to conventional city transportation in terms of definite departure schedules, scheduled headways every 17 - 18 minutes, WWS is equipped with air conditioning so it is more comfortable, there is CCTV to increase passengers' sense of security, and it is integrated with stations, terminals and city bus stops.

Therefore, it is very important to know the public's response to WWS through measuring operational performance. integration between public transportation modes which is considered very lacking in Surabaya is also very important to research. This research focuses on the performance of the WWS route 03 feeder and efforts to integrate WWS route 3 with commuter trains that pass through Wonokromo Station. Wonokromo Station is a very important station for travelers in Surabaya which can connect the city of Surabaya with Sidoarjo, Pasuruan, Malang, Blitar, Gresik, Lamongan, Bojonegoro, Jombang, Kediri and Tulungagung.

2 | PREVIOUS RESEARCHES

There are several studies that try to optimize the operational performance of public transport in a city. The use of travel time as a benchmark for the main performance of public transport has been carried out in Zurich (Switzerland) [7]. This is also supported by data showing that city buses spend 9 – 26% of travel time at stops [8]. Passenger numbers have increased by approximately 14% and travel costs have been reduced by €4 million when journey times were reduced by approximately 21% on a series of routes in Munich [9]. Likewise, the Metro Rapid Program in Los Angeles has reduced travel times by 29% and increased bus ridership by 20% in the Wilshire – Whittier Corridor and 50% in the Ventura Blvd Corridor [10]. It is also recommended that the distance between stops should be optimized between 600 – 700 m for buses and 800 m for trams [11]. This is somewhat different from what happens in the urban area of Sidney. Existing data shows that 85% of passengers on weekdays, Saturdays, Sundays and national holidays are within 800 m of the bus stop [12].

The interest of public transport users in Sydney is based on several factors, namely time (travel time, frequency, reliability and comfort of seats), system and efficiency (information and technology, public transport and transit tickets), certainty (safety, accessibility and friendly staff and helpful) and facilities and environment (temperature, space, cleanliness, and other passengers)[12]. There are 3 categories of load factor, namely during peak hours, non-peak hours and at night. For peak hours the load factor is expected to be > 80%, for non-peak hours and at night it is expected to be between 40 – 80%[12]. There are several headway categories, namely (1) 15 – 30 minutes at 05.00 – 06.00 and 22.00 – 24.00, (2) 5 – 10 minutes at 06.00 – 09.00 and 15.00 – 18.00, (3) 10 minutes at 09.00 – 15.00, (4) 10 – 15 minutes from 18.00 – 22.00, (5) 15 minutes on Sundays and national holidays [12]. At least 95% of bus arrival, departure and transit schedules in Sydney are on time.[13].

The potential for integration between public transport has also been researched in Sidney. 40% of public transport users use buses and trains to reach their destination, 25% use trains and trains, 16% use buses twice, 4% use buses and trains twice and buses and trains twice respectively[14].

Speed and travel time greatly influence the proportion of split modes in Poland. A comparative study of average speed and travel time was carried out. Public transportation 1 has a speed of 22.66 km/hour and a travel time of 45.3 minutes. Meanwhile, the second public transport has a speed of 24.94 km/hour and a travel time of 42.29 minutes. Even though the speed of public transport 1 is lower, it gets a passenger proportion of 32%, minibuses 50% and trams 18%. Meanwhile, with a speed of 24.94 km/hour the bus received 21% passengers, the minibus 41% and the tram 9%[15]. So if the speed of public transport is high and the travel time is low, it is not certain that it will get a larger number of passengers.

Public transport integration places great importance on price integration. The integration of public transport ticket prices is to ensure passengers get the best economic and financial conditions when combining various means of transport in a trip. There are four elements of price integration, namely an intelligent and integrated ticket system, ticket unification, integrated ticket facilities, and transportation costs. Therefore, it is very important to realize the integration of public transport prices in different modes so as to provide door-to-door services to passengers[16].

An example of price integration is that it applies throughout the TransJakarta corridor and there is no additional shuttle fee between corridors and buses. The flat rate is set at IDR 3,500 (0.23). In 2018, PT Transport Jakarta was integrated with Mikro Trans (Jak Lingko) which has a time-based payment scheme, amounting to IDR 5,000 for a period of 3 hours[17].

LRT headway service planning in Newcastle is in Table 1 [18]:

TABLE 1 LRT Service Planning – Minimum Service Frequency Guidelines

Service Type		Newcastle Light Rail		
Days of Operation		7 Days		
Average Stop Spacing		400-800 m		
Time Period	Monday to Friday	Saturday	Sunday	Public Holiday
05.00 – 07.00	15’	30’	30’	30’
07.00 – 19.00	10’	15’	15’	15’
19.00 – 24.00	15’	15’	30’	30’
00.00 – 01.00	30’	30’	30’	30’
01.00 – 05.00	Nil	Nil	Nil	Nil

The capacity inside the LRT is 6 people standing per m2. The departure schedule is required to be at least 95% on time schedule[18]. Public transport integration represents only the first level of the following ones[19]:

1. integration of fares, services, terminals/stops and information about public transport,
2. provision of infrastructure integration, management, pricing policies for private vehicles and public transport
3. integration of passenger and goods transport,
4. integration with transport authorities,
5. integration of land use policies with transportation planning,

6. integration of public transport policies with transport education, health and social policies,
7. integration of transport policies with other policies.

The hierarchy of the public transport performance optimization process consists of two sides, namely user oriented and operator oriented. User oriented consists of security, accessibility, regularity and speed of travel. Operator oriented consists of operational costs, staff ratio per bus, load factor, fleet availability, and % of fatalities per km, and % of km canceled [20]. The performance of public transport operations in Indonesia is measured based on travel time, headway, circulation time, load factor and passenger comfort. The method used to measure passenger satisfaction uses Importance Performance Analysis (IPA). The results of research in Medan (Indonesia) found that headway, circulation time and load factor had to be improved because they did not meet standards. Meanwhile, from the passenger's point of view, what must be improved is the physical condition, security and comfort of bus stops [21]. In modern cities, private vehicles cause serious road congestion and pollution problems. If the road network capacity is insufficient, traffic accidents will increase and road safety will decrease. Therefore, it is very important to try to achieve change people's travel behavior towards the use of more sustainable means of transport such as public transport, bicycles, walking, car sharing and carpooling. All this can be achieved using the concept of transportation demand management [22].

3 | METHOD

This research method will collect 2 sources of data, namely primary data and secondary data. After sufficient data has been collected, data processing and analysis is carried out. The final step of this research method is to provide conclusions and suggestions for public transport stakeholders in Surabaya. The following will explain in detail the steps in conducting this research.

3.1 | Data Collection

Primary and secondary data in research conducted in Medan (Indonesia) are the number of passengers, travel time, passenger boarding data, headway, bus specifications, data on the number of passengers for the previous period, bus service maps [21]. Secondary data and primary data for measuring public transport performance carried out in Valencia (Spain) are as follows: public transport ticket prices, comfort, security officers, waiting time, cleanliness, information, drivers, number of transits, safety, ease of payment, seat availability , convenience of smart cards, speed, staff, coverage area, infrastructure, and passenger satisfaction [23]. According to the Technical Guidelines of the Ministry of Transportation of the Republic of Indonesia, measuring public transport performance consists of route, headway, arrival time, departure time, hull code, time table, stop name, number of passengers getting on and off, passenger waiting time, route distance, number of fleets, and operational time [24].

Meanwhile, the primary and secondary data collection carried out in this research is a combination of 2 previous studies and technical guidelines: (1) city transport routes [21] [24], (2) headway [21] [24], (3) time and time table arrival at the terminal [23] [24], (5) passenger waiting time [22] [23], (6) route distance [21] [24], (7) number of public transport passengers [21] [24], (8) travel time [21] [24], (9) speed [24] [25], (10) availability of public transport [24] [26] [27], (11) public transport service time [24], (12) load factor [24] [25] [28] [29].

3.2 | Data Processing and Analysis

Below are several performance indicators that will be processed and analyzed at the same time to answer the problems in this research.

1. Urban Transport Routes

   To determine the need for transit routes, it is necessary to analyze the current and future supply of the public transport fleet and the integration process of the different modes. So that urban public transportation is able to provide efficient, comfortable, safe and economical services [30].

2. Headways

Headway is defined as a measure that states the distance or time when the front of successive vehicles passes an observation point on a road section. Headway is the length of time between vehicle arrivals at a stop or station[31]. The formula for getting headway is as follows:

$$H = \frac{60}{F} \tag{1}$$

Note:
H = Intermediate time/headway (minutes);
F = Frequency

3. Time of arrival

   Public transport arrival time is a key factor in passenger satisfaction and use of public transport. Bus arrival time information reduces passenger anxiety and waiting times. Therefore, providing accurate bus arrival time information to passengers is very important in public transportation[32].

4. Arrival time table at each stop

   The arrival time schedule at each stop or station is very important for passengers, especially if it can be realized in real time via the application. The amount of time spent waiting at public transport stations is a key element in passengers' assessment of service quality and mode choice decisions. If the travel time is short, passengers don't really look at the schedule because vehicles arrive frequently. Therefore these passengers arrive regularly at the station. On the other hand, at longer waiting times, passengers consult the timetable to reduce waiting times[33].

5. Passenger Waiting Time

   Waiting time is an important factor in influencing passenger satisfaction regarding the quality of service on public transportation. Therefore, it is important for traffic departments to understand passengers' perception of waiting time to improve their image and increase passenger numbers[34].

6. Public Transport Mileage

   Public transport distance measurement data is very useful for determining fuel consumption models in urban traffic. The impact of traffic during rush hours and congestion also affects fuel consumption[35]. The distance between Terminal A and Terminal B may also not be the same because the roads passed are not necessarily the same.

7. Number of Public Transport Passengers

   There is an interesting finding in the USA that fare levels and service frequency can lead to at least a doubling (or halving) of public transport use in certain urban areas[36]. The number of WWS and commuter train passengers to date is still not the main transportation for the people of Surabaya. Therefore, it is very important to periodically evaluate the number of passengers on public transportation in Surabaya.

8. Public Transport Travel Time

   The required travel time from the passenger's point of view is a decisive criterion for assessing service quality[37]. Travel time is an important criterion for passengers to compare the quality of transportation systems in urban areas[38]. The formula for getting travel time is as follows:

$$W = \frac{T}{J} \tag{2}$$

Note:
W = Travel time (minutes/km);
J = Distance between segments (km);

T = Public transport travel time (minutes)

9. Speed

The speed of public transport (buses) in Porto (Portugal) during the afternoon rush hour is lower than the morning rush hour. But the speed at night is higher than during the day and morning periods [27]. The formula to get speed is as follows:

$$K = \frac{60\,\mathrm{J}}{W} \tag{3}$$

10. Availability of Public Transportation

The availability of public transport in urban areas also influences the mode choice of travelers [26] [39]. The availability of public transportation is very important, so this research will also carry out primary and secondary data collection. The formula for obtaining the number of public transport fleets is as follows [24]:

$$N = \frac{LR}{V} \times \frac{60}{H} \tag{4}$$

Note:
N = Number of fleets required per route per hour;
V = Average operational speed average (km/h);
Lr = Route length (km);
H = Headway (minutes)

11. Public Transport Service Times

Service time is the time required for public passenger transport to serve a particular route in one day which is calculated based on the start and end times of the public passenger vehicle service [24].

12. Load Factor

Bus service performance can be determined by attributes such as service hours, service frequency, and passenger load factors [25] [28]. Load factor is the passenger load calculated and the amount divided by the available public transportation capacity (sitting and standing) [24]. The formula for getting the Load factor is as follows:

$$\text{Load Factor} = \frac{\text{Total Passengers}}{\text{Public Transport Capacity}} \tag{5}$$

There is a classification regarding Quality Service of Load Factor [40].

TABLE 2 Quality Service of Load Factor

Quality of Service	Load Passenger (Passenger/seat)	Comments
A	0.00 – 0.50	No Passenger needs to sit next to another
B	0.51 – 0.75	Passenger can choose where to sit
C	0.76 – 1.00	All passengers can seat
D	1.01 – 1.25	Comfortable standee lot for design
E	1.26 – 1.50	Maximum schedule load
F	1.50	Crush load

4 | RESULT AND DISCUSSION

4.1 | Number of Passengers and Load Factor

The survey was conducted on weekdays and weekends using the sample vehicle method. Weekends are taken on Saturday and weekdays are taken on Tuesday. The route reviewed is WWS feeder route 03, namely from Joyoboyo Main Terminal to Gunung Anyar and vice versa. The WWS 03 route was chosen because it has the opportunity to be integrated with Wonokromo Train Station. The Wonokromo train station is very special because it connects Surabaya with Sidoarjo, Pasuruan, Malang, Blitar, Mojokerto, Jombang, Kertosono, Kediri, Gresik, Lamongan and Madiun. The WWS Route 03 feeder's carrying capacity is 10 passengers (Daihatsu Grand Max). There are 52 WWS Route 03 fleets in operation (Surabaya City Transportation Agency, 12 July 2023).

TABLE 3 Load Factor of Route 03 WWS

No.	Day	Date	Route	Arrival Time	Numb of Pass	Capacity	LF	LF Average
1	Sat	29-Jul-23	TIJ - GA	13.09	5	10	0.5	0.525
2	Sat	29-Jul-23	TIJ - GA	17.08	9	10	0.9	
3	Sat	29-Jul-23	GA - TIJ	14.28	4	10	0.4	
4	Sat	29-Jul-23	GA - TIJ	16.57	3	10	0.3	
5	Tue	01-Aug-23	TIJ - GA	12.47	5	10	0.5	0.55
6	Tue	01-Aug-23	TIJ - GA	16.33	10	10	1	
7	Tue	01-Aug-23	GA - TIJ	13.45	4	10	0.4	
8	Tue	01-Aug-23	GA - TIJ	17.13	3	10	0.3	
LF Average								0.5375

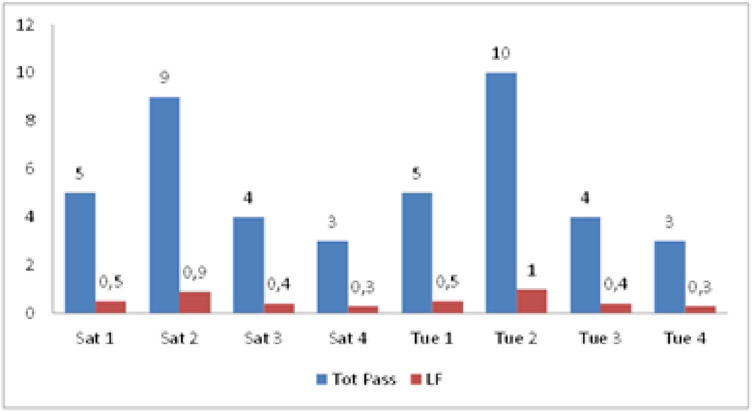

FIGURE 1 Number of Passengers and Load Factor WWS Route 03.

From the 8 WWS 03 feeder vehicles, it appears that the highest number of passengers was in the Tuesday 2 period with 10 passengers and the lowest was on Saturday 4 and Tuesday 4 with 3 passengers. The load factor also corresponds to the number of passengers, the highest is on Tuesday 2 with a load factor of 0.9 and the lowest load factor occurs on Saturday 4 and Tuesday 4. The average load factor for Saturday is 0.525 and the average load factor for Tuesday is 0.55. For ideal conditions, the load factor value is 0.76 – 1.00, where all passengers can get a seat. Of the 8 sample vehicles for which data collection has been carried out, only 2 vehicles have a load factor value of 0.76 – 1.00, namely on 1st 2nd and 2nd Tuesday. This shows that there are still 6 vehicles that do not have a load factor in ideal condition or in other words, there is still a shortage of passengers. To analyze the accuracy of the departure time with the existing schedule, WWS route 03 time table data is needed as follows.

No.	Vehicle	Departure Timetable	Actual Departure Hours	Note
1	Sat 1	13.09	13.09	On time
2	Sat 2	17.07	17.08	Late, 1 min
3	Sat 3	14.17	14.28	Late, 11 min
4	Sat 4	16.50	16.57	Late, 7 min
5	Tue 1	12.35	12.47	Late, 12 min
6	Tue 2	16.33	16.33	On time
7	Tue 3	13.43	13.45	Late, 2 min
8	Tue 4	17.07	17.13	Late, 6 min
Late Average				Late, 4.9 min

TABLE 4 WWS 03 Time Table and Actual Departure Time

From Table 4 and Figure 2 , it is found that the average delay in departure time for the WWS 03 feeder for the 8 sample vehicles is 4.9 minutes. This will of course reduce the interest of WWS 03 feeder users to continue using this mode in the future.

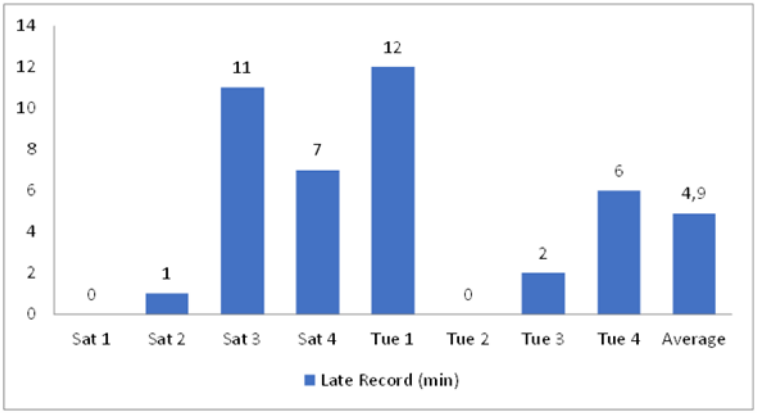

FIGURE 2 WWS Route 03 Feeder Delay

4.2 | Headway

The WWS 03 feeder headway can be found from the timetable issued by the Surabaya City Transportation Department. Below in Table 5 is the WWS 03 feeder departure schedule.

From Table 5 it can be seen that the WWS 03 feeder headway is every 18 minutes. Often the WWS 03 feeder departure also experiences delays of up to 11 minutes (see Table 4). If this is allowed to drag on, it will make passengers restless and will reduce passengers' interest in using the WWS 03 feeder mode and there are concerns that they will use private vehicles.

The ideal headway is between 5 -10 minutes, during peak hours the headway ranges from 2 - 5 minutes [24]. If the headway of the WWS 03 feeder in the field is 18 minutes, then it is still too long compared to existing standards [24]. So it is not surprising that the load factor is still lower than the optimal value of 0.7 [24].

4.3 | Passenger Waiting Time

The standard waiting time for passengers at peak times is 7 minutes and at non-peak times a maximum of 15 minutes. According to survey data, the average passenger waiting time is 16.86 minutes. So the actual passenger waiting time is still greater than the existing standard. Passenger waiting time should be reduced by increasing the headway feeder WWS 03.

TABLE 5 WWS 03 Timetable

05.30	05.47	06.04	06.21	06.38
06.55	07.12	07.29	07.46	08.03
08.20	08.37	08.54	09.11	09.28
09.45	10.02	10.19	10.36	10.53
11.10	11.27	11.44	12.01	12.18
12.35	12.52	13.09	13.26	13.43
14.00	14.17	14.34	14.51	15.08
15.25	15.42	15.59	16.16	16.33
16.50	17.07	17.24	17.41	17.58
18.15	18.32	18.49	19.06	19.23
19.40	19.57	20.14	20.31*	20.48*
21.00*				

The high passenger waiting time may be caused by dense traffic in the city of Surabaya so that travel times and waiting times for passengers are also longer. The city of Surabaya is very congested considering that city transportation still relies on private vehicles which reach 94.25% (motorbikes 77.48% and cars 16.37%)[40].

4.4 | Travel Time and Speed

Travel time closely related to travel speed. Travel speed can be found by recording the departure time and arrival time. Meanwhile, the distance traveled has been determined according to the route determined by the Surabaya City Transportation Department. The standard speed during peak hours is a maximum of 30 km/hour and non-peak hours is a maximum of 50 km/hour. Meanwhile, the distance traveled by the WWS 03 feeder is 23.1 km. The following are travel times for 8 WWS feeder vehicles on Saturday 29 July 2023 and Tuesday 1 August 2023.

From Table 6 and Figure 3 it is revealed that the travel time on Saturday, July 29 2023 ranges from 63 to 72 minutes. So, the average travel time is 68.75 minutes on Saturday, July 29 2023. Meanwhile, the average travel time on Tuesday, August 1 2023 is 55.75 minutes.

TABLE 6 Feeder WWS 03 Travel Time

No.	Day	Date	Route	Departure Time	Arrival Time	Travel Time	TT Average
1	Sat 1	29-Jul-23	TIJ – GA	13.09	14.17	68	68.75
2	Sat 2	29-Jul-23	TIJ – GA	17.08	18.20	72	
3	Sat 3	29-Jul-23	GA – TIJ	14.28	15.31	63	
4	Sat 4	29-Jul-23	GA – TIJ	16.57	18.12	72	
5	Tue 1	01-Aug-23	TIJ – GA	12.47	13.43	56	55.75
6	Tue 2	01-Aug-23	TIJ – GA	16.33	17.30	57	
7	Tue 3	01-Aug-23	GA – TIJ	13.45	14.28	53	
8	Tue 4	01-Aug-23	GA – TIJ	17.13	18.10	57	

Meanwhile, travel time varies according to Table 7 . Below, the travel speed for each WWS FD 03 feeder will be calculated.

In Table 7 and Figure 3 it can be seen that the lowest actual speed during rush hour is 19.25 km/hour while the highest actual speed is 24.75 km/hour. According to the Indonesian Ministry of Transportation's standards, the maximum speed during peak hours is 30 km/hour. However, it is a shame that the minimum speed for peak hours is not set, even though it is very important to keep the headway at the terminal constant. For comparison, TransMilenio in Bogota (Colombia) has an operational speed of 25.2 km/hour. As we all know, TransMilenio Bogota is a reference for BRT throughout the world because it has been very

TABLE 7 WWS 03 Feeder Speed

No	Day	Date	Departure Time	Busy Hour/Non Busy Hour	Actual Speed (km/j)	Speed Average (km/jam) (km/jam)
1	Sat 1	29-Jul-23	13.09	NBH	20.38	20.22
2	Sat 2	29-Jul-23	17.08	BH	19.25	
3	Sat 3	29-Jul-23	14.28	NBH	22.00	
4	Sat 4	29-Jul-23	16.57	BH	19.25	
5	Tue 1	01-Aug-23	12.47	BH	24.75	24.88
6	Tue 2	01-Aug-23	16.33	BH	24.32	
7	Tue 3	01-Aug-23	13.45	NBH	26.15	
8	Tue 4	01-Aug-23	17.13	BH	24.32	

successful in attracting public interest of up to 59% [41]. So, from the existing data, the average speed of WWS feeder 03 should be increased to be closer to Trans Milenio Bogota.

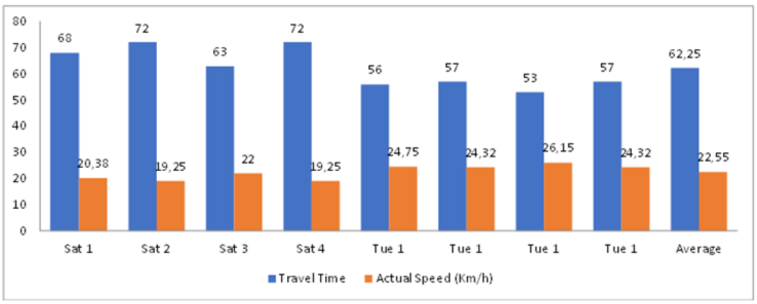

FIGURE 3 Travel Time and Actual Speed of Feeder WWS Route 03.

4.5 | Transportation Availability

The availability of WWS 03 Feeder transport is 11 units. Meanwhile, in planning transportation availability, there are only 10 vehicles. So that fleet availability reaches 110%. This can also be said that the availability of the WWS 03 feeder fleet has exceeded World Bank standards of between 80%-90% [42]. However, if the headway is shortened to 8 minutes, it is very important to increase the number of WWS 03 fleet in the future.

4.6 | Travel Distance

The travel distance for each WWS 03 feeder vehicle per day is between 4 and 5 times. So, if the distance traveled once is 23.1 km, then if you get 4 to 5 trips, the distance traveled is 92.4 -115.5 km < 230 – 260 km/vehicle/day [42]. then the WWS 03 feeder mileage still meets these standards.

4.7 | Integration of WWS Route 03 with Commuter Trains

Public transport integration requires physical, information and monetary (fare) integration. Figure 4 shows a conceptual overview of the hierarchy of public transportation needs for passengers in urban areas. Urban public transport integration is generally divided into 3 levels, namely integration of fares and payment systems, integration of passenger information and coordination of scheduling and real time information [43].

Integration between public transport in urban areas is very important so that public transport is able to withstand the uncontrolled development of private vehicles. The following is an integration concept that is quite ideal in urban areas [45].

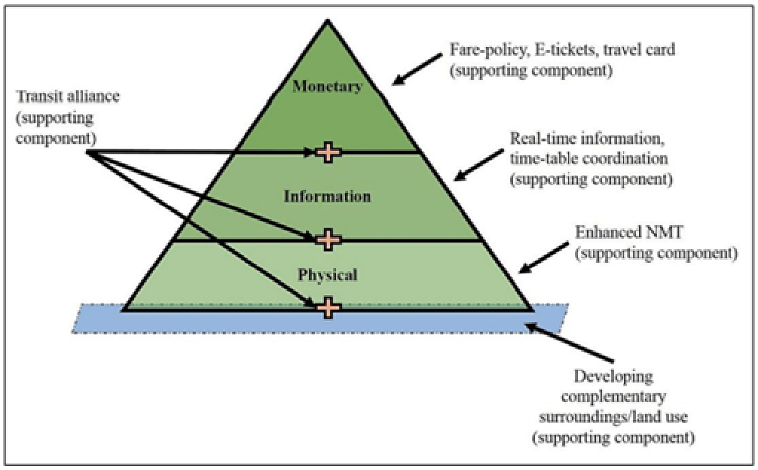

FIGURE 4 Hierarchy of Public Transport Integration Needs

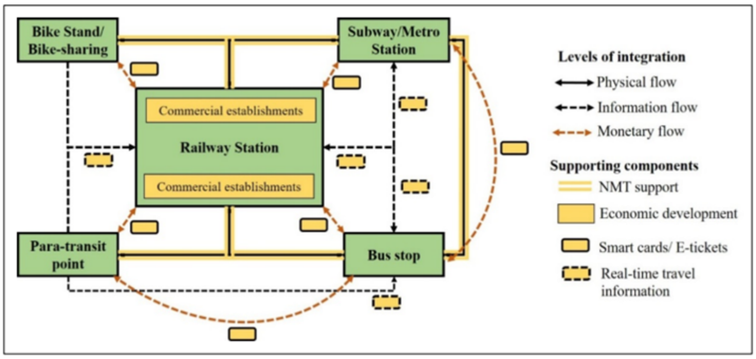

FIGURE 5 Urban Public Transport Integration Concept

In Figure 5 it appears that intermodal integration is through train stations. There is intentionally no physical flow between bicycles and paratransit because it is unlikely that users of these modes will have to come to the train station to use them. Intermodal integration via train stations is bus and subway/metro. The flow of information is also unidirectional for bicycles and paratransit, that is, information regarding train schedules needs to be shared with users who arrive at the station area using these modes and not vice versa, because bicycles and paratransit do not have a fixed schedule. However, tariff integration remains the same, as it is more convenient[44].

The discussion in this article focuses on headway integration between WWS route 03 and commuter trains at Wonokromo Station. This is because there is no integration of tariffs and payment systems as well as scheduling coordination and real time information. This is very important for future research. As is known, through scheduling at Wonokromo Station, there are 7 commuter trains connecting Surabaya with other cities in East Java. Wonokromo Station connects Surabaya City with Sidoarjo, Pasuruan, Malang, Blitar, Gresik, Lamongan, Bojonegoro, Jombang, Kediri and Tulungagung. There are 7 commuter trains that serve these cities and pass through Wonokromo Station. The following is the arrival schedule for the commuter train at Wonokromo station.

From Table 8 9 it appears that the commuter train schedule passes through Wonokromo Station 37 times, either from Surabaya to other cities or vice versa. Meanwhile, the feeder schedule for WWS route 03 is 56 times (Table 5). It is very unfortunate because the WWS 03 feeder route only goes from Gunung Anyar (GA) – Joyoboyo Main Terminal (TIJ) which passes through Wonokromo Station. However, from TIJ – GA it does not pass through Wonokromo Station. So people can only use one side of the route. In terms of headway, it's not worth it, it's only covered 56 times. Even then, the number of departures between commuter trains served at Wonokromo Station is not balanced. To determine the number of commuter trains in operation, it is

TABLE 8 Commuter Train Arrival Schedule at Wonokromo Station

No.	KA DHOHO		
	(surabaya - Blitar)	Arrival	Departure
1	Wonokromo	04.39	04.41
2	Wonokromo	07.58	08.04
3	Wonokromo	10.55	10.58
4	Wonokromo	18.05	18.08
5	Wonokromo	21.13	21.15
Kertosono - Surabaya			
6	Wonokromo	06.36	06.38
Blitar - Surabaya			
7	Wonokromo	09.26	09.29
8	Wonokromo	12.11	12.15
9	Wonokromo	15.04	15.12
10	Wonokromo	18.45	18.47
11	Wonokromo	21.57	21.59
KA PENATARAN			
Blitar - Malang - Surabaya			
12	Wonokromo	08:29	08:34
13	Wonokromo	13:56	14:00
14	Wonokromo	18:21	18:23
15	Wonokromo	21:24	21:27
surabaya - Malang - Blitar			
16	Wonokromo	04:48	04:50
17	Wonokromo	08:30	08:32
18	Wonokromo	11:07	11:09
19	Wonokromo	17:45	17:47
KA TUMAPEL			
Malang - Surabaya			
20	Wonokromo	07.08	07.10
Surabaya - Malang			
21	Wonokromo	19.43	19.46

very important to carry out a large-scale study regarding the origin and destination of private vehicle users who travel outside the city of Surabaya or vice versa.

The challenges of public transportation in the city of Surabaya are very large. This is because private vehicle users can access their vehicles directly within 24 hours. Meanwhile, the existing public transportation services are very limited. Therefore, it is necessary to think about cross-subsidisation efforts between the imposition of private vehicle taxes and subsidies for public transport operations. So that public transport headways can be achieved ideally. There is a concept that if the maximum headway is only around 8 minutes to all destinations, then prospective passengers will not hesitate to use public transportation[45].

5 | CONCLUSION

5.1 | Route 03 WWS feeder performance:

1. The lowest number of passengers on feeder WWS route 03 from 8 sample vehicles is 3 passengers and the highest is 10 passengers. The average number of passengers on Saturday is 5.25 passengers, while on Tuesday it is 5.5 passengers. The lowest load factor is 0.3 and the highest is 1.0. According to LF standards it should be between 0.76 – 1.00, so that all

TABLE 9 Commuter Train Arrival Schedule at Wonokromo Station

No.	KA SUPAS		
	(surabaya - Pasuruan)	Arrival	Departure
22	Wonokromo	07:49	07:52
23	Wonokromo	12:38	12:40
24	Wonokromo	18:39	18:41
Pasuruan - Surabaya			
25	Wonokromo	11:33	11:35
26	Wonokromo	17:34	17:37
27	Wonokromo	22:08	22:11
KA ARJONEGORO			
Psr Turi - Gubeng - Sidoarjo			
28	Wonokromo	07:28	07:30
Sidoarjo - Pasar Turi			
29	Wonokromo	17:16	17:18
Sidoarjo - Surabaya - Bojonegoro			
30	Wonokromo	09:18	09:20
Bojonegoro - Surabaya - Sidoarjo			
31	Wonokromo	15:57	15:59
KA SINDRO			
Sidoarjo - Surabaya - Indro			
32	Wonokromo	10:43	10:48
33	Wonokromo	15:42	15:46
34	Wonokromo	20:10	20:13
Indro - Surabaya - Sidoarjo			
35	Wonokromo	08:57	09:00
36	Wonokromo	13:12	13:17
37	Wonokromo	18:50	18:52

passengers can sit comfortably. Only 2 vehicles meet the LF. So it can be said that WWS feeder route 03 is still short of passengers.

2. Arrival and departure schedules do not match existing information. This is because there is a delay of between 1 minute to 12 minutes. There were 6 vehicles that experienced late arrival. This often raises questions among passengers regarding WWS route 03 services.

3. WWS 03 feeder plan headway is 17 minutes. This is certainly not in accordance with the concept of a maximum headway of 8 minutes, which means that it is very likely that passengers will not switch to using private vehicles again [45].

4. The average passenger waiting time is also too long, namely 16.86 minutes. Passenger waiting time is closely related to headway which should be a maximum of 8 minutes for each public transport departure in urban areas [45].

5. The average WWS 03 feeder travel time on Saturday is 68.75 minutes while on Tuesday it is 55.75 minutes. Meanwhile, the average travel speed on Saturday was 20.22 km/hour and on Tuesday 24.88 km/hour. It is recommended that the travel speed refer to the success of the Trans Milenio Bogota, namely 25.2 km/hour. So the travel speed of the Feeder WWS 03 needs to be increased.

6. WWS 03 fleet availability with 18 minute headway reaches 110%. If the headway is shortened to 8 minutes, it is very necessary to add WWS 03 vehicles.

7. The distance traveled by each WWS 03 feeder vehicle every day is between 4 and 5 times. So, if the distance traveled once is 23.1 km, then if you get 4 to 5 trips, the distance traveled is 92.4 -115.5 km < 230 – 260 km/vehicle/day [42]. then the WWS 03 feeder mileage still meets these standards.

5.2 | Integration of WWS Route 03 with Commuter Trains

The integration of WWS Route 03 with the Commuter Train is very dependent on the departure and arrival schedule of the 7 commuter train routes that pass through Wonokromo Station. If the commuter train schedule passes through Wonokromo Station 37 times, either from Surabaya to other cities or vice versa, while the feeder schedule for WWS route 03 is 56 times (Table 5), then there is a supply imbalance between WWS 03 and the existing commuter trains. So it is very possible that if integrated properly, private vehicle users will not hesitate to use existing public transportation.

References

1. Slamet S. Implementasi Daerah Kota Surabaya No. 7 Tahun 2006 (Studi Tentang Pelaksanaan Kebijakan Transportasi Massal di Kota Surabaya Upaya Mengurangi Kemacetan Lalu Lintas dan Pelayanan Sektor Publik). Universitas Airlangga 2015;p. 1–23. https://www.semanticscholar.org/paper/IMPLEMENTASI-PERATURAN-DAERAH-KOTA-SURABAYA-NOMER-7-Slamet/4a801f5a88a053fec0a4d9a3a6fc8c07ebbb740a.

2. de Rozari A, Wibowo Y. Faktor-faktor yang Menyebabkan Kemacetan Lalu Lintas di Jalan Utama Kota Surabaya (Studi Kasus di Jl. Akhmad Yani dan Raya Darmo Surabaya). Jurnal Universitas 17 Agustus 1945 Surabaya 2014;3 No. 2:42–57. https://ejournal.unesa.ac.id/index.php/paradigma/article/view/9493.

3. de Rozari A, Wibowo Y. Faktor-faktor yang Menyebabkan Kemacetan Lalu Lintas di Jalan Utama Kota Surabaya (Studi Kasus di Jl. Akhmad Yani dan Raya Darmo Surabaya). Paradigma 2014;2 No. 2:1–10. https://www.semanticscholar.org/paper/FAKTOR-FAKTOR-YANG-MENYEBABKAN-KEMACETAN-LALU-DI-Di-Rozari-Wibowo/649347ae9ac3b0c27be4f89aae48c732b7052b41.

4. Arifiyananta RD. Strategi Dinas Perhubungan Kota Surabaya Untuk Mengurangi Kemacetan Jalan Raya Kota Surabaya. Surabaya: Fakultas Ilmu Sosial 2015;3 No. 6. https://ejournal.unesa.ac.id/index.php/publika/article/view/11930.

5. Cathalina M. Strategi Dinas Perhubungan Kota Surabaya Untuk Mengurangi Kemacetan Jalan Raya Kota Surabaya. Surabaya: Fakultas Ilmu Sosial dan Ilmu Politik, Universitas Airlangga 2015;https://www.jawapos.com/surabaya-raya/015543212/underpass-taman-pelangi-jadi-solusi-pemkot-surabaya-untuk-atasi-kemacetan.

6. Dewa DPM. Dampak Kemacetan Lalu Lintas Terhadap Konsumsi Energi di Surabaya dan Alternatif Solusinya. Surabaya: Jurusan Ekonomi Pembangunan, Universitas Airlangga 2017;https://repository.unair.ac.id/51888/.

7. Nash A. Improving The Operational Eficiency of Public Transport. Institute of Transportation Planning and Systems, ETH Zurich, Switzerland 2006;https://www.semanticscholar.org/paper/IMPROVING-THE-OPERATIONAL-EFFICIENCY-OF-PUBLIC-Nash/09474b8461c35ccb520501611ff80145fb820cdf.

8. Jacques K, Levinson HS. Improving The Operational Efficiency of Public Transport. Transportation Research Board, Washington DC 1997;https://www.mendeley.com/search/?page=1&query=Report%2026%3A%20Operational%20Analysis%20of%20Bus%20Lanes%20on%20Arterials&sortBy=relevance.

9. Nickel B. Erfolgsrezept der Stadtbahnen, Der Nahverkehr. Transportation Research Board, Washington DC 2005;https://eurailpress-archiv.de/SingleView.aspx?show=14778.

10. Disclaimer T. Elements Needed to Create High-Ridership Transit Systems: Interim Guidebook. Interim Guidebook 2005;https://nap.nationalacademies.org/catalog/22052/elements-needed-to-create-high-ridership-transit-systems-interim-guidebook.

11. Verifier S, Drive AH. Design of Multimodal Transport Systems, Setting The Scene, Review of Literature and Basic Concepts. Delft University Press 2000;https://www.mendeley.com/search/?page=1&query=Design%20of%20Multimodal%20Transport%20Systems%2C%20Setting%20The%20Scene%2C%20Review%20of%20Literature%20and%20Basic%20Concepts&sortBy=relevance.

12. Luyima E, Kasande R. NSW Long Term Transport Master Plan. Transport for NSW 2012;https://www.mendeley.com/search/?page=1&query=NSW%20Long%20Term%20Transport%20Master%20Plan%E2%80%9D&sortBy=relevance.

13. Luyima E, Kasande R. Sydney Metropolitan Bus Services Contract. Transport for NSW 2012;https://www.mendeley.com/search/?page=1&query=NSW%20Long%20Term%20Transport%20Master%20Plan%E2%80%9D&sortBy=relevance.

14. Luyima E, Kasande R. Integrated Public Transport Service Planning Guides, Sidney Metropolitan Area. Transport for NSW 2013;https://www.mendeley.com/search/?page=1&query=NSW%20Long%20Term%20Transport%20Master%20Plan%E2%80%9D&sortBy=relevance.

15. Solecka K, Żak J. Integration of The Urban Public Transportation System with The Application of Traffic Simulation. Transportation Research Procedia 2014;3:259–268. https://www.sciencedirect.com/science/article/pii/S2352146514001689?via%3Dihub.

16. Nosal K, Solecka K. Application of AHP for Multi-Criteria Evaluation of Variants of the Integration of Urban Public Transport. Transportation Research Procedia 2014;3:269–278. https://www.sciencedirect.com/science/article/pii/S2352146514001690?via%3Dihub.

17. ITDP. Public Transport Reform Guideline for Indonesian Cities. Transport Policy and Development Associate ITDP Indonesia 2019;3. https://www.mendeley.com/search/?page=1&query=Public%20Transport%20Reform%20Guideline%20for%20Indonesian%20Cities&sortBy=relevance.

18. Luyima E, Kasande R. Integrated Public Transport Service Planning Guides, Outer Metropolitan Area. Transport for NSW 2016;https://www.mendeley.com/search/?page=1&query=NSW%20Long%20Term%20Transport%20Master%20Plan%E2%80%9D&sortBy=relevance.

19. Preston J. What's so Funny about Peace, Love and Transport Integration. Research in Transportation Economics 2010;29:329–338. https://www.sciencedirect.com/science/article/pii/S0739885910000727?via%3Dihub.

20. Cyril A, Mulangi RH, George V. Performance Optimization of Public Transport Using Integrated AHP–GP Methodology. Urban Rail Transit 2019;5 No. 2:133–144. https://link.springer.com/article/10.1007/s40864-019-0103-2.

21. Surbakti MS, Bakara MR. Operational Performance Analysis of Trans Mebidang Bus (Case Study: Binjai terminal - Medan). IOP Conference Series: Materials Science an Engineering 2020;https://iopscience.iop.org/article/10.1088/1757-899X/801/1/012027.

22. Budd L, Ison S. Public Transport Integration. Public transport integration 2017;19 No. 2:127–132. https://www.taylorfrancis.com/chapters/edit/10.4324/9780367816698-7/public-transport-integration-lucy-budd-stephen-ison.

23. Rodriguez A, alvrodri V, Satizabal DR, Paris D. Importance-Performance Analysis in Public Transportation: Methodological Revision for Practical Implementation. Transportation Research Record 2019;2673:1–14. https://journals.sagepub.com/doi/10.1177/0361198118825125.

24. Ir, Abubakar I, MSc. Pedoman Teknis Penyelenggaraan Angkutan Penumpang Umum di Wilayah Perkotaan Dalam Trayek Tetap dan Teratur. Departemen Perhubungan Republik Indonesia 2002;https://perhubungan2.wordpress.com/angkutan-perairan-daratan/download-peraturan-asdp/sk-dirjen-687-tahun-2002-ttg-tentang-pedoman-teknis-penyelenggaraan-angkutan-penumpang-umum-di-wilayah-perkotaan-dalam-

25. Md Rohani M, Wijeyesekera DC, Abd Karim AT. Bus Operation, Quality Service and The Role of Bus Provider and Driver. Procedia Engineering 2013;53:167–178. https://www.sciencedirect.com/science/article/pii/S1877705813001410?via%3Dihub.

26. Abane AM. Travel behaviour in Ghana: empirical observations from four metropolitan areas. Journal of Transport Geography 2011;19:313–322. https://www.sciencedirect.com/science/article/pii/S0966692310000347?via%3Dihub.

27. Almeida F, Lobo A, Couto A, Ferreira JP, Ferreira S. Urban factors influencing the vehicle speed of public transport. Transportation Research Procedia 2022;62:318–324. https://www.sciencedirect.com/science/article/pii/S2352146522001673?via%3Dihub.

28. Suwardo W, Napiah M, Kamaruddin I. Punctuality and Expected Waiting Time of Stage Buses in Mixed Traffic. Jurnal Transportasi 2013;8 N0. 3:213–226. https://www.mendeley.com/search/?page=1&query=Punctuality%20and%20Expected%20Waiting%20Time%20of%20Stage%20Buses%20in%20Mixed%20Traffic&sortBy=relevance.

29. Norhisham S, Abu Bakar MF, Abd Samad ZH, Syamsir A, Zaini N, Katman HY, et al. Evaluating Passenger Load Factor of Public Bus Services in West Klang Valley. ICACE 2019;p. 95–102. https://link.springer.com/chapter/10.1007/978-981-15-1193-6_11.

30. Henao JJ, Calderón P, C AG. Metodología Para Estudio de Demanda de Transporte Público de Pasajeros en Zonas Rurales. Revista Facultad de Ingeniería Universidad de Antioquia 2010;p. 106–118. https://www.mendeley.com/search/?page=1&query=Metodolog%C3%ADa%20Para%20Estudio%20de%20Demanda%20de%20Transporte%20P%C3%BAblico%20de%20Pasajeros%20en%20Zonas%20Rurales&sortBy=relevance.

31. Ahmad BS, Wirawati S, Wipranata BI. ITDP/Institute for Transportation and Development Policy, Bus Rapid Transit, Planning Guide, 3rd Edition. Jurnal Sains, Teknologi, Urban, Perancangan, Arsitektur (Stupa) 2007;https://www.mendeley.com/search/?page=1&query=ITDP%2FInstitute%20for%20Transportation%20and%20Development%20Policy&sortBy=relevance.

32. Mete S, Çelik E, Gül M. Predicting the Time of Bus Arrival for Public Transportation by Time Series Models. Journal of Transportation and Logistics 2022;7 No. 2:441–455. https://iupress.istanbul.edu.tr/en/journal/jtl/article/predicting-the-time-of-bus-arrival-for-public-transportation-by-time-series-models.

33. Fallis A. Passenger Arrival Rates at Public Transport Stations. Journal of Chemical Information and Modeling 2013;7 No. 2. https://www.mendeley.com/search/?page=1&query=Passenger%20Arrival%20Rates%20at%20Public%20Transport%20Stations&sortBy=relevance.

34. Lisa K. Passenger Arrival Rates at Public Transport Stations. Institute for Transport Planning and Systems Swiss Federal Institute of Technology, ETH Zurich, Switzerland 2021;https://ethz.ch/content/dam/ethz/special-interest/baug/ivt/ivt-dam/publications/students/601-700/sa688short.pdf.

35. Śmieszek M, Mateichyk V. Determining The Fuel Consumption of a Public City Bus in Urban Traffic. IOP Conference Series: Materials Science and Engineering, Volume 1199 2021;p. 1–13. https://iopscience.iop.org/article/10.1088/1757-899X/1199/1/012080.

36. Taylor BD, Miller D, Iseki H, Fink C. Nature and/or Nurture? Analyzing The Determinants of Transit Ridership in Urbanized Areas. Transportation Research Part A, Policy and Practice 2008;43:60–77. https://www.sciencedirect.com/science/article/pii/S0965856408001274?via%3Dihub.

37. Viergutz K, Brinkmann F. Demand analysis and willingness to use new mobility concepts. Autonomous Vehicles and Future Mobility 2019;p. 85–92. https://www.sciencedirect.com/science/article/abs/pii/B978012817696200007X?via%3Dihub.

38. Viergutz K, Krajzewicz D. Analysis of the Travel Time of Various Transportation Systems in Urban Context. Transportation Research Procedia 2019;41:313–323. https://www.sciencedirect.com/science/article/pii/S2352146519304685?via%3Dihub.

39. Borhan MN, Syamsunur D, Akhir NM, Yazid MRM, Ismail A, Rahmat RA. Travel behaviour in Ghana: empirical Predicting the Use of Public Transportation: A Case Study from Putrajaya, Malaysiaobservations from four metropolitan areas. The Scientific World Journal 2014;p. 313–322. https://onlinelibrary.wiley.com/doi/10.1155/2014/784145.

40. BPS. Badan Pusat Statistik Indonesia. Badan Pusat Statistik Indonesia 2022;https://www.mendeley.com/search/?page=1&query=Badan%20Pusat%20Statistik&sortBy=relevance.

41. Hidalgo D, Pereira L, Estupiñán N, Jiménez PL. TransMilenio BRT system in Bogota, high performance and positive impact – Main results of an ex-post evaluation. Research in Transportation Economics 2013;39:133–138. https://www.sciencedirect.com/science/article/pii/S0739885912000777.

42. Armstrong-Wright A, Thiriez S. Bus Services - Reducing Costs, Raising Standards. World Bank Technical Paper 1987;https://www.mendeley.com/search/?page=1&query=Bus%20Services%20Reducing%20Costs%2C%20Raising%20Standards&sortBy=relevance.

43. Breithaupt M, Velaga N, Wright RS. Public Transport Planning , Management , Integration and Transit Alliances. Research in Transportation Business and Management 2012;https://www.mendeley.com/search/?page=1&query=Public%20Transport%20Integration%20and%20Transit%20Alliances&sortBy=relevance.

44. Nag D, BS M, Goswami A, Bharule S. Framework for Public Transport Integration at Railway Stations and Its Implications for Quality of Life. ADBI Working Paper Series 2019;https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3551888.

45. Mulley C, Nelson JD. Public Transport Network Planning. International Encyclopedia of Transportation 2021;p. 388–394. https://www.sciencedirect.com/science/article/abs/pii/B978008102671710781X?via%3Dihub.

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