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Planning Study of Corridors 1, 2 and 3 in Malang City Bus Rapid Transit Implemention

Hestiara Silalahi*, Nusa Sebayang [b], Annur Ma'ruf [b]

[a'b]Civil Engineering, National Institute of Technology Malang, 65152, Indonesia

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ABSTRACT

Malang City is a city located in East Java. The number of residents in Malang City continues to increase, causing congestion. To overcome this problem, the development of mass transportation systems such as Bus Rapid Transit is needed. In this study, the planning of corridors 1, 2, and 3 in Bus Rapid Transit was carried out and analyzed the prediction of road section performance as a result of BRT corridor planning in Malang City. The analysis results show that corridor 1 is 9.284km long on the route Jl. Ahmad Yani, corridor 2 is 6.055km long on the route Jl. Letjen Sutoyo - Jl. W.R. Supratman, and corridor 3 is 10.867km long on the route Jl. S. Supriadi. The performance of some road sections shows that they do not meet the requirements of the degree of saturation <0.85 and the minimum standard of LOS-C. On Jl. Ahmad Yani in the south direction Straight after the BRT on corridor 1 there was a decrease in delay of 4.662 seconds/smp (A). On Jl. W.R.Supratman towards the East turning left after the BRT in corridor 2 there was a decrease in delay of 90.566 seconds/smp (F), on Jl. Supriadi in the South Straight direction after the BRT in corridor 3 there was a decrease in the average delay of 22.288 seconds/smp (C) After being seen from the results of the analysis of the level of service on the implementation of BRT, the corridor that reached the target was only corridor 1.

1. Introduction

According to one of the experts, Morlok (1983) Transportation is the movement of people or goods from the place of origin to the destination followed by a change in time and place [1]. In transportation there are two most important elements, namely transfer / movement and physically changing the place of goods (commodities) and passengers to another place, in the book Introduction to Transportation [2]. Malang City is also nicknamed the city of students and a city that has a million tourist spots. People from various regions with different interests flock to Malang City, both for the purpose of seeking quality higher education and to enjoy the natural charm of Malang City. So that the growth of Malang City has consequences in terms of traffic and transportation in Malang City.

An increase in population can have a significant impact on traffic and transportation. If the transportation infrastructure cannot keep up with the increase in population, congestion, delays, and inconvenience to local residents can occur. The success is not only in increased travel time efficiency and reduced congestion, but in the positive impact on the environment that can reduce greenhouse gas emissions and improve air quality [3]. Malang City already has several types of public transportation, such as taxis, angkot, and other digital-based transportation, but transportation facilities and public transportation operating facilities are not fully adequate and meet the transportation needs of the people of Malang City. Public transportation is a means of transporting passengers carried out by a rental or payment system. Another definition of public transportation (also known as mass transportation) is a transportation system that aims to move large numbers of passengers to different destinations. In this case, public transportation plays an important role in supporting the economy of metropolitan cities [4].

Increased growth in the number of private vehicles and reduced public transportation operations, resulting in high traffic volumes on every road in Malang City, so that the level of road service decreases and congestion often occurs on existing roads. Malang City needs to implement Mass Transportation as a good solution to reduce congestion, reduce air pollution and others. Therefore, the authors plan to implement Bus Rapid Transit (BRT) as a solution to overcome congestion in Malang City. According to Wright & Hook Bus

*Corresponding author: Name of Department, University, Postal Code, Country
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Rapid Transit (BRT) is a bus-based mass transportation system that provides fast, convenient, and efficient services using dedicated lanes separated from general traffic. BRT is designed to provide transportation services equivalent to rail systems, but with lower development costs [5]. Bus Rapid Transit (BRT) is a bus-based transportation system using a special lane and operating in a corridor by not allowing other vehicles to enter the designated lane, comfort system, punctuality and also has a scheduled system [6]. The benefits of Bus Rapid Transit (BRT) itself are reducing congestion, energy efficiency, accessibility, improving air quality, affordable costs [7].

Based on the analysis and application of BRT models in other cities in Indonesia, the development of this system has been proven to solve transportation problems. Determination of corridors according to the Decree of the Director General of Land Transportation No. 687/Aj.206/DRJD/2002 is carried out by considering several factors such as land use patterns, public transportation passenger movement patterns, population density, service areas, and network characteristics [8]. Therefore, the Implementation of Bus Rapid Transit (BRT) in Malang City which includes corridor 1 with routes Raden Intan street - Ahmad Yani street - Letjen Supratman street - Letjen Sutoyo street - W.R. Supratman street - Tumenggung Suryo street - Sunandar Priyo Sudarmo street - Raden Panji Suroso street, corridor 2 with the route W.R. Supratman street - Jaksa A. Suprapto street - Semeru street - Arjuno street - Kawi street - Arif Rahman Hakim street - Merdeka Utara street - Merdeka Timur street - Agus Salim street - K.H. Achmad Dahlan street - Panglima Sudirman street, corridor 3 with the route Supriadi street - Satsui Tubun street - Colonel Sugiono street - Jl. Achmad Dahlan street- Panglima Sudirman street, corridor 3 with the route Supriadi street - Satsui Tubun street - Colonel Sugiono street - Jl. Laksamada Martadinata street - Gatot Subroto street - K.H. Ahmad Dahlan street - Agus Salim street - Merdeka Selatan street- Kauman street- K.H. Hasyim Ashari street - Arif Margono street which is expected to help reduce congestion, facilitate accessibility to various important destinations and improve the quality of public transportation.

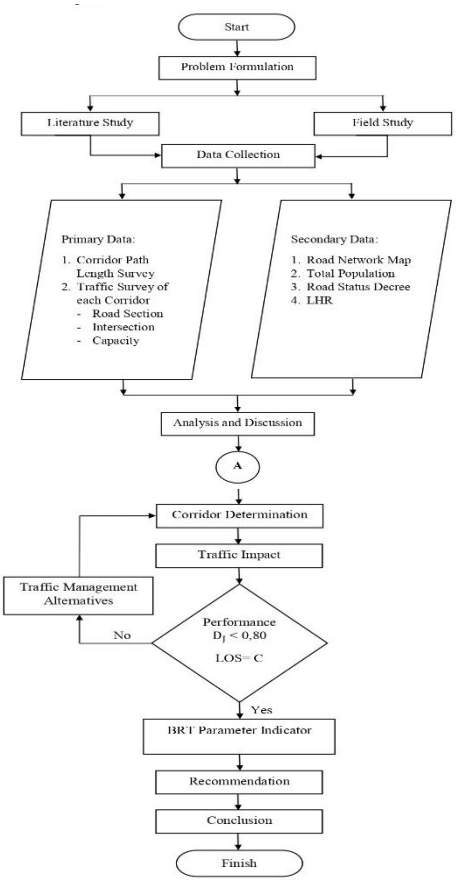
2. Method

A methodology for applying holistic travel path analysis by combining length of track surveys, traffic surveys, capacity, information from road network maps, population data, road status information, and daily traffic (LHR) in order to identify potential optimal routes or traffic problems that will arise on corridors 1, 2, and 3 in Malang City, which have not yet implemented Bus Rapid Transit (BRT). The main focus of this method is to get a detailed understanding of the condition of the existing transportation infrastructure in Malang City and find out the possible impact of the implementation of Bus Rapid Transit (BRT) on the performance of Malang City roads. Through the travel path analysis method, the authors will find out more specific information related to traffic, good road quality in Malang City. Data obtained from corridor length surveys, traffic surveys, and capacity will be integrated with information from road network maps, population data, and then integrated with information from road network maps, population data, secondary road status information and daily traffic (LHR). This data integrity is the main basis for mapping and evaluating the efficiency and reliability of the road network.

potential transportation problems that may occur in the area under study. The population in this study includes all public transportation users in Malang City, including students, workers, and others who are in the corridor 1, 2, and 3 areas with samples that have been taken randomly from strategic locations in the city.

The total population in BRT corridors 1, 2, and 3 in Malang City is 234,333 people. Due to time, cost, and labor constraints, the study used a representative sample. In determining the minimum sample size using the Slovin formula [9]. Data was obtained through the collection of questionnaire surveys distributed to respondents to collect information related to interest in moving from private vehicles to public transportation in the form of BRT in the 400m area around the corridor [10].

Although Malang City does not currently have a BRT system, this methodology is expected to provide a solid foundation for future plans to develop a more efficient transportation system in Malang City. By combining primary and secondary data, the methodology provides the detailed insights needed to formulate a sustainable transportation development plan, which has the potential to improve mobility quality and alleviate regional transportation problems. The flowchart is shown below.



Flow chart

3. Result and Discussion

3.1.Overview of Transportation in Malang City

Based on data from the Central Bureau of Statistics, Malang City experienced an average population growth rate from 5 sub-districts of 0.11% per year 2021-2023. As well as the growth in the number of motorized vehicles in East Java in 2018-2022, motorcycles increased by 3.60%, light vehicles in the form of cars 3.77% and heavy vehicles in the form of buses and trucks 2.81%, which identifies the challenges of traffic congestion are increasingly complex due to people's dependence on private vehicles and the ineffectiveness of the urban traffic management system.

3.2. Population Analysis

Before conducting Population Analysis, data collection through questionnaires is carried out, the initial stage is to group the population based on the kelurahan in the corridor area 1, 2 and 3 Bus Rapid Transit (BRT) which is obtained 234,333 people. The next step is to calculate the minimum number of respondents needed using the sloviin formula as follows:

$$N = \frac{N}{1+N\,(e)^2} \quad \text{...(1)}$$

Where:

n = Sample Size

N = Population

E = Permissible Error Rate

The population in the area amounted to 234,333 people, so to reduce errors, an error tolerance of 10% (0.1%) was used. The Slovin formula was used to determine the study sample size with the following calculation:

$$n = \frac{234.333}{1+234.3333\,(0,10)^2}$$

$$n = 99,971 = 100 \text{ sample}$$

After obtaining the minimum number of respondents as many as 100 samples, the next step is to distribute questionnaires to respondents via google form to respondents who match the parameters that have been applied. The results of data collection from the sample showed a total of 110 respondents, so that the results of the questionnaire on the availability to move using BRT were obtained in the figure.

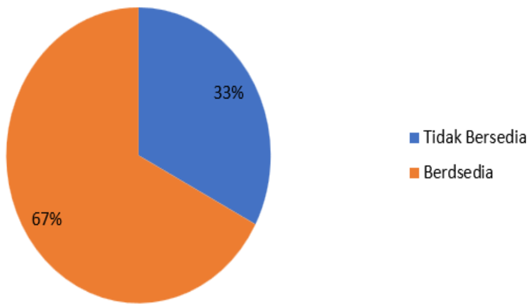


Figure 2: Percentage of Respondents who moved

Table 1. Percentage of Respondents Willing to Switch BRT by Vehicle Type

Corridor	Vehicle Type	Percentage		Total
		Willing (People)	Not Willing (People)	
1	Motorcycle	93%	8%	100
	Car	50%	50%	
	public transportation	82%	18%	
	bike	100%	0	
2	Motorcycle	52%	48%	
	Car	33%	67%	
	public transportation	80%	20%	
	bike	0	0	
3	Motorcycle	81%	19%	
	Car	25%	75%	
	public transportation	67%	33%	
	bike	0%	0%	

3.2. Determination of Bus Rapid Transit (BRT) Routes

The routes or road sections designated for Bus Rapid Transit (BRT) corridors 1, 2, and 3 cross the main roads of office centers, schools, shopping, health, and others. The corridors were selected based on the Decree of the Director General of Land Transportation Number SK.687/AJ.206/DRJD/2002 which exists to support the efficiency and effectiveness of BRT services [ ].

The following are the proposed corridors 1, 2, and 3 of Bus Rapid Transit (BRT) in Malang City as follows:

1. Corridor 1

Corridor 1 with a route length of 9.284 km which can be seen in Figure 4, passes through several main and strategic roads in Malang City. The corridor connects several important areas in Malang City, such as schools, offices, shops, so it is expected to meet the mobility needs of the community in corridor 1.

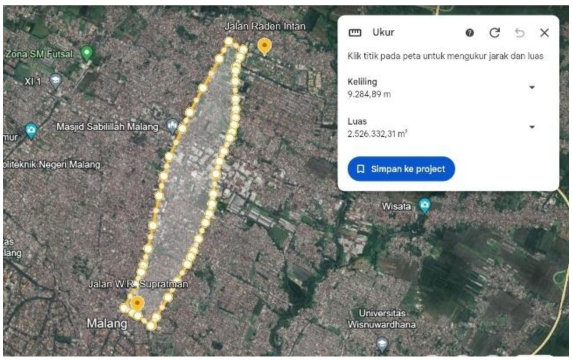


Figure 1 Corridor Track Length

Table 2. of Proposed BRT Corridor 1 in Malang City

Corridor	Route	Track length (km)
1	Raden Intan street, Ahmad Yani street, Letjen Supratman street, Letjen Sutoyo street, W.R. Supratman street, Tumenggung Suryo street, Sunandar Priyo Sudarmo street, Raden Panji Suroso street.	9,28

2. Corridor 2

Corridor 2 with a route length of 6.055 km which can be seen in Figure 5, passes through several main and strategic roads in Malang City. The corridor connects several important areas in Malang City, such as schools, shops, hospitals, squares so that it is expected to meet the mobility needs of the community in corridor 2.

Figure 2 Corridor Track Length

Table 3. of Proposed BRT Corridor 2 in Malang City

Corridor	Route	Track length (km)
2	W.R. Supratman street, Jaksa A. Suprapto street, Semeru street, Arjuno street, Kawi street, Arif Rahman Hakim street, Merdeka Utara street, Merdeka Timur street, Agus Salim street, K.H. Achmad Dahlan street, Panglima Sudirman street.	6,055

3. Corridor 3

Corridor 3 with a route length of 10,867 km which can be seen in figure 6, passes through several main and strategic roads in Malang City. The corridor connects several important areas in Malang City, so it is expected to meet the mobility needs of the community in corridor 3.

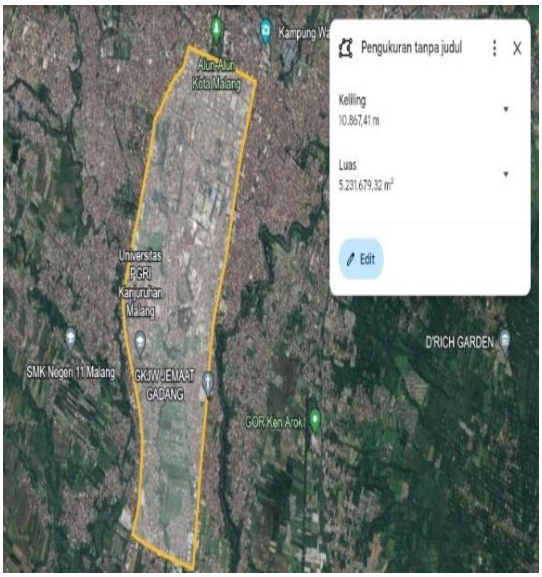


Figure 3. Corridor Track Length 3

Table 4. of Proposed BRT Corridor 2 in Malang City

Corridor	Route	Track length (km)
3	Supriadi street, Satsui Tubun street, Colonel Sugiono street, Jl. Laksamada Martadinata street, Gatot Subroto street, K.H. Ahmad Dahlan street, Agus Salim street, Merdeka Selatan street, Kauman street,K.H. Hasyim Ashari street,Arif Margono street.	10,867

3.4. Prediction of Road Intersection Performance Before and After Bus *Rapid Transit* (BRT)

In order to increase the effectiveness of the implementation of *Bus Rapid Transit* (BRT) as public transportation in Malang City, an in-depth analysis was carried out on the performance of existing road intersections in corridors 1, 2, and 3. This analysis aims to identify congestion points and their causative factors, so that strategic steps can be determined in the implementation of BRT.

The following is a map of BRT routes corridors 1, 2, and 3 which illustrates the percentage reduction in the number of private vehicles in each corridor, and BRT predictions are made when passing through the road section at the intersection based on the decision of the

Director General of Land Transportation Number SK.687/AJ.206/DRJD/2002 [ ], *the ideal headway* time is 5-10 minutes, then it is assumed that the intermediate time is 10 minutes.

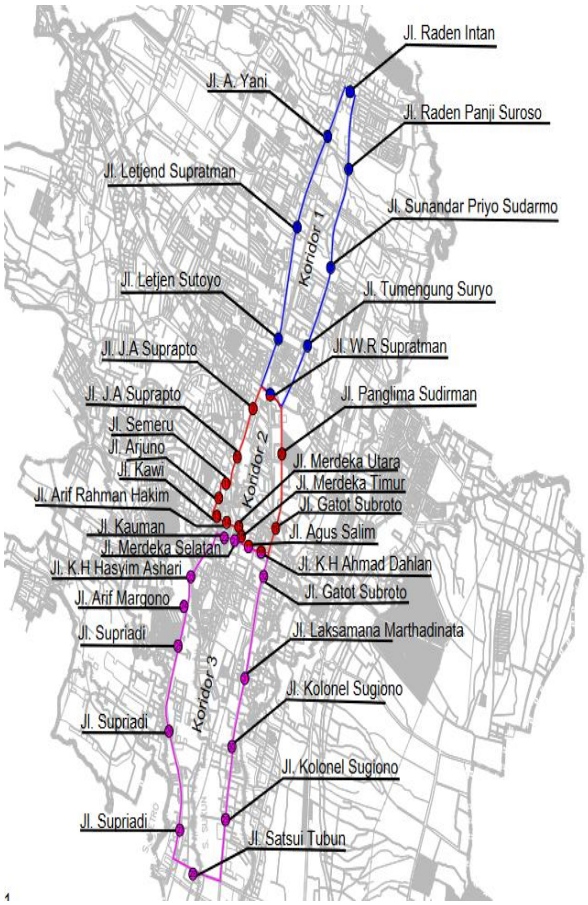


Figure 4. Vehicle Reduction Map of Each Corridor

The next step is to predict the simulation performance of the implementation of *Bus Rapid Transit* (BRT) corridors 1, 2, and 3 in accordance with each intersection by considering the reduction in the volume of private vehicles based on the percentage of people who are willing to switch to public transportation, using the formula SA-1 to SA-5 which results in the level of service at the intersection [11], so that the calculation of the road section at each intersection is carried out as follows:

1. Junction of Jl.Borobudur – Jl.Ahmad Yani

The following are the results of a comparison of the amount of traffic volume and performance of the Straight South Ahmad Yani Road section crossed by corridor 1, where the volume and performance have decreased significantly, but the performance results have not met the requirements and evaluation is needed.

Table 5. Comparison of Traffic Volume at the Junction of Jl. Ahmad Yani – Jl. Borobudur before and after the BRT

Jam Puncak	Ahmad Yani Selatan Lurus (smp/jam)				Selisih	
	Sebelum BRT		Setelah BRT			
	Sepeda Motor	Mobil	Sepeda Motor	Mobil	Sepeda Motor	Mobil
Pagi	150,9	574	12,1	287	138,8	287
Siang	218,2	670	17,5	335	200,7	335
Sore	136,9	599	11	299	125,9	300

Tabel 6. Comparison of Road Performance at the Intersection of Simpang Jl. Ahmad Yani – Jl. Borobudur sebelum dan setelah ada BRT

Jam Puncak	Jl. Ahmad Yani Selatan (smp/jam)				Selisih	
	Sebelum BRT		Setelah BRT			
	Derajat Kejenuhan	Tundaan (detik)	Derajat Kejenuhan	Tundaan (detik)	Derajat Kejenuhan	Tundaan (detik)
Pagi	0,913	14,547	0,537	4,220	0,376	10,327
Siang	1,099	39,055	0,624	5,201	0,475	33,854
Sore	0,945	17,394	0,563	4,565	0,382	12,829

2. Simpang Jl.W.R.Supratman – Jl. J.A. Suprapto

The following are the results of a comparison of the amount of traffic volume and performance of the section Jl.W.R.Supratman – Jl. J.A. Suprapto Eastbound turn left which is crossed by corridor 2, where the amount of volume and performance has decreased significantly, but the performance results have not met the requirements and need to be evaluated.

Table 7. Comparison of the size of traffic volume at the intersection of Jl.W.R.Supratman – Jl. J.A. Suprapto Eastbound before and after the BRT

Peak Hours	Jl. W.R. Supratman - Jl. J.A. Suprapto (junior high school/hour)				Difference	
	Before BRT		After BRT			
	Motorcycle	Car	Motorcycle	Car	Motorcycle	Car
Morning	29,1	36	13,9	16	15,2	20
Noon	28,9	64	11,4	28	17,5	36
Afternoon	16,5	49	7,9	21	8,6	28

Table 8. Comparison of Road Performance at the Intersection of Jl.W.R.Supratman – Jl. J.A. Suprapto Eastbound before and after the BRT

Peak Hours	Jl. W.R. Supratman - Jl. J.A. Suprapto (junior high school/hour)				Difference	
	Before BRT		After BRT			
	Degree of Saturation	Delay (seconds)	Degree of Saturation	Delay (seconds)	Degree of Saturation	Delay (seconds)
Morning	0,935	34,537	0,861	21,963	0,074	12,574
Noon	1,165	196,797	1,370	241,944	-0,205	-45,147
Afternoon	0,735	11,081	0,655	7,792	0,08	3,289

3. Simpang Jl.Supriadi – Jl. Janti Barat

The following is a comparison of the amount of traffic volume and performance of the section Jl. Supriadi – Jl. Janti Barat Straight South which is crossed by corridor 3, where the volume and performance have decreased significantly, but the performance results have not met the requirements and need to be evaluated.

Table 9. Comparison of Traffic Volume at the Junction of Jl.Supriadi – Jl. Janti Barat Southbound before and after there is a BRT

Peak Hours	Jl. Supriadi Selatan Lurus (smp/det)				Difference	
	Before BRT		After BRT			
	Motorcycle	Car	Motorcycle	Car	Motorcycle	Car
Morning	576,2	463	109,5	250	466,7	250
Noon	385,2	361	73,2	195	312	166
Afternoon	184,0	666	35,0	360	149	306

Table 10. Comparison of Road Performance at the Intersection of Jl.Supriadi – Jl. Janti Barat Southbound before and after there is a BRT

Peak Hours	Jl. Supriadi - Jl. Janti Barat (junior high school/hour)				Difference	
	Before BRT		After BRT			
	Degree of Saturation	Delay (seconds)	Degree of Saturation	Delay (seconds)	Degree of Saturation	Delay (seconds)
Morning	1,786	266,000	0,802	10,814	0,984	255,186
Noon	1,271	105,228	0,960	50,013	0,311	55,215
Afternoon	1,291	107,453	0,664	6,037	0,627	101,416

Based on the corridor plan for Bus Rapid Transit *(BRT) 1, 2, and 3* that has been described above, the BRT affected is the intersection of Jl. Ahmad Yani -Jl. Ahmad Yani Borobudur which affects the section of Jl. Ahmad Yani in the direction of the south, the intersection of Jl. Letjen Sutoyo - Jl.W.R. Supratman - Jl. J.A. Suprapto - Jl. Kaliurang which affects the section of Jl.W.R.Supratman to the right - Jl. Kaliurang straight, Jl. Supriadi -Jl. Janti Barat eastbound to the left and right as a result of *the Bus Rapid Transit* (BRT), the volume of private vehicles at the intersection decreased significantly during peak hours. However, the performance of the road sections affected *by the Bus Rapid Transit* (BRT) Jl. W.R. Supratman – Jl.J.A.Suprapto, and Jl. Supriadi – Jl. Janti Barat, has not met the saturation level of ≤0.85 and the minimum standard of LOS=C, despite the decline. In contrast to Jl. Ahmad Yani – Jl. Borobudur to the South, which has met the requirements for the degree of saturation and the minimum LOS standard.

4. CONCLUSION

The conclusions obtained from the results of the planning study of corridors 1, 2, and 3 *Bus Rapid Transit* (BRT) in Malang City to overcome congestion include Corridor 1 along 9.28 km through Jalan Raden Intan, Jalan Ahmad Yani, Jalan Letjen Supratman, Jalan Letjen Sutoyo, Jalan W.R. Supratman, Jalan Tumenggung Suryo, Jalan Sunandar Priyo Sudarmo, Jalan Raden Panji Suroso; corridor 2 along 6,055 km through Jalan W.R. Supratman, Jalan Jaksa A. Suprapto, Jalan Semeru, Jalan Arjuno, Jalan Kawi, Jalan Arif Rahman Hakim, Jalan Merdeka Utara, Jalan Merdeka Timur, Jalan Agus Salim, Jalan K.H. Achmad Dahlan, Jalan Panglima Sudirman; Corridor 3 is 10,867 km long through Jalan Supriadi, Jalan Satsui Tubun, Jalan Colonel Sugiono, Jl. Laksamada Martadinata, Jalan Gatot Subroto, Jalan K.H. Ahmad Dahlan, Jalan Agus Salim, Jalan Merdeka Selatan, Jalan Kauman, Jalan K.H. Hasyim Ashari, Jalan Arif Margono. Simulation of the performance of road junctions shows a decrease in the degree of saturation and average delays after the operation of the BRT, although there are several intersections that still do not reach the expected service level targets, such as at the intersection of Jl. W.R.Supratman-Jl.J.A.Suprapto and the intersection of Jl. Supriadi-Jl. West Janti. However, some intersections have managed to achieve a good level of service, such as at the intersection of Jl. Ahmad Yani- Jl. Borobudur Straight South.

5. BIBLIOGRAPHY

[1] Morlok, E. K. (1978). Introduction to transportation engineering and planning. McGraw-Hill.

[2] S. Fatimah, Introduction to Transportation, DS. Pulung, Kec. Pulung, Ponorogo Regency: Myria Publisher, 2019.

[3] Ministry of Transportation of the Republic of Indonesia. (2022, March 10). Public transportation policy. Ministry of Transportation of the Republic of Indonesia. https://www.kemenhub.go.id/kebijakan-transportasi-publik.

[4] Eysenbach D 2011 Public transportation" green energy: an a-to-z guide. Ed., Oaks: Mulvaney, D. and Robbins P. Thousand Oaks (CA.: SAGE Publications. Inc.).

[5] Wright, L., & Hook, W. (2007). Bus rapid transit planning guide. Institute for Transportation & Development Policy.

[6] Ministry of Transportation of the Republic of Indonesia. (2022). Bus Rapid Transit System in Indonesia. Ministry of Transportation of the Republic of Indonesia.https://www.kemenhub.go.id/brt-indonesia.

[7] Institute for Transportation and Development Policy. (2021). The benefits of BRT. ITDP. https://www.itdp.org/the-benefits-of-brt.

[8] A. Technical Guidelines for the Implementation of Public Passenger Transportation in Urban Areas on Fixed and Regular Routes, Jakarta: Ministry of Transportation of the Republic of Indonesia, Directorate General of Land Transportation, 2002.

[9] A. Racman, Y. A. I. Samanlangi and H. Purnomo, Quantitative, Qualitative and R&D Research Methods, Jl. Proclamation Kp. Krajan RT.4 RW.4, Kel. Tanjungmekar, Kec. Karawang Barat, Kab. Karawang: CV Saba Jaya Publisher, 2016.

[10] A. Guidelines for Planning, Provision, and Utilization of Pedestrian Network Infrastructure and Facilities in Urban Areas, Jakarta: Minister of Public Works of the Republic of Indonesia, 2014.

[11] A. Indonesia Road Capacity Guidelines, Jakarta: Ministry of Public Works and Public Housing,