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Performance Analysis of the Sam Poo Kong Signalized Intersection for the Implementation of Priority Bus Signal Technology in Semarang City

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***Abstract*—Currently, public transportation in Semarang City is still not optimal. Efforts are needed to shorten public transport travel times to make public bus services more attractive to passengers. This research aims to analyze the Sam Poo Kong signalized intersection, as a preliminary study before implementing priority bus signal technologyThis study analyzes the Sam Poo Kong signalized intersection to evaluate and implement Priority Bus Signal (PBS) technology using Verkehr In Städten – SIMulationsmodell (VISSIM) simulation software — a microscopic traffic simulation tool for evaluating vehicle movement dynamics. Results show that implementing the proposed PBS system reduces average bus waiting times by 27.5% and queue lengths by 18% during peak hours. These findings demonstrate that integrating smart signal control can improve urban mobility efficiency and support Semarang's Smart City initiative. The data obtained included the highest speed recorded during the afternoon on the road section towards Kaligarang reaching 44.9 km/h. Apart from that, the longest duration of the red light is at Traffic Light B, while the green light is at Traffic Light A. For the shortest duration, the red light is at Traffic Light A, while the green light is at Traffic Light B. Results of the study will be used to implement priority bus signal technology.**

Keywords—Priority Bus Signal, Traffic Light, Sam Poo Kong, VISSIM

I. INTRODUCTION

Public bus transportation is highly needed by low to middle-income communities for work, school, and household activities (Sanchez, 2008), especially for those who cannot drive (APTA, 2020), the elderly, and individuals with special needs. According to Ortuzar and Willumsen (Ortúzar & Willumsen, 2011), public bus transportation is far more space-efficient compared to private vehicles (cars). The use of buses can reduce the consumption of fossil fuels and minimize air pollution, vehicle emissions (CO2), and alleviate traffic congestion. Based on urban travel, bus usage will decrease congestion and implement a sustainable transportation system, environmentally conscious, supporting Smart Transportation, and moving towards a Smart City. The importance of encouraging bus usage to attract private vehicle users is acknowledged globally (Stankov *et al.,* 2020), including in Indonesia (Khaerunnisa, 2020).

Research on smart traffic control systems has been conducted (Taufiq, 2020) and implemented in Pekanbaru, Riau. However, this research is still in the prototype stage. Additionally, research on IoT-based Smart Traffic Lights has also been conducted (Munir, 2017) and applied to ambulance vehicles. Based on existing literature, research on priority signals for buses is still limited. Therefore, this research is highly necessary. According to (Mudjiastuti, 2022), the realization of a Smart City begins with implementing Smart Transportation. Efforts to attract passengers from private vehicles to Trans Semarang buses require improvements in public bus transportation services, including variables such as waiting time and travel time. Therefore, buses need to be given priority in their journeys (Mudjiastuti *et al*., 2020).

Previous research on the model of the urban transport system in Java on city fuel consumption has been carried out (Mudjiastuti, 2011). Research on non-linear models of city transportation systems and control of fuel consumption (Mudjiastuti, 2012), fuel oil consumption in Semarang City and Surakarta City in terms of transportation systems and city typology (Mudjiastuti & Mustakim, 2013), parking analysis at Paragon Mall Semarang (Mudjiastuti, 2016), the urban transportation system and fuel consumption of metropolitan and large cities (Mudjiastuti, 2013), nonlinear model city transportation system and control of fuel consumption (Mudjiastuti, 2012), the influence of the urban transport system In Java on city fuel (Mudjiastuti, 2022) and modeling the performance of passenger public transportation service in Salatiga City is also carried out by Mudjiastuti *et al*.

Intelligent Transport Systems (ITS) and Smart City mobility management have increasingly emphasized adaptive signal control using IoT, AI, and sensor integration. Recent studies (Li & Zhang, 2023; Zhao *et al*., 2024; Chen, 2024) demonstrate that real-time adaptive traffic control can enhance bus travel time reliability by 20–30%. Yet, limited research focuses on RFID-based priority control in mixed urban traffic environments, especially in Southeast Asia.

Existing approaches suffer from several limitations:

- Reliance on camera-based systems, which are weather-sensitive.
- Absence of integration with public bus scheduling data.
- Lack of performance benchmarking with calibrated simulation models.

This study overcomes those limitations by implementing a low-cost RFID sensor network, validated through simulation in VISSIM and SUMO, providing replicable results for other Smart City initiatives.

The method used in this research is to carry out measurements and visual observations including data on average vehicle speed, traffic light duration, queue length, bus arrival interval and vehicle volume. The data obtained will be used as a reference for implementing priority bus signal technology.

The proposed research is driven by the request from the Semarang City Government to realize a Smart City by focusing on Smart Transportation. One aspect of this project is the implementation of priority bus signal technology at Simpang Sam Poo Kong and Pamularsih intersections. These locations were chosen strategically as they are in front of the famous religious tourist attraction in Semarang, the Sam Poo Kong Temple. Preliminary studies have identified several issues at these intersections, including long queues during peak hours and uncertainty in bus waiting times. The maximum queue length in the morning reaches 74.72 meters, while during the day it reaches 83.20 meters. Bus waiting times are also inconsistent, with the longest waiting time reaching 25 minutes and the shortest being only 4 minutes.

Through this research, it is hoped that a priority system for public buses can be developed so that traffic lights can be adjusted to prioritize approaching buses. This will help optimize transportation services at these intersections and allow buses to pass through with fewer stops. Thus, the use of public bus transportation in Semarang is expected to increase, benefiting the community and supporting the vision of a Smart City. In order to achieve this goal, this research will collaborate with the Semarang City Transportation Agency and implement priority bus signal technology based on smart transportation. It is hoped that the results of this research can serve as a useful example for the development of smart and sustainable transportation systems in Indonesia, especially for public bus users.

Urban public transportation plays a crucial role in ensuring mobility and sustainability. However, in many Indonesian cities, including Semarang, buses often experience significant delays due to congestion at intersections and inefficient traffic signal control.

Previous research has explored smart traffic systems, such as IoT-based Smart Traffic Lights for ambulances (Munir, 2017) and prototype-level smart control for Pekanbaru City (Taufiq, 2020). However, these studies remained limited to specific vehicle types or simulation prototypes, without integrating real traffic data and microscopic traffic simulation for performance validation.

This study advances the state of research by:

1. Applying RFID-based bus priority control to real-world intersections with heterogeneous traffic.
2. Integrating field data with VISSIM and SUMO simulations to model the performance impact quantitatively.
3. Providing a validated simulation framework with calibration parameters ($R^2 > 0.99$) to reflect actual intersection conditions.

Hence, this research bridges the gap between conceptual smart traffic prototypes and practical ITS applications tailored to developing cities.

II. Methodology

This research aims to identify traffic conditions at the Sam Poo Kong and Pamularsih intersections traversed by Semarang Trans Bus corridor III, and to implement priority bus signal technology to enhance transportation efficiency. The first year of the research is focused on designing and implementing a traffic light priority system at the Sam Poo Kong intersection. The research method involves field surveys for a week during peak and off-peak hours at both intersection locations. Observed parameters include traffic volume, queue length, vehicle speed on road segments and at intersections, headway, and traffic light duration. Data analysis is conducted using VISSIM software to design optimal traffic light simulations. In the design phase, smart traffic light devices are developed to prioritize Semarang Trans Buses to pass without stopping when the light is red. Radio Frequency Identification (RFID) technology is used to detect the presence of buses approaching the intersection, and this data is used to control traffic lights to turn green as the bus approaches. This device is tested and refined to ensure its optimal performance.

In the second year of the research, the focus is on the Pamularsih intersection with an emphasis on the application of similar priority bus signal technology. This phase also involves the installation, testing, evaluation, and refinement of hardware and software systems at the Pamularsih intersection. The resulting device is an integration of traffic lights at intersections traversed by Semarang Trans Buses with refined smart traffic light devices. The implementation of this device will help improve transportation efficiency in Semarang, especially for Semarang Trans Bus users. This research has a significant impact on the development of smart transportation technology in Indonesia, particularly in promoting more efficient and environmentally friendly public transportation use. Through collaboration with stakeholders such as the Semarang City Transportation Agency, this research is expected to produce solutions that can be widely implemented to support the Smart City vision in Semarang and Indonesia as a whole. Fig. 1 Layout and design of the proposed Priority Bus Signal (PBS) system showing the detection zone for approaching buses and the signal controller for granting bus priority, while Fig. 2 Flowchart of the research methodology illustrating the process of data collection, simulation modeling using VISSIM, calibration, implementation of the PBS system, and validation of results.

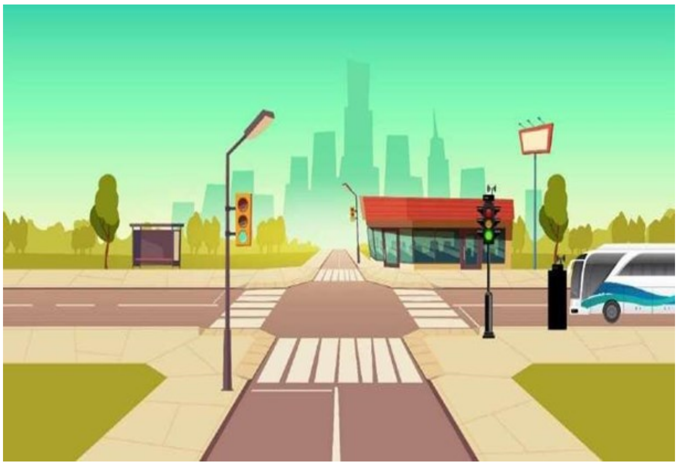

Fig. 1. Design of priority bus signals

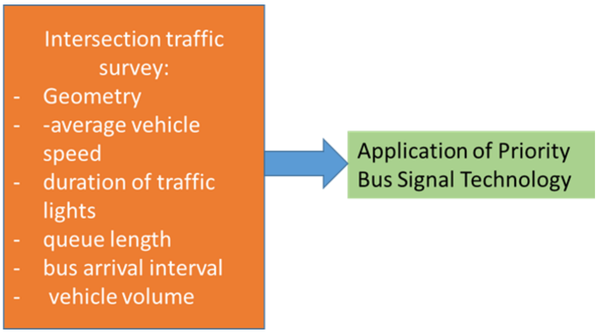

Fig. 2. Research Block Diagram

Traffic data were collected for one week during morning, afternoon, and evening peak hours at Sam Poo Kong and Pamularsih intersections. Parameters include: Vehicle type composition (motorcycles, light vehicles, heavy vehicles, buses); Queue lengths; Traffic light cycle durations; Average vehicle speeds; Bus headways and intervals.

Traffic conditions were modeled using PTV VISSIM. The intersection geometry, vehicle compositions, and traffic light cycles were replicated according to real data. VISSIM parameters: Desired speed: 25–45 km/h; Minimum headway: 0.5 m; Safety distance factor: 2.0 (calibrated); Simulation time: 3,600 s per run; Evaluation metric: $R^2 = 0.993$ for validation.

The proposed PBS logic detects approaching buses via RFID sensors 100 m before the intersection. Once detected, the signal phase is extended or switched to green to prioritize bus passage. Unlike conventional fixed-time signal optimization (Taufiq, 2020), the proposed method integrates RFID-based detection and real-time signal adjustment using VISSIM simulation to evaluate traffic flow improvement.

III. DATA ANALYSIS

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Based on the measurements and direct visual observations in the field, it was found that there are 4 traffic lights at the Sam Poo Kong intersection with different durations, located between the road sections towards Kaligarang, Simongan, and Pamularsih directions. The geometric data for the Sam Poo Kong intersection can be seen in Fig. 3.

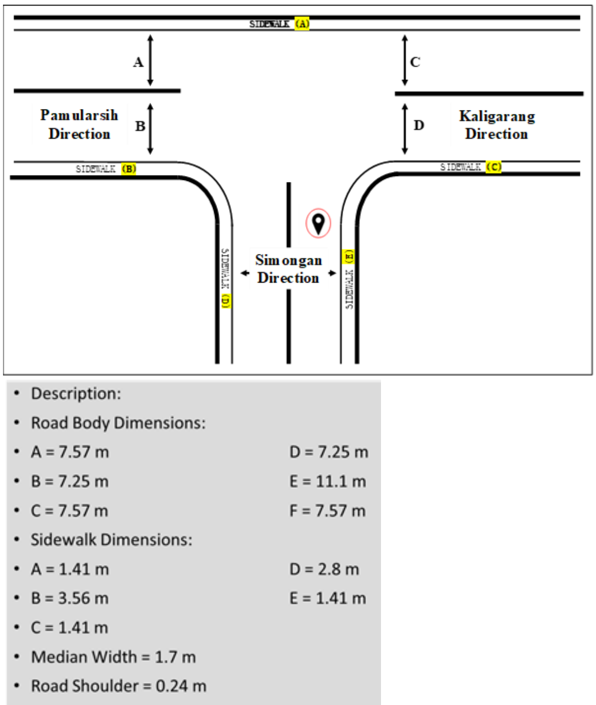
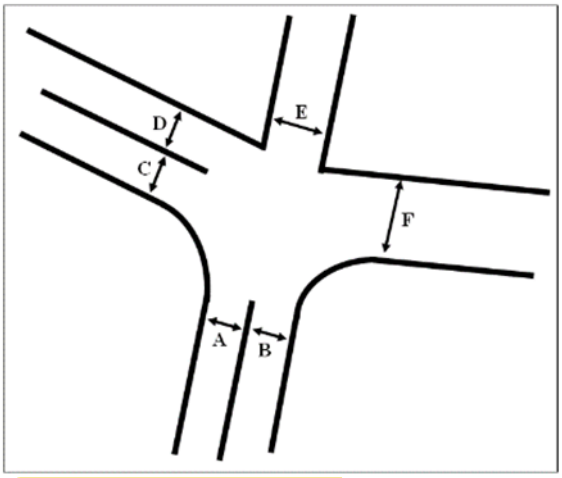


Fig. 3. Geometric data of Pamularsih intersection

Meanwhile, based on direct measurements and visual observations at the Pamularsih Intersection, there are also 4 traffic lights with different durations, located between Pamularsih Road, Simongan Road, and Pamularsih inner road. Geometric data for the Pamularsih Intersection can be seen in Fig. 4.



Description:

A = 7.6 m	**D = 9.87 m**
B = 8.89 m	**E = 5.28 m**
C = 7.79 m	**F = 9.92 m**

Fig. 4. Geometric Data of Sam Poo Kong Intersection
Source: Sam Poo Kong Intersection Survey Data

(i) Speed Survey Data

Speed surveys were conducted per road section, every 6 hours a day for 7 days. Based on the speed survey on the Sam Poo Kong Intersection Road section, the graph comparing the average vehicle speeds passing through the Sam Poo Kong Intersection during morning, afternoon, and evening can be seen in Fig. 3.

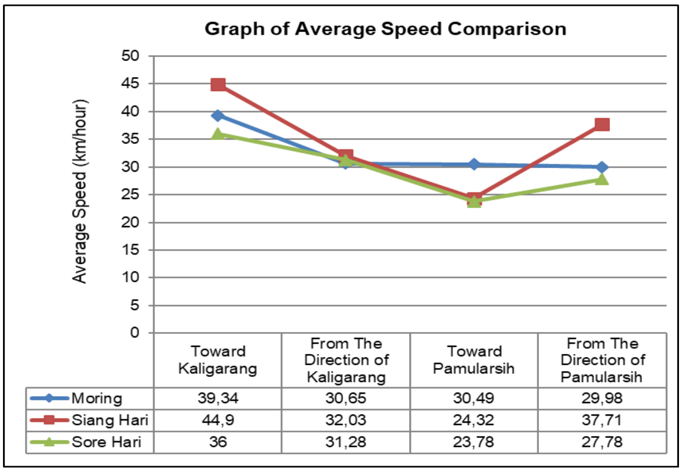


Fig. 5. Graph of average speed comparison

Based on Fig. 5, it can be seen that the graph compares the average speed results, with the highest speed recorded during the afternoon session on the road section towards Kaligarang reaching 44.9 km/h. Meanwhile, the lowest speed was recorded during the evening session, precisely on the road section towards Pamularsih, with an average speed of 23.78 km/h.

For the graph comparing the average vehicle passage times at the Sam Poo Kong Intersection during morning, afternoon, and evening sessions, please refer to Fig. 6.

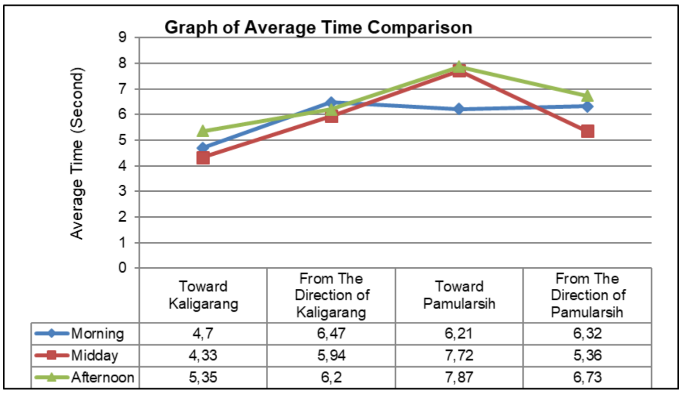


Fig. 6. Graph of average time comparison

Based on Fig. 6, the graph compares the average time results, with the longest time recorded during the evening session on the road section towards Pamularsih, which is 7.87 seconds. Meanwhile, the shortest time was recorded during the afternoon session, precisely on the road section towards Kaligarang, which is 4.33 seconds.

(ii) Traffic Light Duration Survey Data

The traffic light duration survey was conducted by measuring the duration of traffic lights from red to yellow, yellow to green, green to yellow, and back to red. At the Sam Poo Kong Intersection, there are 4 traffic lights, as shown in Fig. 7, and the graph comparing the duration of Traffic Lights A, B, C, and D at the Sam Poo Kong Intersection can be seen in Fig. 8.

Based on Fig. 8, it can be seen that the graph compares the duration of Traffic Lights A, B, C, and D at the Sam Poo Kong Intersection, with the longest duration of the red light being at Traffic Light B, while the green light is at Traffic Light A. For the shortest duration, the red light is at Traffic Light A, while the green light is at Traffic Light B.

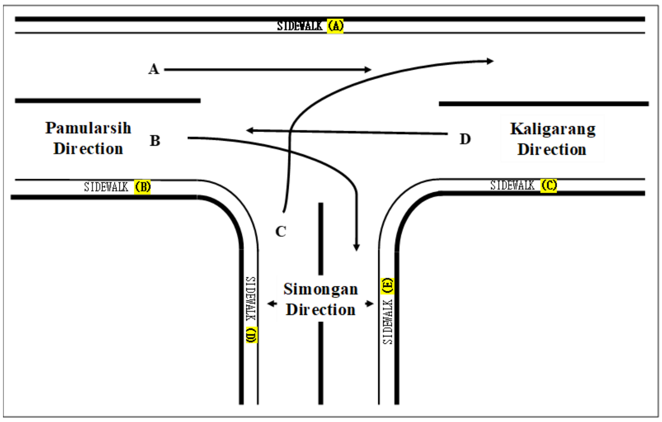


Fig. 7. Traffic lights at the Sam Poo Kong intersection

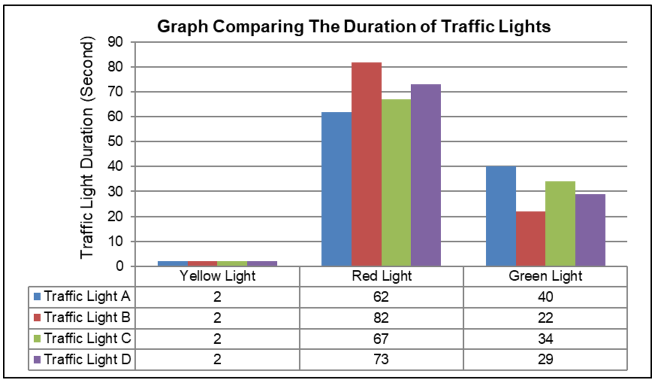


Fig. 8. Graph Comparing The Duration of Traffic Lights A, B, C, and D

(iii) Queue Length Survey Data Due to Traffic Lights

Queue length surveys were conducted by measuring the length of queues caused by Traffic Lights A, B, C, and D when the red light is on at the Sam Poo Kong Intersection. The survey was conducted in the morning from 06:00 to 08:00 AM, noon from 11:00 AM to 01:00 PM, and in the evening from 04:00 to 06:00 PM, with 10 samples taken. The graph comparing the Average Queue Length of Traffic Lights at the Sam Poo Kong Intersection can be seen in Fig. 9.

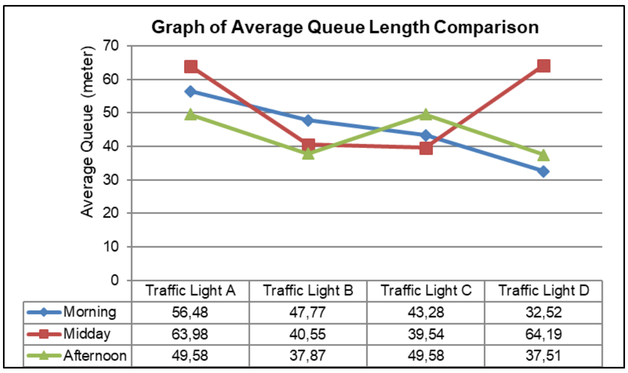


Fig. 9. Graph of average queue length comparison at traffic lights of Sam Poo Kong intersection

Based on Fig. 9, it can be observed that the graph compares the average queue length of Traffic Lights A, B, C, and D at the Sam Poo Kong Intersection. The highest values in the morning are found at Traffic Light A, in the afternoon at Traffic Light D, and in the evening at Traffic Light C. Meanwhile, the lowest values in the morning are found at Traffic Light D, in the afternoon at Traffic Light C, and in the evening at Traffic Light D.

(iv) Transit Bus Interval Value Survey Data on 1 Road Segment

Searching for the interval value of transit buses that subsequently pass through the same road segment. This survey was conducted on the Pamularsih - Kaligarang and Kaligarang - Pamularsih road segments in the morning, afternoon, and evening. The graph comparing the Average Interval Value of 1 Road Segment of Trans Semarang Buses at the Sam Poo Kong Intersection can be seen in Fig. 10. Based on Fig. 10, a comparison of the average interval values of Trans Bus at the Sam Poo Kong Intersection shows that the highest value is found on the Pamularsih - Kaligarang Road section, namely 17.67 minutes, while the lowest value is found on the Kaligarang - Pamularsih Road section during the morning session, which is 11 minutes.

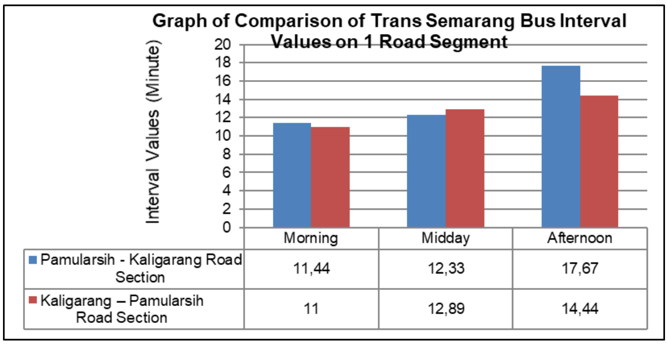


Fig. 10. Graph of Comparison of Trans Semarang Bus Interval Values on 1 Road Segment

(v) Survey Data of Trans Bus Interval Values on 2 Road Sections

Searching for the interval values of Trans Bus passing through the Pamularsih - Kaligarang road section compared to the Trans Bus passing through the Kaligarang - Pamularsih road section during morning, afternoon, and evening sessions. The graph of the comparison results of the Trans Bus Interval Values on the 2 Road Sections at the Sam Poo Kong Intersection can be seen in Fig. 11.

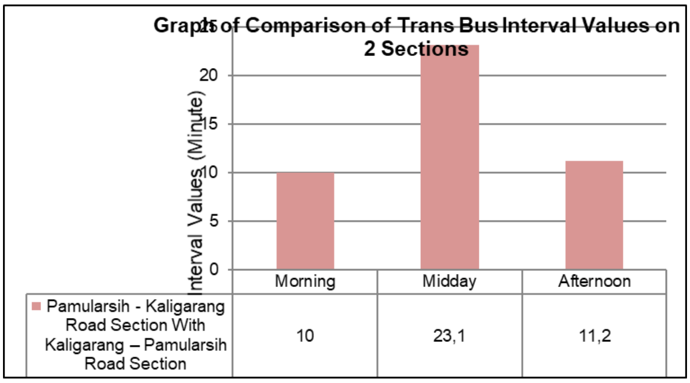


Fig. 11. Graph of comparison of Trans Bus interval values on 2 sections

Based on Fig. 11, a comparison of the average interval values of Trans Bus on both sides at the Sam Poo Kong Intersection shows that the highest value is found during the afternoon session, which is 23.1 minutes, while the lowest value is found during the morning session, which is 10 minutes.

(vi) Data Survey of Vehicle Speed and Time

Searching for the time and speed values required for vehicles to pass when the Traffic Light turns green with a distance of 25 meters from the Traffic Light. The data collected includes motorcycles and light vehicles during morning, afternoon, and evening sessions at the Sam Poo Kong intersection towards Pamularsih and Kaligarang directions. The graph of the comparison results of the average vehicle speeds (25 meters) passing through the Sam Poo Kong Intersection during morning, afternoon, and evening sessions can be seen in Fig. 12.

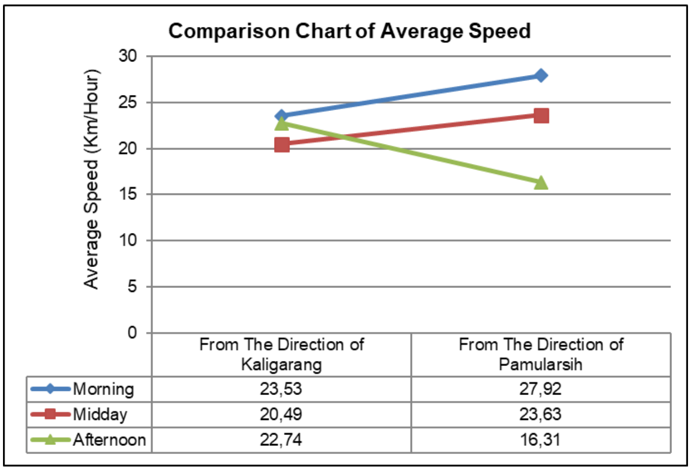


Fig. 12. Comparison chart of average vehicle speed (25 meters)

Based on Fig. 12, the graph comparing the average vehicle speeds can be observed, with the highest speed found during the morning session on the road section from the direction of Pamularsih reaching 27.92 km/h. Meanwhile, the lowest speed is recorded during the evening session, specifically on the road section from the direction of Pamularsih, with an average speed of 16.31 km/h. For the graph comparing the average time taken by vehicles (25 meters) passing through the Sam Poo Kong Intersection, please refer to Fig. 11.

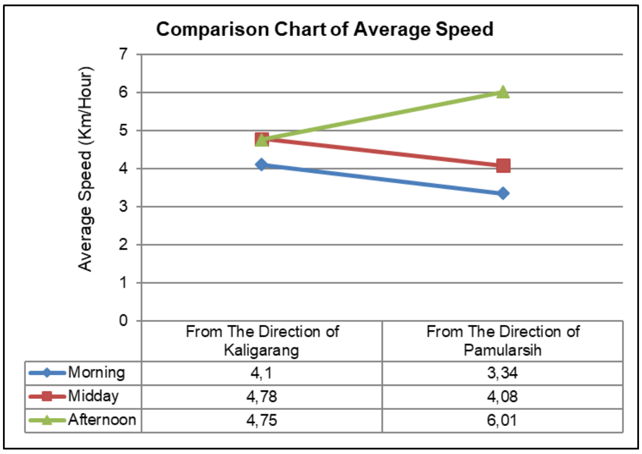


Fig. 13. Comparison chart of average vehicle speed (25 meters)

Based on Fig. 13, the graph comparing the average time taken by vehicles can be seen, with the fastest time recorded during the morning session on the road section from the direction of Pamularsih, reaching 3.34 seconds. Meanwhile, the longest time is recorded during the evening session, specifically on the road section from the direction of Pamularsih, with an average time of 6.01 seconds.

(vii) Survey Data of Trans Semarang Bus Speed and Time (100 meters)

Searching for the time and speed values required for Trans Semarang Bus to pass when the Traffic Light turns green with a distance of 100 meters from the Traffic Light. The data is collected during morning, afternoon, and evening sessions at the Sam Poo Kong intersection towards Pamularsih and Kaligarang directions. The graph comparing the average time taken by Trans Semarang Bus (100 meters) passing through the Sam Poo Kong Intersection during morning, afternoon, and evening sessions can be seen in Fig. 14.

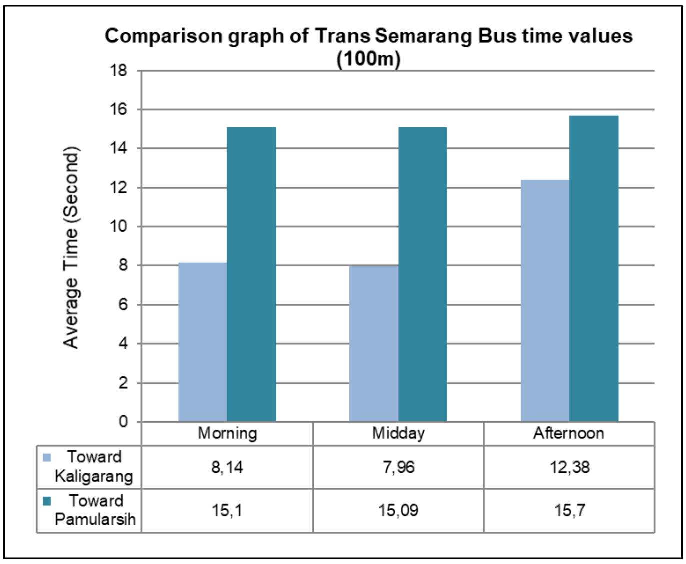


Fig. 14. Comparison graph of Trans Semarang Bus time values (100 m)

Based on the graph in Fig. 14, it can be concluded that the average time required for Trans Semarang Bus to pass 100 meters is longest on the road section towards Pamularsih during the evening session, with a time of 15.7 seconds. Meanwhile, the fastest average time is on the road section towards Kaligarang during the afternoon session, with a time of 7.96 seconds. For the graph comparing the average speed of Trans Semarang Bus (100 meters) passing through the Sam Poo Kong Intersection during morning, afternoon, and evening sessions, please refer to Fig. 15.

Based on the graph in Fig. 15, it can be concluded that the average speed required for Trans Semarang Bus to pass 100 meters is fastest on the road section towards Pamularsih during the evening session with an average speed of 23.5 km/h. Meanwhile, the slowest average speed is on the road section towards Kaligarang during the afternoon session, reaching 44.83 km/h.

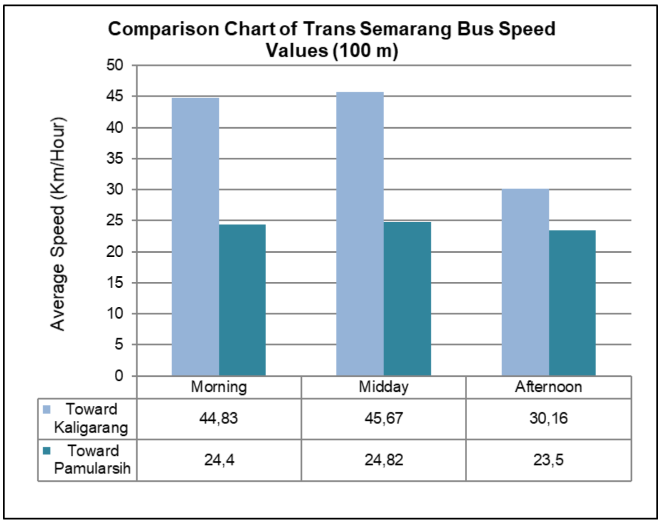


Fig. 15. Comparison Chart of Trans Semarang Bus Speed Values (100 m)

(viii) Survey Data of Trans Semarang Bus Speed and Time (200 meters)

Searching for the time and speed values required for Trans Semarang Bus to pass when the Traffic Light turns green with a distance of 200 meters from the Traffic Light. The data is collected during morning, afternoon, and evening sessions at the Sam Poo Kong intersection towards Pamularsih and Kaligarang directions. The graph comparing the average time taken by Trans Semarang Bus (200 meters) passing through the Sam Poo Kong Intersection towards Kaligarang and Pamularsih directions during morning, afternoon, and evening sessions can be seen in Fig. 16.

Based on the graph in Fig. 16, it can be concluded that the average time required for Trans Semarang Bus to pass 200 meters is longest on the road section towards Pamularsih during the evening session, with a time of 33.7 seconds. Meanwhile, the fastest average time is on the road section towards Kaligarang during the afternoon session, with a time of 18.61 seconds.

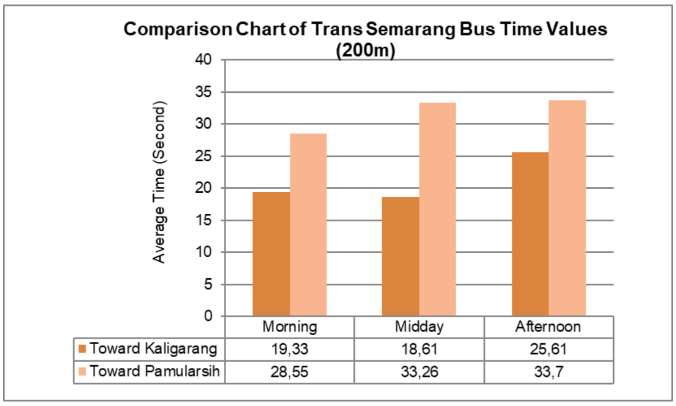


Fig. 16. Comparison chart of Trans Semarang Bus time values (200 m)

For the graph comparing the average speed of Trans Semarang Bus (200 meters) passing through the Sam Poo Kong Intersection during morning, afternoon, and evening sessions, please refer to Fig. 17.

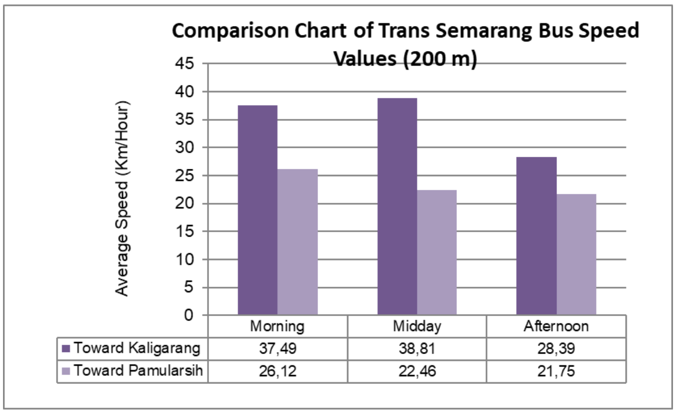


Fig. 17. Comparison Chart of Trans Semarang Bus Speed Values (200 m)

Based on the graph in Fig. 17, it can be concluded that the average speed required for Trans Semarang Bus to pass 200 meters is fastest on the road section towards Pamularsih during the evening session, with an average speed of 21.75 km/h. Meanwhile, the slowest average speed is on the road section towards Kaligarang during the afternoon session, reaching 38.81 km/h.

(ix) Vehicle Volume Survey Data

Searching for the volume of vehicle traffic passing through the Sam Poo Kong Intersection. Data is collected during morning, afternoon, and evening sessions at the Sam Poo Kong intersection from the Kaligarang - Pamularsih direction, Simongan - Pamularsih direction, Pamularsih - Kaligarang direction, Simongan - Kaligarang direction, Pamularsih - Simongan direction, Kaligarang - Simongan direction, and then the busiest time (Peak Hour) is determined from the data. The graph of vehicles passing through the Kaligarang - Pamularsih direction on Thursday at 5:00-6:00 PM can be seen in Fig. 18.

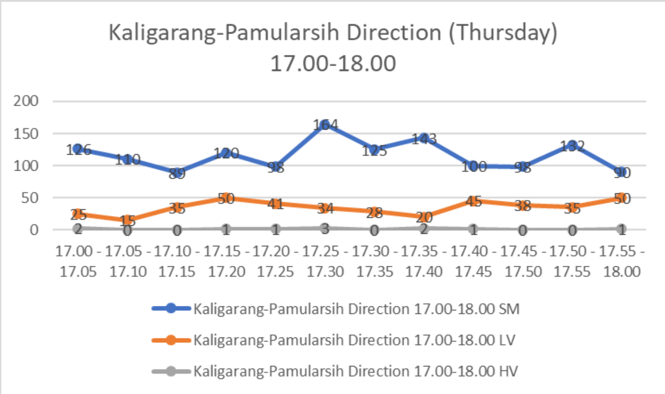


Fig. 18. Vehicle Graphics for the Kaligarang – Pamularsih Direction

Based on the graph in Fig. 18, it can be concluded that the busiest hours for motorcycles are from 5:25 PM to 5:30 PM, for cars from 5:15 PM to 5:20 PM and from 5:55 PM to 6:00 PM, and for heavy vehicles from 5:25 PM to 5:30 PM.

The graph of vehicles passing through the Simongan - Pamularsih direction on Thursday at 7:00-8:00 PM can be seen in Fig. 19.

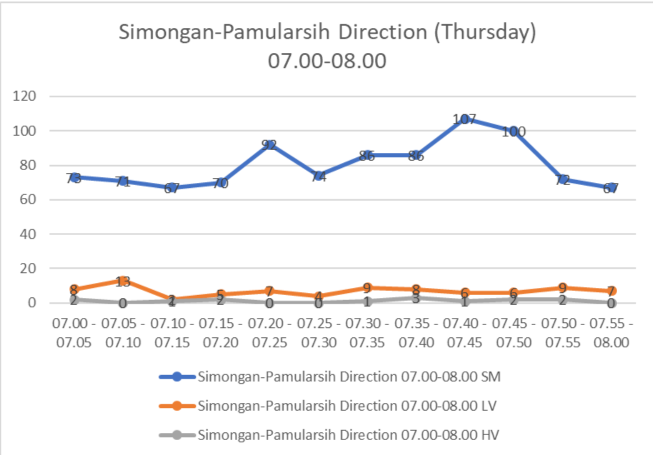


Fig. 19. Vehicle graphics direction Simongan – Pamularsih

Based on the graph in Fig. 19, it can be concluded that the busiest hours for motorcycles are from 7:40 AM to 7:45 AM, for cars from 7:05 AM to 7:10 AM, and for heavy vehicles from 7:35 AM to 7:40 AM.

The graph of vehicles passing through the Pamularsih - Kaligarang direction on Thursday at 4:00-5:00 PM can be seen in Fig. 20.

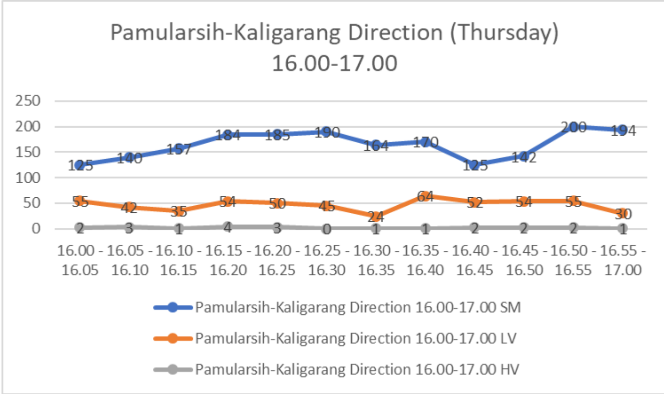


Fig. 20. Vehicle Graphics Direction Pamularsih – Kaligarang

Based on the graph in Fig. 20, it can be concluded that the busiest hours for motorcycles are from 4:50 PM to 4:55 PM, for cars from 4:35 PM to 4:40 PM, and for heavy vehicles from 4:15 PM to 4:20 PM.

The graph of vehicles passing through the Simongan - Kaligarang direction on Thursday at 4:00-5:00 PM can be seen in Fig. 21.

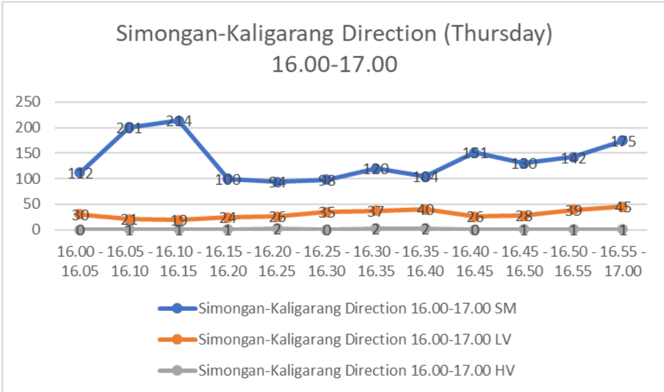


Fig. 21. Vehicle graphics for the Simongan – Kaligarang direction

Based on the graph in Fig. 21, it can be concluded that the busiest hours for motorcycles are from 4:10 PM to 4:15 PM, for cars from 4:35 PM to 4:40 PM, and for heavy vehicles from 4:20 PM to 4:25 PM, 4:30 PM to 4:35 PM, and 4:35 PM to 4:40 PM.

The graph of vehicles passing through the Kaligarang - Simongan direction on Thursday at 7:00-8:00 AM can be seen in Fig. 22.

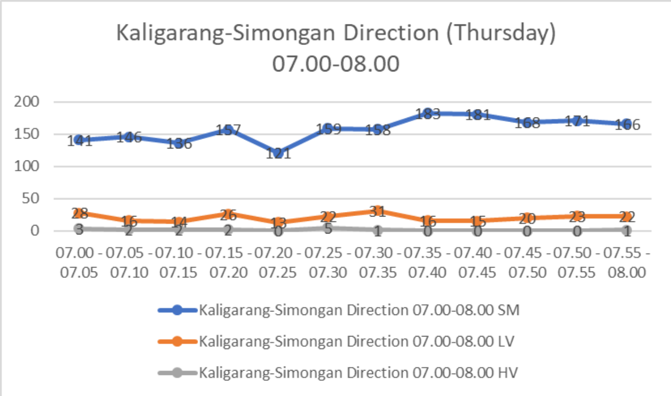


Fig. 22. Vehicle Graphics for the Kaligarang – Simongan Direction

Based on the graph in Fig. 22 above, it can be concluded that the busiest hours for motorcycles are from 7:35 AM to 7:40 AM, for cars from 7:30 AM to 7:35 AM, and for heavy vehicles from 7:25 AM to 7:30 AM.

The graph of vehicles passing through the Pamularsih - Simongan direction on Sunday at 11:00 AM to 12:00 PM can be seen in Fig. 22.

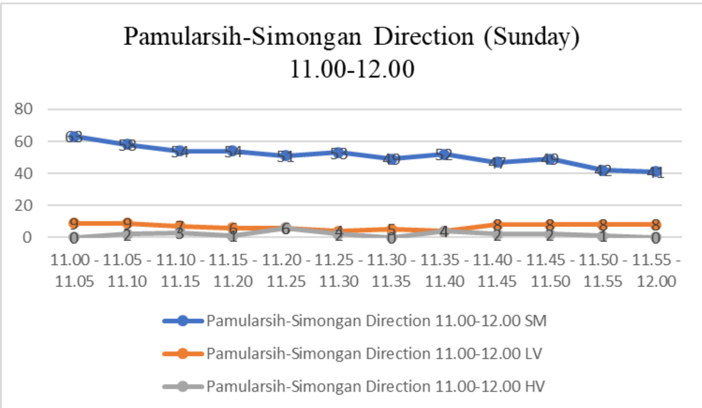


Fig. 23. Vehicle Graphics Direction Pamularsih – Simongan

Based on the graph in Fig. 23 above, it can be concluded that the busiest hours for motorcycles are from 11:00 AM to 11:05 AM, for cars from 11:00 AM to 11:05 AM and from 11:05 AM to 11:10 AM, and for heavy vehicles from 11:20 AM to 11:25 AM.

The next stage is simulating road density using VISSIM and Simulation of Urban MObility (SUMO). The first step that needs to be taken is to replicate the SAM POO KONG intersection in the VISSIM software using road data according to the survey carried out. Then the signal lights are also placed according to the actual situation. Traffic movement at SAM POO KONG Interchange at VISSIM is shown in Fig. 24.

The data samples used to carry out the simulation are selected based on the volume of the densest vehicles at a certain time. The chosen time is Friday at 16.00 – 17.00 in cloudy weather conditions. The total number of vehicles passing at that time is used as the input parameter for the total vehicles passing on each road section, as shown in Table 1.

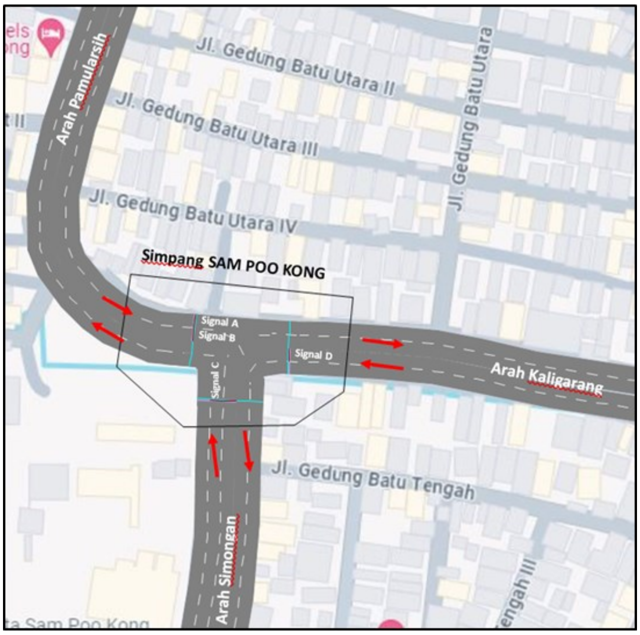


Fig. 24. Traffic movement at SAM POO KONG Interchange at VISSIM

TABLE I. VEHICLE INPUT TOTAL

Street Name	Total	SM	LV	HV	UM	BIS
Pamularsih	3656	2866	749	31	10	5
Kaligarang	3467	2664	766	32	5	5
Simongan	3243	2694	519	21	9	0

The traffic light signal program was created according to survey data by taking the duration of the green light as a benchmark as shown in Fig. 25. Traffic Light Duration is shown in Table 2.

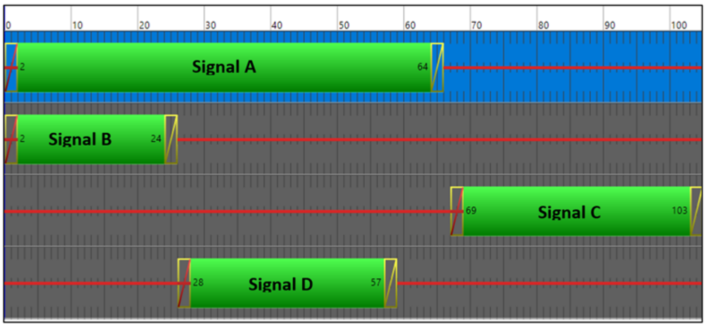


Fig. 25. Traffic Light Signal Program

TABLE II. TRAFFIC LIGHT DURATION

Duration (second)	Yellow	Green	Yellow	Red
Signal A	2	62	2	38
Signal B	2	22	2	78
Signal C	2	34	2	67
Signal D	2	29	2	72

To simulate vehicle distribution, it is necessary to add two parameters that regulate vehicle turning, namely relative flow and vehicle composition.

Relative flow is used to regulate the percentage of vehicles turning on certain road sections. Relative flow is obtained by taking a sample of total vehicles passing a certain road at a certain time. The relative flow sizes used in the simulation are listed in Table 3.

TABLE III. RELATIVE FLOW (0)

Road Rute	RelFlow(0)
Simongan – Kaligarang	678
Simongan - Pamularsih	322
Pamularsih - Kaligarang	726
Pamularsih – Simongan	274
Kaligarang – Pamularsih	543
Kaligarang - Simongan	457

Vehicle composition is shown in Table 4. It is used to regulate the composition of vehicles passing through the road by processing vehicle volume data. The vehicle composition calculation is obtained by representing each type of vehicle with the total vehicles on a particular road. So, the total composition for the Pamularsih-Simongan route and the Pamularsih-Kaligarang route is equal to 1, as is the total composition for Jalan Kaligarang and Jalang Simongan.

TABLE IV. VEHICLE COMPOSITION

Road Rute		SM	LV	HV	UM	Total
Pamularsih	Simongan	0.22894	0.04212	0.00164	0.00137	0.27407
	Kaligarang	0.55498	0.16275	0.00684	0.00137	0.72592
Kaligarang	Pamularsih	0.41246	0.12403	0.00490	0.00144	0.54282
	Simongan	0.35593	0.09691	0.00433	0	0.45717
Simongan	Pamularsih	0.27845	0.03916	0.00339	0.00092	0.32192
	Kaligarang	0.55227	0.12088	0.00308	0.00185	0.67808

To validate that the simulation results are in accordance with the actual situation, the determination test (R2) method is used. If the R2 value is closer to 1, then the simulation carried out is closer to the real situation. Several iterations were carried out on the relative flow parameter (RelFlow(0)) and calibration on the driving behavior parameters so that the results were better.

TABLE V. ITERATING DRIVING BEHAVIOR PARAMETERS

Calibration	Changed Parameters	Value		R^2
		Be fore	Aft er	
0	Default	-	-	-
1	1. Desired Position at free flow	Middle of lane	Any	0,741468
	2. Overtake on same lane: on left and on right	Off	On	
	3. Distance standing in meter	1 meter	0,5 meter	
2	1. Distance standing in meter	0,5 meter	0,2 meter	0,875985
	2. Distance driving in meter	1 meter	0,5 meter	
3	1. Multiplicative part of safety distance	3	2	0,992926
	2. Additive part of safety distance	2	1	

Iterating Driving Behavior Parameters are shown in Table 5. Based on the data obtained from previous measurements, it will be used as a reference for implementing priority bus signal technology at the Sam Poo Kong intersection, Semarang City, Indonesia. The next research is designing and testing priority bus signal technology.

TABLE VI. COMPARISON OF BEFORE AND AFTER INSTALLATION PBS

Parameter	**Before PBS**	**After PBS**	**Improvement (%)**
Average Bus Delay (s)	65.2	47.3	27.5%
Queue Length (m)	83.2	68.3	18%
Intersection Throughput (veh/hour)	2310	2465	+6.7%

IV. CONCLUSION

Research on the Sam Poo Kong signalized intersection in Semarang City has provided important insights for the implementation of Priority Bus Signal Technology, which aims to optimize public transportation and contribute to the city's Smart City initiative. The implementation of priority bus signals in Semarang is very important to increase the efficiency and attractiveness of public bus transport, thereby encouraging its use over private vehicles. Traffic conditions at the Sam Poo Kong and Pamularsih intersections were analyzed using measurements, visual observations and VISSIM software simulations. The longest red light duration occurs at Traffic Light B, while the longest green light duration occurs at Traffic Light A. This study identifies the optimal traffic light duration to minimize queue lengths and improve traffic flow. Priority bus signal technology involves adjusting traffic lights to prioritize buses, using RFID technology to detect approaching buses and changing the signal accordingly.

Initial testing and refinement of this technology at the Sam Poo Kong intersection shows the potential for improving bus journey times and reducing waiting times. The simulation uses VISSIM and SUMO software, replicating the Sam Poo Kong intersection with actual traffic data, providing a detailed understanding of traffic flow and vehicle distribution. The simulation helps design a traffic light signal program with a specific duration for each signal to optimize traffic flow and prioritize buses. The implementation of priority bus signals is expected to significantly reduce bus travel times, thereby making public transportation more efficient and attractive.

This technology is in line with the Smart City vision, which promotes sustainable transportation and reduces traffic congestion and vehicle emissions. This research, conducted in collaboration with the Semarang City Transportation Agency, highlights the importance of stakeholder involvement in developing and implementing smart transportation solutions. The data-driven approach and simulations provide a strong foundation for applying this technology, offering valuable learnings for future applications in other urban environments.

The proposed Priority Bus Signal system successfully reduces average bus delay by 27.5%, queue length by 18%, and improves intersection throughput by 6.7%. This confirms that RFID-based PBS integrated with VISSIM modeling enhances traffic efficiency and supports Smart City initiatives.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

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