Optimization of the Signalized Intersection on Emi Saelan Road - Basuki Rahmat Road Using Vissim Software

Agusalim S. Yabasa[1*]; Arief Setiawan[2]; Syamsul Arifin[3]

[1]Departemen of Civil Engineering, Tadulako University, Palu, Indonesia
[2]Departemen of Civil Engineering, Tadulako University, Palu, Indonesia
[3]Departemen of Civil Engineering, Tadulako University, Palu, Indonesia

Coresponding Author: Agusalim S. Yabasa[1*]

Publication Date: 2025/07/31

Abstract: The Emi Saelan – Basuki Rahmat intersection is a signalized junction connecting a national road and a provincial road in the city of Palu. This intersection experiences a high level of traffic conflict due to the surrounding land use, which includes commercial areas, schools, hotels, restaurants, and access to Mutiara Sis Aljufri Airport. These activities contribute to high traffic volumes, leading to congestion and traffic disorder. This study aims to analyze the intersection's performance using PTV VISSIM software, with evaluation parameters including queue length, delay, and level of service (LOS). Simulation results under existing conditions indicate that all approaches operate at LOS F (delay > 80 seconds), with the longest queue reaching 189 meters and the highest delay recorded at 93 seconds on the south approach. Optimization efforts were carried out by adjusting the green time based on the total cycle time recommended in the 2023 Indonesian Highway Capacity Guidelines (PKJI 2023). The optimization results showed an improvement in the level of service on the north, east, and west approaches to LOS E (delay > 55–80 seconds), along with reduced queue lengths and delays compared to existing conditions.

Keywords: *Signalized Intersection, PKJI 2023, VISSIM, Queue Length, Delay.*

How to Cite: Agusalim S. Yabasa; Arief Setiawan; Syamsul Arifin (2025) Optimization of the Signalized Intersection on Emi Saelan Road - Basuki Rahmat Road Using Vissim Software. *International Journal of Innovative Science and Research Technology*, 10(7), 2387-2397. https://doi.org/10.38124/ijisrt/25jul1485

I. INTRODUCTION

Palu City is one of the regions experiencing rapid development each year, both in terms of physical infrastructure and the intensity of community activities. The city center serves as a major attraction for urban movement, leading to an increase in travel demand and a surge in traffic flow along several key road segments. This phenomenon directly affects the performance of intersections, which function as critical nodes for the convergence and distribution of vehicular movements.

One of the intersections significantly affected is the signalized intersection at Emi Saelan Road – Basuki Rahmat Road. This intersection connects a national road with a provincial road and frequently encounters vehicular movement conflicts due to the high volume of traffic. The surrounding land use—which includes educational institutions, retail shops, shopping centers, restaurants, supermarkets, and access to Mutiara Sis Aljufri Airport—contributes to the growing traffic volume, resulting in congestion and traffic disorder.

Traffic congestion has become a major issue that negatively impacts road service performance and hampers road user activities. Previous studies conducted at this location were primarily based on conventional analyses using the Indonesian Highway Capacity Guidelines (PKJI), without incorporating a microscopic simulation approach. However, a simulation-based approach can provide a more detailed and realistic depiction of traffic conditions at the intersection.

To address these complex issues, an evaluation of intersection performance using traffic simulation modeling is required. This study employs the PTV Vissim software to conduct microscopic simulations representing both existing conditions and improvement scenarios at the Emi Saelan Road – Basuki Rahmat Road intersection. The primary objective of this research is to analyze the traffic performance and propose appropriate solutions to improve the efficiency and orderliness of the intersection in Palu City.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25jul1485

II. METHOD

➢ *Research Flowchart*

The following is a flowchart for the research on the Emi Saelan – Basuki Rahmat intersection.

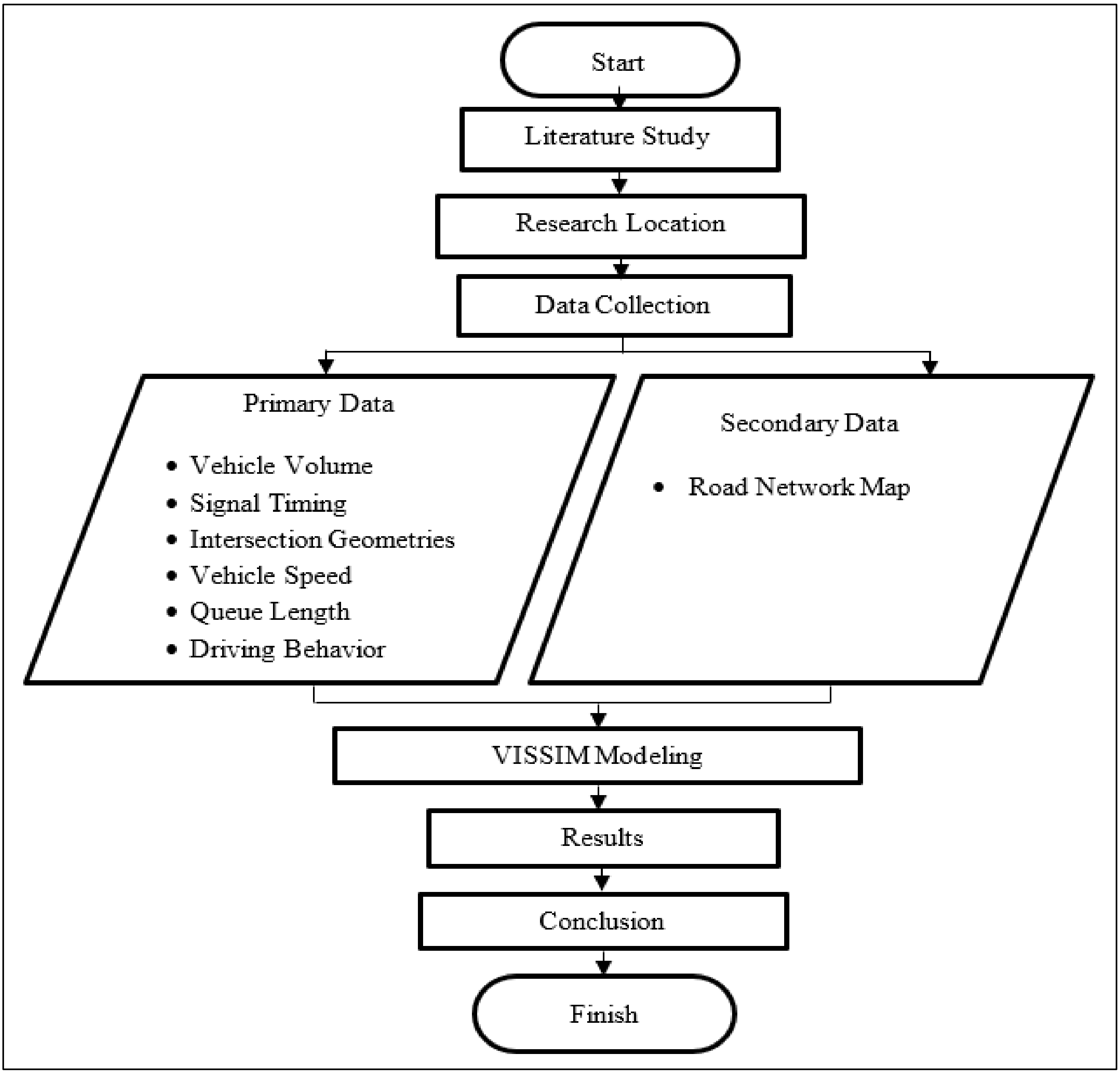

Fig 1 Research Flowchart

➢ *Data Analysis Method*

Data analysis using software such as Microsoft Excel and PTV Vissim will then produce intersection performance data.

- *Software Microsoft Excel*

Data obtained in the field, such as intersection geometric data, vehicle volume, cycle time data, speed data, and driving behavior data, are then summarized and analyzed using Microsoft Excel in the form of tables and graphs.

- *Vissim Software*

When using Vissim software, several parameters must be determined for the simulation model to run. The parameters that must be set to run the simulation model at a signalized intersection are as follows:

✓ Create a link first to create a connector.
✓ Determine the vehicle type in 2D/3D Models, add and adjust vehicle types in Vehicle Types, Vehicle Classes, and adjust speeds and Vehicle Compositions.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25jul1485

- ✓ Input traffic volume in Vehicle Inputs first so that vehicles can exit/appear during the run.
- ✓ Determine the travel route in Static Vehicle Routing Decisions
- ✓ Determine the traffic light cycle in the 3D Traffic Signal menu
- ✓ Set the conflict area in the Conflict Areas menu
- ✓ Select the evaluation type and run the simulation
- ✓ Perform calibration using trial and error until results are close to the observed data.Repeat step 7 until the results obtained are close to the field observations

III. RESULT AND DISCUSSION

➢ *Geometric Characteristics of Intersections*

The Emi Saelan – Basuki Rahmat intersection is a four-way intersection consisting of four arms: Emi Saelan Street on the north side, Basuki Rahmat Street on the east side, Towua Street on the south side, and I Gusti Ngurah Rai Street on the west side.

Table 1 Geometric Characteristics of the Emi Saelan–Basuki Rahmat Street Intersection

Intersection Geometric	Emi Saelan Road (2/2 UD)		Basuki Rahmat Road (2/2 UD)		Towua Road (2/2 UD)		I Gusti Ngurah Rai Road (2/2 UD)	
	Left	Right	Left	Right	Left	Right	Left	Right
Number of Lanes	2	2	2	2	1	1	2	2
Number of Routes	1	1	1	1	1	1	1	1
Lane Width (m)	3,5	3,5	3,5	3,5	4,75	4,75	2,75	2,75
Route Width (m)	7	7	7	7	4,75	4,75	5,5	5,5
Median Width	-	-	-	-	-	-	-	-

➢ *Vehicle Types*

The VISSIM application database contains several vehicle types by default, defined in 3 dimensions, including length, width, and height, according to the existing vehicle model. LV vehicles include city cars, sedans, multi-purpose vehicles (MPVs), minibuses, and pickup trucks. HV vehicles include small trucks and large trucks, small buses and large buses. MC vehicles include underbone motorcycles, automatic motorcycles, and sportbikes.

➢ *Signal Timing Data*

Traffic control at the Emi Saelan – Basuki Rahmat intersection uses a four-phase system: phase 1 for the Emi Saelan intersection, phase 2 for the Towua intersection, phase 3 for the Basuki Rahmat intersection, and phase 4 for the I Gusti Ngurah Rai intersection.

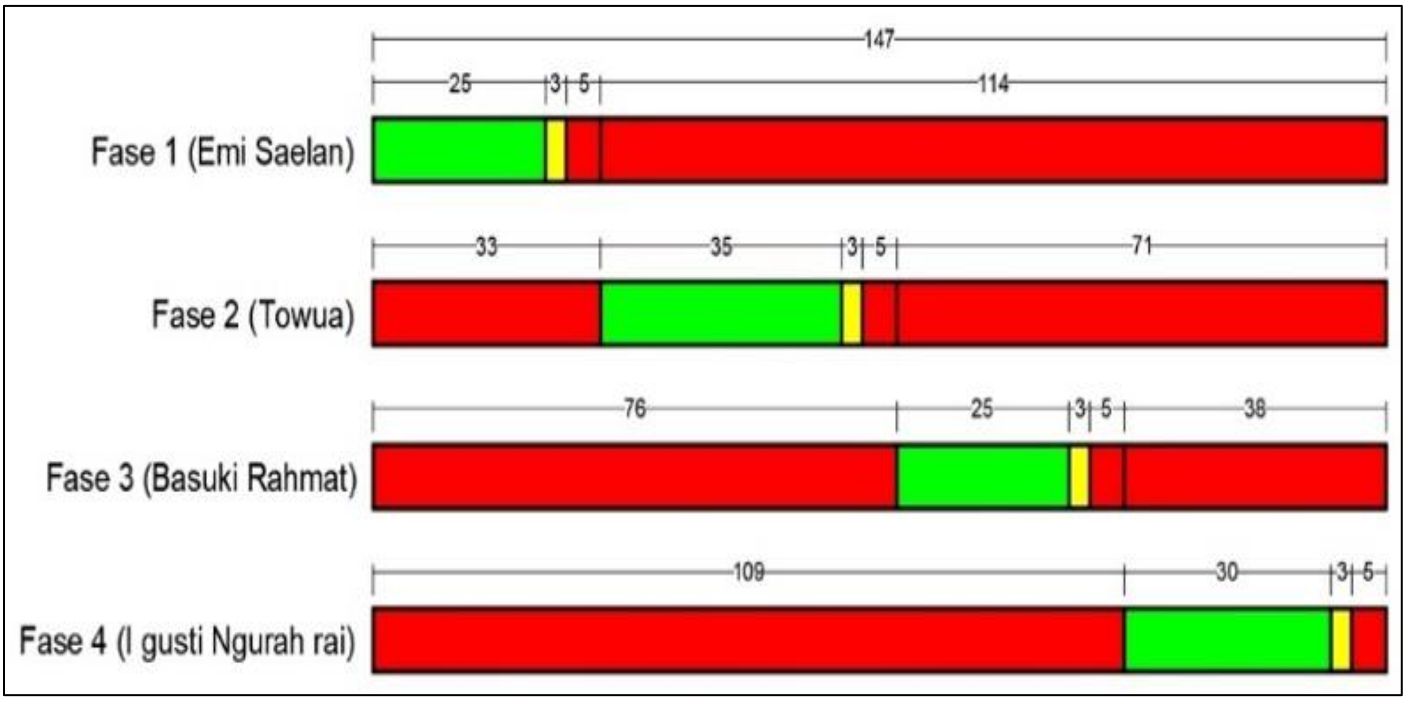

Fig 2 Cycle Time Phase Diagram

➢ *Vehicle Volume*

Vehicle volume data at The Emi Saelan – Basuki Rahmat intersection was collected on Tuesday, September 24, 2024, from 6:00 a.m. to 10:00 p.m. WITA (16 hours).

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25jul1485

Table 2 Peak Traffic Volume Data

Period	From	To	Vehicle (Vehicle/Hour)			Total (Vehicle/Hour)
			MC	LV	HV	
06.45 WITA - 07.45 WITA	North	West	382	90	0	1889
		South	561	135	3	
		East	562	154	2	
	Total		1505	379	5	
	South	East	101	102	17	2719
		North	1224	333	37	
		West	710	174	21	
	Total		2035	609	75	
	East	North	305	150	2	1171
		West	472	147	5	
		South	63	27	0	
	Total		840	324	7	
	West	Selatan	562	98	2	2783
		East	596	186	4	
		South	1115	220	0	
	Total		2273	504	6	**8562**

The composition of travel routes and vehicles at an intersection will affect intersection performance, particularly queue length. The distribution of traffic flow at each intersection arm during peak hours (6:45–7:45 WITA) can be seen in Figure 3.

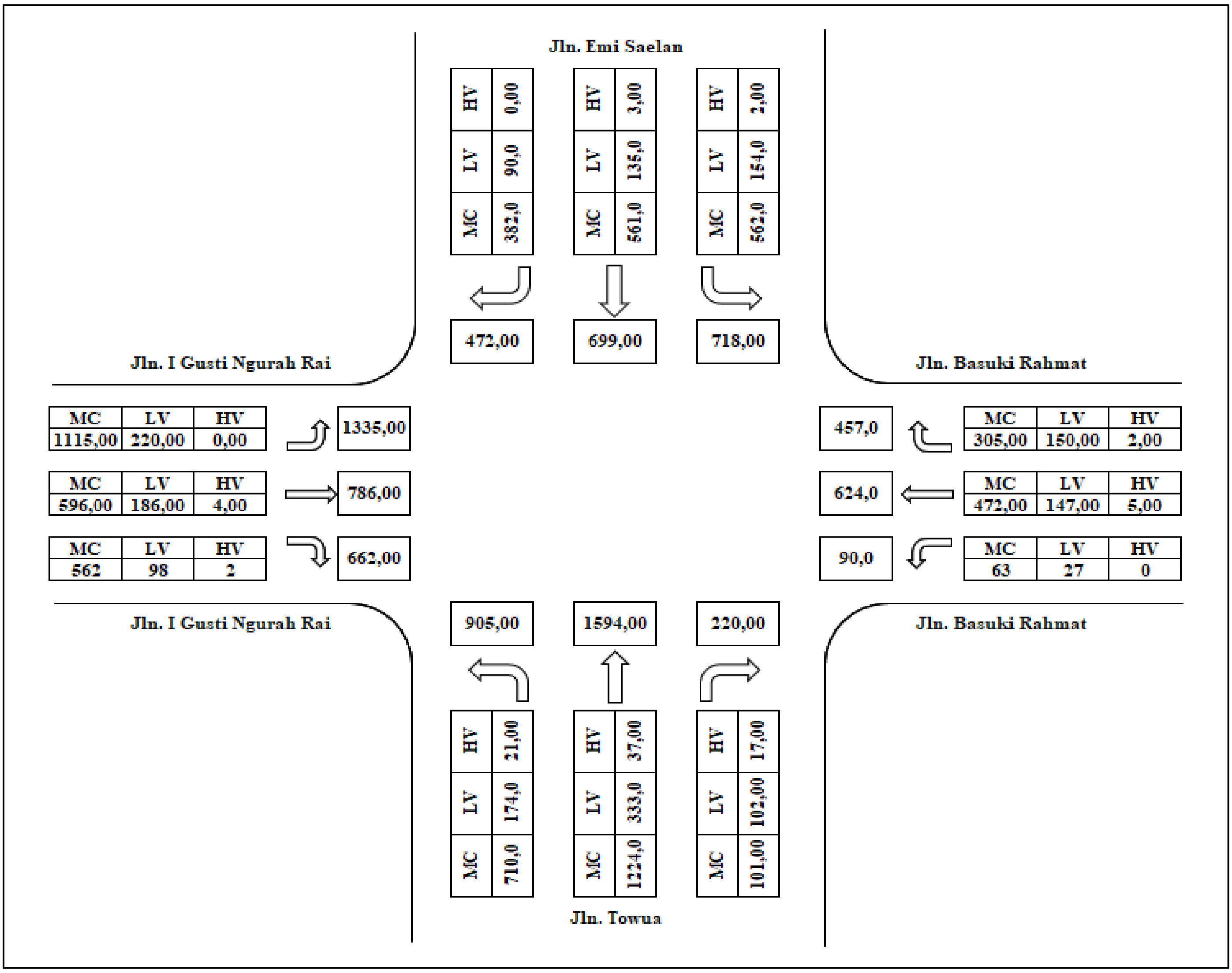

Fig 3 Traffic Flow Distribution During Morning Peak Hour (06.45 – 07.45 WITA)

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25jul1485

The distribution of traffic movement at the Emi Saelan Street – Basuki Rahmat Street intersection shows that the morning peak hour occurs at 06.45 – 07.45 WITA, marked by a significant increase in traffic volume, especially by two-wheeled vehicles (motorcycles) which dominate the flow of vehicles. At this time, community activities are very dense because it coincides with the departure hours for schools, campuses, and offices. College and school students who start their studies in the morning are the largest group of road users, followed by employees and workers heading to work.

➢ *Speed*

Vehicle speed data obtained through the results of a field survey on Tuesday, October 1, 2024 at each approach is shown in Figure 4,5,6.

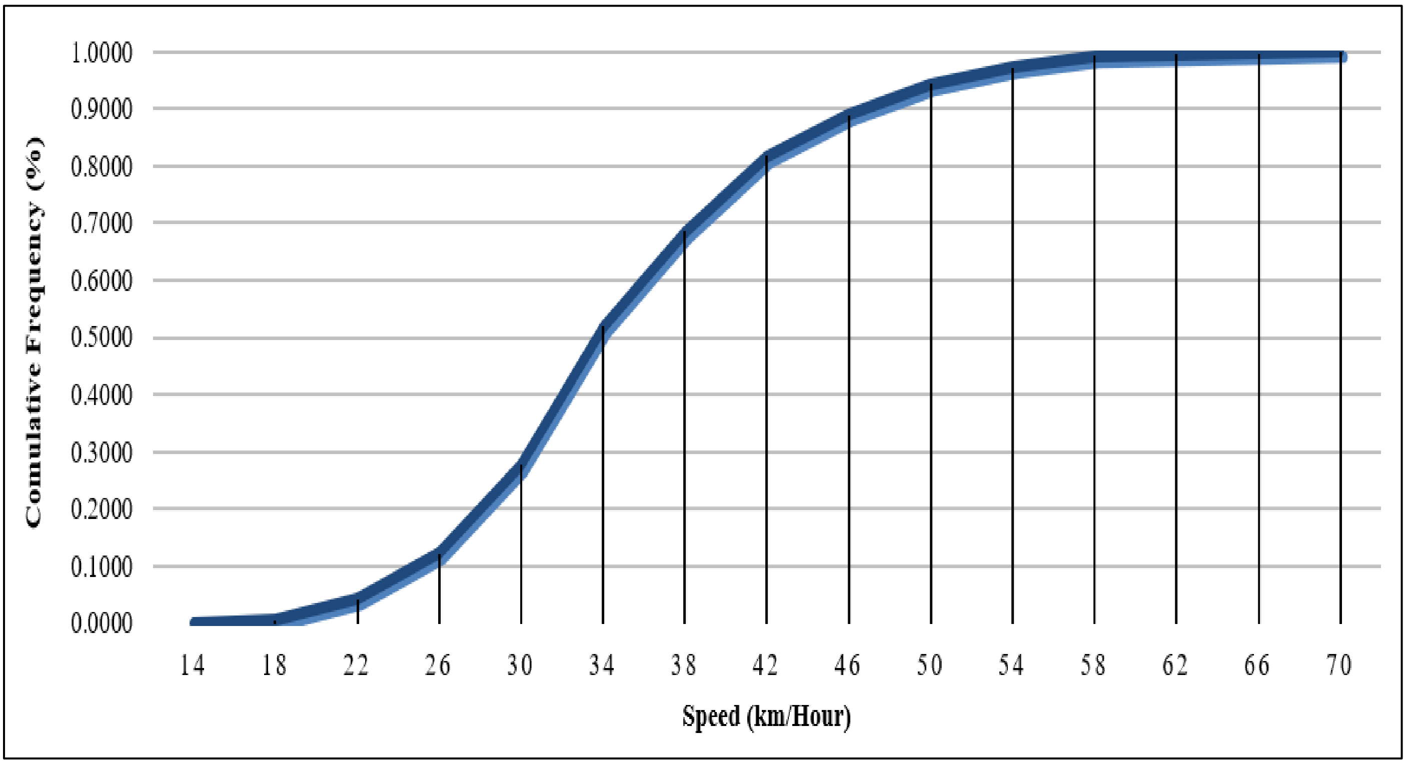

Fig 4 Cumulative Distribution of Motorcycle Free Speed

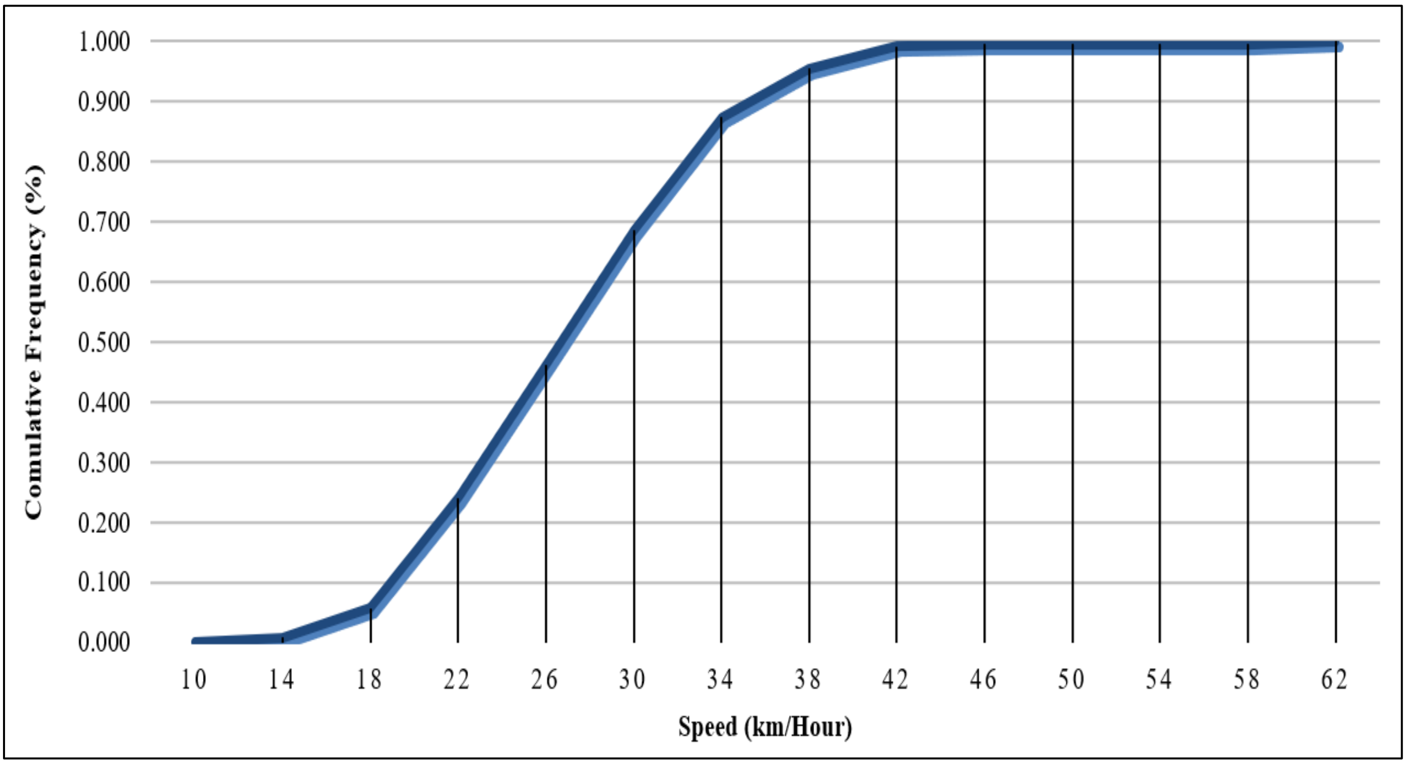

Fig 5 Cumulative Distribution of Car Free Speed

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25jul1485

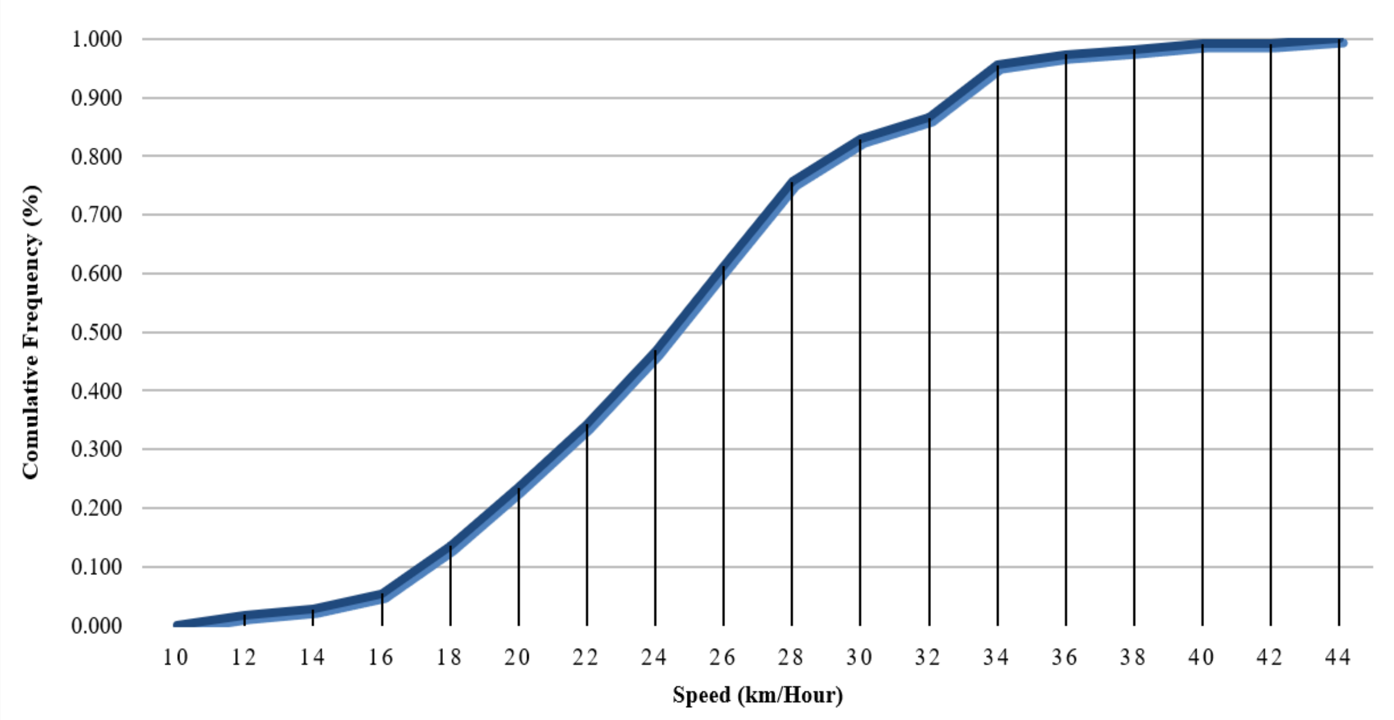

Fig 6 Cumulative Distribution of Free Speed (HGV)

Figures 4, 5, and 6 show the cumulative speed frequency curves for three vehicle types: motorcycles, light vehicles, and heavy vehicles. Heavy vehicles have the lowest speed distribution. Approximately 100% of heavy vehicles travel at speeds below 38 km/h. This indicates that heavy vehicles tend to travel slower than other vehicle types.

Light vehicles have a wider speed distribution than heavy vehicles, with most vehicles traveling between 24 and 36 km/h. This distribution indicates relatively stable and controlled speeds. Motorcycles show the widest and highest speed distribution. Approximately 50% of motorcycles travel at speeds below 36 km/h, but recorded maximum speeds reach up to 66 km/h. This indicates that motorcycles tend to travel faster on the road.

➤ *Calibration*

The calibration process in the simulation modeling was carried out by adjusting driver behavior parameters through trial and error until the simulation results in VISSIM adequately represented the actual conditions at the study site.Changes in driver behavior configuration at the Emi Saelan – Basuki Rahmat intersection can be seen in Table 3.

Table 3 Trial and Error in the Calibration Process of the Emi Saelan – Basuki Rahmat Road Intersection

No.	Parameters Changed	Value	
		Before	After
1	Has Overtaking lane	Off	On
2	Reduce Speed	No	Yes
3	Average standstill distance	2	0,5
4	Additive part of safety distance	2	1
5	Multiplicative part of safety distance	3	1
6	Desired position at free flow	Middle of Lane	Any
7	Overtake on same lane: on left & on right	Off	On
8	Distance standing (at 0 km/h) (m)	1	0,2
9	Distance driving (at 50 km/h) (m)	1	0,5

The Wiedemann 74 model has three main parameters: the average standstill distance, which determines the average distance between two consecutive vehicles. The value varies between -0.1 meters and +1.0 meters, typically distributed around 0.0 meters with a standard deviation of 0.3 meters. The additive part of the safety distance, which is the value used to calculate the safe distance, and the multiplicative part of the safety distance, which is the safety distance multiplier.

The Wiedemann 74 model used to regulate driver behavior in this study determines the safe distance between one vehicle and another in front of and behind (following). The calculation of the safe distance is as follows.

Vehicle safety distance (d) = ax + bx

= ax + (bx_add + bx_mult x z) x √v

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25jul1485

(ax) is the average standstill distance, (bx_add) is the additive part of the safety distance, (bx_mult) is the multiplicative part of the safety distance, and (v) is the average speed of the light vehicle at the final calibration.

Fig 7 Before Calibration

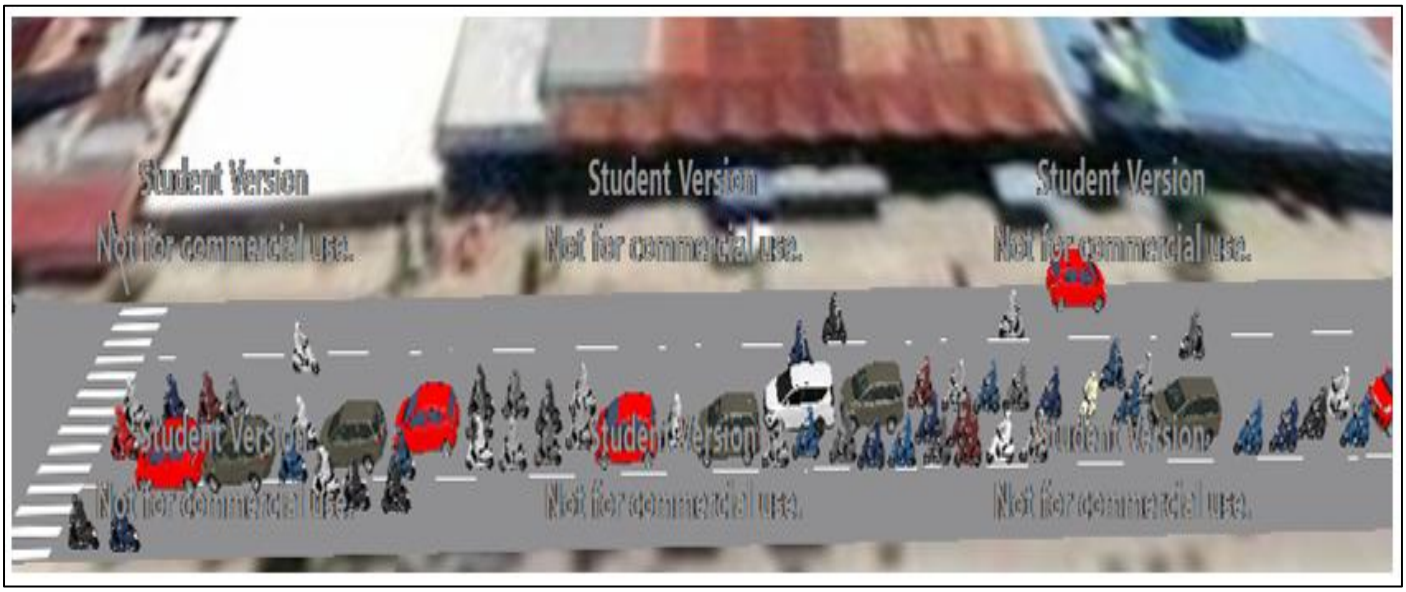

Fig 8 After Calibration

Figure 7 illustrates vehicle movements that are orderly and consistently remain within their respective lanes, reflecting a traffic condition that is still well-regulated. In contrast, Figure 8 shows that the pattern of vehicle movements becomes more irregular, with vehicles following at very close distances and frequent occurrences of overtaking maneuvers.

➢ *Validation*

In this study, the indicators used as references in the validation process were vehicle volume and queue length. To measure the accuracy of vehicle volume between simulation results and observational data, the GEH (Geoffrey E. Havers) statistical method was used, which is commonly used in transportation model evaluation because it can assess absolute differences by considering average values. Meanwhile, to evaluate the error rate in queue length, the MAPE (Main Absolute Percentage Error) method was used, which measures the average absolute percentage error between simulation results and actual data. The GEH formula is expressed in equation 1 below:

$$GEH = \left[\sqrt{\frac{(qsimulated - q\ observated)^2}{0{,}5\ x\ (q\ simulated + q\ Observated)}} \right] \quad (1)$$

Description: q = traffic volume (vehicles/hour)

The GEH equation calculation for GEH values <5.0 is considered an acceptable simulation. Values 5.0 ≤ GEH ≤ 10.0 require re-examination, and GEH values >10 are likely incorrect data input.

Table 4 GEH Test Results after Calibration

Location	Intersection approach	Vehicle Volume (vehicles/hour)		GEH	Results
		Observation	Vissim		
Emi Saelan Road – Basuki Rahmat Road	North	1889	1713	4,1	Accepted
	South	2719	2505	4,2	Accepted
	East	1171	1136	1,0	Accepted
	West	2783	2563	4,3	Accepted

Table 4 shows the results of the GEH statistical test for the vehicle volume variable at each intersection approach. The GEH value for the north approach is 4.1, the south approach is 4.2, the east approach is 1.0, and the west approach is 4.3. All GEH values <5 indicate that the simulation results are close to actual traffic conditions in the field, therefore this simulation model is declared valid.

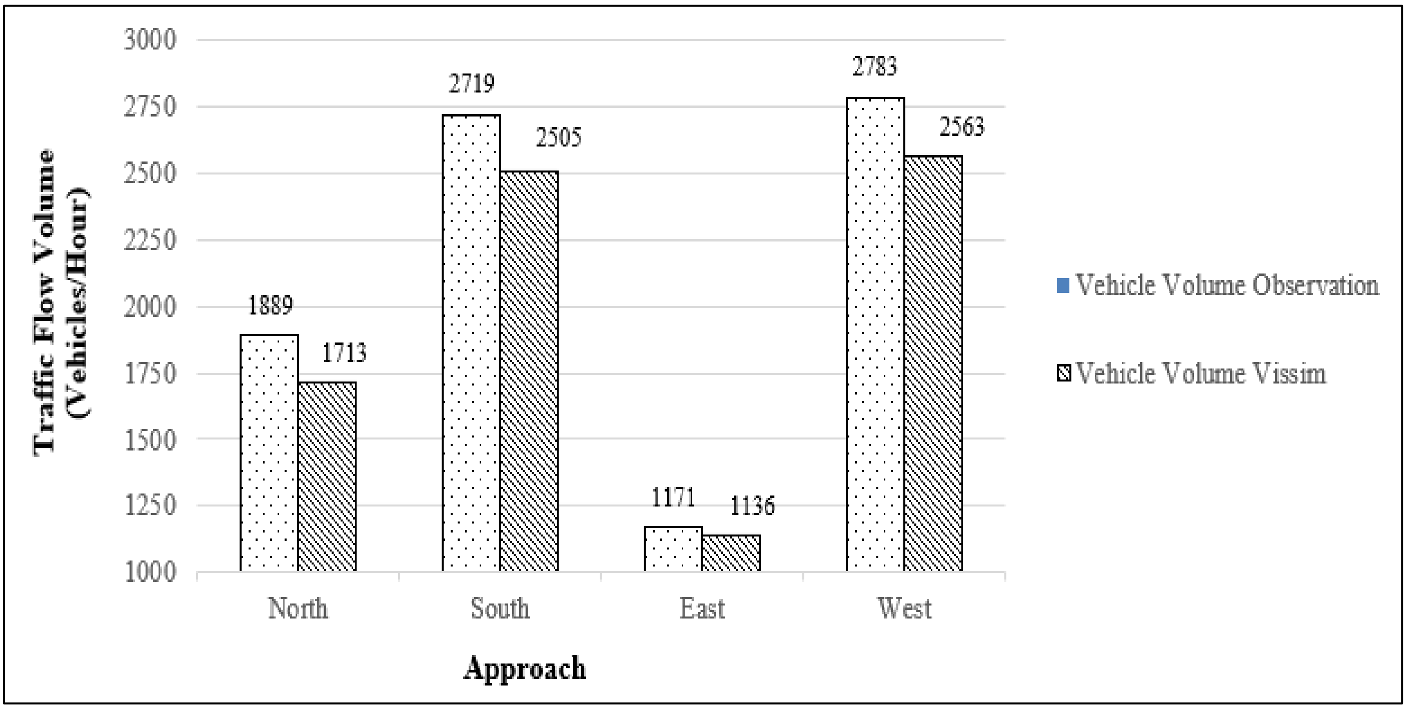

Fig 9 GEH Test Results After Calibration

Validation for queue length uses the MAPE (Mean Absolute Percentage Error) formula. The MAPE formula is as in equation 2 below:

$$\text{MAPE} = \frac{1}{n}\sum_{t=1}^{n} \frac{At - Ft}{At} + \cdots x\ 100\% \quad (2)$$

Description:

n = Number / Total data
At = Field data
Ft = Simulation data

A range of MAPE values <10% indicates excellent forecasting capability, 10-20% indicates good forecasting capability, 20-50% indicates fair forecasting capability, and >50% indicates poor forecasting capability.

Table 5 MAPE Test Results after Calibration

Intersection approach	Queue Length							MAPE (%)	Results
	Observation	Running Simulation					Average		
		1	2	3	4	5			
North	135	83	211	107	85	153	128	5,4	Accepted
South	200	203	199	183	176	186	189	5,3	Accepted
East	110	72	142	89	97	110	102	7,3	Accepted
West	150	122	203	104	174	109	142	5,0	Accepted

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25jul1485

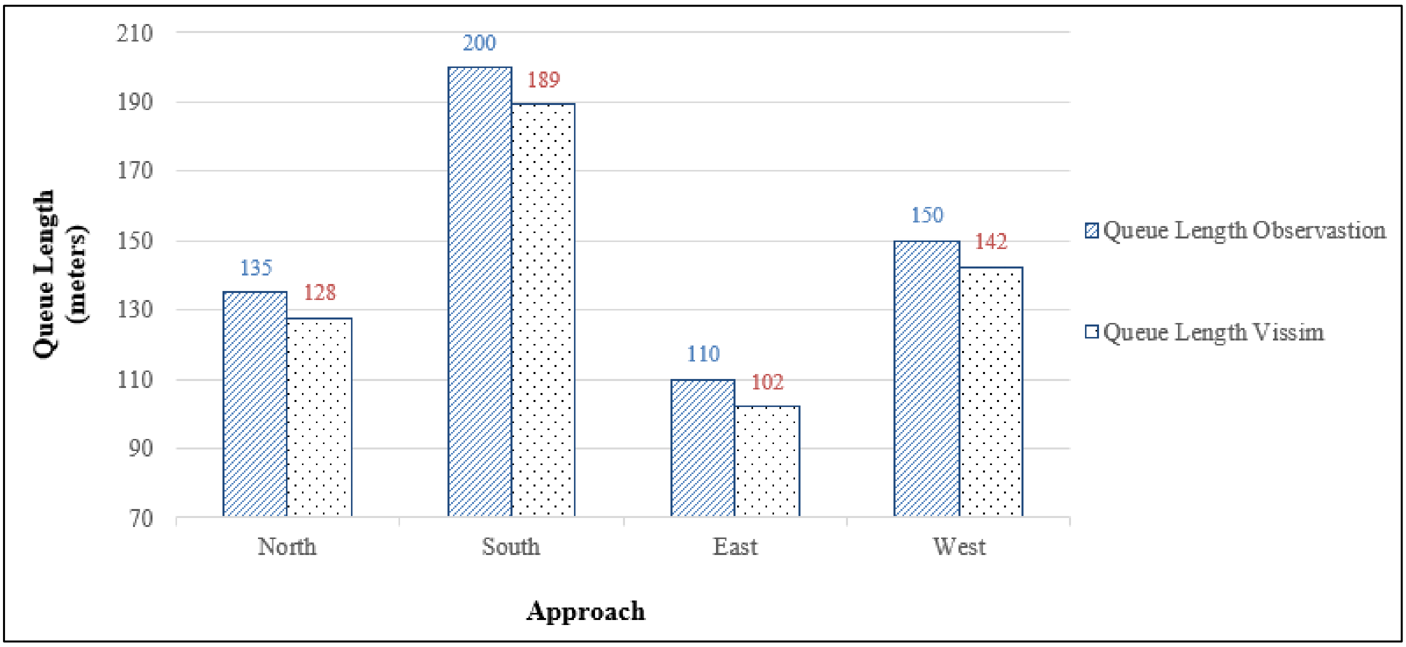

Fig 10 MAPE Test Results After Calibration

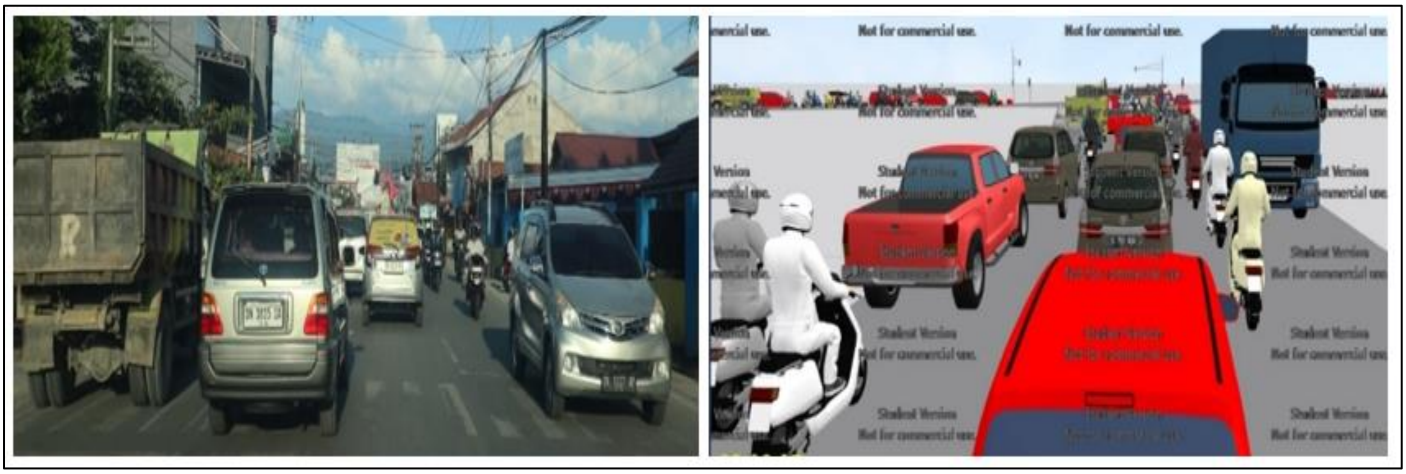
(a) Before Calibration (b) After Calibration
Fig 11 3D View of Intersection Calibration

Figure 9 shows a visualization of the simulation model which is not too far from the description of conditions in the field, where the position of the vehicle and the distance between the left, right and front and rear of the vehicle show a position which is almost similar between the model and the field, this means that the simulation created is valid.

➢ *Microsimulation Results Under Existing Conditions*

The results of the traffic performance analysis at the Jalan Emi Saelan – Jalan Basuki Rahmat intersection under existing conditions using Vissim software are shown in Table 6.

Table 6 VISSIM Microsimulation Results at Existing Intersections

Location	Intersection approach	Traffic Volume (vehicles/hour)	Queue Length (meters)	Delay (second)	LOS (HCM) 2010
Emi Saelan Road Intersection – Basuki Rahmat Road	North	1713	128	82	F (>80 det)
	South	2505	189	93	F (>80 det)
	East	1136	102	82	F (>80 det)
	West	2563	142	92	F (>80 det)

Table 6 shows that during the morning peak, the longest queues from the VISSIM simulation occurred on the southbound arm (189 meters), and the shortest on the eastbound arm (102 meters). The highest delay of 93 seconds occurred on the southbound arm, while the other arms were in the range of 82–92 seconds. Because all delays exceeded 80 seconds, the intersection was classified as Level of Service (LOS) category F across all approaches.

➢ *Alternative Handling of Intersections*

In this study, a green time optimization analysis was conducted as an alternative solution using microscopic simulations. Green time optimization was performed by adjusting the total cycle time based on the 2023 PKJI provisions, which is 130 seconds, changing all red times to 2 seconds and the time between greens to 5 seconds. Adjustments were made by redistributing the green time in each phase based on the existing traffic volume.

Table 7 Signal Time Data on Alternative

Signal Time	North Emi Saelan (second)	South Towua (second)	East Basuki Rahmat (second)	West I Gusti Ngurah Rai (second)
Red	101	90	110	89
Yellow	3	3	3	3
Green	24	35	15	36
All Red	2	2	2	2
Total	130	130	130	130

After obtaining the signal time values for each intersection arm, a simulation was performed using Vissim software. The simulation results produced data on queue lengths, delays, and service level indexes.

Table 8 Alternative Green Time Optimization Simulation Results

Location	Intersection approach	Queue Length (meters)	Delay (second)	LOS (HCM) 2010
Emi Saelan Road Intersection – Basuki Rahmat Road	North	141	66	E (>55 – 80 detik)
	South	168	87	F (>80 detik)
	East	83	77	E (>55 – 80 detik)
	West	128	59	E (>55 – 80 detik)

Based on the results of the Vissim simulation for alternative 1 (green time optimization), the service level index on the north, east and west arms is in category E (LOS > 55-80 seconds), while on the south arm it is in category F (LOS > 80 seconds).

Table 9 Comparison of Alternative Simulation Results and Existing Conditions

Condition		Queue Length (meters)				Delay (second)			
		U	S	T	B	U	S	T	B
Existing		128	189	102	142	82	93	82	92
Alternative	Outcome	141	168	83	128	66	87	77	59
	Difference	+13	-22	-19	-16	-16	-6	-5	-33

Based on the comparison results in Table 4.12, the North arm shows a 13-meter increase in queue length and a 16-second reduction in delay compared to the existing condition. The South arm experiences a 22-meter decrease in queue length, followed by a 6-second decrease in delay. Meanwhile, the East arm experiences a 19-meter decrease in queue length and a 5-second decrease in delay. The West arm shows a 16-meter decrease in queue length and a significant decrease in delay, namely 33 seconds.

IV. CONCLUSION

The simulation results show that the signalized intersection is at service level F (delay value > 80 seconds), with the highest queue and delay occurring on the south arm (189 meters and 93 seconds) due to high traffic volume, especially from the south and west. The alternative handling implemented is signal time optimization where there is an increase in the road service level on the north, east and west arms to E (> 55 – 80 seconds) with the highest delay on the south arm (87 seconds) and a queue length of 168 meters.

REFERENCES

[1]. Gustavsson, F.N. (2007). Transportation Research Progress. New York: Nova Science Publishers, Inc
[2]. HCM (2010). Highway Capacity Manual, Transportation Research Board National Research Counccil. Washington DC.
[3]. Hobbs, F. (1995). Perencanaan dan Teknik Lalu Lintas (Vol. Edisi Kedua). Yogyakarta: Gajah Mada University Press.
[4]. Irawan, M. Z., dan Putri, N. H. (2015). Kalibrasi Vissim untuk mikrosimulasi arus lalu lintas tercampur pada simpang bersinyal (Studi Kasus: Simpang Tugu, Yogyakarta). Jurnal penelitian transportasi multimoda, 13, 97 - 106. DOI:10.25104/mtm.v13i3.180
[5]. Maulana, A., dan Nugraha, F. A. (2019). Studi Mikrosimulasi Penilaian Kinerja Persimpangan Bersinyal Jalan Ir. H. Juanda - Cikapayang. 26 No 2, Agustus 2019, 183-188.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25jul1485

[6]. Menteri Perhubungan. (2015). Peraturan Menteri Perhubungan Nomor : PM 96 Tahun 2015 tentang Pedoman Pelaksanaan Kegiatan Manajemen dan Rekayasa Lalu Lintas. Jakarta: Menteri Perhubungan.
[7]. Romadhona, P. J., Ikhsan, T. N., dan Prasetyo, D. (2019). Aplikasi Permodelan Lalu Lintas PTV Vissim 9.0. Yogyakarta: UII Press Yogyakarta.
[8]. Putri, N. H., dan Irawan, M. Z. (2015). Mikrosimulasi Mixed Traffic Pada Simpang Bersinyal Dengan Perangkat Lunak Vissim (studi Kasus: Simpang Tugu, Yogyakarta), dalam Prosiding The 18th FSTPT Internasional Symposium, Unila, Bandar Lampung
[9]. Sugiyono. (2014). Metode Penelitian Pendekatan Kuantitatif, Kualitatif, dan R&D. Bandung: Alfabeta.
[10]. Yulianyahya, R. W., Irawan, M. Z., dan Dewanti. (2019). Pengaruh Perilaku Mengemudi Agresif Terhadap Kinerja Simpang Bersinyal (Studi Kasus ; Simpang Gayam dan Simpang Wirobrajan, Yogyakarta). 52, Dalam Prosiding Seminar Nasional Pascasarjana, Departemen Teknik Sipil FT-UI, Depok, 4 Juli 2019