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Optimization of Vehicle Queue Length Using PTV Vissim at Talang Buluh Intersection, Banyuasin Regency

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Abstract. Traffic congestion is a common issue in developing metropolitan areas, impacting both economically and socially. Long vehicle queues result in delays for many vehicles, which increases travel time and contributes to deteriorating air quality due to emissions from motor vehicles at intersections. One of the influencing factors is the non-optimization of intersections due to delays. Previous studies commonly use the Highway Capacity Manual Indonesia, 2023, to analyze intersection optimization. However, this study will utilize PTV Vissim software. In planning the intersection, some factors must be considered, such as capacity, density, speed, and type. An average daily traffic survey and a road geometric survey will be conducted in the field survey. The analysis will be performed using PTV Vissim software to optimize the 3 (Three) Talang Buluh intersection in Banyuasin Regency by examining the impact of vehicle queue length and evaluating policies for improving traffic management. According to the analysis results, the data from the First Scenario shows that the maximum vehicle queue length reaches 124.02 meters, with an average delay of 18.75 seconds from the Palembang direction. In the second scenario, installing traffic signal control devices increased the queue length to 287.95 meters from the Betung direction, with the most extended delay reaching 129.52 seconds. The third scenario, which involved geometric changes at the intersection, successfully reduced the vehicle queue length to just 47.70 meters from the Palembang City direction. Additionally, the most extended delay recorded was only 11.59 seconds, demonstrating the effectiveness of this approach, though it is costly and unsuitable for short-term use. Overall, Scenario 1 can serve as a short-term solution for intersection optimization. However, if road widening improvements are feasible, Scenario 3 is the optimal solution for enhancing traffic efficiency and effectiveness, significantly reducing vehicle queues and delays. This is crucial for implementing long-term traffic management strategies at the Talang Buluh Intersection in Banyuasin Regency.

Keywords: Transportation; Intersection; Vehicle; Microsimulation; Congestion.

INTRODUCTION

Congestion is common in every city that is in the stage of developing into a metropolitan city. Sometimes, congestion causes a lot of harm to the community, from economic to social aspects. Long queues of vehicles increase travel time and improve the quality of the environment. One of the influencing factors is the non-optimization of intersections. Previous studies commonly use the Highway Capacity Manual Indonesia to analyze intersection optimization. Some factors must be considered in planning the intersection, including capacity, traffic density, speed, and type [16].

Traffic congestion at intersections is affected by vehicle density and queue length, contributing to delays that slow traffic and reduce intersection efficiency. As noted by Rikki Sofyan Rizal et al. (2022), these delays are derived from the total average time vehicles face congestion, which has a negative impact on traffic flow and safety and can thus be said to be a form of rider inconvenience due to loss of travel time. Since speed is a key measure of traffic service quality, improving intersection capacity is essential to reduce travel time, improve overall performance, and assist policymakers in developing effective traffic management strategies. [11] To find out the effect of this, according to the Indonesian Road Capacity Guidelines book in 2023, one of the influences on the length of the vehicle queue is seen from the degree of saturation. The degree of saturation can be defined as the ratio of flow to intersection capacity and as the main factor in determining the performance level of intersections and road segments by looking at the degree of saturation (DS) value. The degree of saturation value will show whether the road has a capacity problem or not. To analyze the intersection's level of service, this research uses software from PTV Vissim. PTV Vissim software is used to analyze intersection performance, as research by Raudhati et al. (2019) demonstrated that vehicle queue length impacts intersection efficiency and contributes to air pollution from motor vehicles passing through the intersection. [6]

The current condition at the Simpang Tiga Talang Buluh, Banyuasin Regency, involves the intersection of the national road section 004 Batas Kota Palembang-Betung and Diponegoro Road. As a key economic corridor on the island of Sumatra, this route links several provinces, including Lampung, Jambi, Bengkulu, Riau, and Aceh. For this reason, this study aims to optimize the Talang Buluh intersection in Banyuasin Regency by analyzing the effect of vehicle queue length and policies on optimizing traffic management.

METHODOLOGY

This study was carried out using PTV Vissim software, which has been validated and calibrated to reflect real-world conditions closely. The following is a flowchart outlining the research process in this journal :

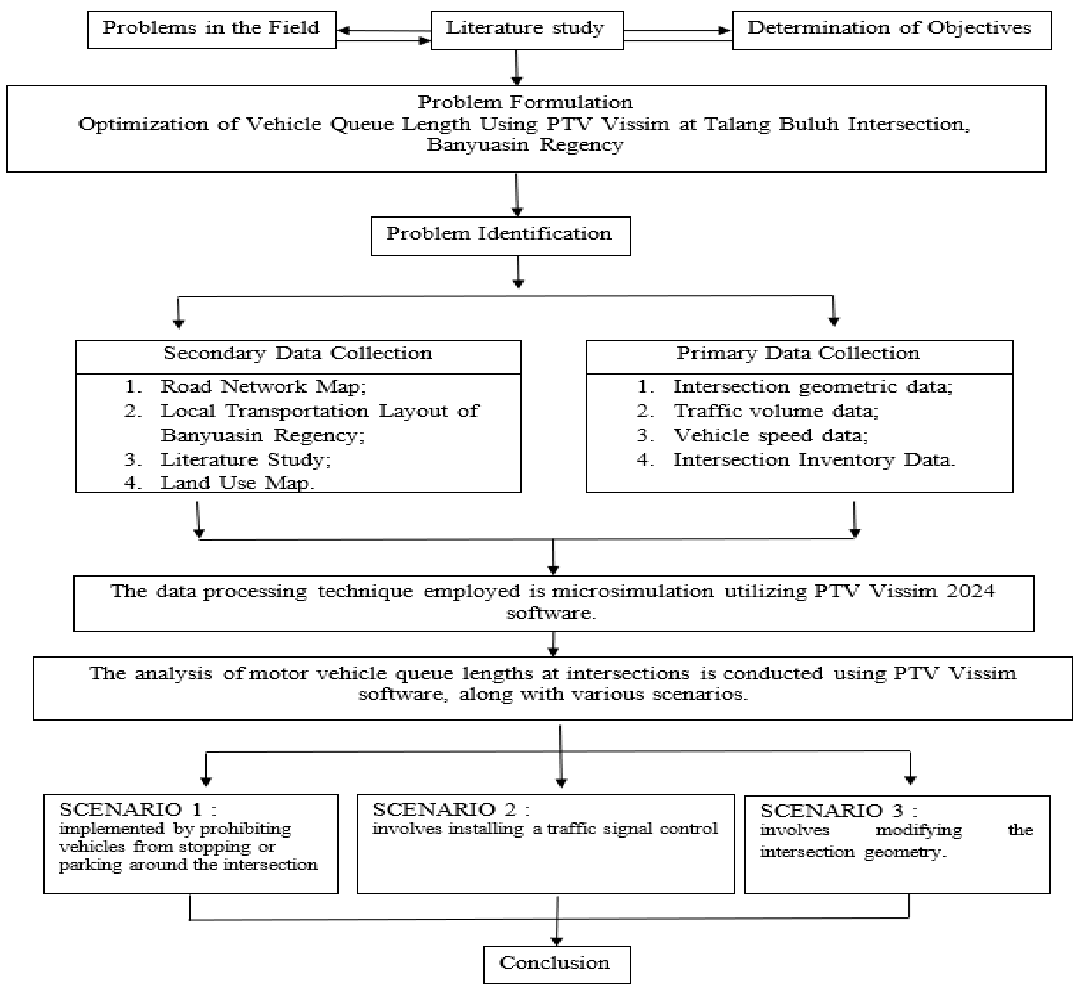

FIGURE 1. Flowchart outlining the research process

Intersection

An intersection is an integral part of the road traffic network, as a node of the meet 2 (two) or more roads, which join, intersect, or cross accordingly. [3] [5] [10] [15] [16] Intersections are divided into 2 (two) types: Grade Intersection and Grade Separate Intersection. A grade-separated intersection meets two or more roads on one plane at the same elevation. The design of this intersection is a T or Y-shaped, four-foot or more intersection for intersections that are not level where one road and another road do not meet in one plane, such as an intersection with a flyover. Intersection control can be divided into 2 (two): unsignalized and signalized.

An unsignalized intersection is where the driver of the vehicle must decide for himself whether it is safe or not to enter the intersection if the signalized intersection is an intersection that is regulated by a traffic signal (APILL) and must meet several conditions, such as a minimum flow above 750 vehicles/day and 175 pedestrians/hour for 8 hours on an ongoing basis, the average waiting time of the vehicle has exceeded 30 seconds, accidents often occur at the intersection, for this reason, it must adjust the technical guidelines for traffic regulation according to the Decree of the Director General of Land Transportation Number: 273 / HK.105 / DRJD / 96 cited from Haradongan, (2019). [9]

In the intersection area, traffic issues become more complex due to the constraints caused by varying traffic flow directions and patterns. [4] So that with a variety of characters that can have an impact on congestion if there is no traffic control at the intersection, with the following problems that exist at the intersection:

1. Traffic volume and road capacity (affecting bottlenecks)
2. Vehicle speed;
3. Road geometrics;
4. Side obstacles (parked vehicle users and traders)
5. Driving behavior.

Data Collection

Primary data used for analysis included road geometric data, traffic volume, and vehicle speed data, which were calculated and analyzed as follows:

1. Intersection geometric data was collected to determine the existing conditions at the foot of the intersection and around the road section;
2. Traffic volume was conducted by surveying turning movements at each leg of the intersection to determine the number of vehicles passing through the intersection;
3. Vehicle speed can be done using a speed gun, for which measurements are made using a speed gun by determining the location point of the surveyor by directing the speed gun in the direction of the arrival of the vehicle whose speed you want to know, and for the maximum recommended distance of 300 meters from the surveyor's point, for the angle of shooting the target vehicle must not be perpendicular to the target vehicle, by directing the red dot of the speed gun towards the passing vehicle. The unit used is kilometers per hour (kph).

Analysis with PTV Vissim software

The collected survey data is analyzed to assess the current conditions of the intersection, which are then input into the PTV Vissim application to evaluate the performance of the 3 (Three) Talang Buluh intersection in Banyuasin Regency. The data is processed using PTV Vissim, providing insights into vehicle queue length, traffic volume, delay time, and air pollution levels from motorized vehicles.

PTV Vissim software data processing includes calibration and validation to align with actual field conditions. The analysis can proceed to the next stage if the data is accurate. However, if discrepancies are found, adjustments to Driving Behavior settings are required, as illustrated in the flowchart below :

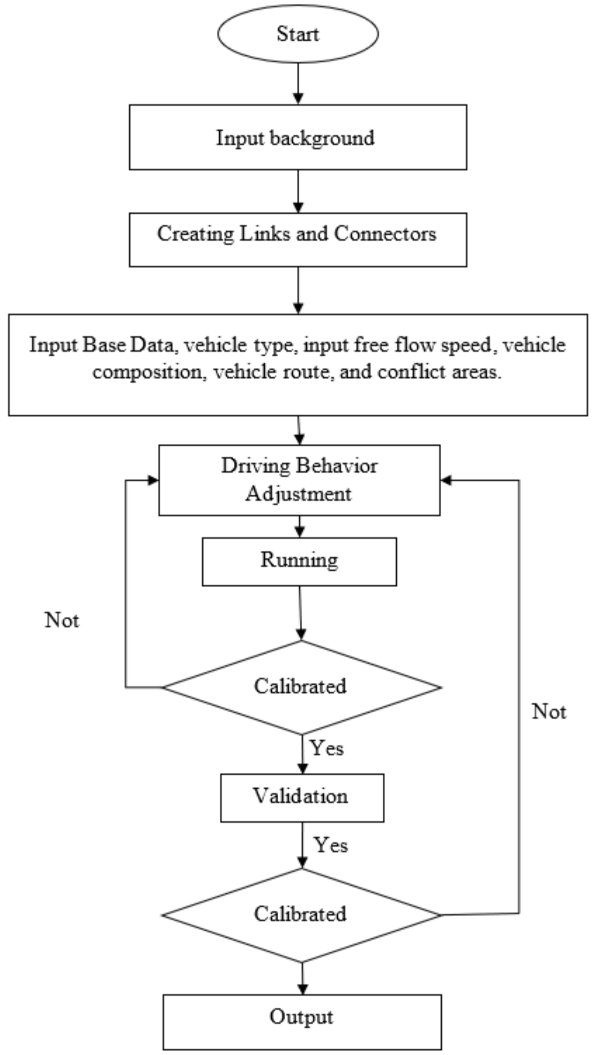

FIGURE 2. Flowchart of PTV Vissim software

A trial and error process is carried out with several trials to produce data that matches the conditions in the field. The calibration performed is located in the driving behavior menu. In the driving behavior section, the parameters changed for calibration are following lateral movement and lane change. This research can be continued by analyzing changes in road section performance that traffic speed parameters can measure. A validation test process on vehicle volume is carried out in each experiment. If it has met the validation test, use the best value from the whole test.

Calibration

Vissim simulation model calibration establishes appropriate parameter values so that the model can replicate traffic to conditions that are as similar as possible. The calibration process can be done based on driver behavior by referring to previous research on calibration using Vissim, and the method used is trial and error. The calibration process is carried out based on the amount of traffic flow volume and queue length, according to Nurjannah Haryanti Putri and Muhammad Zudhy Irawan (2015). To make it easier to calibrate in vision software for specific areas, a review of previous research regarding calibration that has been done as a reference material in research is carried out. The parameters selected in the calibration process are as follows:

1. Desired position at free flow, which is the presence/position of the vehicle in the lane during free flow;
2. Overtake on the same lane, which is the behavior in overtaking, by setting the minimum distance;
3. Distance standing, which is the distance between drivers side by side when stopping;

4. Distance driving, which is the distance between drivers side by side when walking;
5. Average standstill distance, which is a parameter that determines the desired average safe distance between two vehicles;
6. Additive part of safety distance, which is a parameter that determines the safety distance, such as a driver braking suddenly;
7. The multiplicative part of safety distance is an additional safety distance determining parameter for abnormal driving conditions.

Validation

Validation of the Vissim simulation model is a process of testing the correctness of the calibration results by comparing observations and simulation results. The validation process is carried out based on the amount of traffic flow volume and queue length, according to (Irawan et al., 2015).

Validation involves verifying the calibration results by assessing the entered data, including basic and calibration parameters adjusted through calculations. The accuracy of these data in representing actual conditions is evaluated using the Geoffrey E. Havers (GEH) statistical test method to determine the model's reliability based on VISSIM and field survey results. In the model calibration process, the Geoffrey E. Havers (GEH) method in 1970 developed the GEH formula, which is used to validate the results of traffic simulation modeling and is a modified statistical formula based on chi-squared calculations by correlating the value of the calculation of its results with the results of the Vissim simulation calculation or it can be said that the comparison of the absolute value with the relative results of Vissim. The GEH formula calculation and the specific score criteria outlined in Table 1 are presented below.

$$\text{GEH} = \sqrt{\frac{(\text{Qobservation}-\text{Qsimulation})^2}{0{,}5\ x\ (\text{Qobservation}-\text{Qsimulation})}}$$

Keterangan :
Qobservation = Survey data on traffic flow volume (Vehicle/Hour)
Q simulation = PTV Vissim simulation result data

TABLE 1. Assessment of GEH (Geoffrey E. Havers) Statistical Test Results

Value	Description
GEH < 5,0	Accepted
5,0 ≤ GEH ≤ 10,0	kemungkinan model *error* atau data salah
GEH > 10,0	Rejected

Source: Geoffrey E. Havers

RESULT AND DISCUSSION

The results of the existing condition data survey were carried out for 12 hours, on holidays on July 21, 2024, and weekdays on July 22, 2024, from 08.00 am - 4.00 pm, from the results of the data survey in the field as follows:

Intersection Geometric Condition

For geometric conditions based on the results of the road geometric survey, the following data were obtained:

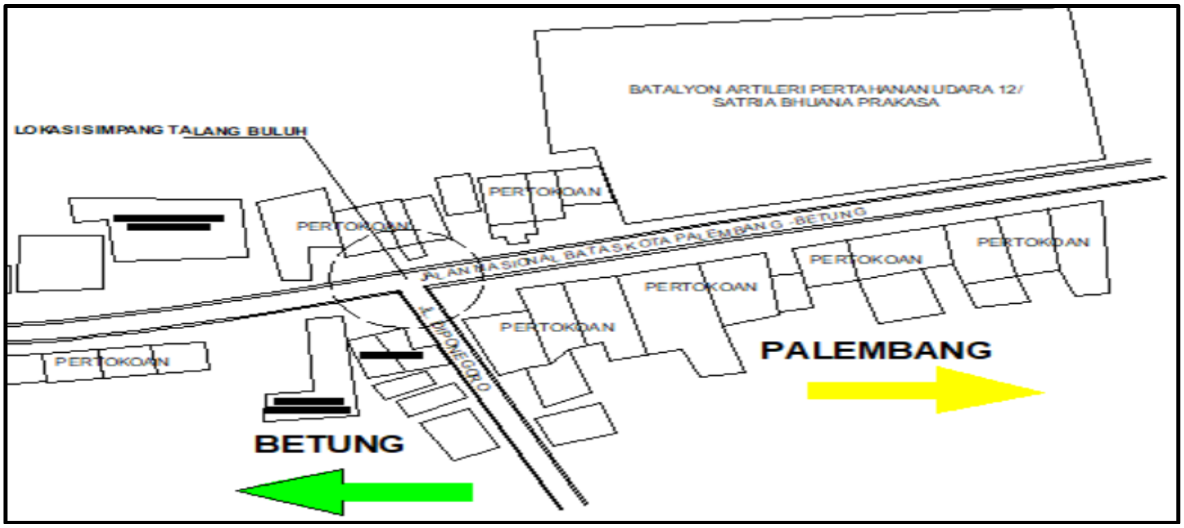

FIGURE 3. Location map of Intersection Talang Buluh

Intersection Talang Buluh is located at KM.18 of the National road Palembang - Betung, from Palembang city ± 4 km to the intersection. With geometric data of the intersection :

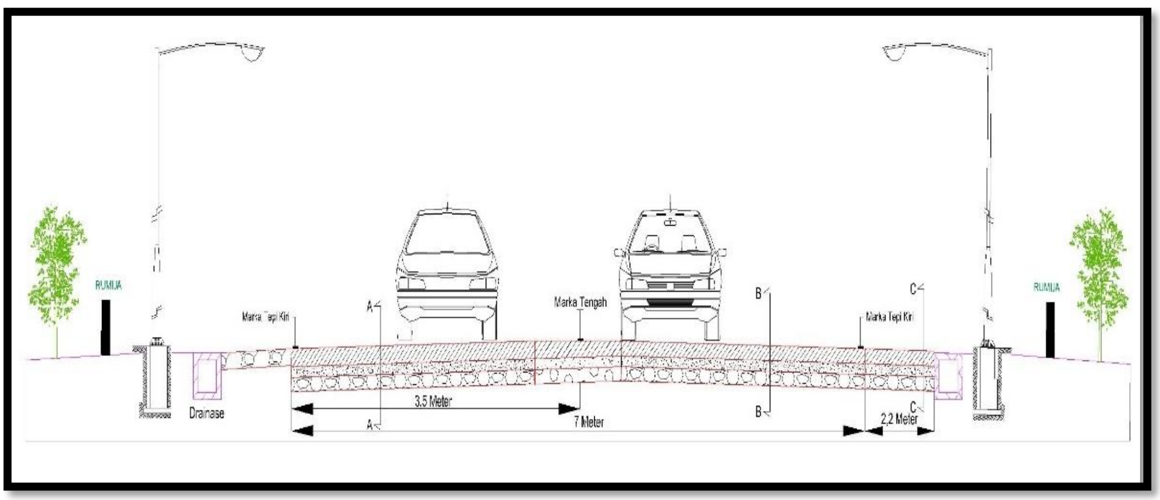

FIGURE 4. Cross-section of national road Palembang – Betung

TABLE 2. National road Palembang - Betung 2/2 UD

Pendekat	**Lebar (meter)**
W_{entry}	3,5
Lajur 1	3,5
Lajur 2	3,5
W_{exit}	3,5
Lajur 1	3,5
Lajur 2	3,5

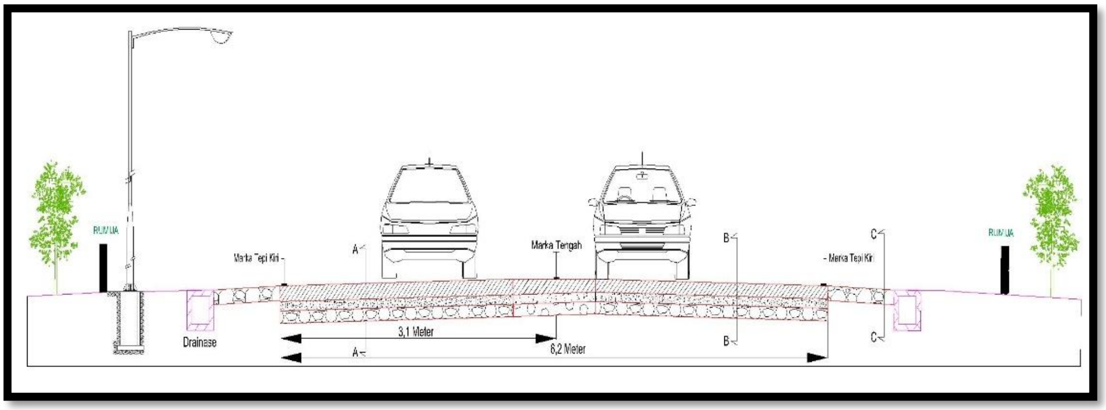

FIGURE 5. Cross-section of Diponegoro Road

TABLE 3. Diponegoro Road 2/2 UD

Pendekat	Width (meter)
W_{entry}	3,2
Lane 1	3,1
Lane 2	3,1
W_{exit}	3,2
Lane 1	3,1
Lane 2	3,1

After obtaining road geometric data, an average daily traffic survey was conducted at Intersection Talang Buluh, Banyuasin Regency.

Volume of traffic

Surveys were conducted to determine the volume of vehicles for 12 hours on holidays on July 21, 2024, and weekdays on July 22, 2024, from 08.00 am - 4.00 pm with the following data:

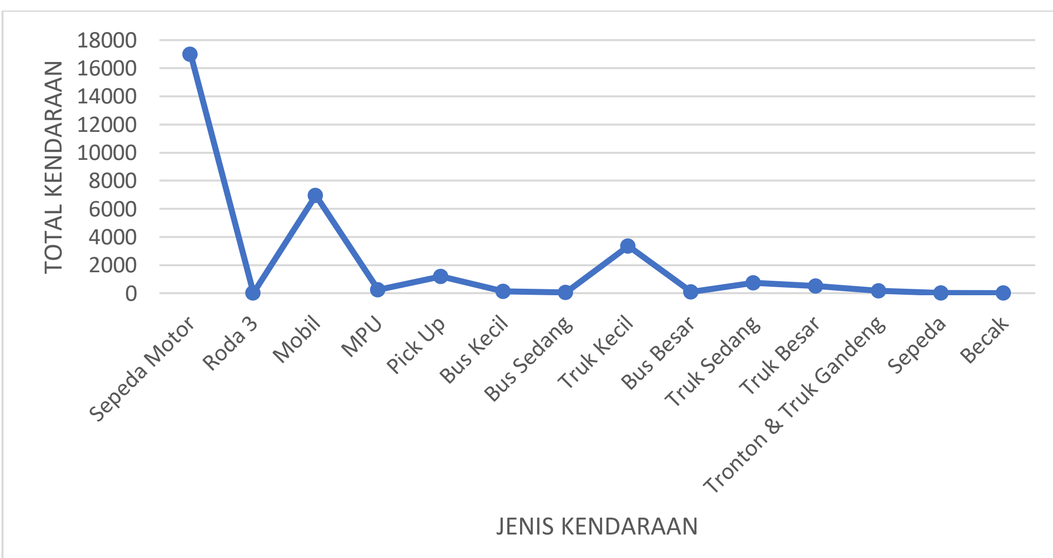

FIGURE 6. Traffic volumes on weekdays

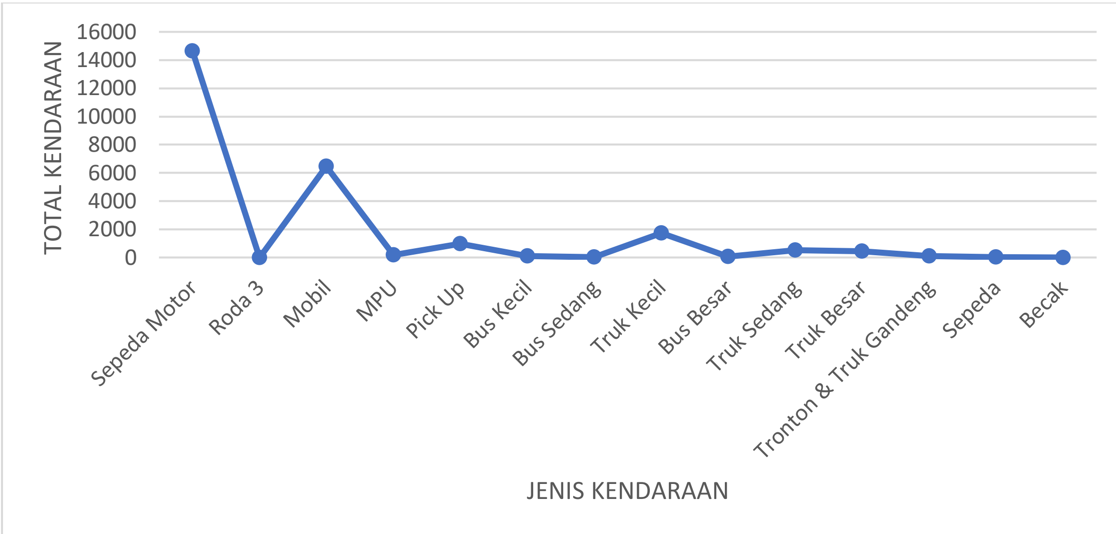

FIGURE 7. Traffic volumes on holidays

Based on survey data conducted for 12 hours on weekdays and holidays, the total number of vehicles is obtained as follows :

TABLE 4. Comparison of vehicle volume on weekdays and holidays

Date	Number Of Motor Vehicles
19 November 2023 (Sunday)	25287
20 November 2023 (Monday)	30414

Vehicle Velocity

Vehicle speeds were obtained using a speed gun by random sampling, and the following are the results of the field survey data:

TABLE 5. Vehicle speed Palembang city boundary road - Betung

Vehicle Type	Maximum Speed (KMH)	Minimum Speed (KMH)	Average Speed (KMH)
Motorcycle	63	25	36
Car	42	13	29,7
Pick up	40	16	29,6
Small Bus	40	20	29,1
Medium Bus	38	18	28,1
Big Bus	33	15	25,3
Small Truck	38	19	28,5
Medium truck	35	21	27,6
Big Truck	33	17	24,9
Heavy-duty Truck	31	14	22,3

TABLE 6. Vehicle speed Diponegoro Road

Vehicle Type	Maximum Speed (KMH)	Minimum Speed (KMH)	Average Speed (KMH)
Motorcycle	46	22	34

Vehicle Type	Maximum Speed (KMH)	Minimum Speed (KMH)	Average Speed (KMH)
Car	37	22	31,2
Pick up	40	24	33,6
Small Bus	34	25	30
Medium Bus	0	0	0
Big Bus	0	0	0
Small Truck	38	29	34,7
Medium truck	34	28	30,4
Big Truck	0	0	0
Heavy-duty truck	0	0	0

FIGURE 8. Traffic conditions around the intersection

Data calibration and validation

The survey data in the field is entered into the PTV Vissim application and calibrated until it is close to existing conditions, which then validates whether the results can be accepted. Using the following lane change and lateral parameters in PTV Vissim is critical to simulated vehicle behavior in a transportation network so that the simulation results are closer to existing conditions. The following are the calibration results by changing the following parameters, lane change parameters, and lateral parameters:

TABLE 7. Adjustments to driver behavior parameters for calibration purposes.

Calibration To	Modified parameters	Value	
		Before	After
0	*Default*	-	-

Calibration To	Modified parameters	Value	
		Before	After
1	*Following* (*Look ahead distance maximum*)	250 meter	150 meter
	Number of interaction object	4	10
2	*Number of interaction object*	10	2
	Average standstill distance	2 meter	0,20 meter
	Additive part of safety distance (m)	2	0,10
	Multiple Parts of a Safety Distance	3	1
3	*Overtake reduces speed areas.*	-	5 second
	Desired position at free-flow	*Middle of lane*	*Any*
	Distance Driving	1	0,4
4	*Overtake Left*	-	√
	Overtake Right	-	√

Adjusting the driving behavior in the following lane change and lateral parameters will make the simulation results more realistic and accurate in solving traffic problems. Changing these parameters helps make decisions related to traffic management at the intersection.

Validation is used to determine the results of the calibration that has been done, as the basic parameters and calibration parameters are adjusted through calculations to present actual conditions using the Geoffrey E. Havers (GEH) statistical test. Based on this data, the results of the number of vehicles/hour from the field survey and the results of the PTV Vissim simulation are validated, and these results, if Accepted, can be continued to make treatments to reduce delays, vehicle queue lengths, and air pollution from vehicles by comparing problem-solving scenarios. The following are the results of the GEH test that has been carried out.

TABLE 8. Data validation results

Name of Road	Data Survey	Simulation PTV Vissim	Method GEH	Description
Jalan Nasional Batas Kota Palembang – Betung (Dari Palembang)	1017	1001	0,50	Accepted
Jalan Diponegoro (Dari Talang Buluh)	355	354	0,07	Accepted
Jalan Nasional Batas Kota Palembang – Betung (Dari Betung)	1163	1153	0,28	Accepted

Results from the GEH test then all data Accepted and fulfilled because it is below the score of 5 (five), which is then carried out in scenario 1, prohibiting vehicles from stopping around the intersection, scenario 2, installation of traffic signal control devices, and scenario three geometric changes to the intersection by widening the intersection legs.

Data analysis

Data analysis is carried out after obtaining existing condition data that has been validated to determine the effect of the length of the vehicle queue at the foot of the intersection, and based on three scenarios, the results will be used as an evaluation to reduce the length of the queue of motorized vehicles.

FIGURE 9. A simulated view of PTV Vissim under existing conditions.

Scenario 1

Scenario 1 is implemented by prohibiting vehicles from stopping or parking around the intersection and restricting traders to eliminating side obstacles. The results regarding vehicle queue length and delay are presented in Table 10 and Table 11. Based on these tables, the delay time has decreased in all directions. However, the vehicle queue length has increased from the Palembang City direction, while from the Betung direction, it has decreased from 206.02 meters to 52.5 meters. In Talang Buluh Village, no vehicle queue was observed. The limitation of this scenario is that it serves only as a short-term solution. If the volume of vehicles continues to grow each year without any increase in road capacity, the intersection's level of service will deteriorate over time.

FIGURE 10. Results Scenario 1

Scenario 2

Scenario 2 involves installing a traffic signal control device to regulate the intersection using traffic lights, which is expected to provide better results. The cycle time was calculated based on three phases using the Webster method and analyzed with Microsoft Excel. The planned cycle time was determined to be 34 seconds, with green light durations of 15 seconds for the Palembang and Betung directions and 5 seconds for the Talang Buluh direction. The results of Scenario 2, presented in Table 10 and 11, indicate that the intersection's level of service deteriorates compared to both the existing conditions and Scenario 1. This decline is due to increased delay time and longer vehicle queues, making this scenario ineffective for implementation.

FIGURE 11. Results Scenario 2

Scenario 3

Scenario 3 involves modifying the intersection geometry by widening the road to 7 meters per lane, resulting in a total lane width of 14 meters. The geometric expansion for the Batas Kota Palembang - Betung national road extends 100 meters from the intersection, while for Diponegoro Road, the widened section covers 20 meters from the intersection. The results of this scenario are presented in Table 10 and Table 11.

Based on these findings, Scenario 3 is considered a long-term solution due to the significant reduction in vehicle queue length and delay time compared to existing conditions and other scenarios, making it the most effective option. However, its drawback lies in the high cost associated with road widening and the time required for construction.

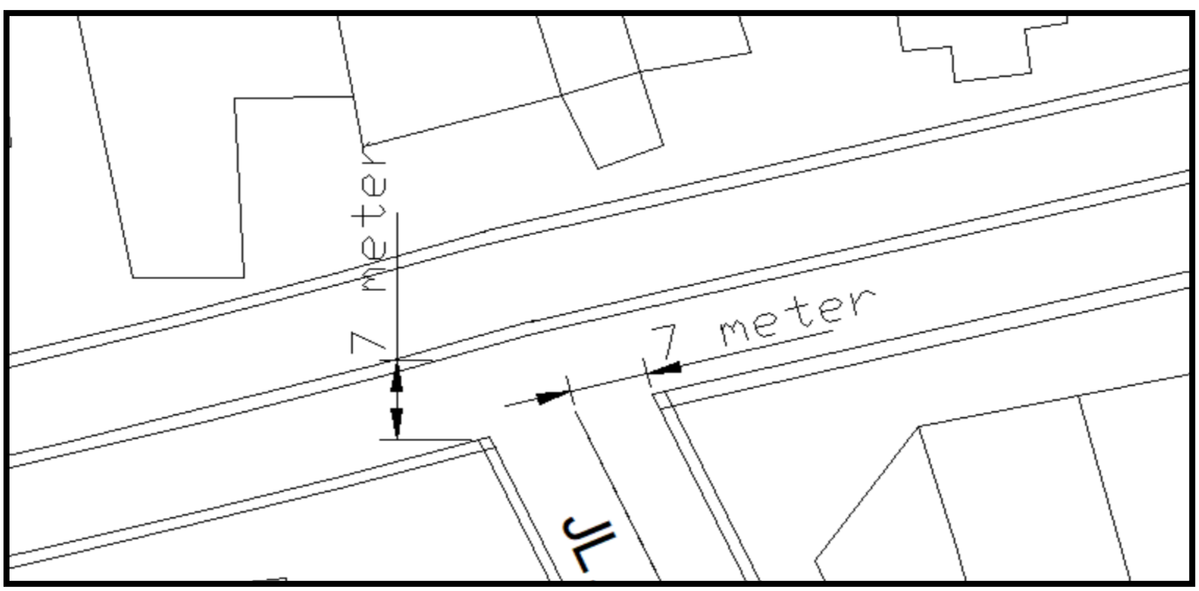

FIGURE 12. Changes to intersection geometrics, with lane widening in Scenario 3

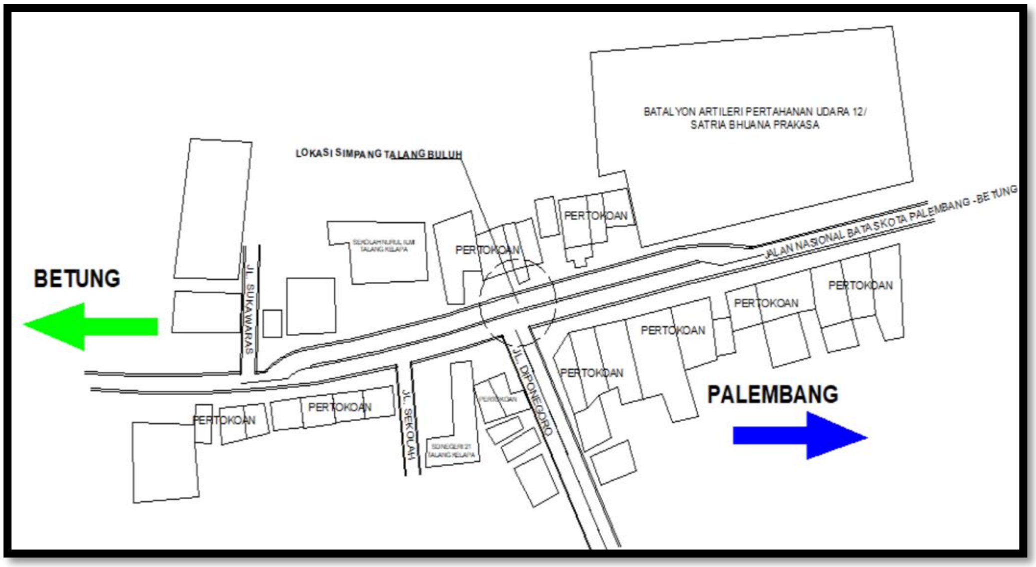

FIGURE 13. Changes in Intersection Geometrics in Vissim Scenario 3 Simulation

The simulations were conducted using Software PTV Vissim microsimulation, running for 3600 seconds. This software was chosen as evaluation material for optimizing queue length at the Talang Buluh Intersection in Banyuasin Regency.

FIGURE 14. Geometric changes at each leg of the intersection in Vissim Simulation Scenario 3

From the three scenarios that have been implemented, the comparison results regarding the number of vehicles, vehicle queue length, and delay time are as follows :

TABLE 9. Results of comparison of vehicles

Name of road	Number of Vehicles (vehicles/hour)				
	Survey Results	PTV Vissim Simulation			
		Existing Condition	Scenario 1	Scenario 2	Scenario 3
Jalan Nasional Batas Kota Palembang – Betung (Dari Palembang)	1017	1001	1206	1051	1010
Jalan Diponegoro (Dari Talang Buluh)	355	354	353	324	324

Name of road	Number of Vehicles (vehicles/hour)				
	Survey Results	PTV Vissim Simulation			
		Existing Condition	Scenario 1	Scenario 2	Scenario 3
Jalan Nasional Batas Kota Palembang – Betung (Dari Betung)	1163	1153	1153	863	845

TABLE 10. Results of vehicle queue length comparison

Name of road	Queue Length of Vehicles (Meter)			
	Existing Condition	Scenario 1	Scenario 2	Scenario 3
Jalan Nasional Batas Kota Palembang – Betung (Dari Palembang)	56,82	124,02	112,17	47,70
Jalan Diponegoro (Dari Talang Buluh)	0	0	51,68	0
Jalan Nasional Batas Kota Palembang – Betung (Dari Betung)	206,02	52,50	287,95	31,64

TABLE 11. Hasil perbandingan waktu tundaan kendaraan

Name of road	Delay time (seconds)			
	Existing Condition	Scenario 1	Scenario 2	Scenario 3
Jalan Nasional Batas Kota Palembang – Betung (Dari Palembang)	35,22	18,75	25,81	11,59
Jalan Diponegoro (Dari Talang Buluh)	4,57	1,64	21,98	1,03
Jalan Nasional Batas Kota Palembang – Betung (Dari Betung)	27,22	14,62	129,52	5,84

CONCLUSION

From the analysis, it can be concluded that Scenario 3 shows the best performance in reducing vehicle queue length and delay time when compared to existing conditions, as well as Scenario 1 and Scenario 2.

- **Scenario 1** shows the maximum vehicle queue length reaching **124.02 meters** with an average delay time of **18.75 seconds** from the Palembang direction. Although better than the existing conditions, it can still be maximized again for intersection optimization.
- **Scenario 2**, by installing traffic signal control devices, experienced an increase in queue length to **287.95 meters** from the Betung direction, with the longest delay time reaching **129.52 seconds**. These results show that without geometric changes, this solution is ineffective and makes the congestion longer, making installing traffic signal control devices ineffective.
- In comparison, **Scenario 3** presents geometric changes to the intersection, which successfully reduces the length of the vehicle queue to only **47.70 meters** from the direction of Palembang City. In addition, the longest recorded delay time of only **11.59 seconds** confirms the effectiveness of this approach, but it is costly and cannot be used as a short-term solution**.**

Overall, Scenario 1 can be a short-term solution to improve intersection performance. However, if road widening is feasible, Scenario 3 is the most effective option, significantly reducing vehicle queues and delays and improving traffic efficiency and effectiveness. This makes it a crucial consideration for long-term traffic management strategies at the Talang Buluh Intersection in Banyuasin Regency.

To support sustainable transportation research and development, the following recommendations are proposed:

1. Encouraging a shift from private vehicles to public transportation through awareness campaigns promoting public transport use and integrating public transport, cycling, and walking into the transportation network. Develop infrastructure that supports safe cycling lanes and pedestrian-friendly pathways while enhancing the convenience and reliability of public transportation systems;
2. Implement Smart Traffic Management by designing and implementing intelligent traffic systems that enhance traffic flow, alleviate congestion, and encourage the use of eco-friendly vehicles. Utilize traffic signal optimization, real-time data analysis, and predictive modeling to boost transportation efficiency. Additionally, improve PTV Vissim software or develop customized traffic simulation software that is specifically adapted to Indonesian road conditions;
3. Carry out additional research on the social, economic, and health impacts of congestion at intersections by promoting the collection of big data related to traffic patterns, transportation usage, and environmental and health effects. This data will aid in making evidence-based decisions and help optimize transportation networks while identifying areas that can be improved for sustainable transportation.

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