Micro-Simulation of Traffic at the 3-Way Junction with PTV VISSIM Software (Jalan A.P. Pettarani-Jalan Boulevard-JalanPelita Raya)

Delviyana Sariri, Muralia Hustim, Mubassirang Pasra

Abstract: This study aims to determine the traffic performance at 3-way junction of Jalan A.P. Pettarani- Jalan Boulevard-JalanPelita Raya. The study conducted a survey to obtain the geometric data and vehicle volume and then analyzed using PTV Vissim software which refers to the calibration process and validation of the simulation model using the volume and length of queues of vehicles in the field. The calibration was carried out by trial and error by considering the driver's behavior follow by the GEH Test on the vehicle volume. The simulation result was validated by Chi-Square Test on the length of the vehicle queue. Furthermore, traffic engineering is conducted with optimization of phase time and cycle time whereby optimization with increasing the cycle time from 105 seconds to 120 seconds demonstrated better traffic performance than the existing traffic performance.

Keywords: GEH Test, PTV Vissim software, Traffic simulation

I. INTRODUCTION

The increasing population growth rate in Makassar City causes higher traffic growth. On the other hand, the escalation of vehicle volume does not comparable to the improvement of road infrastructure coupled with the driver's behavior while on a road trip. These things often cause congestion, especially in the intersection area. Jalan A.P. Pettarani is one of the crucial points in the city of Makassar. The number of office centers, settlements, businesses and shopping that exist along the road causes frequent congestion, especially during peak hours. Jalan A.P. Pettarani is connected by several intersections that are close together. One of them is the intersection of Jalan Boulevard - Jalan A.P. Pettarani and Jalan A.P. Pettarani - JalanPelita Raya. The mushrooming of cafes, restaurants, hotels and shopping centers along Jalan Boulevard is a source of attraction that causes conditions of high intensity of traffic activity at the intersection.

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So that based on the description above, it is necessary to conduct further studies related to traffic performance at the intersection.

Traffic simulation investigates through modern computer technique is an effective tool to identify and determine the solution to overcome the traffic congestion problem [1]. The level of traffic model can be divided into micro-model, meso-model and macro-model, while micro-model is the high level traffic model that describes the detail of whole system and its internal relationship [2, 3]. VISSIM software is currently widely used in transportation planning and management because it is safe, fast and can directly make various alternative solutions for the operational period of the intersection without having to go down in the field [4 - 6] . Besides that, the simulation can be further optimizing by integration of different software such as VISSIM and Synchro [7]. This study determine the existing performance of 3-way junction (Jalan A.P. JalanPettarani – Bouevard, Jalan PELITA Raya) by conducting traffic modeling and then optimize the Traffic Signer Tool at the intersection. The type of modeling used is a micro-simulation model with Vissim software.

II. METHODOLOGY

The framework of this study includes preliminary studies, survey design, data collection and micro-simulation of traffic analysis. The preliminary study begins by reviewing the background of the problem, formulating the problem to the research objectives follow by preliminary survey to determine the condition of the existing research sites and identify the equipment and placement point of the survey tool. The next stage is the design of a survey to determine the equipment to be used during the survey as well as the time of the survey and followed by the data collection process both primary and secondary. The collected data is analysing by Microsoft Excel and Vissim software. The simulation model is calibrated and validated prior the optimization of the intersection performance.

Research Location and Intersection Traffic Circulation System

A traffic intersection of 3-way junction (Jalan A. P. Pettarani - Jalan Boulevard and Jalan A. P. Pettarani - JalanPelita Raya) is considered in this study.

The signalized intersections are (Jalan AP Pettarani North - Jalan AP Pettarani South - Jalan Boulevard) which had three phases of movement and one un-signalized intersection (JalanPelita Raya). The intersection layout and the direction of traffic movement at the intersection are shown in Figure 1.

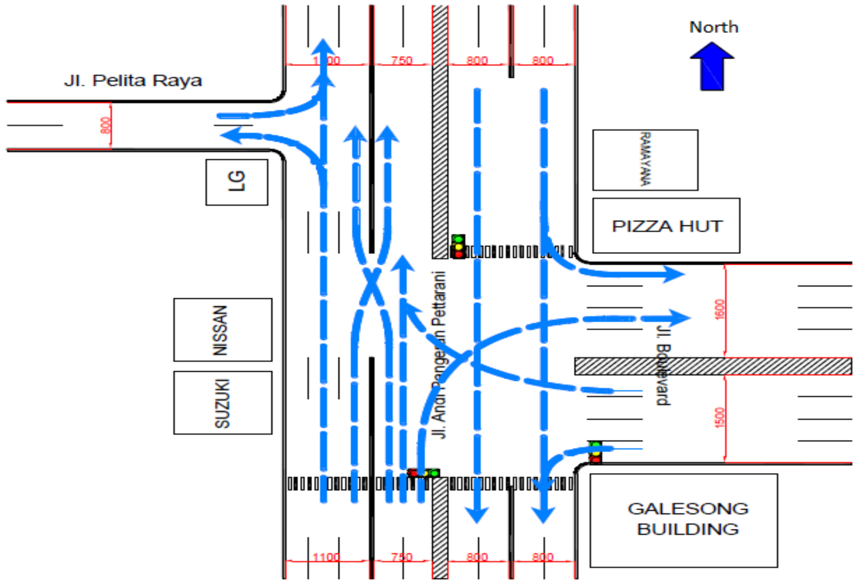

Fig. 1 Location Plan and Intersection Circulation System

Data Collection

The collected data in this study consists of primary data and secondary data. Primary data is data obtained directly at study locations such as geometric data intersections, cycle times, volume of vehicles passing, vehicle speed and queue length. While for secondary data obtained from related agencies and online media (internet). Secondary data includes Google Earth satellite imagery maps, data on the number of motorized vehicles and the growth of Makassar city roads.as well as the type and dimensions of vehicles.

Data Analysis Method Uses Vissim Software

The Vissim micro-simulation process starts from defining the geometric data intersections to create a road network. The vehicle types, composition, speed and volume of the vehicle and set the vehicle route is defined. Calibration and validation is conducted once define the Signal Control.

Calibration and Validation of Traffic Micro-Simulation Models

Calibration is the process of adjusting parameters of simulation to match real-world data. Traffic data is used as a comparison in the calibration process, which is the amount of traffic flow at the intersection [8]. The method used is trial and error with reference to previous studies and the test of Geoffrey E. Havers and the description of result are shown in Table 1.

Table. 1 Conclusions from Calculation Results Statistical Formulas Geoffrey E. Havers[9].

GEH <5.0	accepted
5.0 ≤ GEH ≤ 10.0	Warning: possible error model or bad data
GEH> 10.0	rejected

The validation process involves comparison of simulation results and observation data collected from field studies. The model is valid if the data output generated from the model to match the real-world data. In this study, the intersection performancenamely travels time (seconds) and vehicle queue (meters) is used as a comparison between modeling results and observation results.

Time Optimization of Traffic Signer Tool

The method used is changing the phase time or cycle time at the intersection that shows poor traffic performance. Rerun and validate the Vissim process with different parameter to produce an alternative optimization output.

III. ANALYSIS AND DISCUSSION

Traffic volume is the number of vehicles passing at the intersection. The data on traffic volume is obtained from direct survey results from morning to evening (06.00-18.00 WITA). The traffic volume data for each period at the intersection is presented in the form of a graph in Figure 2.Based on data on traffic volume obtained, the volume of vehicles in each period is fluctuates and varies and the largest volume occurs in the Fast Track South Pettarani. The traffic volume graph shows that the morning peak hours occur at 7:00 a.m. to 9:00 p.m., afternoon peak hour is 1:00 p.m. to 2 p.m., while the evening peak hours occur at 4:00 p.m. to 6 p.m.

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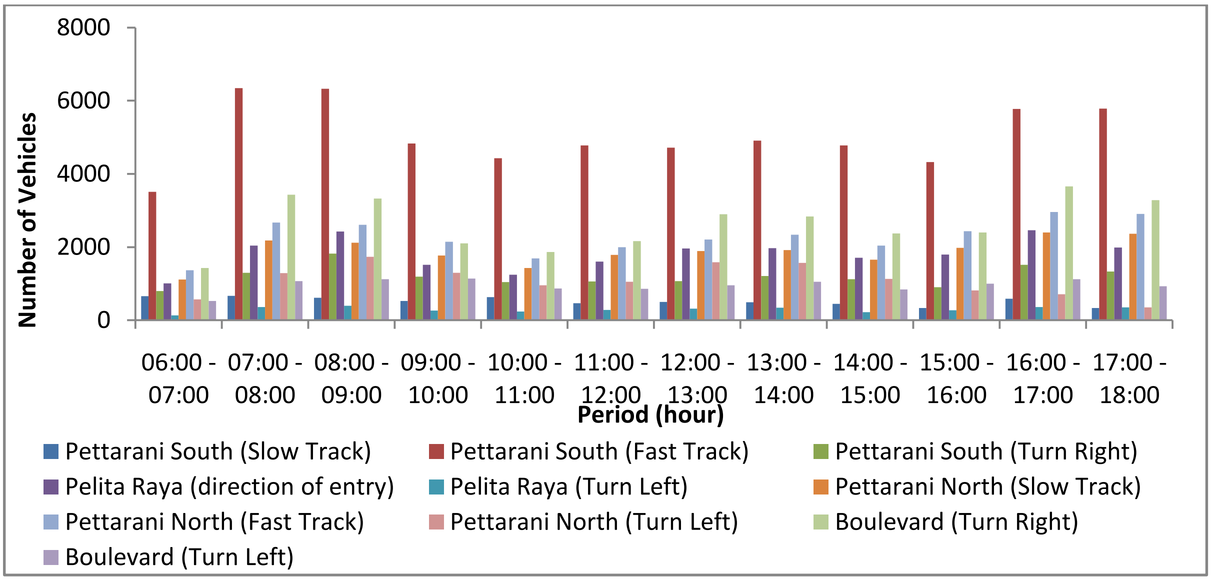

Fig. 2. Traffic volume data for each period at the intersection

Micro Calibration and Validation - Intersection Traffic Simulation

The first stage in micro-simulation modeling with Vissim software is the determination of parameter values (calibration) of models that match the real-world data. The dependent variable used is traffic volume while the independent variable used is the traffic parameters available in Vissim. The initial step is to develop the parameters of driving behavior by trial and error method. The GEH (Geoffrey E. Havers) test analysis is conducted on vehicle volume in the peak hour and non-peak hour in morning, afternoon and evening. The defined parameter values and calibration values at the intersection are tabulated in Table 2 and the Geoffrey E. Havers Value in Table 3.Table 2 shows that some parameters have the same value in each period while the Average Standstill Distance and Lateral Distance Standing parameters have different values based on the simulation time period. Table 3 shows that the results of the calibration with the GEH Test for all approaches in each period have fulfilled the requirements. Where, the value obtained is <5 which mean the simulation model can be accepted or calibrated.

Table. 2 Calibration Parameter Value

Parameter	**Period**					
	06:00-07:00	**07:00-08:00**	**11:00-12:00**	**13:00-14:00**	**15:00-16:00**	**16:00-17:00**
Average Standstill Distance	0.6	0.4	0.5	0.4	0.5	0.4
Add. Part of Desired Safety Distance	0.45	0.45	0.45	0.45	0.45	0.45
Mul. Part of Desired Safety Distance	1	1	1	1	1	1
No. of Observed Vehicle	2	2	2	2	2	2
Desired Lateral Position	*any*	*any*	*any*	*any*	*any*	*any*
Lateral Distance Driving	0.2	0.2	0.2	0.2	0.2	0.2
Lateral Distance Standing	0.65	0.45	0.55	0.55	0.55	0.50
Safety Distance Reduction Factor	0.45	0.45	0.45	0.45	0.45	0.45
Minimum Headway	0.5	0.5	0.5	0.5	0.5	0.5

Table. 3 Geoffrey E. Havers Calibration Test Results on Traffic Volume

Result	Road / approach	Period					
		06:00 – 07:00	07:00 – 08:00	11:00 – 12:00	13:00 – 14:00	15:00 – 16 :00	16:00 – 17:00
GEH test	Fast Track South Pettarani	2.12	3.87	3.32	2.42	1.96	3.82
	Slow Track South Pettarani	0.69	0.31	0.23	0.42	0.30	0.86
	Pelita Raya Turn Left	1.72	2.53	2.26	2.40	2.26	2.61
	Fast Track North Pettarani	0.99	0.46	0.33	0.43	0.54	0.89
	Slow Track North Pettarani	1.01	2.55	1.54	2.23	1.28	2.20
	Boulevard	0.41	2.08	1.53	2.45	2.80	3.85
Description		**Accept**	**Accept**	**Accept**	**Accept**	**Accept**	**Accept**

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Table. 4 Validation Results with Chi-Square Test

Result	Road	Period					
		06:00 – 07:00	07:00 – 08:00	11:00 – 12:00	13:00 – 14:00	15:00 – 16 :00	16:00 – 17:00
GEH test	Fast Track South Pettarani	0.834	3.189	2.584	2.162	6.742	1.523
	Slow Track South Pettarani	1.018	1.984	0.964	0.155	0.368	0.310
	Pelita Raya Turn Left	0.000	0.000	0.000	0.000	0.000	0.000
	Fast Track North Pettarani	0.343	1.978	3.858	2.185	0.622	1.055
	Slow Track North Pettarani	0.214	0.073	0.143	1.263	0.269	2.584
	Boulevard	1.614	0.094	0.457	0.844	0.546	0.034
Total		4.023	7.318	8.006	6.608	8.546	5.506
Description		Accept	Accept	Accept	Accept	Accept	Accept

The validation process is then carried out on the simulation model to measure the accuracy of the models and parameters. The reference in the validation this time and the length of vehicle queue. Chi square Test analysis test is used to compare the queue length in the simulation model with the observation results in the field. The validation results are shown in Table 4. Table 4 shows that based on the results of Chi-Square Test with a degree of confidence in Chi-Square Test of 95% or $\alpha = 0.05$ where the table value x2 in the Chi-Square table is 11.07 while the Chi-Square table calculated for all approaches is 4.023; 7.318; 8.006; 6.608; 8.546 and 5.506 that means the model meets the requirements of x2. The result of calculating ≤ x2 results of Chi-Square table so that the model is declared valid.

Micro-simulation performance analysis at the existing intersection

Existing traffic performance based on micro-simulation results is based on the value of queue length as shown in Figure 3.Figure 3 shows that the value of a large queue length occurs in almost all approaches. The longest queue length occurred at the Slow Track North Approach during peak hours (peak hour) in the evening (16: 00-17: 00) of 338.06 m and the results were not much different from the Fast Track North Approach and East Boulevard Approach about 317.01 m (16: 00-17: 00) and 223.91 m (16: 00-17: 00) respectively. The simulation results show poor traffic performance at the intersection.

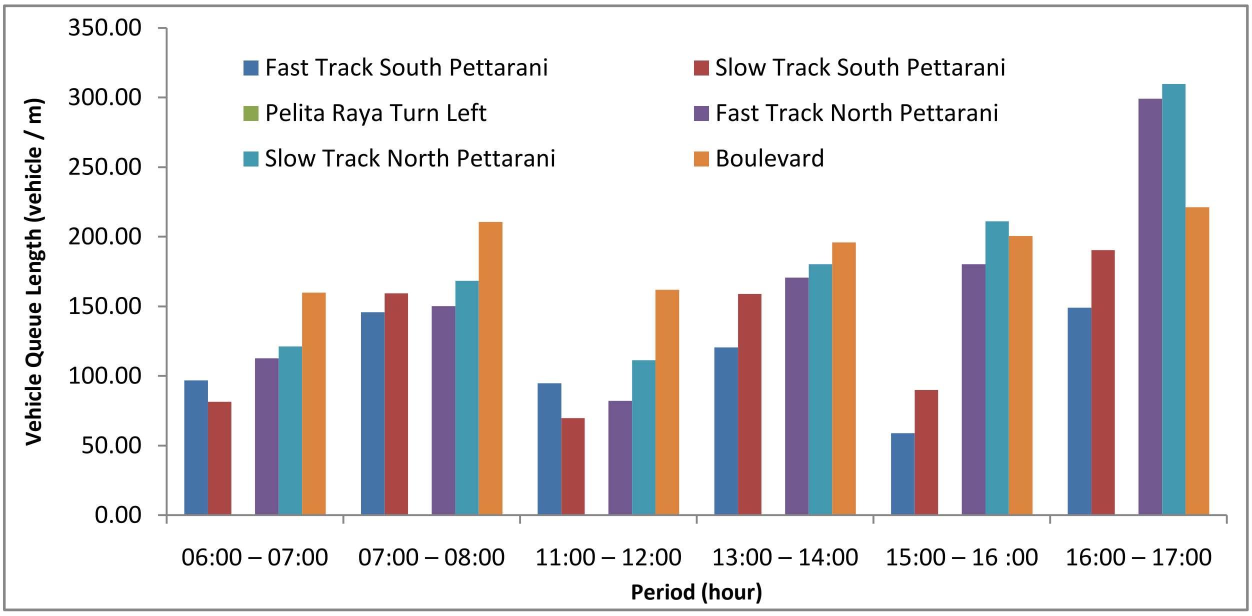

Fig. 3 Queue Length at Existing Junction

Optimization of Micro-Simulation Cycle at Intersection

Based on the simulation results shown in Figure 3, there is a necessary to optimize the intersection, especially in the Slow Track North Approach, Fast Track North Approach and East Boulevard Approach. Optimization is done by two alternatives, namely changing the phase time and extends the time. The traffic optimizations of simulation are presented in Table 5 and the output queue length of each alternative is shown in Table 6.

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Table. 5 Optimization result of changes in Signal Time and Cycle Time at Intersection

Condition	Road /approach	Signal Time (Second)			Cycle Time (Second)
		Green	Red	Yellow	
Existing	North Pettarani	45	50	3	105
	East Boulevard	25	70	3	
	South Pettarani	20	70	3	
Alternative 1	North Pettarani	48	53	3	105
	East Boulevard	22	67	3	
	South Pettarani	20	70	3	
Alternative 2	North Pettarani	50	55	3	120
	East Boulevard	30	75	3	
	South Pettarani	25	75	3	

Table. 6 Output Queue Length in each Alternative

Road /approach	Existing	Alternative 1	Alternative 2
Fast Track South Pettarani	148.94	147.29	123.79
Slow Track South Pettarani	190.51	199.43	185.04
Fast Track North Pettarani	299.24	297.66	292.28
Slow Track North Pettarani	309.77	308.24	303.99
Boulevard	221.17	222.89	206.22

Table 6 shows that the simulation results on the first and second alternative of intersection performance. Base on the length queue. The first alternative only shows improvement in Fast Track South Pettarani, Fast Track North Pettarani and Slow Track North Pettarani. While, Slow Track South Pettarani and Boulevard Approach demonstrate the length of the queue increased.

The simulation results on the second alternative show a better intersection performance than the existing intersection conditions in all approaches, especially in the Fast Track South Pettarani Approach. The result also shows the second alternative hasbetter intersection performance than the first alternativebut the change is not significant changes. This is because the condition of the traffic flow at the intersection is already very saturated so that the addition of cycle time does not drastically improve the intersection performance.

IV. CONCLUSION

The performance of Micro-simulation on Vissim software refers to the calibration and validation process, where the calibration process uses several parameters of driving behavior such as Average Standstill Distance, Lateral Distance Driving and Lateral Distance Standing as a model benchmark.

The worst traffic performance occurs at the 3-way junction is Slow Track North Pettarani approach with the queue length reaching 309.77 m.The best optimization solution is to increase the cycle time from 105 seconds to 120 seconds, which reduce thequeue length of the vehicle to 303.99 m.

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