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Performance of PUE Bongo – I Gusti Ngurah Rai Intersection Based on Vissim Simulation

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Abstract: The Pue Bongo – I Gusti Ngurah Rai – Padanjakaya intersection is an unsignalized intersection in Palu City, precisely between the borders of Palupi Village and Pengawu Village, Tatanga District, Palu City, which was previously a three-way intersection due to the construction of the new Palupi Bridge which was built together with the construction of the Palu City inner ring road which was included in the post-earthquake reconstruction project so that the intersection became a four-way intersection. and became very dense with quite high traffic flow, causing increased congestion and accidents, even to the point of death. This study aims to analyze the performance of the Pue Bongo – I Gusti Ngurah Rai intersection using PTV Vissim software because this software is a simulation model that can analyze traffic performance with output results close to field conditions. PTV Vissim is a macrosimulation program used for traffic management. This program uses computer software to mathematically model the transportation system. To prove that there is no significant difference between the model output results and the results of observations in the field, calibration and validation are then carried out. The output results of the Pue Bongo – I Gusti Ngurah Rai intersection model are close to the observation results with the GEH test results <5 on traffic flow, the calculated t value <t table on queue length, and on travel time the relative difference test results show a percentage difference value of 6%. From these results it can be concluded that the model is calibrated and validated. The results of the performance analysis are the average queue length for each arm of 32 meters, travel time of 146 seconds, and intersection delay of 18 seconds.

***Keywords**: Unsignalized Intersection, PTV Vissim, Calibration, Validation, Traffic Performance.*

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I. INTRODUCTION

Road transportation infrastructure is one of the infrastructures for smooth traffic in an area. The increasing activity of the population of an area also increases the movement of people, goods and services so that the need for transportation services will also increase. The scope of transportation problems includes several things, one of which is the need for movement. This occurs because of the need to reach places of work, education, and economic centers. Failure to meet the need for This movement causes congestion, delays or even accidents. This movement causes congestion, delays or even accidents. This also happened at the Pue Bongo – I Gusti Ngurah Rai – Padanjakaya Intersection in Palu City. The Pue Bongo – I Gusti Ngurah Rai – Padanjakaya Intersection is one of the unsignalized intersections in Palu City, precisely between Palupi Village and Pengawu Village, Tatanga District, Palu City, which was previously a three-way intersection due to the construction of the Palupi Bridge which was just built together with with the construction of the inner ring road of Palu City which is included in the post-earthquake reconstruction project so that the intersection becomes a four-way intersection. Therefore, the intersection becomes very dense with quite high traffic flow, causing increased density, congestion and accidents, even to the point of death.

This study aims to analyze the performance of the Pue Bongo - I Gusti Ngurah Rai intersection with the addition of arms. The performance analysis study of the Pue Bongo - I Gusti Ngurah Rai intersection was conducted using the PTV Vissim simulation program. PTV Vissim is a macrosimulation program used for traffic management. This program uses computer software to mathematically model the transportation system. The PTV Vissim simulation program is software for modeling field conditions in the form of 2D and 3D simulations, based on road user behavior that can facilitate the analysis and optimization of signalized intersection performance. To obtain accurate and realistic results, a calibration and validation process is needed on the model created.

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PTV Vissim is a microsimulation program for planning, analyzing, and optimizing traffic flow developed by PTV (Planung Transport Verkehr AG) from Germany. Having advantages compared to other methods, the PTV Vissim simulation program is able to simulate private vehicles, public transportation, multi-modal traffic flow, and pedestrian engineering which can be calibrated based on each behavior, can simulate field conditions in 3D.

II. METHOD

A. Traffic Model Calibration

Here is the process of adjusting the driving behavior parameters that are carried out repeatedly so that the simulation results match the observation data in the field. In this study, the number of traffic flows on the intersection arms is used as a comparative variable for the suitability between the simulation results and field observation data (Yulianto B and Setiono, 2013). The GEH value is used in equation [1] and the details of the calculation results are presented in table 1.

Table 1: Conclusions from the Results of the GEH Statistical Formula Calculations

GEH ≤ 5,0 ≤	**Accepted**
GEH ≤ 5,0	Error or bad model warning
GEH > 10,00	Bad

$$GEH = \sqrt{\frac{2(qm - qo)^2}{(qm + qo)}} \quad \text{..................[1]}$$

Where:
q = traffic volume data of vehicle flow (vehicles/hour)

B. Traffic Model Validation

Traffic validation in vissim is a process to test the correctness of calibration by comparing simulation results and observation results, traffic model validation here is a process to determine whether the traffic simulation model created can represent the existing reality accurately. The traffic simulation model is said to be valid if the output of the model output is close to the observation data in the field using the Geoffrey E. Harvers (GEH) statistical test method. In this study, intersection performance, namely travel time (seconds) and vehicle queue length (meters) are used as comparative variables between modeling results and observation results (Yulianto B and Setiono, 2013).

Validation on queue length using T test method. T test is used to determine the probability of linearity of related data, determine whether measurement results can be compared statistically with standard values, and also to compare two tools statistically to determine whether they are the same or not. T test is declared accepted if the t count value is smaller than the t table value (t count < t table). T test value is calculated using equation [2]

$$t = \frac{x_1 - x_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \quad \text{...[2]}$$

Description:
x1 = Average of the first data set
x2 = Average of the second data set
n = Number of data
s = Standard deviation with the formula

Validation at travel time using relative difference suitability test. Relative difference is the difference measured by comparing the absolute difference value with the observation value so that it does not have a unit. The absolute difference value can be calculated using the following equation [4].

$$\text{Difference Relative} = \frac{\text{Model Results} - \text{Observations}}{\text{Observations}}$$

C. Data Collection

Data collection at the Pue Bongo - I Gusti Ngurah Rai intersection consists of primary data and secondary data, primary data in this study were conducted through several field surveys. The survey conducted was geometric data of the Pue Bongo - I Gusti Ngurah Rai intersection, an inventory of highway sections and intersections, the existing conditions were taken in the form of road segments consisting of length, width. gradient and number of lanes. The geometric intersection consists of length, width, gradient and number of lanes including designated lanes and designated storage lengths. observing and recording the types of vehicles entering/crossing the intersection, recording the traffic flow of the Pue Bongo - I Gusti Ngurah Rai intersection, traffic data is needed to see the density of the number of vehicles on a road or intersection consisting of changes in speed data, intersection control devices at the research location. vehicle speed, and queue length, travel time survey, vehicle characteristics, in this case the data that needs to be obtained includes vehicle composition, traffic light cycle values for signalized intersections, Implementation of the survey using CCTV devices installed in certain places that can monitor all vehicles crossing the Pue Bongo - I Gusti Ngurah Rai intersection was carried out on Thursdays obtained in a week during peak hours, namely 06.00-10.00, in the morning at 16.00 - 18.00 in the afternoon and peak hours at 16.30-17.30, with a location at the Pue Bongo Intersection consisting of Jalan Pue Bongo (north arm), Jalan Pue Bongo II (south arm), Jalan I Gusti Ngurah Rai (east arm) and Jalan Padanjakaya (west arm). The following intersection locations and traffic flow directions can be seen in Figure 1.

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Fig 1: Geometric structure of Pue Bongo Intersection and Traffic Movement

Secondary data collection based on data obtained from the Palu City Transportation Agency. The operation of the APILL lights at the Pue Bongo Intersection still uses a portable APILL with four phases. The following is a phase diagram of the Pue Bongo Intersection movement presented in Figure 2.

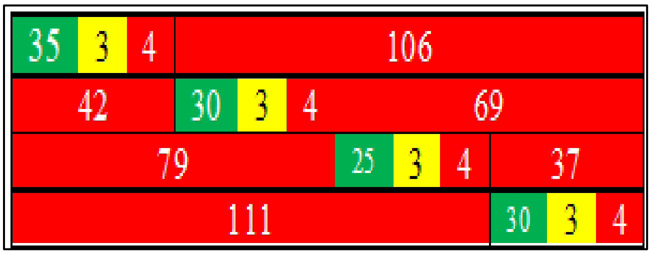

Fig 2: Movement Phases and Cycle Times

Figure 2. Shows the movement of Simpang Pue Bongo has four phases with the division, namely the first phase is the movement of the north arm with a green time of 35 seconds; the second phase is the movement of the east arm with a green time of 30 seconds; the third phase is the movement of the south arm with a green time of 25 seconds; and the fourth phase is the movement of the west arm with a green cycle time of 30 seconds.

Modeling on PTV Vissim

PTV Vissim is a microsimulation program for planning, analyzing, and optimizing traffic flow developed by PTV (Planung Transport Verkehr AG) from Germany. The PTV Vissim simulation program is capable of simulating private vehicles, public transportation, multi-modal traffic flow, and pedestrian engineering which can be calibrated based on their respective behaviors. The building blocks of the PTV Vissim simulation program are:

- Infrastructure blocks are used to create traffic infrastructure models such as highways, rails and parking facilities, public transportation routes which are also the origin and destination areas of travel,
- Traffic blocks are used to carry out technical vehicle arrangements such as vehicle volume and vehicle proportions and are also used to regulate traffic flow specifications such as determining travel routes and road loading.
- The control block contains elements for performing traffic control, such as defining four-way stops, major/minor priority rules with certain interval times, and traffic signal settings.
- Output block is a block that handles all types of output data. In this block, data processing provided by the previous three main blocks will be carried out. Output can be generated during the simulation either as animated vehicles and traffic control status or as statistical data of detector readings and vehicle status presented in a dialog box.

The data obtained from the field survey is then used to create a model in the PTV Vissim simulation program which is then used as a comparison with the model output results. Creating a model in the PTV Vissim simulation program by adjusting the driving behavior parameters that are changed repeatedly so that different random seed values produce convincing output.

III. RESULTS AND DISCUSSION

A. Volume and Composition

Traffic volume is the number of vehicles passing through an intersection or road section in one time interval, then the traffic composition is calculated to determine the percentage of each type of vehicle that makes up the traffic at the intersection. Traffic volume and composition data can be seen in Figure 3.

The highest flow data at certain peak hours will be the reference data to evaluate performance at the intersection. This data is taken because it is the maximum data where there is a dense traffic flow so that it is considered to be able to represent other data. The vehicle volume data calculated throughout the period from 06.00 - 18.00 WITA is described in graphic form.

The traffic volume in a week is obtained on Thursday is the highest traffic volume while the hourly traffic on Thursday, there is the highest volume at 16.30 - 17.30 with a total traffic volume of 5172 vehicles. So it can be concluded that the peak hour that will be the reference for evaluating performance at the Pue Bongo - I Gusti Ngurah Rai intersection is the peak hour on Thursday at 16.30 - 17.30. The traffic volume of vehicle types on Thursday at 16.30 - 17.30 can be seen in Table 2 below.

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Table 2: Hourly Traffic Volume on Thursday, March 7, 2024

Time	Pue Bongo	I Gusti Ngurah Rai	Pue Bongo II	Padanjakaya	Rata-rata
06,00-07,00	530	562	731	634	614
06,15-07,15	703	698	864	776	760
06,30-07,30	762	797	951	849	840
06,45-07,45	879	847	1052	965	936
07,00-08,00	964	883	1051	989	972
07,15-08,15	887	941	1118	1058	1001
07,30-08,30	965	1011	1171	1181	1082
07,45-08,45	970	1013	1100	1119	1051
08,00-09,00	929	1008	1033	1050	1005
08,15-09,15	1009	960	926	1031	982
08,30-09,30	1012	926	836	957	933
08,45-09,45	1002	881	770	905	890
09,00-10,00	1037	913	701	917	892
09,15-10,15	1059	936	719	900	904
09,30-10,30	1116	957	673	839	896
09,45-10,45	1087	961	696	872	904
10,00-11,00	1098	913	688	836	884
10,15-11,15	1087	845	631	791	839
10,30-11,30	1017	828	673	798	829
10,45-11,45	1153	870	688	782	873
11,00-12,00	1125	849	678	747	850
11,15-12,15	1171	922	721	787	900
11,30-12,30	1205	943	725	801	919
11,45-12,45	1161	941	698	779	895
12,00-13,00	1125	939	710	783	889
12,15-13,15	1079	966	690	757	873
12,30-13,30	1062	982	660	700	851
12,45-13,45	1010	947	653	720	833
13,00-14,00	1076	968	667	767	870
13,15-14,15	1072	957	685	749	866
13,30-14,30	1036	879	688	755	840
13,45-14,45	1116	953	722	762	888
14,00-15,00	1148	970	718	779	904
14,15-15,15	1132	906	662	783	871
14,30-15,30	1226	952	809	902	972
14,45-15,45	1235	959	824	905	981
15,00-16,00	1184	940	825	857	952
15,15-16,15	1301	1013	919	965	1050
15,30-16,30	1404	1123	839	964	1083
15,45-16,45	1475	1144	882	1023	1131
16,00-17,00	1613	1176	906	1088	1196
16,15-17,15	1693	1269	932	1140	1259
16,30-17,30	1816	1285	924	1147	1293
16,45-17,45	1759	1242	805	1090	1224
17,00-18,00	1824	1270	793	1102	1247

It can be seen from Figure 3. that on Thursday, March 7, 2024, the highest hourly traffic volume was at 16.30 - 17.30 with a total traffic volume of 5172 vehicles. So it can be concluded that the peak hour will be the reference to evaluate the performance at the Pue Bongo – I Gusti Ngurah Rai intersection, namely the peak hour on Thursday at 16.30 – 17.30. The traffic volume of vehicle types on Thursday at 16.30 – 17.30 can be seen in Figure 3 below:

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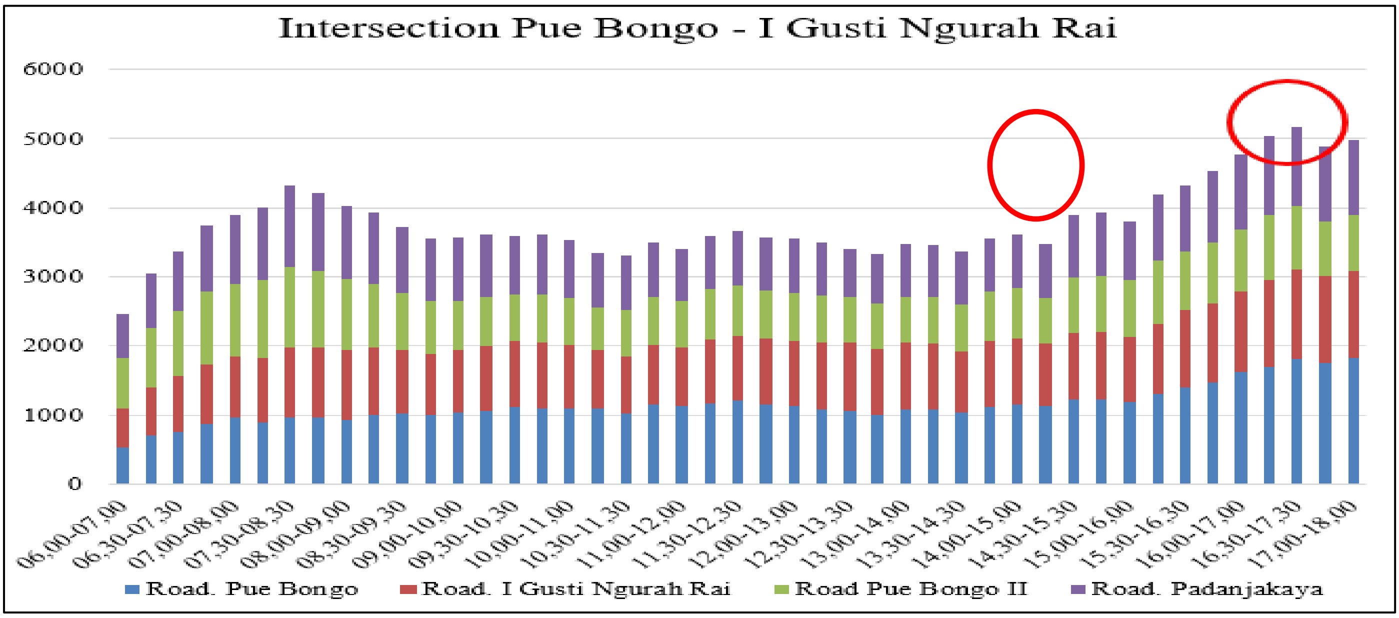

Fig 3: Hourly Traffic Volume Graph for Thursday, March 7, 2024

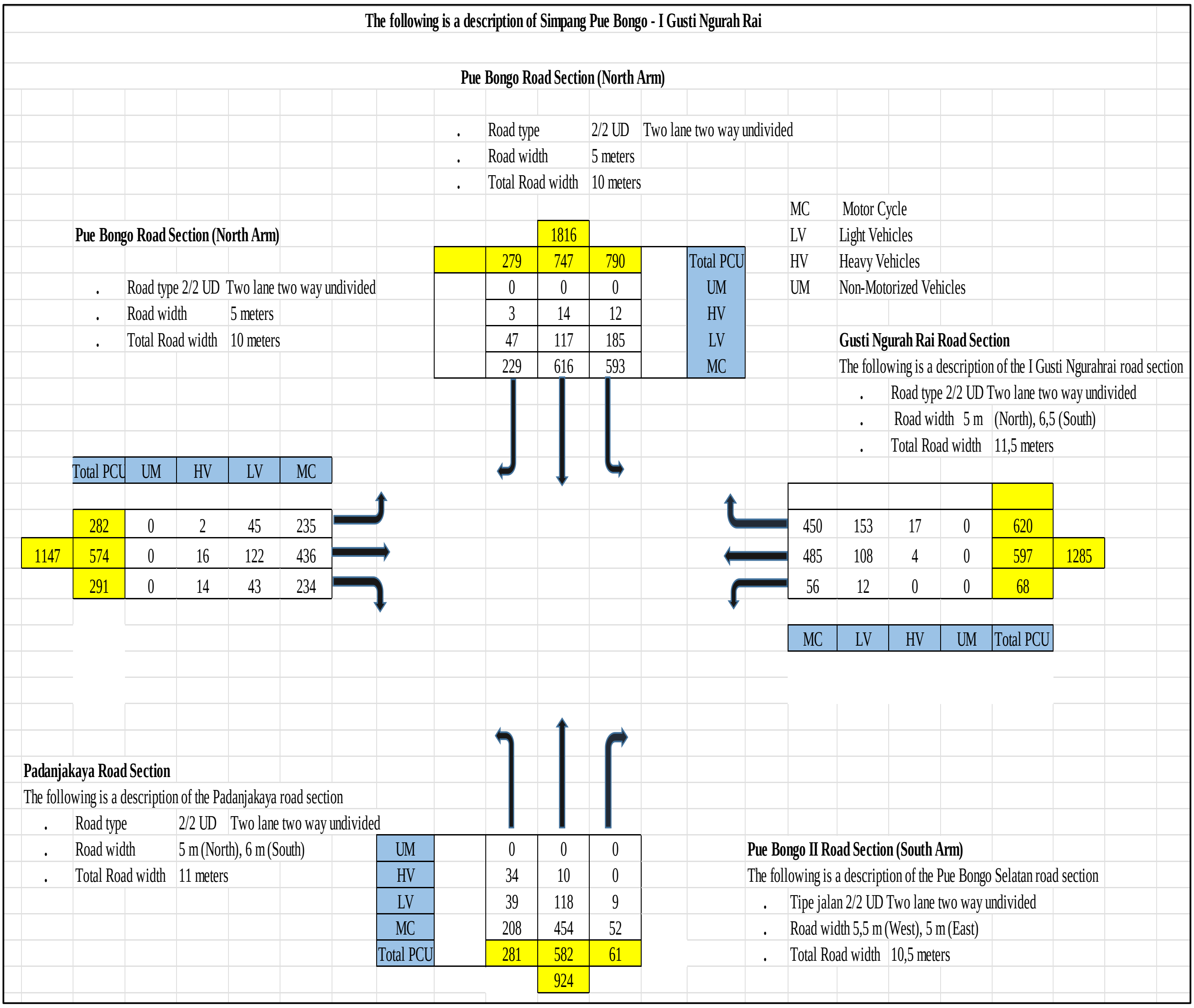

Fig 4: Traffic Volume and Composition During Peak Hours

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From Figure 4 above, it can be seen that the high volume and composition of traffic during peak hours is caused by motorbikes (SM) with a total of 4048 vehicles/hour and light vehicles (MP). dengan total 998 vehicles/hour. While on the I Gusti Ngurah Rai road approach with a total of 1285 vehicles/hour and the Pue Bongo road approach with a total of 1816 vehicles/hour.

B. Model Calibration Results

After adjusting the parameters, the model was run 5 times with different random seed (RS) values to produce convincing output. In this study, to find out the significant differences between simulation results and observation data The field of traffic flow in each arm of the intersection is used as a comparative variable for the suitability between the simulation results and field observation data. The following are the calibration results of the Pue Bongo – I Gusti Ngurah Rai Intersection presented in Table 3.

Table 3: GEH Calibration Results

Traffic Flow		**q Model**						**q Observation**	**GEH Value**	**Information**
		Run to					**Average**			
		1	**2**	**3**	**4**	**5**				
North	Go out	1794	1880	1905	1830	2012	1884,2	1816	1,59	Ok
East		1220	1450	1334	1280	1281	1313	1285	0,78	Ok
South		911	934	875	862	870	890,4	924	1,16	Ok
West		1128	1124	1102	1129	1135	1123,6	1147	0,69	Ok
North	In	1527	1511	1530	1540	1498	1521,2	1561	1,01	Ok
East		1402	1385	1436	1422	1448	1418,6	1425	0,17	Ok
South		1190	1187	1224	1185	1248	1206,8	1195	0,34	Ok
West		1146	1124	1121	1132	1122	1129	1157	0,83	Ok

Table 3 shows that the GEH value of traffic flow during the afternoon peak hour at each intersection arm is less than 5, so that statistik GEH is declared acceptable. Based on these results, the base model at the afternoon peak hour is declared calibrated.

C. Validation Results

The validation process is carried out to determine whether the traffic simulation created is in accordance with field conditions by comparing the simulation results with observation data. The comparative variables used are travel time (seconds) and queue length for each 10-minute interval. (meters). The traffic simulation model is said to be valid if the output produced is close to the data from field observations. The suitability test used on the queue length is the T test. The results of the T test for the queue length at each 10-minute interval during peak hours are presented in Table 4.

Table 4: T-Test Results

Cross Arm	**Minute Interval to**	**Maximum Queue Length**		**tcount**	**ttable**	**Information**
		Models	**Observations**			
North	16:40:52	55	55	1,3219	2,7765	OK
	16:50:52	63	65			
	17:00:52	69	55			
	17:10:52	63	59			
	17:20:52	61	59			
	17:30:52	60	59			
East	16:41:44	56	57	-0,373	2,7765	OK
	16:51:00	61	63			
	17:01:44	55	58			
	17:11:44	58	64			
	17:21:44	58	61			
	17:31:44	59	62			

Table 4 shows the results of calculating the length of the queue at peak hours in the afternoon for the north arm and east arm less than ttable (tcount < ttable) Tarafsig 0,050 so that it is declared accepted, which means that there is no significant difference between the maximum queue length of the simulation output and the data from field observations during the afternoon peak hour.

The suitability test used on travel time is the relative difference test. The results of the travel time difference test during the afternoon peak hour are presented in Table 5..

Table 5: Travel Time Results

Origin-Destination of the Trip	**Average Travel Time (seconds)**		**Relative Percentage Difference**	**Information**
	Models	**Observations**		
North-South	196	185	6%	OK

Table 5 above shows the results of the relative percentage difference in travel time during the afternoon peak hour from north to south. by 6% so that the relative difference test is declared acceptable.

D. Intersection Performance Analysis Results

The performance analysis process of the Pue Bongo – I Gusti Ngurah Rai intersection in existing conditions uses the output results obtained from the run process against the simulation of the Pue Bongo intersection in existing conditions. The intersection performance parameters used in The analysis is the queue length, travel time and intersection delay. The results of the performance analysis of the Pue Bongo – I Gusti Ngurah Rai intersection can be seen in Tables 6 – 8.

Table 6: Queue Length from Model Simulation Results

Cross Arm	**Model Queue Length (meters)**					
	***Run* to**					**Average**
	1	**2**	**3**	**4**	**5**	
North	38	56	74	45	81	59
East	22	23	24	20	23	22
South	25	24	26	24	25	25
West	23	21	23	21	21	22

Table 6 shows the results of the average queue length for the Pue Bongo – I Gusti Ngurah Rai intersection model. The length of the north arm queue 59 meters, on the east arm 22 meters, on the south arm 25 meters and on the west arm 22 meters

Table 7: Travel Time from Simulation and Observation Results

No	**Travel Route**	**Average travel time (seconds)**						
		***Run* to**					**Average**	**Observations**
		1	**2**	**3**	**4**	**5**		
1	North-West	124	114	123	120	122	121	114
2	North-South	199	193	195	195	197	196	185
3	North-East	187	192	194	194	196	193	182
4	North-East	173	170	175	175	182	175	165
5	East-West	176	173	173	178	175	175	166
6	East-South	89	83	85	86	87	86	81
7	South-East	82	78	79	81	81	80	75
8	South-North	175	178	176	176	179	177	165
9	South-West	122	124	134	121	122	125	118
10	West-South	126	130	124	124	128	126	120
11	West-East	171	176	170	178	173	174	165
12	West-North	123	125	124	124	120	123	116

Table 7 shows the travel time of Crossroads Pue Bongo – I Gusti Ngurah Rai model. After running 5 times, the average travel time for each route is as follows:

- North to West = 121 seconds
- North to South = 196 seconds
- North to East = 193 seconds
- East to North = 175 seconds
- East to West = 175 seconds
- East to South = 86 seconds
- South to East = 80 seconds
- South to North = 177 seconds
- South to West = 125 seconds
- West to South = 126 seconds
- West to East = 174 seconds
- West to North = 123 seconds

Table 8: Simulation Result Delay

Delay (seconds)					
Run to-					**Average**
1	2	3	4	5	
15	20	18	16	22	18

IV. CONCLUSION

The existing condition of the Pue Bongo – I Gusti Ngurah Rai Intersection Model can be calibrated and validated because the comparison results of traffic flow data volume data, queue length, and travel time in the model show no significant difference between the output and the results of field

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observations. This is evidenced by the results of the GEH statistical test on traffic flow showing a value of less than 5, and on the queue length the T test results show a calculated t value smaller than the t table value t count < t table and P (two tailed) 0.05 and on travel time the results of the relative difference test show a percentage difference of 6%. The results of the performance analysis of the Pue Bongo – I Gusti Ngurah Rai Intersection with the change in the intersection model, namely from a three-way intersection to a four-way intersection, namely the average queue length of each arm is 32 meters, travel time is 146 seconds, and intersection delay is 18 seconds.

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