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OPTIMIZATION OF INTERCEPTION COORDINATION ON IR ROAD. SOEKARNO, KEDIRI, TABANAN THROUGH A MICROSIMULATION APPROACH

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ABSTRACT
Ir. Soekarno road area, Kediri, Tabanan Regency is an arterial road section that connects the Tabanan area to Jembrana Regency. The road section is a section of freight and public transportation between cities between provinces. Simpang Yeh Ganga, Simpang Dukuh, Simpang Kasih Ibu and Simpang Gerokgak have a distance between intersections of less than 800 meters which allows optimization of intersection coordination. The analysis carried out can obtain the performance value of the existing intersection before optimization, calculation of the coordination cycle time so that it can be applied using Vissim simulation in obtaining performance after optimization of the coordination cycle time. Validation is carried out by comparing the volume of segments at each intersection with an independent sample t-test statistical test with a significance value above 0.05 so that the modeling results can represent conditions in the field. From the results of the analysis and simulation, it was obtained to equalize the cycle time of each intersection to 105 seconds by adjusting the green time value according to the load of the vehicle coming on each strain. The queue value obtained became optimal and the delay was reduced in the range of 0.75 - 22.53 seconds with a decrease value of 4.97% - 40.71%.

Keywords: cycle time optimization; intersection coordination; vissim

INTRODUCTION
The movement of population activities in urban and rural areas is increasing every year, this is based on increasing population growth in urban and rural areas. Along with population growth, the growth in motor vehicle ownership is also increasing every year. The increasing population growth and vehicle ownership has an impact on increasing people's movement activities on the roads. In line with this, it is necessary to regulate traffic both on sections and at intersections to create smoothness, security, safety and comfort in traffic on the highway.

Road intersections are areas where traffic conflicts occur where two or more roads meet or intersect (Abubakar, 1996). The main function of an intersection is to regulate and divert vehicles from all directions so that they can move safely and smoothly. Intersections can also help reduce traffic congestion and accidents by providing clear signals, signs and directions for drivers. Apart from that, intersections can also be used to facilitate the movement of pedestrians and cyclists (Warpani, 2002). Intersections are an important part of highways because most of the efficiency, safety, speed, operational costs and traffic capacity depend on intersection planning (Putranto, 2016). Conflicts arise between two or more road users or drivers when turning and crossing another road. To control these conflicts, traffic regulations were created to determine who has first right to use the intersection. Meanwhile, a road section is a part or portion of a road that is between two nodes or at-grade/non-at-grade intersections, whether equipped with traffic signs (APILL) or not.

There are rarely signalized intersections that are quite close on Jalan Ir. Soekarno, Kediri, Tabanan can cause queues and delays at every intersection. On Jalan Ir. Soekarno, Kediri, Tabanan have several intersections, including Simpang Yeh Gangga, Simpang Dukuh, Simpang Kasih Ibu, and Simpang Gerokgak which have a distance between intersections of less than 800 meters. With the coordination of the 4 intersections, it is hoped that it will improve the performance of the intersection by reducing the number of queues at the intersection as well as optimizing APILL with green waves between intersections using the transportation modeling method using the PTV micro-simulation approach. Vissim. Modeling validation used the Independent t-test to test the suitability of the volume produced in modeling to the primary survey results obtained from observations in the field. This aims to obtain existing performance at intersections, optimize intersection times and signalized intersection performance through a modeling results approach by applying the time optimization results obtained.

METHOD

To determine the appropriate research method and design, it must be based on the objectives and formulation of the research problem, the data used is primary data and secondary data. Secondary data was obtained from previous research (volume, inventory and vehicle speed), the Denpasar City Transportation Department (APILL cycle) and the Denpasar City Central Statistics Agency (population number, vehicle growth and land use). Meanwhile, the primary data obtained was in the form of an inventory survey of road sections and intersections, a speed survey, and a traffic enumeration survey on sections and intersections. The analysis carried out in this research includes analyzing the performance of signalized intersections in existing conditions, analyzing alternative calculations for signalized intersection coordination, applying vissim modeling to conditions before and after optimizing the intersection cycle time and then comparing the results obtained. Calibration in the vissim simulation is then carried out using the following parameters: Desire Position at free flow, Overtake at same line, Standing Distance, Driving Distance, Average Standstill distance, Additive part of safety distance, Multiplicative part of safety distance, waiting time before diffusion, min headway (front/rear), safety distance diffusion factor.

The data obtained is entered into Vissim modeling. Inventory data on road sections and intersections, traffic volume, vehicle composition, travel time between intersections, APILL signal times. Get 2D/3D visualization and performance values of roads and intersections. The model output data was validated using the independent t-test statistical test by comparing the model output volume values with the traffic volume values obtained during the initial survey of the research location. If there is a significant difference in values, the driver's behavior is conditioned in the form of calibration by adjusting the parameter values above. The statistical test results show a significant allowable value, which shows that the modeling results have entered the analysis stage and can represent traffic conditions in the field.

Research sites

Primary data collection was carried out on Friday, October 7 2022 by conducting an inventory survey, turning movement survey at intersections, and travel time survey between intersections. To be clearer as follows:

The research area is located on the Ir. Soekarno, Tabanan.

The research area is divided into 5 (segments) based on the similarity of road types and sections between intersections.

1. Segment 1 (one) is the section from Soekarno intersection to Gerokgak intersection.
2. Segment 2 (two) is the section from the Gerokgak intersection to the Kasih Ibu intersection.
3. Segment 3 (three) is the section from the Kasih Ibu intersection to the Dukuh intersection.
4. Segment 4 (four) is the section from the Dukuh intersection to the Yeh Gangga intersection.
5. Segment 5 (five) is the section from the Yeh Gangga intersection to the Adipura intersection.

RESULTS AND DISCUSSION

Geometric Condition of Road Ir. Soekarno Tabanan

Road geometric condition data Ir. Soekarno Tabanan can be seen in the table below.

Table 1.
The distance between intersections on Jalan Ir. Soekarno Tabanan

Origin of Simpang	Towards the intersection	Distance (m)
Yeh Ganga	Hamlet	630
Hamlet	A mother's love	576
A mother's love	Gerokgak	479

Traffic Volume Fluctuations at Intersections

Yeh Gangga intersection

Recapitulation data on vehicle volume calculations based on the results of the survey at Simpang Yeh Gangga which started at 06.00 – 18.00 WITA

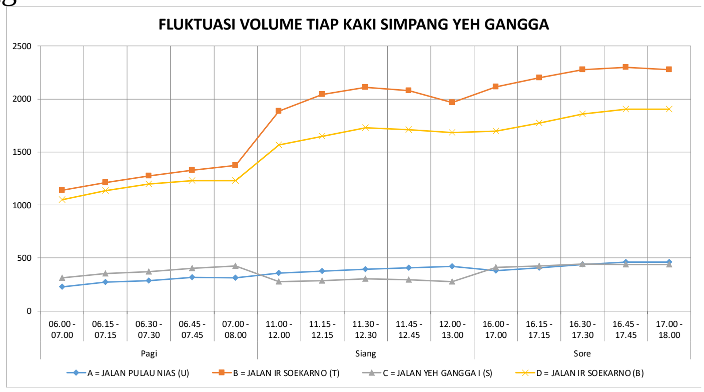

Figure 2 Fluctuations in Traffic Volume at Yeh Gangga Interchange

Dukuh intersection

Data recapitulation of vehicle volume calculations based on the results of the survey at Simpang Dukuh which started at 06.00 – 18.00 WITA

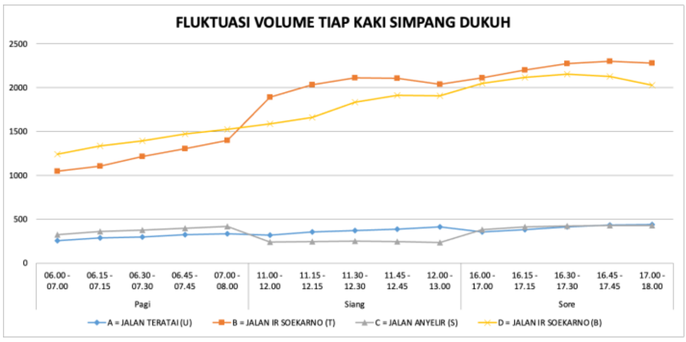

Figure 3. Fluctuations in Dukuh Interchange Traffic Volume

Mother's Love Crossing

Data recapitulation of vehicle volume calculations based on the results of the survey at Simpang Kasih Ibu which started at 06.00 – 18.00 WITA.

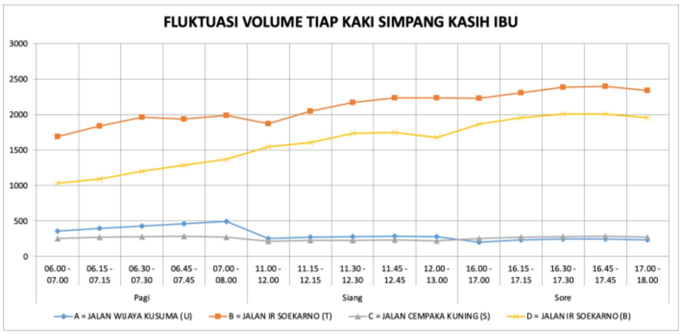

Figure 4. Traffic Volume Fluctuations at the Mother's Love Intersection

Gerokgak intersection

Data recapitulation of vehicle volume calculations based on the results of the survey at Simpang Gerokgak which started at 06.00 – 18.00 WITA.

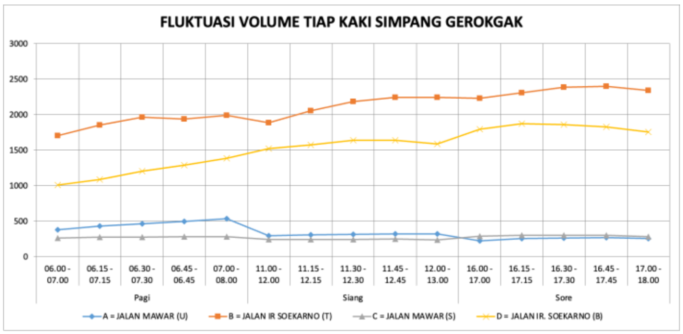

Figure 5. Fluctuations in traffic volume at the Gerokgak intersection

APILL Signal Cycle Data

Table 2.
APILL Cycle Data for Research Area

Intersection	Number of Phases	Green Time Total (seconds)	Loss Time Intergreen (detik)	Cycle Time (detik)
Yeh Ganga	3	77	15	92
Hamlet	3	73	15	88
A mother's love	3	51	15	66
Movement	3	88	15	103

Performance of Existing Signalized Intersections

Based on data from the Central Statistics Agency (2022), the population of Tabanan City is 465,332 people. The performance of signalized intersections is taken from 3 indicators, namely the degree of saturation, queue length and delays through calculations in the Indonesian Road Capacity Manual. The performance of signalized intersections at Yeh Gangga Interchange can be seen in the following table.

Table 3.
Performance of the Existing Yeh Gangga Interchange

Performance Indicators	Yeh Gangga Simpang Performance			
	T	B	S	U
Degree of Saturation	0,25	0,20	0,28	0,33
Queue Length (meters)	4,87	4,15	3,81	4,88
Average Traffic Delay (sec/pcu)	49,69	49,63	46,80	47,16
Geometric Mean Delay (sec/pcu)	1,60	1,75	1,74	1,80
Average Delay (sec/smp)	51,28	51,38	48,54	48,96
Intersection Delay				50,57

Table 4.
Performance of the Existing Dukuh Intersection

Performance Indicators	Simpang Dukuh Performance			
	T	B	S	U
Degree of Saturation	0,75	0,68	0,69	0,69
Queue Length (meters)	37,40	31,77	18,36	18,19
Average Traffic Delay (sec/pcu)	45,68	45,12	47,88	47,71
Geometric Mean Delay (sec/pcu)	2,82	2,48	3,36	3,35
Average Delay (sec/smp)	48,51	47,60	51,24	51,07
Intersection Delay			48,53	

Table 5.
Performance of the Existing Simpang Kasih Ibu

Performance Indicators	Performance of the Existing Simpang Kasih Ibu			
	T	B	S	U
Degree of Saturation	0,64	0,55	0,29	0,23
Queue Length (meters)	28,92	24,53	5,52	3,75
Average Traffic Delay (sec/pcu)	44,88	44,48	40,93	40,62
Geometric Mean Delay (sec/pcu)	2,51	2,05	2,38	2,25
Average Delay (sec/smp)	47,39	46,53	43,31	42,88
Intersection Delay			46,70	

Table 6.
Performance of the Existing Gerokgak Intersection

Performance Indicators	Gerokgak Interchange Performance			
	T	B	S	U
Degree of Saturation	0,71	0,58	0,14	0,13
Queue Length (meters)	27,06	23,22	3,23	2,73
Average Traffic Delay (sec/pcu)	51,77	50,83	48,00	47,86
Geometric Mean Delay (sec/pcu)	2,28	1,76	2,03	1,97
Average Delay (sec/smp)	54,05	52,59	50,03	49,83
Intersection Delay			53,13	

Existing Intersection Coordination

Signal coordination between intersections functions to optimize intersection operations by regulating the number of phases, intervals and time of the green phase so as to reduce total obstacles at adjacent intersections. Based on the survey results at the study location, the average travel speed (v) from Simpang Yeh Gangga to Simpang Dukuh was 42 km/hour, converted to 11.67 m/sec. Travel speed (v) also applies in the reverse direction. Distance (l) from Simpang Yeh Gangga to Simpang Dukuh is 630 m. The offset values for existing conditions are as follows.

Offset = distance / speed = l / v

Offset = 630 / 11.67 = 54 sec

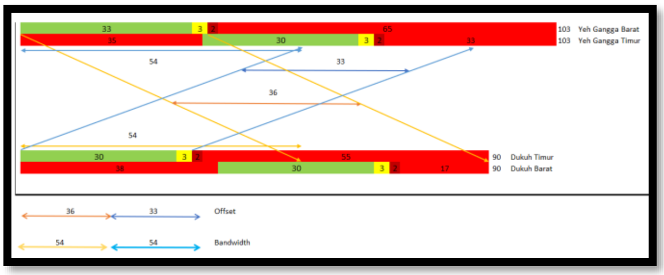

Figure 6. Space and Time Diagram at the Yeh Gangga – Dukuh Interchange

With the same calculations, the space and time diagrams for other intersections are obtained as follows:

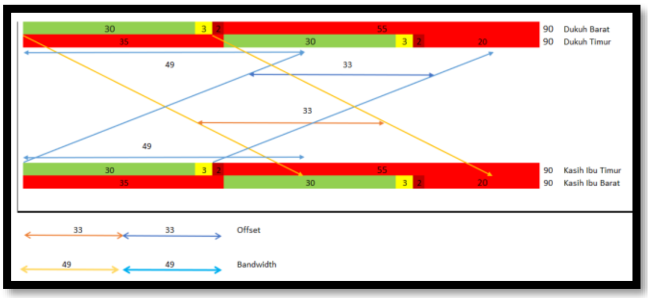

Figure 7. Space and Time Diagram at the Dukuh - Mother's Love Intersection

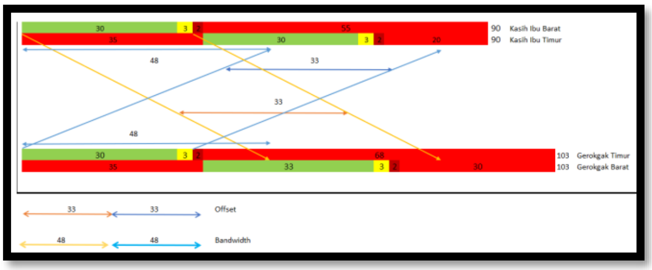

Figure 8. Space and Time Diagram at the Mother's Love Intersection – Gerokgak Intersection

Vissim Simulation Model Development

Modeling in Vissim requires data to input traffic conditions, such as: inventory of sections and intersections, traffic volume, vehicle speed distribution, APILL signal composition and traffic engineering management applied in the field.

Vissim Calibration Process

Calibration was carried out by changing several parameters of driver behavior according to observations at the research location. Validation is carried out to determine the tolerance limit for differences in results between data analysis in the field and simulation output results.

Table 6.
Adjustment of driver behavior to simulation calibration

Parameter	Nilai	Satuan
Desire Position at free flow	*any*	
Overtake on the same line	*on*	*on left and right*
Distance Standing	0.4	meter at 0 km/h
Distance Driving	0.4	meter at 50 km/h
Average Standstill distance	0.4	meter
Additive part of safety distance	0.4	
Multiplicative part of safety distance	0.8	
waiting time before diffusion	20	second
min headway (front/rear)	0.4	meter
safety distance diffusion factor	0.4	

Vissim Validation Process

Validation to determine the comparison between the results of the field survey and the Vissim simulation output using the SPSS program as a calculation. The t-test uses the Independent t-test method. As for decision making in the independent sample t-test, it can be concluded that H0 is accepted because the sig value (2- tailed) > 0.05.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Output	Equal variances assumed	.006	.938	.123	18	.903	27.000	219.228	-433.581	487.581
	Equal variances not assumed			.123	17.991	.903	27.000	219.228	-433.597	487.597

Figure 9. Independent t-test analysis results

APILL Cycle Time Optimization

From the results of the existing intersection coordination analysis, it can be concluded that the Yeh Gangga - Dukuh - Ibu Kasih and Gerokgak intersection do not yet have signal coordination. Based on this, an alternative analysis of signal coordination arrangements was carried out by considering the results of intersection performance in existing conditions. The first thing to do is equalize the signal cycle time to 105 seconds in accordance with the largest signal cycle time, namely at the Gerokgak intersection. Then divide the interval and signal phase time at other intersections. Because the queue lengths and delays are greatest at the east and west approaches, the division of green time must be greater at the east and west approaches than at the north and south approaches.

Table 7.
Cycle time optimization calculations

Intersection	Cycle Time	Fase	Intergreen	Green Time			
				Utara	Timur	Selatan	Barat
Yeh Ganga	105	3	15	20	35	20	35
Hamlet	105	3	15	15	35	15	45
A mother's love	105	3	15	15	35	15	45
Gerokgak	105	3	15	20	35	20	35

Intersection Performance of Vissim Output Results After APILL Signal Coordination

The cycles obtained from cycle time adjustments and offset and bandwidth calculations are applied in the Vissim application. The results obtained from running the simulation can produce the number of queues at the intersection.

Table 8.
Comparison of Performance Optimization of Coordination Intersection Cycle Time

Intersection	Panjang Antrian			Waktu Delay		
	Sebelum	Optimalisasi	Persentase	Sebelum	Optimalisasi	Persentase
1: Gerakgak intersection	510,21	253,33	-50,35%	55,34	32,81	-40,71%
2: Intersection of Mother's Love	112,92	139,79	23,80%	15,08	14,33	-4,97%
3: Dukuh intersection	126,05	131,44	4,28%	21,45	17,62	-17,86%
4: Yeh Gangga intersection	260,27	184,71	-29,03%	31,28	20,8	-33,50%

CONCLUTION

The performance of signalized intersections at the Yeh Gangga Interchange obtained from Vissim simulation analysis, obtained the highest queue length of 260.27 meters with a delay of 31.28 seconds. At the Dukuh intersection, the highest queue length was 126.05 meters with a delay of 21.45 seconds. At the Kasih Ibu intersection, the highest queue length was 112.92

meters with a delay of 15.08 seconds. At the Gerokgak intersection, the highest queue length was obtained at 510.21 meters with a delay of 55.34 seconds. Simulation calculations were carried out using Vissim simulation analysis by entering updated intersection time settings. The performance results for the Yeh Gangga intersection were obtained, namely the highest queue length was 184 .71 and a delay of 20.8 seconds with a decrease in delay time of 33.5%. At the Dukuh intersection, the highest queue length was obtained at 131.44 meters with a delay of 17.62 seconds with a decrease in delay time of 17.86%. At the Kasih Ibu intersection, the highest queue length was obtained at 139.79 meters with a delay of 14.33 seconds with a decrease in delay time of 4.97%. In Gerokgak, the highest queue length was obtained at 253.33 meters with a delay of 32.81 seconds with a decrease in delay time of 40.71%.

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