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PERFORMANCE EVALUATION OF SIGNIFICANT INTERSECTIONS (APILL ADAPTIVE RADAR AND LOOP DETECTOR)

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ABSTRACT
The size of the performance of the intersection can be determined based on the length of the queue, the number of vehicles stopped, and the delay. To minimize delays at signalized intersections, it is necessary to adjust each phase's cycle time and green time according to the traffic flow. Adaptive APILL is considered the answer to that. In Tegal City, two adaptive APILL have been installed: the adaptive radar APILL and the loop detector adaptive APILL. However, the performance of the adaptive APILL that is already installed is not known with certainty. Therefore, the researcher conducted a study to determine the performance of each existing adaptive APILL. The research was conducted as an experiment by treating the cycle time setting at the adaptive APILL intersection, namely when the adaptive APILL is on and the adaptive APILL is off. VISSIM and SSAM are used to analyze the performance of intersections and conflicts. From the results of the analysis, it can be concluded that 1) The performance of the intersection is less than optimal when adaptive radar APILL at Intersection 4 Alun-Alun Tegal on 2) The performance of the intersection is more optimal when loop detector adaptive APILL is at Simpang 4 Hang Tegal on.

Keywords**:** adaptive apill; intersection performance; vissim; ssam

INTRODUCTION
The most important elements in conducting an intersection performance evaluation are traffic lights, capacity and level of service. The size of the intersection performance can be determined based on the length of the queue, the number of stopped vehicles and delays (Wikrama, 2011). Delays consist of traffic delays, namely waiting time caused by traffic interactions and geometry delays caused by slowing down and accelerating vehicles that turn at intersections and or are stopped due to traffic lights (Lumintang et al, 2013). To minimize delays at signalized intersections, it is necessary to adjust the cycle time and green time of each phase according to the traffic flow. Considering that the traffic flow always fluctuates within a certain period of time, the most reliable signalized intersection cycle timing is to adjust the traffic flow at that time (real time) or what is called an adaptive signalized intersection. Through the Regulation of the Minister of Transportation PM number. 49 of 2014 concerning APILL, the Ministry of Transportation has regulated signalized intersection cycle times which consist of 3 types, namely fixed cycle times, semi-adaptive cycle times and adaptive cycle times.

In Tegal City there are 26 signalized intersections consisting of 23 intersections with fixed cycle time signals and 3 intersections with adaptive signals, namely 1 intersection with an adaptive signal using radar and 2 intersections with an adaptive signal using a loop detector. However, since the implementation of adaptive signalized intersections in Tegal City until now, no studies have been conducted to evaluate whether their implementation has a significant effect on the performance of signalized intersections.

Research conducted by the State (2017) regarding the evaluation of the performance of the intersection with a comparison of 3 scenarios shows the results in scenario-1 (do nothing) the performance of the intersection at service level F compared to scenario-2 (resetting APILL using a single program technique) the performance of the intersection increases to level service

E, scenario-2 is qualitatively better with an indicator of a decrease in the average delay reaching 22% to 118% against treatment-1. While the analysis results of scenario-3 (resetting using multi-program technique) are much better than scenario-1 and scenario-2 offering very good intersection performance. In addition, based on research conducted by Musyarofah (2015) regarding adaptive detectors at intersections with Gamping signals, it is known that the adaptive detectors of the ATCS system installed are less accurate in distinguishing the types of passing vehicles.

Based on the background above, it is very necessary to conduct research to find out how much influence the intersections have adaptive radar signals and loop detectors in Tegal City have on improving intersection performance. To find out that effect, this research was conducted with the title "Performance Evaluation of Radar and Loop Adaptive APILL Signal Intersections Detector."

METHODS

The research was conducted at intersections in Tegal City that had implemented an adaptive APILL system, namely Tegal Square 4 intersection equipped with adaptive APILL using radar and 4 Gantung intersection equipped with adaptive APILL using a loop detector. This research is an experimental research, namely an investigation in such a way that the phenomenon or event can be isolated from other influences (Yusuf, 2014). The researcher treated the cycle time settings at the adaptive APILL intersection. The treatment referred to is setting cycle times according to existing conditions where adaptive APILL is enabled (on) and setting fixed cycle times, where adaptive APILL is turned off (off). The purpose of this treatment is to compare the performance of the APILL intersection in each treatment.

The data collection method was carried out by conducting several surveys, namely geometric intersection surveys, traffic enumeration surveys on roads and turning traffic enumeration surveys. The geometric intersection survey was carried out by carrying out surveys directly in the field by observing and measuring the road sections at the research location points. The traffic enumeration survey was obtained by conducting a survey on Jl Ahmad Yani using a counter. The volume of vehicles that are still in units of vehicles per hour (veh/hour) is then multiplied by the equivalent value of a passenger car (emp) to become a passenger car unit (pcu/hour). A survey on enumeration of turning traffic was conducted to obtain data on volume of turning movements, distribution of traffic movements, and volume (turning) during planning hours. Traffic enumeration was carried out 2 (two) times, namely when the adaptive APILL was on and off separately for each traffic arm and direction.

The analysis in this study includes an analysis of intersection performance and safety analysis. Intersection performance analysis was performed using VISSIM software. VISSIM is a time and behavior based microscopic simulation developed for urban traffic models. The program can be used to analyze traffic operations under the constraints of road line configurations, traffic composition, rest stops, etc. VISSIM is used to obtain the level of service (LOS) value from LOS_A to LOS_F with the provisions of the range of delay values as shown in Table 1.

Tabel 1.
Level of Service (LOS)

LOS	Delay
LOS_A	< 10 s
LOS_B	> 10 s – 20 s
LOS_C	> 20 s – 35 s
LOS_D	> 35 s – 55 s
LOS_E	> 55 s – 80 s
LOS_F	> 80 s

Safety analysis was carried out using the SSAM (Surrogate Safety Assessment Model) software based on the results of the simulation using the VISSIM software. SSAM is a method that combines microsimulation and automatic conflict analysis and analyzes the frequency and character of the types of conflicts between vehicles in a traffic flow which is used to assess traffic safety without waiting for the number of accidents and injuries to actually occur. The SSAM program can find several results from the VISSIM data output, namely the trj format which is able to show the total conflicts that occur including crossing and rear ends (Rusmandani et al, 2020).

RESULTS

Simpang 4 Tegal City Square is a confluence of 4 roads, namely Jl. Jend Ahmad Yani – Jl. KH. Mansyur - Jl. HOS Cokroaminoto – Jl. P. Diponegoro with detailed road sections as shown in Figure 1.

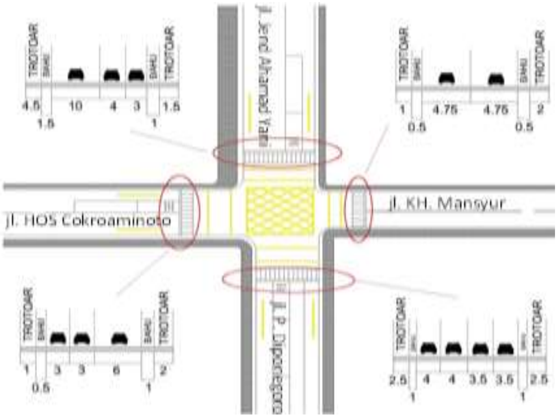

Image 1.

Detail of Jalan Simpang 4 Alun-alun

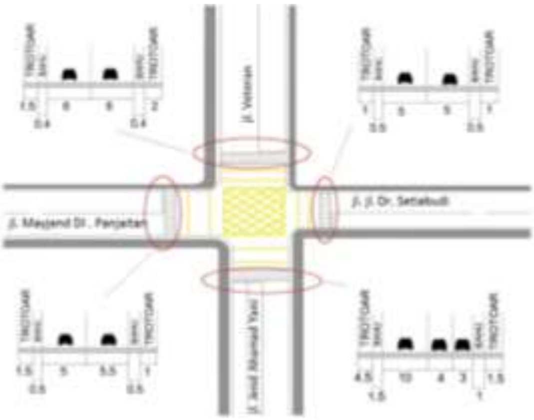

Figure 2.

Details of the Simpang 4 road section

While the 4 Hanging intersection is a confluence of 4 roads, namely Jl. Jend Ahmad Yani – Jl. Dr. Setiabudi – Jl. Major General DI. Panjaitan – Jl. Veterans with detailed road sections as shown in Figure 2.

Traffic Volumes

The traffic enumeration survey on the road was carried out on Jl. Ahmad Yani for one day from 06.00 to 18.00 for one hour calculation time. The survey results can be seen in Figure 3.

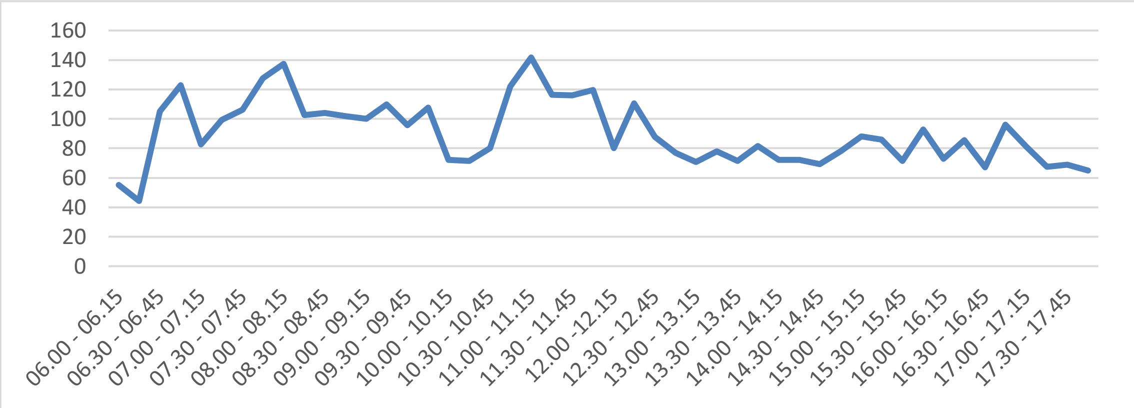

Figure 3. Vehicle Fluctuations

The graph shows that peak hours occur at 10.45 - 11.45 with vehicles passing as many as 947 vehicles/hour and passenger cars unit 496 pcu/hour.

VISSIM calibration

Calibration of the VISSIM model serves to assess the suitability between the simulation model and the observation model in order to produce output that matches the reality on the ground by adjusting the driving behavior parameters. Table 2 shows the parameters before and after being changed in the VISSIM simulation modeling.

Table 2.
VISSIM calibration
VISSIM Simulation Validation

Trial Ke	Changed parameters	Nilai	
		Before	After
Default	Desired position at free flow	Middle of lane	Middle of lane
	Overtake on same lane left & on right	Off	Off
1	Desired position at free flow	Middle of lane	any
	Overtake on same lane left & on right	Off	On
2	Average standstill distance	2	0,5
	Additive part of safety distance	2	0,5
	Multiplicative part safety distance	3	1

Validation is carried out to measure the accuracy of the model simulation and the parameters that have been set beforehand. In calculating this model validation using the Geoffey E. Harvers 9 (GEH) formula. With the provision that if GEH < 5.0 then the simulation model is declared accepted or valid, and vice versa. The GEH test results are shown in Table 3 and Table 4.

Table 3.
GEH Test Results Adaptive APILL Traffic Volume On

Intersection	Street	Survey Results	Model results	GEH	Information
4 Alun-alun	P. Diponegoro	1222	1218	0,01	Received
	HOS. Cokroaminoto	674	648	1,02	Received
4 Gantung	Ahmad Yani	948	954	0,03	Received
	DI. Panjaitan	638	628	0,15	Received
	Veteran	449	420	1,94	Received
	DR. Setia budi	374	409	2,02	Received

Table 4.
GEH Test Results APILL Traffic Volume Adaptive Off

intersection	Street	Survey Results	Model results	GEH	Information
4 Alun-alun	P. Diponegoro	1138	1110	0,70	Received
	HOS. Cokroaminoto	569	576	0,09	Received
4 Gantung	Ahmad Yani	920	906	0,21	Received
	DI. Panjaitan	722	762	2,16	Received
	Veteran	514	468	4,31	Received
	DR. Setia budi	400	438	3,45	Received

The GEH test results related to traffic volume in the simulation for each road approach show a GEH value < 5.0. Therefore, it can be concluded that by changing the parameters mentioned, the simulation model is declared valid and in accordance with the traffic flow conditions in the field.

Determination of Intersection Performance Value with VISSIM

The performance of an intersection can be seen from the LOS value which is based on the delay value. Based on data processing using the VISSIM software, the performance values are obtained as shown in Table 5.

Table 5.
Intersection Performance

Information	Intersection 4 of the square		Simpang 4 Hang	
	APILL adaptif *on*	APILL adaptif *off*	APILL adaptif *on*	APILL adaptif *off*
Antrian	6,773	5,12	13,57	16,41
Tundaan	9,41	8,14	35,59	39,45
LOS	LOS_A	LOS_A	LOS_D	LOS_D

The condition of Simpang 4 Alun-alun when adaptive APILL is on is included in the LOS A category with a queue length of 6.773 meters and a delay of 9.41 seconds. Whereas when APILL is adaptive Off, it is LOS A category with a queue of 5.12 meters and a delay of 8.14 seconds. The condition of Simpang 4 Hangs when adaptive APILL is on is included in the LOS D category with a queue length of 13.57 meters and a delay of 35.59 seconds. Meanwhile, when the adaptive APILL is off, it enters the LOS D category with a queue of 16.41 meters and a delay of 39.45 seconds.

Intersection Conflict Evaluation with SSAM

Calculation of traffic conflicts is done with the SSAM software from the processing of VISSIM data in the form of a trj file. The processing results can be seen in Table 6.

Table 6

Traffic Conflict

conflict type	Intersection 4 of the square		Simpang 4 Hang	
	APILL adaptif *on*	APILL adaptif *off*	APILL adaptif *on*	APILL adaptif *off*
Cross	0	0	5	6
Rear End	60	30	63	64

Conflicts that occurred at Simpang 4 Alun-alun in the adaptive APILL on condition were 60 incidents at the rear end, while when the adaptive APILL off condition occurred 30 incidents in the rear end. The conflict that occurred at Simpang 4 Gantung in the adaptive APILL condition was on, namely 5 cross events and 63 rear end events, whereas when the adaptive APILL off condition there were 6 cross events and 64 rear end events.

DISCUSSION

Based on the results of the intersection performance analysis that has been carried out, it can be seen that the intersection performance at Alun-alun 4 Intersection is in the LOS A category, but when viewed from the queue length and delay time the conditions when adaptive APILL is off are better than when adaptive APILL is on. Meanwhile, the performance of the intersection at Simpang 4 Simpang is in the LOS D category, but when viewed from the length of the queue and the delay time, the conditions when adaptive APILL is on tend to be better than when adaptive APILL is off.

Apart from the performance of the intersection, traffic conflicts that occur must also be considered in a traffic study. Based on the analysis conducted using SSAM, it is known that there are fewer conflicts that occur at Simpang 4 Alun-alun when adaptive APILL is off than when adaptive APILL is on. Whereas conflicts that occur at Simpang Gantung when adaptive APILL is on are fewer than when adaptive APILL is off.

Based on a study of the performance aspects of the intersection and the traffic conflicts that occur, the results show that the intersection of 4 Alun-alun using radar-adaptive APILL is considered better when adaptive APILL is off than adaptive APILL is on, it can be seen that there is a decrease in queue length by 24, 4% and a decrease in delay time of 13.5% when APILL adaptive is off. On the other hand, at the Simpang 4 Simpang using the adaptive APILL loop detector, the results showed that the intersection conditions were better when the adaptive APILL was on than the adaptive APIL was off, it was seen that there was an increase in queue length of 20.9% and an increase in delay time of 10.8 % when adaptive APILL is off.

Things that need to be noted for each type of adaptive APILL installed are that the radar adaptive APILL at Simpang 4 Alun-alun has been installed since 2019 and until now it has never been calibrated. Meanwhile, the APILL adaptive loop detector will only be installed in 2021 and is considered to not require calibration. The performance of the radar adaptive APILL is considered to be poor when compared to the loop detector adaptive APILL. The condition of the APILL adaptive radar can decrease due to frequent blackouts and there is often a possibility that the direction of the radar sensor may shift which causes the number of vehicles detected to change, while the APILL adaptive loop detector is more stable because it is installed under the road body.

CONCLUSION

Based on the analysis using VISSIM and SSAM software, the results show that the performance of the adaptive APILL of the existing radar at Simpang 4 Alun-alun Tegal is less optimal when compared to the fixed time cycle APILL, this can be seen when the adaptive APILL is off, namely a decrease in queue length from 6.77 m to 5.12 m, the delay time also decreased from 9.41 seconds to 8.14 seconds and reduced conflicts from 60 rear end events to 30 rear end events. The performance of the adaptive APILL loop detector at Simpang 4 Tegal is more optimal when compared to the APILL fixed time cycle, this can be seen when the adaptive APILL is off, namely an increase in queue length from 13.57m to 16.41m, delay time has also increased from 35 .59 seconds to 39.45 seconds, as well as an increase in conflict from 5 crosses and 63 rear ends to 6 crosses and 64 rear ends. The performance of the radar adaptive APILL is not good when compared to the loop detector adaptive APILL. This is because the condition of the APILL adaptive radar can decrease due to frequent blackouts and there is often a possibility that the direction of the radar sensor shifts which causes the number of detected vehicles to change while the APILL adaptive loop detector is more stable because it is installed under the road body.

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