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Comparative Analysis of Mlipahan Signaling Intersection Performance Using Vissim Ptv Software and Mkji Method 1997

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Abstract

The growth of motor vehicles in Surakarta from year to year always increases while road capacity does not develop. Therefore, there are often traffic jams everywhere. The discipline of every road user also plays an important role in overcoming congestion on the highway. Stages carried out from problem formulation, research objectives, and literature review, Then preliminary surveys, geometric surveys, vehicle volume surveys, and vehicle speed surveysMonday saturation degrees (DS) decreased after changing the cycle time. This means that the traffic volume at the Mlipahan intersection has decreased due to the resetting of traffic lights on Monday Road capacity: north 1,647 smp / hour, south 1,610 smp / hour, west 786 smp / hour, east 1,348 smp / hour. Saturation Degrees: North 1.15, South 1.12, West 1.15, and East 1.13. Queue Length: North 203 m, South 195 m, West 93 m, and East 145 m. obtained a value of 210 sec/smp. Sunday obtained Road capacity: North 1,763 smp / hour, South 1,549 smp / hour, West 818 smp / hour, and East 1,050 smp / hour. Saturation Degree: North 0.54, South 0.51, West 0.95, and East 0.91. Queue Length: North 92 m, South 89 m, West 87 m, and East 104 m. And the delay was obtained at 36 sec/smp. With PTV-VISSIM software, the queue length is obtained: North 97 m, South 129 m, West 198 m, and East 83 m. The delay was obtained at 72 sec/skr. And Service Level Intersection F or poor.

Keywords: Signaling Interchange, Analysis, Performance

Introduction

The growth of motor vehicles in Surakarta from year to year always increases while road capacity does not develop. Therefore, there are often traffic jams everywhere. The discipline of every road user also plays an important role in overcoming congestion on the highway. This is because not a few road users are impatient in driving because they want to immediately arrive at their respective destinations. If the road speed at the intersection is red, road users will try to get ahead of the queue by taking another lane of road so that it can interfere with vehicles that will cross the other road lane and can also reduce the capacity of the existing road.

According to Rusdiyanto (2014), at intersections using signals, the flow of vehicles entering the intersection alternately is regulated using traffic lights. The traffic

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flow through it is quite high, so the use of unsignaled intersections is no longer adequate. Traffic lights have the main function as a regulator of the right of way for traffic movements including pedestrians. According to Kurnia Anggi (2013), the intersection in question is the meeting of one plane between two or more lanes on the highway.

According to Dwi Prasetyanto (2019), traffic flow is an interaction between drivers, vehicles, and roads. No traffic flow is the same even under similar circumstances. So that the flow on a certain road section always varies (Carpintero, Vassallo, & Soliño, 2015);(Saw, Katti, & Joshi, 2015). However, parameters are needed that can indicate the condition of the road section, or that will be used as a basis for planning. These parameters are volume, speed and density, level of service, degree of saturation and degree of accompaniment.

According to Syaiful (2022), traffic signals consist of three types, namely green to walk, yellow means allowing vehicles to enter the meeting if there are no other vehicles before the red light appears and red to stop. According to Widarto (2022), a traffic light is an electrical device with a timing system that gives the right of way to one or more traffic flows so that this traffic flow can pass through intersections safely and efficiently. According to Soltani (2016), conflictis the flow of traffic from various directions will meet at an intersection point, this condition causes conflicts between road users from different directions.

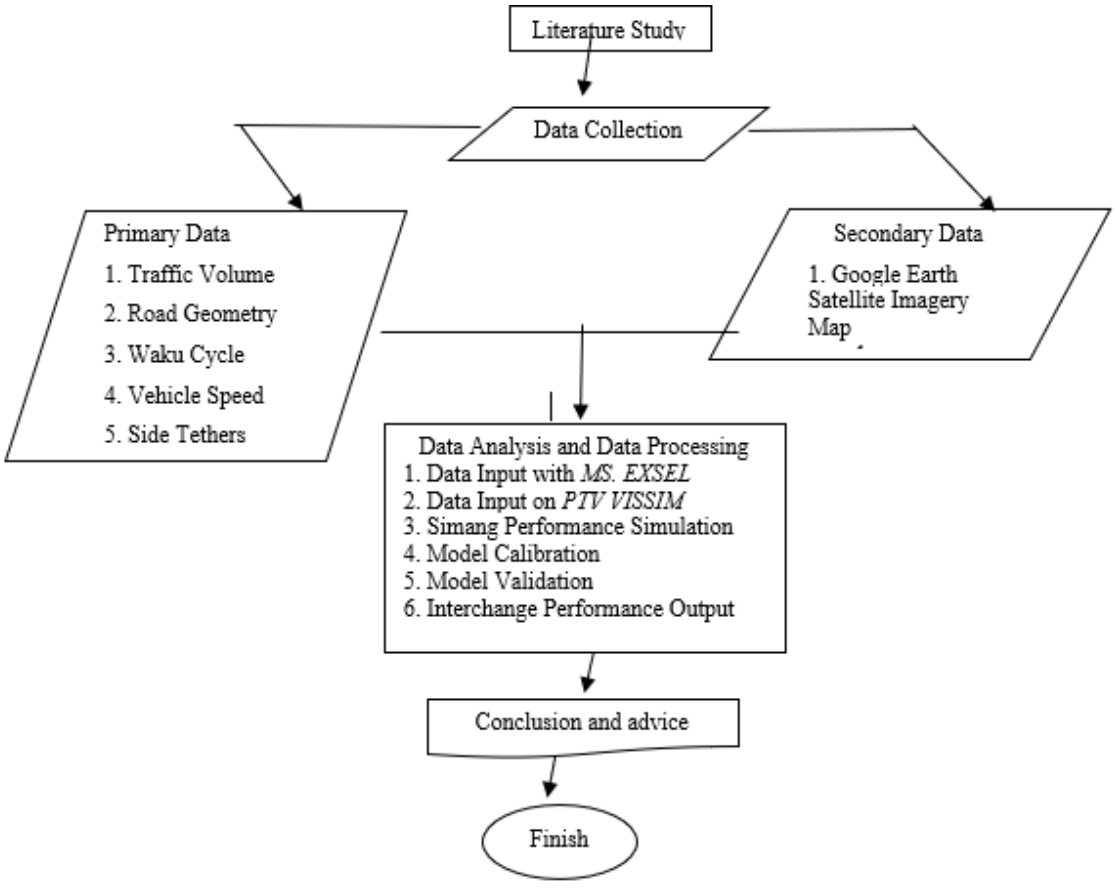
MKJI 1997 is a manual used to calculate road traffic performance but cannot be used to view or analyze network. Road facilities that can be analyzed for performance are only at signalized intersections, non-signaled intersections, interlocks and roundabouts, simple interchanges, urban roads, out-of-town roads, and expressways. VISSIM is a multimodal microscopic flow traffic simulation software that can analyze the operation of private vehicles and public transportation with problems such as lane configuration, vehicle composition, traffic signals and others (Ullah et al., 2021);(Ji, 2020);(Rakkesh, Weerasinghe, & Ranasinghe, 2016), so VISSIM becomes a useful tool for the evaluation of various alternative steps based on transportation engineering measures and effectiveness planning (Hendrayati, Askolani, Achyarsyah, Sudrajat, & Syahidah, 2020);(Meng, Zhou, J., Liu, B., & Mao, 2021);(Kurniawan & Putritama, 2020). VISSIM was developed by PTV (Planung Transport Verkehr AG) in Karlsruhe, Germany.

VISSIM stands for "Verkehr Stadten – SIMulationsmodell" which means "Traffic in the City – Simulation Model". The program provides animation capabilities with enhancements in three dimensions. According to Ramadhan (2019), the Model is a tool or media that can be used to reflect and simplify a reality (the real world) measurably. Calibration in VISSIM is a process in forming appropriate parameter values so that the model can replicate traffic to conditions that are as similar as possible. The calibration process can be carried out based on the observed behavior of the driver of the area (Flew, Martin, & Suzor, 2019). The method used is trial and error by referring to previous research on calibration and validation using VISSIM (Hutabarat, Peslinof, Afrianto, & Fendriani, 2023).

The formulation of the problem in this study is as follows: 1) What are the results of the analysis of vehicle volume, queue length, delay time, capacity, degree of saturation at the Juanda intersection using the 1997 MKJI Method? 2) What are the results of the analysis of queue length (Qlen), delay value (VehDelay) and Level of Service (LOS) using PTV-VISSIM 2023 Student Version Software? What are the results of the comparison of queue length (Qlen), delay value (VehDelay) and Level of Service (LOS) with the MKJI 1997 method and PTV-VISSIM 2023 Student Version Software?

Research Method

This study took place at the intersection of four Mlipahan. Jalan Ir. Juanda has many intersections, one of which is the Mlikahan Signaled Interchange. This interchange consists of Jalan Ir. Juanda, and Jalan Gotong Royong.



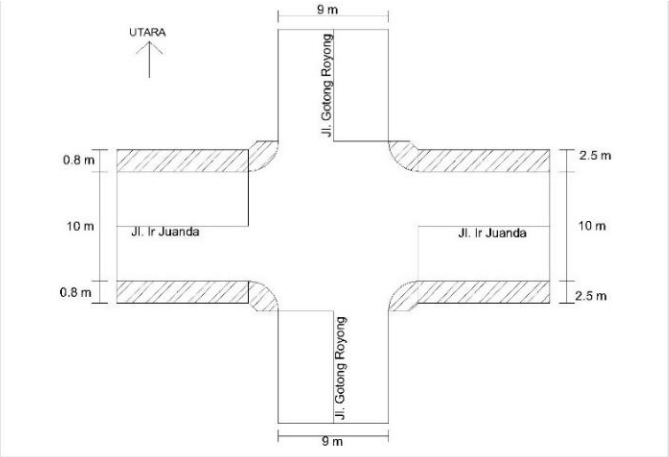
Source: Personal Data, 2023
Picture 1. Research Flow Chart

Results and Discussion

Geometric Conditions of Simpang

Geometric conditions at the Mlipahan signaled intersection, Surakarta from the results of surveys directly in the field using measuring instruments and observations. There are four arms, namely the North arm Jl. Gotong Royong, the East arm Jl. Ir. Juanda,

the South arm Jl. Gotong Royong, the West arm Jl. Ir. Juanda. For the size of the Mlipahan Simpang geometry can be seen in Picture 2 and Table 1.



Source: Personal Data, 2023

Picture 2. Geometric Conditions of Simpang Mlipahan

Table 1. Mlipahan Simpang Size

Geometric Simpang	Jl. Ir Juanda East		Jl. Ir Juanda West		Jl. Gotong Royong North		Jl. Gotong Royong South	
	Right (m)	Left (m)	Right (m)	Left (m)	Right (m)	Left (m)	Right (m)	Left (m)
Shoulder Width	2.5	2.5	0.8	0.8	-	-	-	-
Number of Lanes	1	1	1	1	1	1	1	1
Number of Paths	1	1	1	1	1	1	1	1
Lane Width	5	5	5	5	4.5	4.5	4.5	4.5
Median Width	-	-	-	-	-	-	-	-

Source: Personal Data, 2023

Traffic Light Cycle Simpang Mlipahan

It is necessary to do cycle time engineering in the form of optimization of traffic light signals to find out the cycle time of traffic lights at intersections that are the object of this study. The cycle time at each intersection can be seen in Table 2.

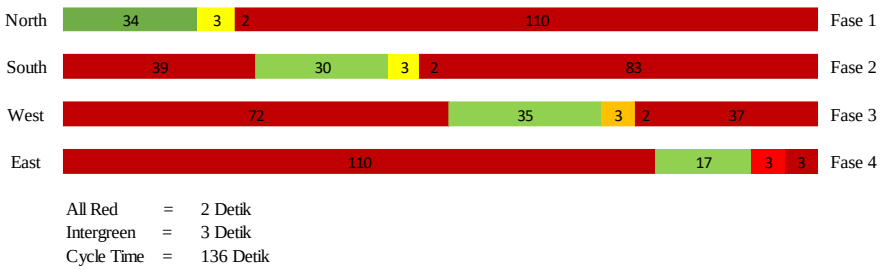
Table 2. Cycle Time of Mlipahan Interchange Signal

Approach Code	On Time (seconds)			
	Green	Yellow	All Red	Red
North	34	3	2	110
South	30	3	2	122
West	35	3	2	109
East	17	3	2	113

Source: Personal Data, 2023

From the results of recording the duration carried out on each leg of the Mlipahan intersection obtained as in Table 2 where the duration of green time is longer on the West

foot which is an average of 35 seconds, red time is longer on the South foot which is an average of 122 seconds, while the yellow time for each leg is on average for 3 seconds.



Source: Personal Data, 2023

Picture 3. Mlipahan Simpang Cycle Time Diagram

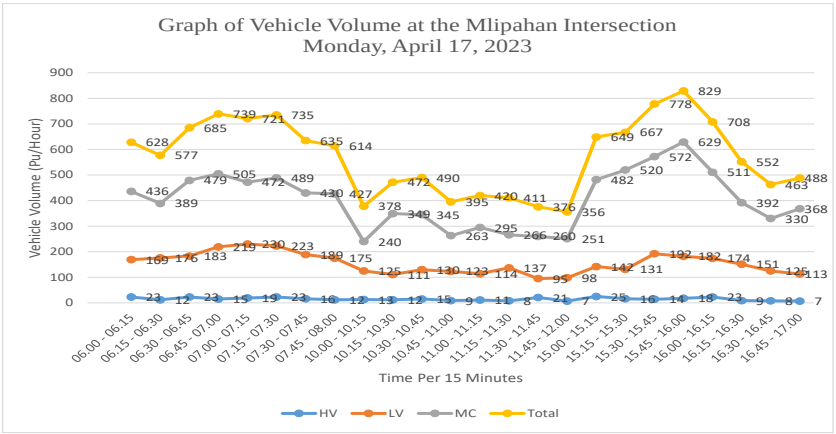
Monday's Traffic Flow Data

Traffic flow data on Monday is taken in the morning, afternoon and evening with a time period of 2 hours. Vehicle data obtained from survey results at peak hours, then hourly vehicle data is converted into light vehicle units (skr). From Monday's survey, the total number of vehicles passing on Monday can be seen in Table 3 and for the Graph can be seen in picture 4.

Table 3. Traffic Volume on Monday Simpang Mlipahan

No	VLHR Type	Vehicle / hour				Number of Junior High School / Hour			
		North	South	West	East	North	South	West	East
1	Heavy Vehicle (HV)	151	82	52	74	196.3	106.6	67.6	96.2
2	Light Vehicle (LV)	1051	1114	563	979	1051	1114	563	979
3	Motorcycles (MC)	3209	2923	1358	2932	1604.5	1461.5	679	1466
4	Non-Motor Vehicles (UM)	31	44	17	13	-	-	-	-

Source: Personal Data, 2023



Source: Personal Data, 2023

Picture 4. Vehicle Volume Graph for Monday Mlipahan Interchange

It can be concluded from Picture 4 that the vehicle that crosses the intersection the most every 15 minutes is a motorcycle (MC). The flow of vehicles is dense in the morning and evening, while during the day tends to slope.

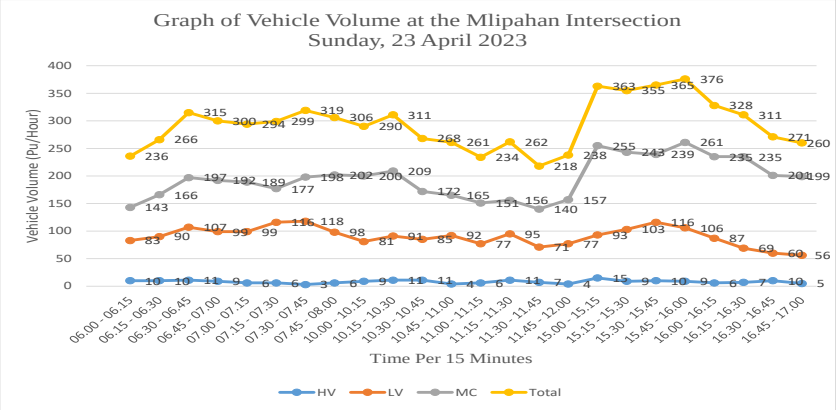
Sunday Traffic Flow Data

Traffic flow data on Sunday is taken in the morning, afternoon and evening with a time period of 2 hours. Vehicle data obtained from survey results at peak hours, then hourly vehicle data is converted into light vehicle units (skr). From the survey on Sunday, the total number of vehicles passing on Sunday can be seen in Table 4 and for the Graph can be seen in Picture 5.

Table 4. Traffic Volume on Sunday Simpang Mlipahan

No	VLHR Type	Vehicle / hour				Number of Junior High School / Hour			
		North	South	West	East	North	South	West	East
1	Heavy Vehicle (HV)	55	47	59	43	71.5	61.1	76.7	55.9
2	Light Vehicle (LV)	558	492	438	621	558	492	438	621
3	Motorcycles (MC)	1078	1160	1011	1412	539	580	505.5	706
4	Non-Motor Vehicles (UM)	24	11	14	14	-	-	-	-

Source: Personal Data, 2023



Source: Personal Data, 2023

Picture 5. Vehicle Volume Graph for Sunday Simpang Mlipahan

Calculation of MKJI 1997 Monday and Sunday

Traffic Flow (Q)

Based on the provisions of MKJI regulations and conditions in the field, the data used as traffic flow for junior high school / hour is protected conditions can be seen in Table 5.

Table 5 Vehicle Conversion to Passenger Car Unit

Vehicle Type	emp for approach type	
	Sheltered	Fight
Heavy Vehicle (HV)	1,3	1,3
Light Vehicle (LV)	1,0	1,0
Motorcycles (MC)	0,2	0,4

Source: MKJI, 1997

Calculate for each vehicle ratio can be calculated by the formula:

$$Q(RT, ST, LT) = QLV + QHV \times empHV + QMC \times empMC \quad (1)$$

where Q = Traffic Flow, emp = Passenger Car Unit Conversion.

Capacity (C)

To calculate the intersection capacity at the Mlipahan Interchange according to MKJI 1997, you can use the following formula:

$$C = S \frac{gi}{c} \quad (2)$$

where S = Saturation Current, gi = Green Time, c = Cycle TimSaturated current (S)

The Saturation Current (S) can be determined in the 1997 MKJI guide. It can be seen in the following formula:

$$S = S0 \; x \; FCS \; x \; FSF \; x \; FG \; x \; FP \; x \; FRT \; x \; FLT \quad (3)$$

where S_0 = Base Saturation Current , F_{CS} = City Size Factor, F_{SF} = Side Obstacle Adjustment Factor, F_G = Slope Factor, F_P = Parking Vehicle Factor, F_{RT} = Left Turn Factor, F_{LT} = Right Turn Factor.

Signal Timers (c)

Cycle Time (c) of Simpang Mlipahan is obtained by the formula according to MKJI 1997:

$$c = \frac{1{,}5 \; x \; LTI + 5}{1 - \sum FRCRIT} \quad (4)$$

where LTI = Lost Time Intersection , $\sum FR_{CRIT}$ = The highest RF value of all departing at a signal phase.

Saturation Degree (DS)

To calculate the degree of saturation (DS) according to MKJI 1997 can use the following formula:

$$DS = \frac{Q}{C} \quad (5)$$

where Q = Traffic Flow , C = Interchange Capacity.

Queue Length (NQ)

The length of the queue is the number of vehicles at the intersection of each lane when the red light turns on (Department P.U., 1997). The formula for determining the average queue length based on MKJI 1997, is:

$$NQ = NQ1 + NQ2 \quad (6)$$

where N_{Q1} = Number of junior high schools remaining from the previous green phase, N_{Q2} = Number of junior high schools coming in there red phase.

For a recapitulation of the calculation of MKJI 1997 on Monday and Sunday, April 16, 2023, see Table 6 and Table 7 below:

Table 6. Results of MKJI 1997 Calculation on Monday

Approach	Base Value (S0)	FCS	FSF	FG	FP	FRT	FLT	S	Q	g	c	DS
North	5580	0.94	0.95	1	0.78	1.06	0.93	3841	1889	39	1647	1.1
South	5580	0.94	0.95	1	0.78	1.13	0.95	4185	1805	35	1610	1.1
West	6420	0.94	0.95	1	0.80	1.06	0.92	4471	902	16	786	1.1
East	6420	0.94	0.95	1	1	1.09	0.93	5841	1517	21	1348	1.1

Source: Personal Data, 2023

Table 7. Results of MKJI 1997 Calculation on Sunday

Approach	Base Value (S0)	FCS	FSF	FG	FP	FRT	FLT	S	Q	g	c	DS
North	5580	0.94	0.95	1	0.77996	1.12	0.95	4113	946	39	1763	0.54
South	5580	0.94	0.95	1	0.78025	1.10	0.94	4028	785	35	1549	0.51
West	6420	0.94	0.95	1	0.8019	1.08	0.93	4654	777	16	818	0.95
East	6420	0.94	0.95	1	0.80392	1.07	0.92	4550	959	21	1050	0.91

Source: Personal Data, 2023

Signaling Interchange Analysis Using PTV-Vissim Softwere 2023

In this analysis at Simpang Mlipahan, researchers used PTV Vissim 2023 Software (Student Version). For the average recapitulation results using PTV-VISSIM 2023 Student Version software, please see Table 8.

Table 8. Recapitulation of Average Running Results of PTV VISSIM

Movement	*Qlen (m)*	*VehDelay (m)*	*LOS*
Jl. Gotong Royon Utara	97	105	LOS_F
Jl. Gotong Royong Selatan	129	107	LOS_F
Jl. Ir Juanda Barat	198	47	LOS_F
Jl. Ir JuandaTimur	204	30	LOS_F

Source: Personal Data, 2023

Based on the Running results, it can be concluded that Simpang Mlipahan has an average delay value (VehDelay) Jl. Gotong Royong Utara is 97 sec/skr, Jl. Gotong Royong Selatan is 129 sec/skr, Jl. Ir Juanda Barat is 197 sec/skr , and Jl. Ir Juanda Timur is 204 sec/skr. The average Level of Service is F (very poor). The results of existing modeling can be seen that traffic flow becomes restrained, there are long vehicle queues, low vehicle speed.

Alternative Solutions at Mipahan Interchange on Monday

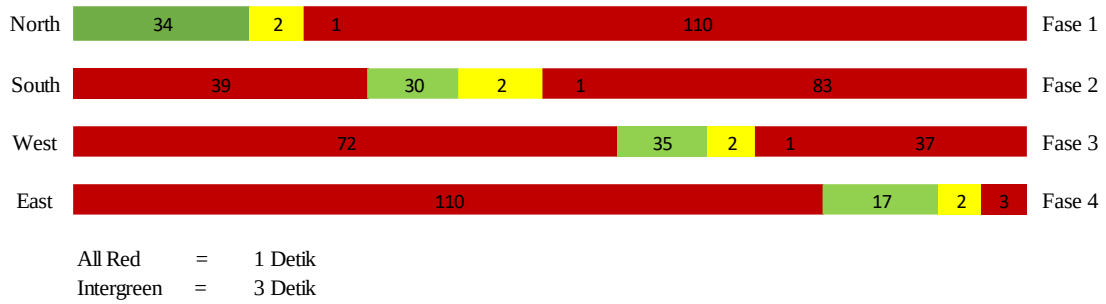
An alternative solution for optimizing the performance of Simpang Mlipahan to reduce Saturation Drama (DS) is to change the cycle time.

Table 9. Alternate Cycle Times

	North	South	West	East	Total
Green Time	34	30	35	17	116
Amber	2	2	2	2	
Red All	1	1	1	1	
Intergreen	3	3	3	3	12
Cycle Time					128

Source: Personal Data, 2023

From Table 9 it can be seen that the cycle time or cycle time which was originally 136 seconds, is now changed to 128 seconds with the original amber time of 3 seconds changed to 2 seconds each arm of the intersection. The red all time was originally 2 seconds changed to 1 second each interchange arm and the intergreen time which was originally 5 seconds was changed to 3 seconds each interchange arm. For an alternate cycle time diagram of Simpang Mlipahan can be seen in Picture 6.



Source: Personal Data, 2023

Picture 6. Alternate Cycle Time Diagram of Simpang Mlipahan

For recapitulation, the calculation of alternative solutions at Simpang Mlipahan is calculated by the same formula taken from MKJI 1997. So the calculation results can be seen in Table 10.

Table 10. Recapitulation of Calculation of Alternative Solutions on Monday

Approach	Base Value (S0)	FCS	FSF	FG	FP	FRT	FLT	S	Q	g	c	DS
North	5580	0.94	0.95	1	0.78	1.06	0.93	3841	1889	39	2506	0.8
South	5580	0.94	0.95	1	0.78	1.13	0.95	4185	1805	35	2450	0.7
West	6420	0.94	0.95	1	0.80	1.06	0.92	4471	902	16	1197	0.8
East	6420	0.94	0.95	1	1	1.09	0.93	5841	1517	21	2052	0.7

Source: Personal Data, 2023

From the recapitulation data in Table 10, it can be seen that the degree of saturation (DS) on Monday decreased. This means that the traffic volume at the Mlipahan intersection has decreased due to the resetting of the traffic light (APPIL) which originally had a cycle time of 136 after being changed to 126 seconds. According to MKJI (1997) cycle time planning for intersection four with the ideal time is between 80 – 130 seconds. This means that the cycle time at the Mlipahan Simpang has shown the ideal time for the intersection cycle.

Conclusion

From the results of the Performance Analysis of the Mlipahan Signaled Interchange in Surakarta City, it can be concluded as follows: 1) On Monday, road capacity was obtained: north 1,647 smp / hour, south 1,610 smp / hour, west 786 smp / hour, east 1,348 smp / hour. Saturation Degrees: North 1.15, South 1.12, West 1.15, and East 1.13. Queue Length: North 203 m, South 195 m, West 93 m, and East 145 m. obtained a value of 210 sec/smp. 2) On Sunday, road capacity was obtained: North 1,763 smp / hour, South 1,549 smp / hour, West 818 smp / hour, and East 1,050 smp / hour. Saturation Degree: North 0.54, South 0.51, West 0.95, and East 0.91. Queue Length: North 92 m, South 89 m, West 87 m, and East 104 m. And the delay was obtained at 36 sec/smp. 3) With PTV-VISSIM software, the queue length is obtained: North 97 m, South 129 m, West 198 m, and East 83 m. The delay is obtained at 72 sec / skr. And Service Level Intersection F or poor.

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