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OPTIMIZATION OF INTERSECTION PERFORMANCE AND VEHICLE TRAFFIC FLOW AT THE FOUR DHOHO PLAZA INTERSECTION, KEDIRI CITY USING THE 1997 MKJI METHOD

Evita Fitrianis Hidiyati[1*], Laksono Djoko Nugroho[2], Haris Muhammadun[3]
[1-3]Master of Civil Engineering 17 August 1945 Surabaya University
E-mail: [1)] evita.fitrianis08@gmail.com, [2)] laksononugroho7366@gmail.com,
[3)] hardun.wtu1@gmail.com

Abstract

Kediri is the third largest city in East Java after Surabaya and Malang with a population growth of 289,418 people in 2023. The International Airport will open at the end of 2023 in Kediri. However, rapid population growth has also led to an increase in mobility and the number of motorized vehicles on the streets of Kediri City, including at the research site in Dhoho Plaza. The analysis of the signaled intersection was carried out using the MKJI 1997 method, and Visual PTV Vissim for three days on Monday, Friday, and Sunday. Based on the results of the analysis, a cycle time of 90.7 was obtained which affected saturation in each arm of the intersection. There is a potential reduction in signal light waiting time from 135 seconds to 118 seconds by repairing side obstacles. The solution to overcome side obstacles is to improve facilities such as traffic lights and adjust the timing of signal lights. The change in the value of side barriers also has a significant impact on waiting times, queues, and fuel costs at the intersection of Pasar Pahing, with congestion cost efficiency reaching Rp. 22,679,183 in the next 5 years.

Keywords: *Congestion Fee, MKJI 1997, Interchange Signaling*

1. INTRODUCTION

Kediri, the third largest city in East Java after Surabaya and Malang, is known for its cultural heritage, history, and natural beauty. Its population reaches 289,418 people (BPS Kota Kediri 2022), and significant economic growth attracts visitors from various regions. Although Kediri City offers abundant shopping centers, population density and the growth of motorized vehicles have led to traffic congestion. Congestion, where traffic flow exceeds road capacity, is a serious challenge in Kediri City. This situation is caused by population density and an inadequate transportation system. Traffic intersections, as road nodes, are also a focus of attention as they often lead to conflicts between traffic participants. This challenge is not only a local problem, but also reflects transportation problems in developing countries such as Indonesia. Limited resources and suboptimal operation of the transportation system further complicate the problem. Congestion not only hampers mobility, but also impacts air pollution and public health.

To solve this problem, comprehensive measures are required. Analytical methods such as MKJI 1997, and PTV Vissim simulation software can help design effective solutions. MKJI 1997 is used for the analysis of saturation level and road service. PTV Vissim, as a simulation software, helps simulate complex interactions between vehicles and analyze their impact on traffic flow. It can be used to optimize traffic signal controllers and minimize congestion, emissions, and fuel consumption. Several studies have been conducted using a combination of MKJI 1997 and PTV Vissim methods to analyze the performance of signalized intersections. The results show that cycle time changes, effective width increases, and signal optimization can improve transportation system performance and reduce congestion.

This research can serve as a basis for reviewing and improving the quality of land transportation infrastructure. By understanding more about road capacity optimization, in-depth analysis using and simulation of the impact of changes using PTV Vissim, it is expected that more effective solutions can be found in addressing urban congestion in Kediri City. Nonetheless, there is a need for further research to fill the knowledge gap and identify more innovative strategies in addressing the increasingly complex transportation challenges in Kediri City. Nonetheless, there is a need for further research to fill the knowledge gap and identify more innovative strategies in addressing the increasingly complex transportation challenges in Kediri City.

2. LITERATURE REVIEW

2.1. Signalized Intersection

An intersection is a node in a road network where roads intersect and vehicles pass. Traffic at the foot of an intersection uses the road space simultaneously with other traffic. [9]. Traffic intersections are a factor that needs to be considered for traffic flow in an area. The existence of intersections must be managed properly to support the smooth movement of traffic participants. Intersections are also places where conflicts often arise between traffic participants such as vehicles with other vehicles or vehicles with pedestrians due to the use of shared space at the intersection (Siahaan, Adiman, and Djuniati 2023). One of the ways used to eliminate conflicts at intersections is to regulate the movement of vehicles in the area. Intersections are nodes in the road network where road segments meet and vehicle lanes intersect. Traffic at each intersection uses the intersection road space with other traffic (Wibisono, 2019). Therefore, intersections are the most important factor in determining capacity and travel time on road networks, especially in urban areas. Traffic intersections are a source of traffic conflicts, easily causing accidents due to collisions between vehicles and other vehicles or between vehicles and pedestrians. Therefore, it is an important aspect of traffic control. The main relevant problems at intersections are: (Amrirodiyan et al., 2020)

a. Volume and capacity, which directly affect bottlenecks.
b. Geometric design and freedom of view
c. Road accidents and safety, speed, street lights
d. Parking, access and public development
e. Pedestrians
f. Distance between stores

2.1.1 Types of Intersections

Broadly speaking, the intersection is divided into 2 parts:

1) Level crossing.
2) Non-transectional intersections

A level crossing is an intersection where various roads or ends of roads entering the intersection direct traffic to roads that can be opposite to other traffic (1997, 1997). The intersection according to the type of traffic control facility is separated into two parts:

1) A signalized intersection is a road intersection where the movement or flow of traffic from each approach is regulated by signal lights to pass through the intersection in rotation.
2) An unsignalized intersection is a meeting of roads that does not use signals in its arrangement.

The movement of traffic flow at intersections also forms a maneuver that causes frequent vehicle conflicts and collisions. Basically, vehicle maneuvers can be divided into four types, namely:

1) Diverging
2) Merging
3) Crossing (weaving)
4) Crossing

2.2. Traffic Characteristics

2.2.1. Road Traffic Flow

According to the Directorate General of Highways (1997), traffic flow is the number of motorized vehicles passing through a certain point of time, expressed in vehicles per hour or smp / hour. Urban traffic flow is divided into four (4) types: (Directorate, 1997).

1) Light Vehicle (LV): Includes motorized vehicles with 2 axles and 2.0-3.0 m axle spacing (including passenger cars, microbuses, pick-ups, small trucks, according to Bina Marga classification system).
2) Heave Vehicle (HV): Includes motor vehicles with axle spacing greater than 3.5 m usually with more than four wheels (including buses, two-axle trucks, three-axle trucks, and combination trucks).
3) Motorcycle/Motor cycle (MC): Includes 2 or three-wheeled motorized vehicles (including motorcycles and three-wheeled vehicles according to the Bina Marga classification system).
4) Un-motorized vehicles (UM): Includes wheeled vehicles that use human, animal, and other power (including tricycles, bicycles, horse-drawn carts, strollers and others according to the Bina Marga classification system).

2.2.2. Traffic Volume

Traffic volume indicates the number of vehicles that cross an observation point in one unit of time. Traffic volume can be calculated using the following formula:

$$q = n/t$$

Where:

q = Traffic volume through a point
n = The number of vehicles passing that point in the observation time interval
t = Observation time interval

2.2.3. Basic Saturation Current (So)

Saturation Flow is the highest flow at an intersection when the traffic lights have a prolonged green signal. The amount of saturation flow is obtained through the road width with a correction factor for factors that reduce the ideal flow. These factors include slope, vehicle composition, turning traffic, pedestrian activity and parked vehicles. Determination using the following formula:

So = 600 ×We (2.1)

Description:

We = Entry width of an Approach

2.2.4. Intersection Saturation Flow (S)

Intersection Saturation Flow (S) is the maximum capacity of the intersection that can be achieved before congestion occurs. The value of S can be calculated by considering the volume of vehicles and the duration of a certain time. Saturated Flow Intersection (S) can be expressed as the result of multiplication of the basic saturated current (So) with saturated current in the standard state with an adjustment factor (F) for deviation from the actual conditions of a set of conditions (ideal) that have been set before. The formula for calculating the Intersection Saturation Flow (S) (Siahaan, Adiman, and Djuniati 2023) is as follows:

S = So × F1 × F2 × F3 × F4 × .... × Fn (smp/h)

Description:

So = Basic Saturation Flow F = Adjustment Factor

Adjustments are then made for the following conditions:

1. Size ofCS Cities, millions of inhabitants
2. Side ResistanceSF , a class of side resistance from the road environment and non-motorized vehicles.
3. SlopeG , % increase (+) or decrease (-)
4. ParkingP, stopping line distance - first parked vehicle
5. Turning motionRT, % right-turning
6. LT, % left-turn

So the formula for Intersection Saturation Flow (S) is as follows: S = So × Fcs × Fsf × FG × FP × FRT × FLT (smp/h)

2.2.5. Speed

Speed is a quantity that indicates the distance traveled by a vehicle divided by the travel time. Speed can be measured as point speed, travel speed, space speed and motion speed. Slowness is the time lost when the vehicle stops, or cannot run at the desired speed due to the control system or traffic congestion. The formula for calculating speed:

V = d/t

Where:

V = Speed (km/h, m/set)

d = Distance traveled (km, m) t= travel time (hours, seconds)

2.2.6. Side Barriers

According to the Indonesian Road Capacity Manual (1997), side obstacles are impacts on traffic performance due to roadside activities (Sari et al. 2023). Side obstacles that have an influence on the level of road performance include:

1) Pedestrians walking or crossing along a road segment (PED).
2) Vehicles that stop or park on the side of the road (PSV).
3) Motor vehicles entering or exiting roadside lots (EEV).
4) Slow vehicles, i.e. bicycles, tricycles, delmans, and other slow vehicles (SMV).

3. RESEARCH METHODS

The research subject in this article is at the Four-Signal Intersection Jalan Dhoho Plaza Kediri City which is one of the connecting roads between Kediri City and Tulungagung City, Blitar and Trenggalek where the road often experiences congestion. The survey was conducted for three days, namely on Monday, Friday and Sunday. Data collection was taken 16 hours from 06:00 to 22:00 WIB. The study chose these times with the assumption that they can reflect traffic flow conditions on weekdays, weekends, and when side activities and obstacles occur.

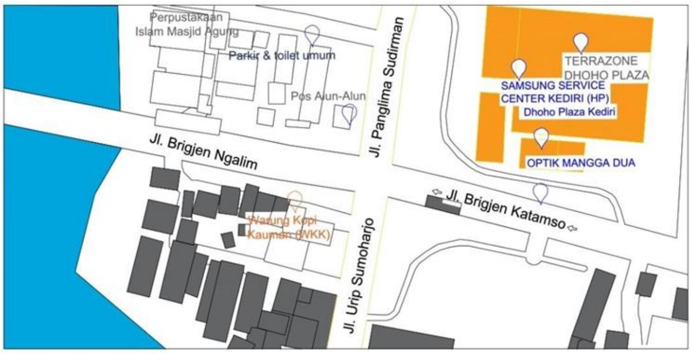

Figure 1. Location of Roads

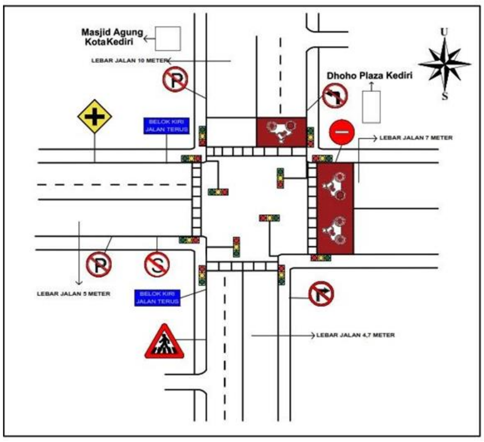

Figure 2. Geometric Details of Research Location Roads

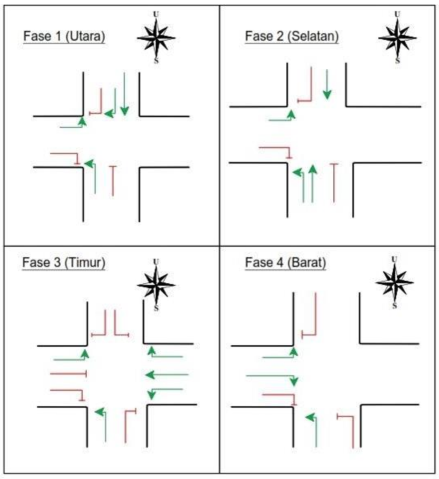

Figure 3. Phase Details on 4-way intersection Dhoho Plaza Kediri

3.1. Data Collection Procedures

The data used in this study can be divided into primary and secondary data:

1. Primary Data

To analyze the intersection of Dhoho Plaza road in Kediri City, essential primary data included vehicle traffic volume, road geometry, speed, capacity, degree of saturation, and signal timing. Traffic volume data, based on MKJI 1997 vehicle classification, was collected through manual surveys. Road geometric parameters, such as lane widths, shoulders, and medians, were measured directly in the field. Vehicle speeds and lags were identified to understand the movement aspects. Signal timing, using the MKJI method, involved collecting red, green, and yellow light timing data for 3 days at the intersection of Jalan Dhoho Plaza Kediri. While these measures provide insights, research gaps still need to be explored to develop innovative strategies to address the transportation complexity in Kediri City(Hidiyati et al. 2023).

2. Secondary Data

Secondary data obtained to complete the analysis included maps of Kediri City, information on road function and class, population, and vehicle statistics. These data were sourced from the Department of Kimpraswil Tingkat I, the Central Bureau of Statistics, and the Department of Transportation of Kediri City. Collecting this information is expected to provide further context and support a more comprehensive understanding of the condition of the city and other factors that may affect the transportation system in Kediri City.

3.2. Data Analysis Technique

Data analysis was carried out with a quantitative approach using the road capacity manual method (MKJI 1997) and visualized using Vissim Software with Alternative Handling. The MKJI 1997 method is used for signalized intersection analysis by considering several main data/principles, namely Traffic Volume, Road Geometrics, Road Capacity, Degree of Saturation, Signal Timing (Optimum Cycle), and Traffic Behavior. PTV Vissim Student 2022 is used to visualize existing conditions and reconstruction of signalized intersections(Kurnia et al. 2023; Indonesia 1997)In addition, there are other alternatives that can be used according to the research location. PTV Vissim is a microscopic multi- modal traffic simulation software developed by PTV Planung Transport Verkehr AG in Karlsruhe, Germany. PTV Vissim can be used to simulate all road users and analyze their impact on traffic flow. PTV Vissim can also be used to simulate new forms of mobility such as CAV and MaaS. PTV Vissim is part of the PTV Vision Traffic Suite which also includes PTV Visum (traffic analysis) and PTV Viswalk (pedestrian simulation)(Sharma, Gupta, and Bhardwaj 2022).

4. RESULTS AND DISCUSSION

4.1. MKJI 1997 Analysis and Calculation Method

4.1.1. Traffic Volume

This road section performance evaluation research was conducted on the section at Dhoho Plaza Intersection four and in this study the traffic flow data taken consisted of three types of vehicles, namely motorcycles (MC), light vehicles (LV), medium heavy vehicles (HV) and non-motorized vehicles (UM). From the data obtained, the results of heavy traffic volume on Sundays are obtained (For Traffic Volume data attached).

Existing geometric data at the intersection of four Dhoho Plaza Kediri can be seen in Figure 1 and Traffic Volume Results according to the following graph:

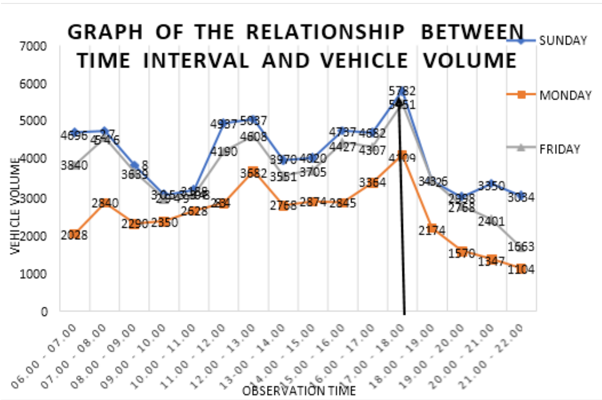

Figure 4. Sunday Peak Hour Volume Graph

The peak hour volume (VJP) is known to occur on Sundays at 17:00 - 18:00 with a total vehicle volume of 5782 vehicles/hour.

Table 1. Traffic Flow Conditions during Peak Hour 17:00 - 18:00 WIB (Combined)

Directions	Street Name	Traffic Flow (smp/hr)		
		Left	Right	Straight
North	Panglima Sudirman	216	350	432
East	Brig. Gen. Katamso	152	167	236
South	Urip Sumoharjo	312	366	332
West	Bandar Ngalim	426	549	236

Source: Researcher Data

In the table above is the peak flow conditions that occur. From the peak flow was presented according to the direction of destination of the vehicle. The above flow is a combination of inflows and outflows in the Arm in that direction.

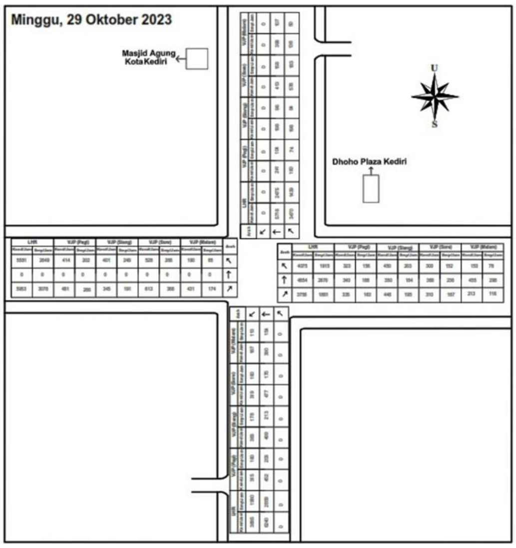

Figure 5. Traffic Volume Survey Results on Sunday
Source: Researcher Data

4.1.2. Basic Saturation Flow (So)

The basic saturation current calculation is done by calculating the effective width of the intersection gate and the vehicle flow through the intersection based on the survey data obtained (Using Formula Pers.2.1). The calculation of saturation current is first done to calculate the factors that affect the capacitance value. The following is the calculation of saturation flow on Jalan Panglima Sudirman (North):

$\boldsymbol{So} = \mathbf{600} \times \boldsymbol{We}$

$\boldsymbol{So} = \mathbf{600} \times \mathbf{10}\ \boldsymbol{m}$

$\boldsymbol{So} = \mathbf{6.000}$ Smp/Hour

After obtaining the results of the calculation of the Basic Saturation Flow (So), then will calculate the value of the Intersection Saturation Flow (S) with formula 2.3. The following is the calculation of the intersection saturation current (S) on Jalan Panglima Sudirman (North):

$\mathbf{S = So \times F_{cs} \times F \times F \times F \times F_{sfG\ P\ RTLT}}$

$\mathbf{S = 6000 \times 0,83 \times 0,94 \times 1 \times 1 \times 1 \times 1}$

S = 4681 smp/hour

Table 2. Observation Data for Calculating Intersection Saturation Flow (S)

Directions	Basic Saturation Current	City Size Factor	Side Obstacle Factor	Slope Factor	Parkig Factors	Right Turn Factor	Left Turn Factor

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	So	Fcs	Fsf	FG	FP	FRT	FLT
North	6000	0,83	0,94	1,00	1,00	1,00	1,00
East	2850	0,83	0,94	1,00	0,74	1,00	1,00
South	4200	0,83	0,94	1,00	0,74	1,00	1,00
West	3000	0,83	0,94	1,00	0,74	1,00	1,00

Source: Researcher Data

The results of the calculation of Basic Saturation Flow (So) and Intersection Saturation Flow (S) on each road section are presented in the table below:

Table 3. Basic Saturation Flow of the Four-Signal Intersection of Dhoho Plaza Kediri

Directions	Street Name	Effective Width (We)	Basic Saturation Current (So)	Intersection Saturation Flow (S)
		m	smp/hour	smp/hour
North	Panglima Sudirman	10	6000	4681
East	Brig. Gen. Katamso	7	4200	1645
South	Urip Sumoharjo	4,5	2850	2425
West	Bandar Ngalim	5	3000	1732

Source: Researcher Data

The table results in the Basic Saturation Flow (So) value for each arm of the road according to the results of the effective width of the road. The table above is the result of the calculation of the approach width with the basic saturation current(Purnomo, Oetomo, and Muhammadun 2022).

4.1.3. Vehicle Speed

Speed data is required for modeling analysis using PTV VISSIM software. The data is obtained using the Speed Gun tool with the method of taking data directly on each type of vehicle passing through the intersection. The results are obtained as in the table below:

Table 4. Heavy Vehicle Speed (HV)

Period	Distance Traveled	Travel Time	SPACE MEAN SPEED	
			m/sec	Km/hour
1	2	3	4	5
06.00 - 07.00	50	6	8,33	30,00
07.00 - 08.00	50	8	6,25	22,50
08.00 - 09.00	50	7	7,14	25,71
09.00 - 10.00	50	7	7,14	25,71
10.00 - 11.00	50	7	7,14	25,71
11.00 - 12.00	50	5	10,00	36,00

12.00 - 13.00	50	7	7,14	25,71
13-00 - 14.00	50	8	6,25	22,50
14.00 - 15.00	50	6	8,33	30,00
15.00 - 16.00	50	6	8,33	30,00
16.00 - 17.00	50	8	6,25	22,50
17.00 - 18.00	50	7	7,14	25,71
18.00 - 19.00	50	8	6,25	22,50
19.00 - 20.00	50	8	6,25	22,50
20.00 - 21.00	50	7	7,14	25,71
21.00 - 22.00	50	8	6,25	22,50

Source: Researcher Data

The above vehicle speed results were obtained using the Speed Gun tool with a distance of 50 meters per point.

4.1.4. Cycle Time

At the Dhoho Plaza four-signal intersection, the results of phase 411 are obtained with the results of green time, All Red Time and Yellow Time.

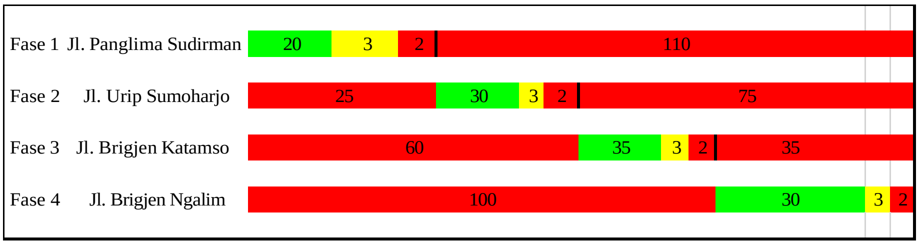

Figure 6. Dhoho Plaza Signaled Four-Junction Phase Diagram

From the results of the Dhoho plaza intersection phase, the following cycle time calculations will be obtained:

Table 5. Cycle Time of each Phase at Dhoho Plaza Intersection

Directions	**Street Name**	**Green Time (gi) (sec)**	**Total Lost Time (LTI) (seconds)**	**Flow divided by Saturated Flow (FR)**	**Signal Cycle Time (co)**
North	Panglima Sudirman	20	20	0,213	90,7
East	Brig. Gen. Katamso	35	20	0,614	90,7
South	Urip Sumoharjo	30	20	0,229	90,7
West	Bandar Ngalim	30	20	0,591	90,7

Source: Analysis Results

The cycle time at the Dhoho Plaza Intersection with 4 Phases results in 90.7 seconds.

4.1.5. Capacity (C) and Degree of Saturation (DS)

The approach capacity is obtained by multiplying the saturation flow with green time with the following calculation results:

Capacity (C)

$$\text{North} = S \times \frac{gi}{co} = 4681 \times \frac{20}{90{,}7} = 1031.8 \text{ smp/hour}$$

Degree of Saturation (DS) Northbound

$$\text{DS (north)} = \frac{Q}{C} = \frac{998}{1031{,}8} = 0{,}97$$

Figure 7. Calculation result

Table 6. Degree Saturation Analysis at Dhoho Plaza Signalized Intersection

Directions	**Street Name**	**Intersection Saturation Flow (S)**	**Capacity (C)**	**Traffic Flow (Q)**	**Degree of Kejenu (DS)**
		smp/Hour	**smp/Hour**	**smp/Hour**	
North	Panglima Sudirman	4681	1031,8	998	0,97
East	Brig.Gen. Katamso	1645	544,0	1011	1,86
South	Urip Sumoharjo	2425	935,3	555	0,59
West	Bandar Ngalim	1732	572,7	1211	2,11

Source: Analysis Results

The results of the analysis in Table 4.13 concluded that the Dhoho Plaza Signalized Intersection has a degree Saturation (DS) value of 1.4 which is in the F category. Improvements are needed to the intersection signal lights to reduce the level of service.

Table 7. Side Obstacle Data

Road Direction	**Pedestrians Feet**		**Kend. Parking**		**Kend. In/Out**		**Kend. Slow**		**Genesis. Hours**	
	Frequency of Occurrence /Hours	**Weight (0.5)**	**Frequency of Occurrence /Hours**	**Weight (1.0)**	**Frequency of Occurrence /Hours**	**Weight (0.7)**	**Frequency of Occurrence /Hours**	**Weight (0.4)**	**Total**	**Weight**
North	169	84,5	195	195	348	243,6	103	41,2	815	564,3
South	209	104,5	177	177	309	216,3	256	102,4	951	600,2
East	187	93,5	138	138	295	206,5	151	60,4	771	498,4
West	25	12,5	20	20	5	3,5	190	76	240	112
TOTAL	**590**	**295**	**530**	**530**	**957**	**669,9**	**700**	**280**	**2777**	**1774,9**

Source: MKJI 1997 and Researcher Source

Based on the 1997 Indonesian Road Capacity Manual (MKJI), the level of side obstacles generated from the table above, with an occurrence weight of 3400, is classified as a High class of side obstacles, with a range of occurrence weights of more than

>900(Panjaitan, Mahmudah, and Legowo 2018). Improvement of the value of side obstacles is done by analyzing the causes of high side obstacle values(Septiana, Mukti, and Kadarini, n.d.). Then, improvements can be made to the factors that cause these side barriers, such as road improvements, pedestrian facility improvements, or parking facility improvements. In addition, additional facilities such as traffic lights, traffic signs, or signal light timings can also be added(F. Candra and W. Widodo 1997).

4.2. Handling of Signalized Intersections

4.2.1. Side Barriers Handling

The decline in intersection performance is partly due to the level of side resistance (side factor). Improvement efforts are made by reducing the level of side obstacles from high results to low side obstacles. This decrease in weight will increase the value of the side obstacle adjustment factor (FCsf), Parking Adjustment Factor, Degree of Saturation (DS) and Cycle Time (c) values significantly. side obstacle adjustment factor (FCsf) from 0.94 to a low side obstacle of 1.00. Parking Adjustment Factor from 0.74 to 1.00 where the first vehicle parking from the intersection is 20 meters from the observation results and provides traffic signs, road markings and a ban on parking and stopping on the roadside close to the intersection. The handling uses Smart Traffic Light where the Saturation Degree results are reduced by the time engineering at Smart Traffic Light. The results of the analysis show the value of the degree of saturation (DS) in the north direction from 0.97 down to 0.40 (Table 4. 19). With the results of cycle time (c) reduced from 135 seconds to 118 seconds. So that the effect of improving side obstacles on the degree of saturation (DS) and cycle time is very significant. Not only handling using Smart Traffic Light but also engineering with the East Arm enforcing direct left turns.

4.2.2. Alternative Handling of Signalized Intersections

From the improvement of side obstacles, the DS value drops and affects the calculated cycle time. The following is a calculation and comparison of cycle times before and after reconstruction(Purwanty, Oetomo, and Nugroho 2023).

Table 8. Cycle Time of each Phase at Dhoho Plaza Intersection

Directions	Street Name	Green Time (gi) (sec)	Total Lost Time (LTI) (seconds)	Flow divided by Saturated Flow (FR)	Signal Cycle Time (c)
North	Panglima Sudirman	15	18	0,200	40,0
East	Brig. Gen. Katamso	30	18	0,427	55,9
South	Urip Sumoharjo	15	18	0,159	38,1
West	Bandar Ngalim	40	18	0,486	62,3

Source: Analysis result

The results obtained by the vehicle volume during the Alternative have been described in the table below:

Table 9. Vehicle Volume using cycle time under Alternative condition

Directions	Street Name	Traffic Flow (Q) Smp/Hour
North	Panglima Sudirman	898
East	Brig. Gen. Katamso	951
South	Urip Sumoharjo	525
West	Bandar Ngalim	1089

Source: Analysis result

The above data is obtained from prediction data from passenger data at the terminal and daily visitors to the city of Kediri.

Table 10. Degree Saturation Analysis at Dhoho Plaza Signalized Intersection

Directions	Street Name	Intersection Saturation Flow (S) smp/Hour	Capacity (C) smp/Hour	Traffic Flow (Q) smp/Hour	Degree of Kejenu (DS)
North	Panglima Sudirman	4980	1866,8	898	0,47
East	Brig. Gen. Katamso	2366	1270,1	951	0,72
South	Urip Sumoharjo	3486	1374,1	525	0,38
West	Bandar Ngalim	2490	1598,9	1089	0,62

Source: Analysis result

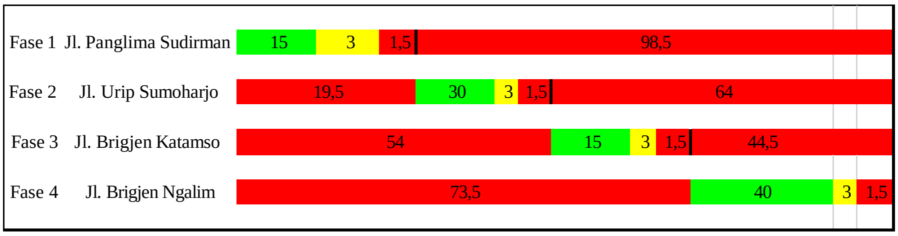

Figure 8. Current Level at Each Approach to Reconstruction Conditions
Source: Direct Observation

From the results of the reconstruction calculation above, it can be seen that the travel time efficiency is reduced from 135 seconds to 118 seconds, or 17 seconds less. The detailed results are shown in the table below.

Table 11. Comparison of Signal Time Before and After Reconstruction

Arms	Signal	Existing			Alternative		
		Yellow	**Green**	**All Red**	**Yellow**	**Green**	**All Red**
U	Phase 1	3	20	112	3	15	100
T	Phase 2	3	30	102	3	30	85
S	Phase 3	3	35	97	3	15	100
B	Phase 4	3	30	102	3	40	75
TOTAL SIGNAL LIGHT TIME		**135**			**118**		

Source: Analysis result

With the results of the above comparison, the results of the Vehicle Queue Length, Maximum Queue Length and also the Number of Vehicles Stopping in Queue are also obtained. The above results have been visualized using PTV Vissim software where the data entered is data with a high degree of saturation obtained visualization as shown belowas(Wulandari and Muchlisin 2021).

Figure 9. The situation in the existing condition at 06.00 - 07.00 WIB

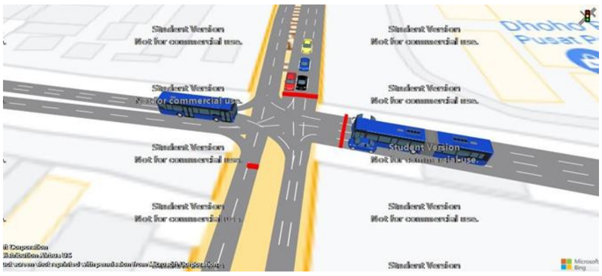

Figure 10. Conditions in Reconstruction conditions at 06.00 - 07.00 WIB
Source: Direct Observation

From this Visualization, the results of the Vehicle Queue Length are obtained with the results below:

Table 12. Queue Length Results obtained from Vissim

RECONSTRUCTION DATA 06:00 - 07:00 HOURS				
No.	**Directions**	**Qlen**	**Qlenmax**	**Qstops**
1	NORTH	12,79	26,84	19
2	EAST	13,42	63,98	26
3	SOUTH	0,03	18,86	3
4	WEST	17,50	111,58	34

Source: Analysis result

These results can be categorized as better than the existing.

5. CONCLUSION

From the cycle time analysis with respect to vehicle type, traffic volume, and vehicle speed, a cycle time (co) of 90.7 was found. The result of this cycle time will affect the Degree of Saturation, where the North Arm reaches 0.97 with level of service E, the East Arm reaches 1.86 with level of service F, the South Arm reaches 0.58 with level of service C, and the West Arm reaches 2.11 with level of service F. The analysis also shows that the waiting/queuing time for signal lights can be reduced from 135 seconds to 118 seconds. Therefore, improving side barriers will have a significant impact on the degree of saturation (DS) and cycle time. In addition to using Smart Traffic Light, engineering by enforcing a direct left turn on the East Arm and the addition of adequate signage is also required. Side obstacles can affect vehicle traffic flow at the Dhoho Plaza four-signal intersection, with an occurrence weight of 3400, classified as a High class of side obstacles. Improvements to side barriers need to be made with the addition of facilities such as traffic lights, traffic signs, or signal light timings and even improvements can plan underground roads to tackle congestion in the next 10 years(Dewanta et al. 2022).

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