

## Intersection Performance Analysis of Jl. Teuku Umar - Jl. Hos Cokroaminoto and Jl. Hos Cokroaminoto - Jl. Dg Pawindu Through Traffic Flow Engineering in Bambaru Market Area

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### ABSTRACT

This study evaluates the traffic performance at the Teuku Umar - Hos Cokroaminoto and Hos Cokroaminoto - Dg Pawindu intersections, which are impacted by market activities and on-street parking in the Bambaru Market area. Using the 1997 Indonesian Road Capacity Manual (MKJI) method, analysis shows that the Teuku Umar - Hos Cokroaminoto intersection initially operates at LOS F (DS 1.04). After traffic flow regulation, it improves slightly to LOS E (DS 0.99). Conversely, the Hos Cokroaminoto - Dg Pawindu intersection maintains an optimal LOS A. The results indicate that systematic traffic management is necessary to mitigate congestion in the area.

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## **INTRODUCTION**

Bambaru Market has a role in providing the needs of the local community. The development of Bambaru Market is located on Jalan Teuku Umar, Jalan Hos Cokroaminoto, and Jalan Dg. Pawindu, on the left and right sides of the road, there are many shops in the Bambaru Market area, which is a factor in overloading the streets around the market and the emergence of new problems in the form of traffic congestion and high side obstacles, namely the loading and unloading of goods on the shoulder of the road. In addition, the absence of adequate parking space also causes vehicles to park on the shoulder (on street parking) in the Bambaru Market Area, which can cause traffic congestion in the Bambaru Market Area. The impact can increase traffic density, decrease speed, and cause a buildup of vehicles at a certain point. This is due to the imbalance between traffic volume and the capacity of existing roads and will eventually lead to congestion. To overcome these problems, it is necessary to test several problem-solving proposals to improve market services and the performance of the road network.

In this study, I used the method of analyzing the performance of road sections and intersections, investigating generation and attraction, and analyzing traffic-impact handling, using the Indonesian Road Capacity Manual (MKJI, 1997) as the performance parameter. Along with the development of cities and the increasing flow of traffic, construction in urban areas is also on the rise, including markets and shopping centres. Market development has had both positive and negative impacts on market managers, traders, and the public as market visitors. It has brought various changes to the building's physical aspects and to the local community's economy. Thus, this is a government step to advance the economy, well-received by the community.

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The strategy to overcome traffic problems is to implement traffic management and engineering measures that optimise the use of road space and intersections in line with their capacity (Iwan Sarwako, 2017). The existence of travel generation and attraction in the area requires support for the performance of transportation facilities and infrastructure. Without adequate transportation

facilities and infrastructure, there will undoubtedly be an imbalance between travel demand and supply, which will ultimately lead to various traffic problems, such as congestion, chaos, and reduced traffic safety (Firdaus, 2017). This study uses methods for analysing the performance of road sections and intersections, generation and attraction, and traffic impact management. For the performance analysis of road sections and intersections using the Indonesian Road Capacity Manual (MKJI, 1997) as a parameter in traffic performance, and for the analysis of generation and attraction using Transportation Planning and Modelling (Tamin, 2000). Traffic, for the analysis of generation and attraction using Transportation Planning and Modelling (Tamin, 2000).

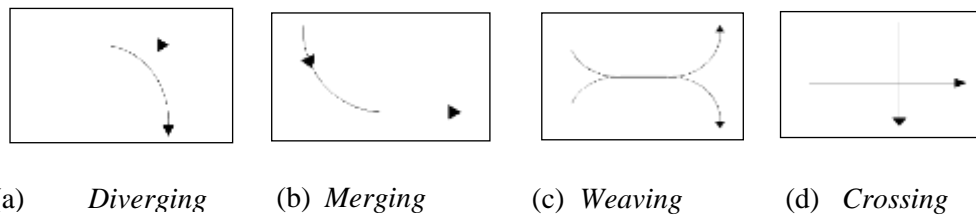
Based on the background of this problem, the objectives of this study are to analyse the existing traffic performance of the intersections Jl. Teuku Umar - Jl. Hos Cokroaminoto and Jl. Hos Cokroaminoto - Jl. Dg Pawindu. In addition, this study aims to analyse traffic performance at intersections along the route, in accordance with traffic flow regulations, in the Bambaru Market area.

## THEORETICAL REVIEW

One-way traffic management is a traffic pattern that converts two-way roads into one-way roads to increase road and intersection capacity. This system is commonly used in urban areas to improve traffic safety and smooth traffic flow. According to Alamsyah (2008), there are three traffic management strategies:

- a. Capacity Management: Use the capacity of road sections and intersection capacity as effectively as possible so that traffic movements can run smoothly.
- b. Priority Management. Several options can be implemented in priority management, especially prioritizing public transport that uses mass transit, as these vehicles move in large numbers, enabling efficient use of road sections.
- c. Demand Management The strategy of managing existing *demand* in accordance with available capacity (*supply*), some techniques that can be done are: Changing vehicle routes to move vehicles from congested areas to non-congested areas, Parking policy, Implementation of odd-even, *three-in-one*, and *road pricing* methods.

The traffic volume of a road section is the number of vehicles passing a specific point on the road section in a particular unit of time (Directorate General of Highways, 1997). The two-way traffic volume at the busiest hour of the day serves as the basis for analyzing existing road sections and intersections. For analysis purposes, the vehicles surveyed were classified into: a) *Light Vehicles (LV)*, consisting of Jeeps, *Station Wagons*, *Colt*, Sedan, Mini Bus, Combi, *Pick Up*, etc; b) *Heavy Vehicles (HV)*, consisting of Buses and Trucks; and c) *Motorcycles (Motorcycle/MC)*. There are 4 (four) basic types of vehicle manoeuvres, namely: *diverging*, *merging*, *crossing*, and *weaving*, as shown in **Figure 1**.



**Figure 1. Basic Types of Movement**

Based on MKJI issued by the Director General of Highways (1997), in analysing the performance of an unsignalled intersection, several parameters need to be considered as follows:

1. Input Data

The input data in question are the results of field surveys in the form of:

a. Geometric Conditions

These geometric conditions include the type of intersection, consisting of 4 (four) or 3 (three) arms, and whether the intersection is major or minor. In addition, things that need to be considered are the average width of the approach/foot width of the intersection, and also the type of median on the significant road (main).

b. Environmental Conditions

Environmental conditions include:

- 1) City size class, which is the size that includes the development and population of an urban area.
- 2) Side obstacles, which are activities from a land use or that occur in the road area, that can affect the traffic flow of the intersection.

c. Traffic Conditions

Traffic flow on urban roads consists of various types of vehicles, each with its own characteristics; a comparison unit is needed. In this case, all vehicle types are converted into passenger car units (smp). The following is a division of vehicle types and conversion factors for each type of vehicle based on MKJI published by the Director General of Bina Marga.

Table 1. Vehicle Type

No.	Vehicle Type	Definition
1	Non-motorised Vehicles (UM)	Bicycle, Rickshaw, Cart
2	Motorised Vehicle (MC)	Motorbike
3	Light Vehicle (LV)	Sedan, Pick up, Angkot
4	Heavy Vehicle (HV)	Bus, Truck

Source: Directorate General of Highways (1997)

The equivalent value of passenger vehicles (emp) is obtained from **Table 2**.

Table 2. Passenger Vehicle Equivalent Value

Vehicle Type	Emp value for each approach	
	Protected (P)	Opponent (O)
Light Vehicle (LV)	1.0	1.0

Heavy Vehicle (HV)	1.3	1.3
Motorcycle (MC)	0.2	0.4

Source: Directorate General of Highways (1997)

## 2. Capacity Calculation

The things needed in calculating road capacity at unsignalled intersections are as follows:

### a. Approach Width and Intersection Type

Approach width measurements are taken at a distance of 10 m from the imaginary line connecting the intersecting roads, which is considered to represent the effective approach width for each approach. The average approach width calculation is the sum of the approach widths at the intersection divided by the number of arms at the intersection.

### b. Base Capacity (Co)

The fundamental capacity value is determined from **Table 3**.

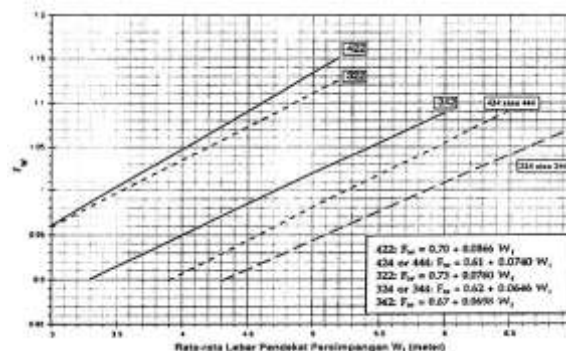
Table 3. Base Capacity

Intersection Type IT	Base Capacity (smp/hr)
322	2700
342	2900
324 or 344	3200
422	2900
424 or 444	3400

Source: Directorate General of Highways (1997)

### c. Approach Width Adjustment Factor (Fw)

The average width of all approaches  $W$  and the intersection type IT are input variables. The limit values given in **Figure 2** are the empirical base ranges from the manual.



Source: Directorate General of Highways (1997)

**Figure 2. Approach Width Adjustment Factor**

### d. Main Lane Median Adjustment Factor (FM)

The main road median adjustment ( $F_M$ ) can only be used on 4-lane main roads. The input variable is the type of central road median.

e. City Size Adjustment Factor ( $F_{cs}$ )

The city size adjustment factor is determined from **Table 4**.

Table 4. City Size Adjustment Factor ( $F_{cs}$ )

City Size ( $C_s$ )	City Population (Million)	City Size Adjustment Factor ( $F_{cs}$ )
Very small	< 0.1	0.82
Small	0.1 - 0.49	0.83
Medium	0.5 - 0.99	0.94
Large	1.0 - 3.0	1.00
Very large	> 3.0	1.05

Source: Directorate General of Highways (1997)

f. Road Environment Type Adjustment Factor and Side Obstacles (FRSU)

According to the Directorate General of Highways (1997), there are four types of factors that affect side obstacles, namely:

- i. Pedestrians (weight = 0.5)
- ii. Vehicle parking/stopping (weight = 1.0)
- iii. Vehicle exit/entry (weight = 0.7)
- iv. Non-motorised vehicles (weight = 0.4)

The frequency of each side obstacle event was enumerated within 200m to the left and right of the cross-section observed for capacity, and then multiplied by a weight.

g. Left Turn Adjustment Factor (FLT)

The left-turn adjustment factor is determined based on **Figure 3**. Left turn ( $P_{LT}$ ) is an input variable. The given limit value is based on the empirical range in the manual.

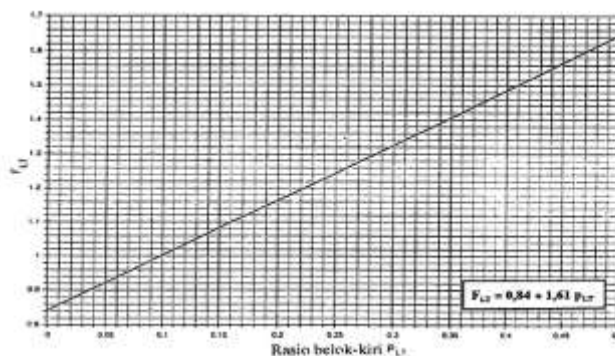
$$F_{LT} = 0.84 + 1.61 P_{LT} \dots \dots \dots (1)$$

Where:

$P_{LT}$  = Percentage of left turns on the approach.

$F_{LT}$  = Left turn adjustment factor.

The value of the correction factor for left turns is shown in **Figure 3**.



Source: Directorate General of Highways (1997)

**Figure 3. Left Turn Adjustment Factor**



C	= Capacity (smp/h)	$F_{RSU}$	= Adjustment Factors for Road Environment Type, Obstacles, and Non-Motorised Vehicles
$C_o$	= Base Capacity (smp/h)	FLT	= Left Turn Adjustment Factor
$F_w$	= Approach Width Adjustment Factor	FRT	= Right Turn Adjustment Factor
$F_{CS}$	= City Size Adjustment Factor	$F_{MI}$	= Minor Road Flow Ratio Factor Intersection Performance Levels
$F_M$	= Median Width Adjustment Factor		= Measures of performance levels and traffic behaviour at intersections can be found in the following factors:

k. *Degree of Saturation (DS = Degree of Saturation)*

The degree of saturation can be determined by using formula 4. The required variables are the total flow and road capacity.

$$DS = Q_{TOT} / C \dots\dots\dots (4)$$

Description:

DS	=	<i>Degree of Saturation</i>
$Q_{TOT}$	=	Total Flow ( <i>Quantity</i> ) (smp/hour)
C	=	<i>Capacity</i> (smp/hr)

1. *Delay*

The calculation of the delay value is divided into two types, namely: geometric delay and traffic delay. The calculation results for the two types of delays will be summed to obtain the total delay value.

1) *Intersection Traffic Delay (DT<sub>I</sub>)*

The intersection traffic delay is the average traffic delay for all motorised vehicles entering the intersection. The value of DT<sub>I</sub> is determined from the empirical curve between DT<sub>I</sub> and DS. The degree of saturation is the input variable used.

2) *Main Road Traffic Delay (DT<sub>MA</sub>)*

The main road traffic delay is the average traffic delay of all motor vehicles entering the intersection from the main road. The value of the main road traffic delay (DT<sub>MA</sub>) is determined from the empirical curve relating DT<sub>MA</sub> to DS. The degree of saturation is an input variable.

3) *Minor Road Traffic Delay (DT<sub>MI</sub>)*

The average minor road traffic delay is determined based on the average intersection delay and the average main road delay.

$$DT_{MI} = (Q_{TOT} \times DT_I - Q_{MAX} \times DT_{MA}) / Q_{MI} \dots\dots\dots (5)$$

Description:

$DT_{MI}$	=	Minor road traffic delay (sec/smp)	$Q_{MA}$	=	Main road flow (smp/h)
$Q_{TOT}$	=	Total Flow (smp/h)	$DT_{MA}$	=	Main road traffic delay
$DT_I$	=	Intersection traffic delay (sec/smp)	$Q_{MI}$	=	Minor road flow (smp/h)

4) *Intersection Geometric Delay (DG)*

Geometric Delay is the average geometric delay of all motorised vehicles entering the intersection. DG is calculated using the following formula:

For  $DS < 1.0$

$$DG = (1-DS) \times (P_r \times 6 + (1- P_r) \times 3) + DS \times 4 \text{ (sec/smp) ..... (6)}$$

For  $DS \geq 1.0$

$$DG = 4$$

Description:

DG = Intersection geometric delay (sec/smp)

DS = Degree of Saturation

$P_r$  = Total Turning Ratio

5) Intersection *Delay* ( $D = Delay$ )

The intersection delay is the sum of the intersection traffic delay and the intersection geometric delay. The intersection delay can be formulated as follows:

$$D = DG + DT_1 \text{ (seconds/smp) ..... (7)}$$

Where:

DG = Geometric Intersection Delay (seconds/smp)

$DT_1$  = Intersection Traffic Delay (sec/smp)

m. Queuing Opportunity (QP%)

The range of queuing opportunity values is determined from the empirical relationship between queuing opportunities and degrees of saturation. The degree of saturation becomes the input variable.

## METHODOLOGY

### *Research Type*

The research used is quantitative. Quantitative research is a research method that emphasizes numerical data to conclude. Sugiyono's (2008: 7) survey method is a quantitative research method used to obtain data that occurred in the past or present, about the beliefs, opinions, characteristics, and behaviour of the object under study. At the same time, quantitative research, according to Sugiyono (2018), is a research method based on the philosophy of positivism (concrete data), research data in the form of numbers to be measured using statistics as a calculation test tool, related to the problem under study, to produce a conclusion.

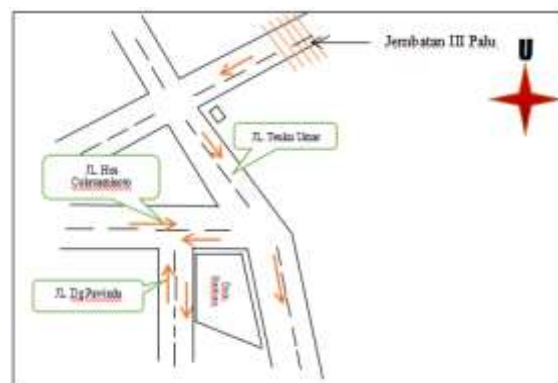
### *Research Location*

The location of this research was conducted at the intersection of JL. Hos Cokroaminoto - JL. Dg. Pawindu and JL. Teuku Umar - JL. Hos Cokroaminoto.



Source: Spatial Data Processing (2022)

**Figure 6. Research Location**



Source: Preliminary Survey (2022)

**Figure 7. Sketch of Research Location of Intersection**

### ***Analysis Method***

Primary data collection of traffic flow is carried out by recording the clarified traffic flow method starting from traffic volume data which includes the number of motorbikes (MC), light vehicles (LV) and heavy vehicles (HV) and also taking data on side obstacles which include pedestrians (PED), stopped vehicles (PSV), vehicles entering and leaving the side of the road (EEV), and slow vehicles (UM) namely bicycles, carts and others. At the same time, secondary data collection can be obtained from relevant agencies. The analysis only reviewed the affected road sections around the Bambaru Market area.

This analysis and research use the Indonesian Road Capacity Guidelines method to calculate the performance of road sections and intersections, as presented in Chapter II. Intersection performance in the form of capacity, degree of saturation, queuing opportunities, delays, and level of service of the intersection.

After the data is analysed, alternative measures to improve road performance can be implemented to address traffic problems. After that, conclusions and suggestions for alternative improvements to road performance to address problems at the location can be drawn.

## RESULTS AND DISCUSSION

### *Analysis of Movement Attraction*

The analysis of the unsignalled intersections of Jalan Teuku Umar - Jalan Hos Cokroaminoto and Jalan Hos Cokroaminoto - Jalan Dg Pawindu in the existing period aims to determine their performance in the Bambaru market area. The performance of the unsignalled intersection during the existing period is determined by examining the pull in the Bambaru Market area. With 6 Exit / Entry Conditions in the Bambaru Market area. The number of vehicles visiting the Bambaru Market area on Tuesday, 29 November 2022, was 1360/hour from 06.30 - 19.00 WITA. The results of the analysis of pull in units of passenger cars (smp/hour) are shown in **Table 5**.

Table 5. Table of Analysis of Movement Pull Value of Bambaru Market Area (smp / hour)

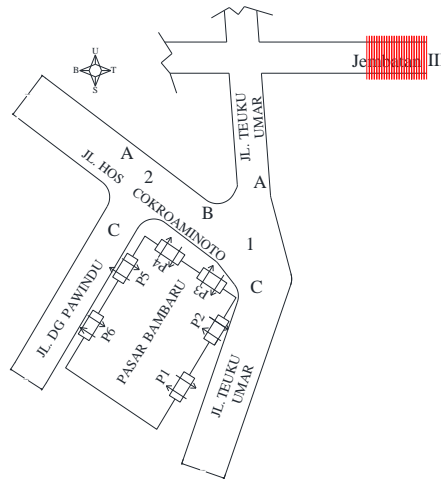
No	Entry		Total (smp/hour)	Exit		Total (smp/hr)
	Car	Motorbike		Car	Motorbike	
1	105	28.5	133.5	112	16.5	128.5

### *Traffic Volume Data*

The traffic survey of the unsignalled intersection of Jalan Teuku Umar - Jalan Hos Cokroaminoto and Jalan Hos Cokroaminoto - Jalan Dg Pawindu intersection was carried out on Tuesday. This survey was carried out from 06:30 to 19:00 WITA. Traffic volume data were obtained from surveyors who recorded the number of vehicles passing through the intersection by vehicle classification using the intersection traffic survey format. The survey data can show traffic volume in vehicles per hour (kend/hr) and the peak hours at the intersection. After all the data has been grouped by vehicle classification, all vehicle types are then equalised into passenger car units (smp) by multiplying the number of each vehicle type by the passenger car equivalent (emp) for the intersection. The passenger car equivalent for each type of vehicle is as follows:

1. Motorcycle (MC) = 0.50
2. Light Vehicle (LV) = 1.00
3. Heavy Vehicle (HV) = 1.30

Then the results are summed over the hourly time interval, yielding the intersection traffic volume in units of passenger cars per hour (smp/h). Activities at Bambaru Market typically run from the morning until the afternoon, so to analyse the performance of the unsignalled intersection during these activities, this study used peak data from the afternoon. These data are considered representative of other data that occur. A picture of the area, including the intersection of Jalan Teuku Umar - Jalan Hos Cokroaminoto and the intersection of Jalan Hos Cokroaminoto - Jalan Dg Pawindu, is shown in **Figure 8**.



**Figure 8. Picture of the area, the intersection of Jalan Teuku Umar - Jalan Hos Cokroaminoto, and the intersection of Jalan Hos Cokroaminoto - Jalan Dg Pawindu**

The survey data for the unsignalled intersections of Jalan Teuku Umar - Jalan Hos Cokroaminoto and Jalan Hos Cokroaminoto - Jalan Dg Pawindu are presented in Table 6 and Table 7.

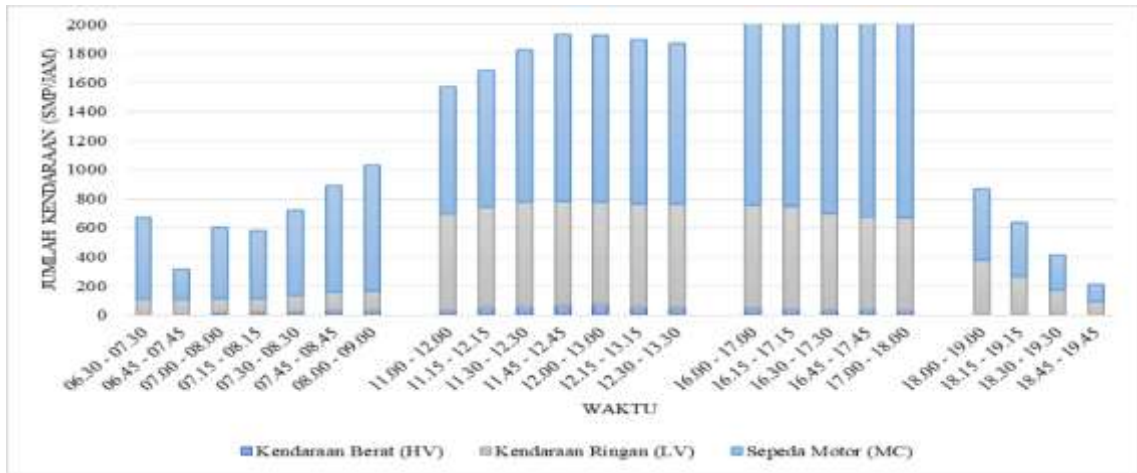
**Table 6. Unsignalled intersection survey results table Teuku Umar Street Intersection - Hos Cokroaminoto Street**

NO	Sinjang	Arah dari Lengan A			Arah dari Lengan B			Arah dari Lengan C			Total (smp/jam)			
		RT			ST			RT				ST		
		Arah ke lengan B			Arah ke lengan C			Arah ke lengan C				Arah ke lengan C		
		MC	LV	HV	MC	LV	HV	MC	LV	HV		MC	LV	HV
0.5	1	1.3	0.5	1	1.3	0.5	1	1.3	0.5	1	1.3			
1	Jalan Teuku Umar - Jalan Hos Cokroaminoto	106	82	5.2	702	345	20.8	42	5	0	621	272	15.6	2215.6

**Table 7. Unsignalled intersection survey results table of Jalan Hos Cokroaminoto - Jalan Dg Pawindu intersection**

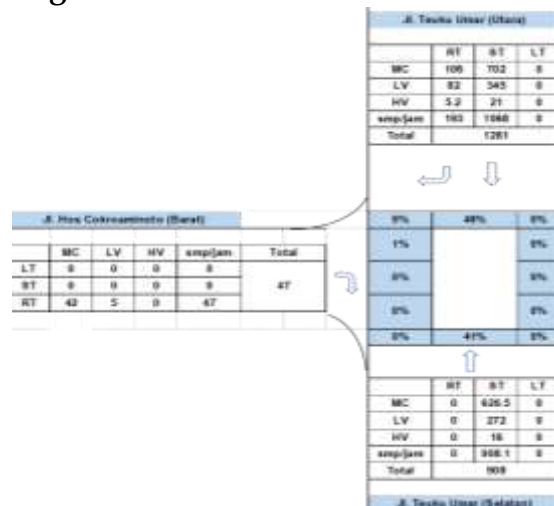
NO	Sinjang	Arah dari Lengan A			Arah dari Lengan B			Arah dari Lengan C			Total (smp/jam)									
		RT			ST			LT				RT								
		Arah ke lengan B			Arah ke lengan C			Arah ke lengan C				Arah ke lengan A			Arah ke lengan B					
		MC	LV	HV	MC	LV	HV	MC	LV	HV		MC	LV	HV	MC	LV	HV			
0.5	1	1.3	0.5	1	1.3	0.5	1	1.3	0.5	1	1.3	0.5	1	1.3	0.5	1	1.3			
1	Jalan Hos Cokroaminoto - Jalan Dg Pawindu	24	3	144	44	5	0	34.5	27	3.9	71	56	1.3	21.5	4	0	44	5	0	489

Based on the traffic survey data in Tables 6 and 7, the observed traffic flow fluctuations at the intersection of Jalan Teuku Umar - Jalan Hos Cokroaminoto in Pasar Bambaru on Tuesday are shown in **Figure 9**.



**Figure 9. Fluctuation of Traffic Flow at the Intersection of Jalan Teuku Umar - Jalan Hos Cokroaminoto**

The distribution of traffic flow at the Teuku Umar Road - Hos Cokroaminoto Road intersection on Tuesday, 29 November 2022, from 16.15 to 17.15 is shown in **Figure 10**.



**Figure 10. Distribution of traffic flow at the intersection of Jalan Teuku Umar - Jalan Hos Cokroaminoto**

The traffic flow fluctuations indicate that the peak hours are 08.00 - 09.00, 11.45 - 12.45, 16.15 - 17.15, and 18.00 - 19.00. Furthermore, the traffic flow fluctuations at the unsignalled intersection of Jalan Hos Cokroaminoto - Jalan Dg Pawindu on Tuesday are shown in **Figure 11**.



## CONCLUSIONS AND RECOMMENDATIONS

1. Based on the results of the analysis and discussion of the existing traffic performance of the intersection Jl. Teuku Umar - Jl. Hos Cokroaminoto, it can be concluded as follows:
  - a) The maximum traffic flow volume of the unsignalised intersection of Jalan Teuku Umar - Jalan Hos Cokroaminoto occurred on Tuesday, 29 November 2022 at 16.15 - 17.15 WITA, which was 1307.5 smp / hour. The degree of saturation (DS) value is 0.67, and the intersection delay is 8.89 sec /mp. Queue opportunities (QP%) 38% - 18%.
  - b) The maximum traffic flow volume of the unsignalised intersection of Jalan Hos Cokroaminoto - Jalan Dg Pawindu occurred on Tuesday, 29 November 2022 at 16.15 - 17.15 WITA, which was 489.30 smp / hour. The degree of saturation (DS) value is 0.28, and the intersection delay is 5.52 sec /mp. Queue opportunities (QP%) 13% - 4%. Judging from this value, the performance of the unsignalised intersection Jl. Hos Cokroaminoto - Jalan Dg Pawindu can be categorised as Level of Service (LoS) A, namely free-flow conditions, low volume, high speed, and drivers can choose the desired speed.
2. Based on the traffic performance of the Jl. Hos Cokroaminoto - Jl. Dg Pawindu intersection after the regulation of traffic flow in the Bambaru Market area, it can be concluded as follows:
  - a) The maximum traffic flow volume of the unsignalised intersection Jalan Teuku Umar - Jalan Hos Cokroaminoto occurred on Tuesday, 29 November 2022, which was 1252.5 smp/hr. The degree of saturation (DS) value is 0.62, the intersection delay is 10.40 sec/smp. Queuing opportunities (QP%) 34% - 16%. Judging from these values, the performance of the unsignalised intersection at Jalan Teuku Umar - Jalan Hos Cokroaminoto can be categorised as Level of Service (LOS) B, with stable flow conditions, speed slightly limited by traffic, and drivers still able to choose their desired speed.
  - b) The maximum traffic flow volume of the unsignalised intersection of Jalan Hos Cokroaminoto - Jalan Dg Pawindu occurred on Tuesday, 29 November 2022 at 577.3 smp/hour. The degree of saturation (DS) value is 0.29, and the intersection delay is 5.57 sec /mp. Queuing opportunities (QP%) 13% - 4%. Based on this value, the performance of the unsignalised intersection at Jalan Hos Cokroaminoto - Jalan Dg Pawindu can be categorised as Level of Service (LOS) A, namely free-flow conditions, low volume, high speed, and drivers can choose the desired speed.

### *Recommendations*

Based on the analysis and conclusions, the saturation and delay values are increasing; related parties must plan traffic management measures, such as installing no-parking signs, to reduce the value of side obstacles. This is done to maintain the level of service at the Teuku Umar Road - Jalan Hos Cokroaminoto unsignalised intersection, which remains good.

## FURTHER STUDY

Future research is recommended to examine intersection performance using longer observation periods and more comprehensive traffic variables, including pedestrian movement, parking behavior, and public transport activity around market areas. Further studies may also evaluate the effectiveness of alternative traffic engineering strategies such as signal optimization, geometric redesign, and smart traffic management systems to improve intersection performance more sustainably.

## ACKNOWLEDGMENT

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