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ANALYSIS OF THE UNSIGNALIZED INTERSECTION OF MUHARTO ROAD, KI AGENG GRIBIG ROAD, AND MAYJEND SUNGKONO ROAD

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ABSTRACT

Delays that occur at intersections greatly affect the performance of the road network. The more intersections there are, the greater the delay value will be. One of the intersections in Malang City is the three unsignalized intersections of Muharto Road, Ki ageng Gribig Road, and Mayjend Sungkono Road or also called the Kedungkandang intersection which is the research location. The research aims to determine the performance and project problems at the Kedungkandang Intersection. The data used in the study include road geometric data, traffic volume, acceptance gap, population, and vehicle growth. Based on the 1997 MKJI guide, the results of the study show that the Kedungkandang intersection is included in the level of service criteria C (DS 1.52) with an intersection delay value of 23.29 sec /mp. Based on the processing of gap data with the Raff method, the gap value is 15.1 seconds for the morning, 16.3 seconds for the afternoon, and 17.2 seconds for the afternoon, thus indicating that driver behavior must wait for a gap when entering the main road. The projection results with the placement of right-turn prohibition signs and geometric widening of Muharto Road and Ki Ageng Gribig Road obtained a level of service value of B (DS 0.69) with an Intersection Delay Value of 12.40 sec/smp.

Keywords: *Gap Acceptance; MKJI 1997; Unsignalized Intersection; Delay.*

1. Introduction

Malang is currently known as the largest education city in East Java province. In addition to the education sector, the number of investors or capital owners who make Malang an industrial area and shops is the cause of the generation and attraction to Malang City experiencing a significant increase. The increasing development of Malang City has had a huge impact on the existing transportation system. This is characterized by the many congestion points located in Malang City as a result of a significant surge in vehicle growth so the performance of road sections is getting worse.

The general goal of transportation planning is to make interaction easy and efficient. One way is to use the transportation system properly and optimally. Transportation consists of three subsystems: the activity system, movement system, and network system.[1]. Traffic processes and management are carried out in an effort to optimize existing space and traffic demands, in order to produce a technical road design that meets the criteria of smooth, safe, and comfortable for the movement of traffic.[2].

Congestion problems generally occur at intersections. One of the causes of congestion occurs due to decreased intersection performance due to a large number of vehicles.[3]. An intersection is a meeting place for traffic flows from two or more roads. The performance of the road network takes into account the delay due to the intersection consisting of signalized and unsignalized intersections. The more intersections on a road network, the greater the chance of delays occurring [4]. As happened at the kedungkandang intersection located on Muharto road, Ki Ajeng Gribig road and Mayjend Sungkono road. A large number of vehicles, especially due to the Sawojajar Toll Road activity, makes this intersection an alternative route so that congestion often occurs. [5]

Vol. 4, No. 1, pp. 13-20, March 2023
e-ISSN: 2775-5592

2. Methods

According to [6] the performance of an intersection can be defined as a measure that describes the operational condition of an intersection facility, the performance of an intersection can be measured by calculating capacity, degree of saturation, delay and queuing opportunities.

The equipment needed in this study are video cameras as field documentation, meters, *stopwatches/watches*, *hand counters, stationery* and *clipboards*, survey forms, *traffic counter* applications. The LHR calculation was carried out for 2 (two) weeks, with a time of 16 hours / day starting at 06:00-22:00. The calculation of vehicles passing through the intersection is classified into four groups, namely:

a) Light vehicles (LV), including: passenger cars, minibuses, private cars, and pick-ups.
b) Heavy vehicles (HV), including: trucks, buses.
c) Motorcycle (MC)
d) Non-motorized vehicles (UM), including: bicycles, rickshaws, wheelbarrows, and delmans.

Primary data is data obtained in the field by direct observation at the study site. Primary data needed include road geometric data (how much is the width of the approach, the number of lanes, the width of the road shoulder from the road section under review.

Traffic flow data is intended to determine the level of traffic density of an intersection based on the volume of traffic that includes the type of vehicle and the direction of vehicle movement, by making direct observations and enumeration at each leg of the intersection within a period of time with the observed data being the number and type/classification of vehicles and the direction of traffic flow.

Observing the *gap* with respect to these differences in driver behavior will result in biased data. To avoid this condition Selter. R.J. (1981) suggests using data only on the first occasion that a driver on a minor road makes a decision after arriving at the intersection to *cross* and *merge* on the main/major road. In this way most observations become acceptable *lag* values.

Secondary data is needed to obtain supporting data needed in the preparation of research. Secondary data will be obtained from books and related journals and from the Central Statistics Agency[7] to obtain data on the population and vehicle growth of Malang City in 2021-2022.

The procedure for calculating the performance of unsignalized intersections in more detail using the USIG form in the [6] guidelines, the calculation procedure for the performance analysis of unsignalized intersections includes forms used to determine the performance of intersections at unsignalized intersections.

Gap is defined as the time between the passage of a vehicle and the arrival of the next vehicle. Technically, the gap is measured from the rear bumper of the vehicle in front to the front humper of the next vehicle. A gap is accepted (called gap *acceptance*) if a vehicle from a side road passes through or into the gap between the arrival of two vehicles on the main road. In several previous studies, it was found that *gap acceptance* behavior is influenced by the waiting time of minor road drivers, major road traffic flow, visibility (day or night), the presence of queues on minor roads, stopping behavior at intersections, and vehicle type (Hidayat et al., 2020).[8].

Raff and Hart (1950) define a critical gap as a gap size where the number of accepted gaps is smaller than given and equal to the number of rejected gaps greater than given is the average value of accepted and rejected gap observations. This definition forms the intersection of two cumulative curves at the sum of the accepted and rejected gaps. The rejected gap curve is obtained by using the total rejected gaps with a rejected gap size greater than the lower limit of the predefined gap size class. The accepted gap curve is obtained from a cumulative curve that describes the total number of accepted gaps smaller than the lower class limit of the predetermined gap size.[9]

Vol. 4, No. 1, pp. 13-20, March 2023
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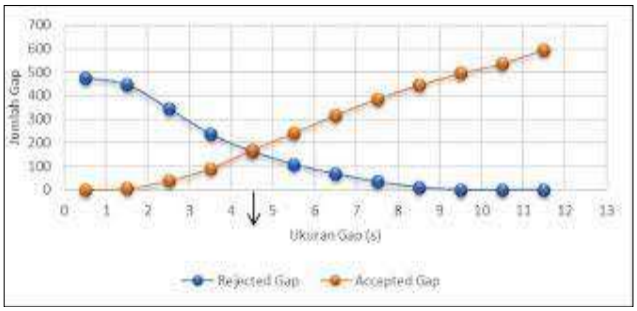

Figure 1. Raff method critical gap determination
Source: MKJI (1997)

The analysis stage is a follow-up after data processing has been completed. The purpose of this stage is to understand and analyze the results of processing in depth, especially in terms of:

a) To determine the performance of the intersection, the analysis is based on MKJI 1997. Meanwhile, to obtain the emp value at the intersection using the capacity method. The selection of this method is due to the limited time and cost of researchers, so it is not possible to use other methods such as: shrinkage method, travel time method, *headway method,* and vehicle hour method.
b) Analyze the number of traffic volume conflicts that occur at unsignalized intersections by counting the number of vehicles from minor roads that successfully enter and pass through the intersection.
c) Analyze the relationship of the number of traffic volume conflicts to the traffic volume at the intersection.
d) Analyzed the accepted gaps and rejected gaps to obtain the "*critical gap*" value at unsignalized intersections using the "*Raff Method*".

Gap data was collected using a camera. The playback was done on a *mobile computer* with the help of *media player software*. The first step is to identify vehicles that get *natural gaps* and *force gaps*, pause the *media player* and record the *gaps of* two mainstream vehicles that are utilized by minor current vehicles, this step is carried out continuously. Recording the gap time by utilizing the time duration listed on the *media player* with the subtraction operation between the final vehicle of the gap and the initial vehicle of the gap. The difference is the natural gap [10]. Gap data collection was carried out during the estimated peak hours (morning, afternoon, and evening) on each observation day.

3. Results and Discussion

Kedungkandang intersection has a geometric condition with three arms with specifications as in the following table:

Table 1. Geometrics of Kedungkandang Triple Intersection

Street Name	Classification	Type	Size	
			Width(m)	Shoulder Width (m)
Jl. Ki Ageng Gribig	Collector	2/2 UD	7,6	1
Jl. Mayjend Sungkono	Collector	4/2 UD	10,6	1
Jl. Muharto	Collector	2/2 UD	8,6	1

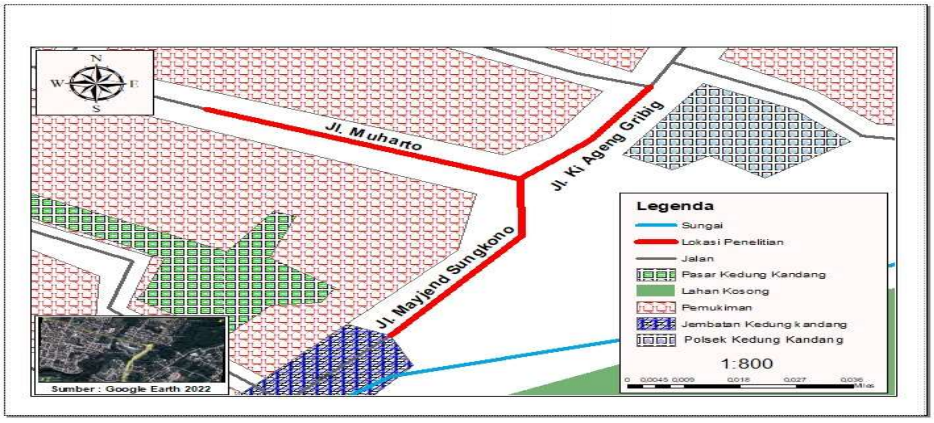

Figure 2. Administration Map of Kedungkandang Intersection

The traffic volume data used in this study is data on June 09 - June 15, 2022.

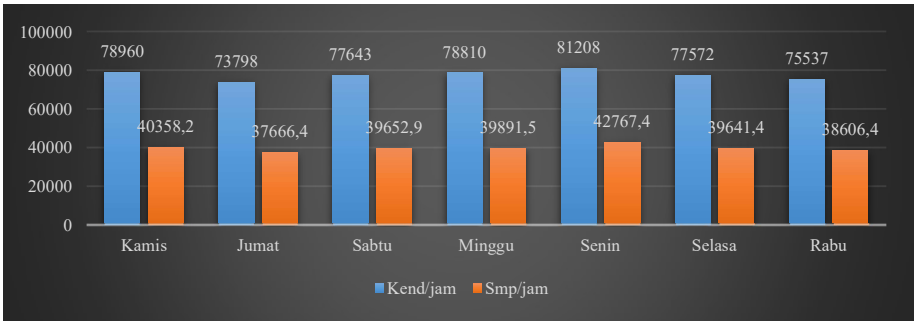

Figure 3. Traffic Volume

From table 3 above, the peak traffic volume can be seen from the volume of vehicles passing through the Kedungkandang intersection from Thursday, June 09, 2022 to Wednesday, June 15, 2022 occurred on Monday, June 13, 2022 for *weekday* and on Sunday, June 12, 2022 for *weekend.*

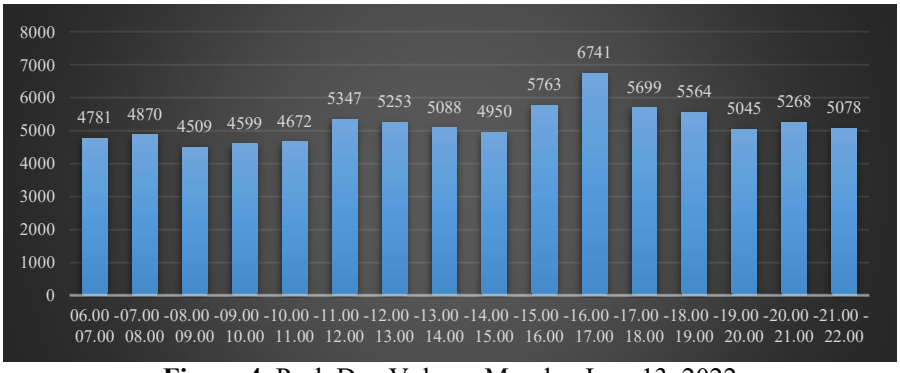

Figure 4. Peak Day Volume Monday June 13, 2022

Vol. 4, No. 1, pp. 13-20, March 2023
e-ISSN: 2775-5592

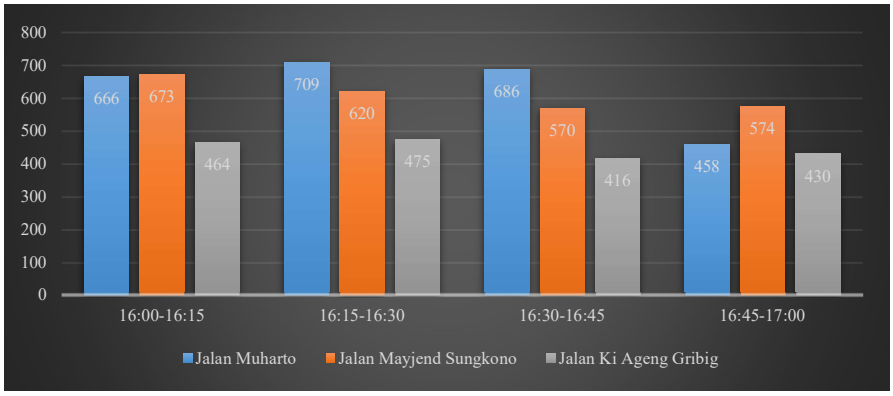

Figure 5. Peak Hour Volume 16:00 pm - 17:00 pm

From the picture above, it is obtained that the total vehicle / hour is 6720 vehicles / hour and the traffic volume (Q Total (smp / hour) is 3510.9 smp / hour. The performance of an intersection can be measured by calculating capacity, degree of saturation, delay and queuing opportunities.

Table 2. Capacity

Base capacity CO smp/h	Capacity Adjustment Factor (F)							Capacity C smp/h
	Fw	Fm	Fcs	Frsu	Flt	Frt	Fmi	
2700	1,07	1,05	1,00	0,95	1,17	0,75	0,91	2303,47

Table 3. Traffic Behavior

Traffic Flow Q smp/h	(DS)	(DT1)	DTMA	DTM1	(DG)	(D)	(QP%)
3510,9	1,52	23,92	16,95	38	4	27,92	224,67
							98,89

From Tables 2 and 3, which are calculated based on the USIG form in MKJI 1997 with a total traffic volume value of 3510.9 smp / hour, the capacity value (C) is 2303.47 smp / hour, the degree of saturation (DS) is 1.52 and the intersection delay (DTI) is 23.92 sec /mp. Compared to research conducted by [5] has a DS value of 1.3. So the kedungkandang intersection has experienced an increase in vehicle volume from year to year.

Based on capacity data and traffic behavior, it can be concluded that the performance of unsignalized intersections in 2022 at the intersection of three Jl. Muharto - Jl. Mayjend Sungkono - Jl. Ki Ageng Gribig in Malang City, has an intersection level of service **C** and has an intersection delay value of 23.92 sec/sm. The delay is relatively high and the chance of queuing is very large, causing inconvenience and traffic congestion. The above results are reinforced by previous research conducted [11] at the kedungkandang intersection which was carried out in early 2022 also showed level of service **C**.

The gap data used is the accepted gap and rejected *gap* data on each peak day calculated based on the morning, afternoon and evening peak hours. Critical *gap* values are obtained from the intersection of the cumulative curves of accepted *gap* values and rejected *gap* values as shown in the graph below.

Vol. 4, No. 1, pp. 13-20, March 2023
e-ISSN: 2775-5592

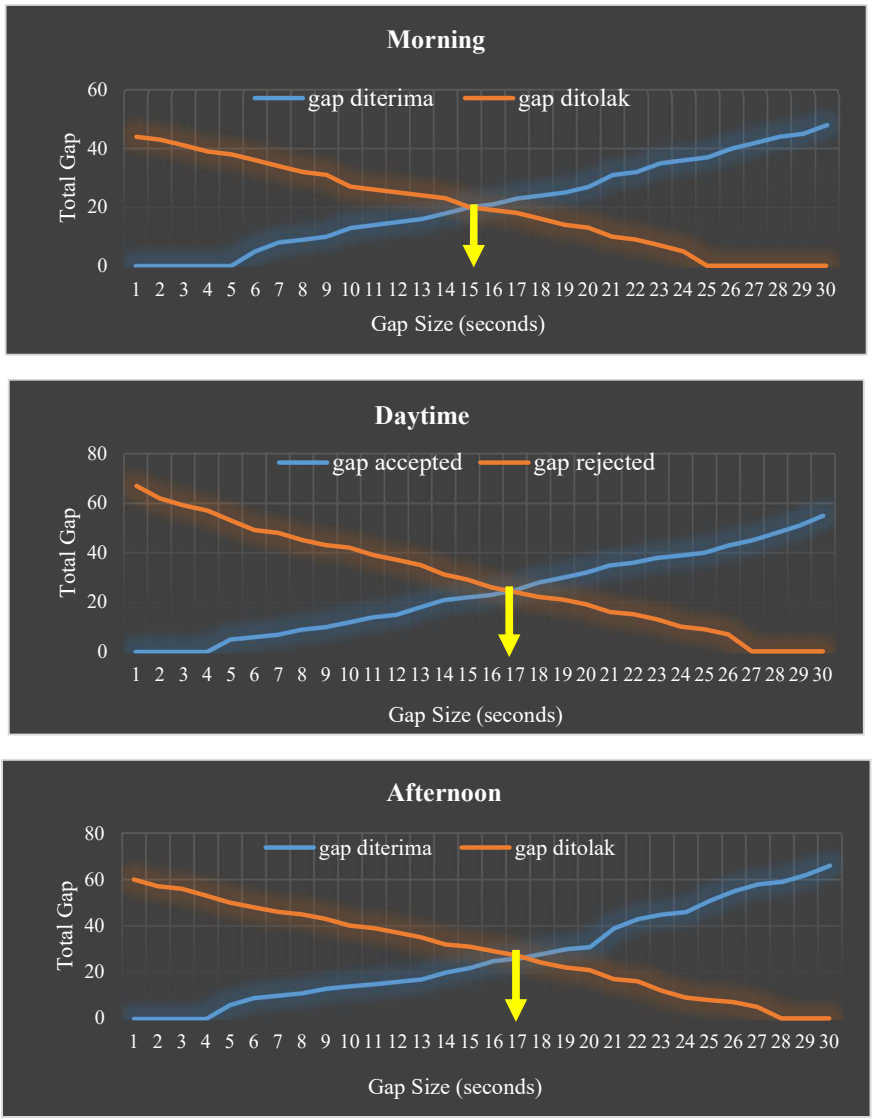

Figure 6. Graph of *Raff* Method Critical *Gap* values

From the *raff* method graph above, it shows the intersection of the two accepted *gap* curves and the rejected gap which results in a critical gap value on Thursday, June 02, 2022 of 15.1 seconds for the morning, 16.7 seconds for the afternoon, and 17.2 seconds for the afternoon.

Table 4. Critical Gap Value of Kedungkandang Intersection Combined Monday and Thursday

Vehicle flow on minor roads	Critical Gap value for vehicles (seconds)		
	Morning	Afternoon	Afternoon
Approach A (Jl. Muharto)	15,1	16,7	17,2

Compared to research conducted by [12] the comparison of *gap acceptance* (*follow-up time*) obtained the Critical *Lag* value at the intersection Untung Suropati approach C (East approach) is 2.81 seconds, this indicates that driver behavior **does not wait for a** gap when entering an

Vol. 4, No. 1, pp. 13-20, March 2023
e-ISSN: 2775-5592

unsignalized intersection. Based on the standard, the Kedungkandang intersection also indicates driver behavior of **waiting for a** gap when entering the main road.

From the results of calculations regarding the performance of the intersection with traffic loading based on data on population and vehicle growth in Malang City, in the next 3-5 years the Kedungkandang intersection will be included in the level of service D criteria, so it is necessary to improve the level of service, namely:

a) **Alternative 1** by installing traffic signs, namely vehicles from approach A (Jl. Muharto) are prohibited from turning right onto approach C (Jl. Mayjend Sungkono) and vehicles from approach D (Jl. Ki Ageng Gribig) are prohibited from turning right onto approach C (Jl. Muharto).
b) **Alternative 2 (Geometric Widening and Intersection Type)**
   - Approach A (Jl. Muharto) road width is enlarged to 10m and approach D (Jl. Ki Ageng Gribig) road width is enlarged to 10m.
   - Change the intersection type from intersection type 322 to intersection type 324 by creating a median on approach D (Jl. Ki Ageng Gribig) with a width of <1m.
c) **Alternative 3 (Combined Alternative 1 and 2)**
   - The flow of vehicles from Jl. Muharto heading to Jl. Mayjend Sungkono must go to Ki Ageng Gribig street first then make a U-turn in front of Kedungkandang Police Station to go to Jl. Mayjend Sungkono.
   - The flow of vehicles from Jl. Ki Ageng Gribig towards Jl. Muharto, for 2-wheeled vehicles and light vehicles can go through the road under the bridge and for heavy vehicles to make a U-turn first after passing the Kedungkandang bridge.

Table 5. Data from the calculation of the road capacity solution of Kedungkandang intersection

No.	Solution	Traffic Flow (Q) Smp/hr	Capacity (C) smp/hour	Degree of Saturation (DS)	Delay Time Intersection (DTI) det/smp
1.	Alternative 1	3510,9	5060.92	0,69	12,40
2.	Alternative 2	3510,9	2260.76	1,55	27,07
3.	Alternative 3	3510,9	4967.08	0,71	12,67

Various alternatives to provide optimization to traffic that is deemed to still need to be optimized, can be through traffic regulation, which is tailored to the needs of the traffic[13].

Based on the data table of the calculation results of the three Kedungkandang intersection capacity solutions above, alternatives 1 and 3 have intersection delays of 12.40 and 12.67, then the three Kedungkandang intersection is included in the level of service of intersection **B** (Stable flow with moderate traffic volume and speed of at least 70 km / h, Low traffic flow density internal traffic barriers have not affected speed and, Drivers still have enough time to choose the speed and lane of the road used), while solution 2 has an intersection delay that is still included in the level of service of intersection **D** .

Thus the solution to overcome the traffic flow problems that occur at the Kedungkandang intersection that has the most potential to be implemented is **alternative I,** namely the placement of signs prohibiting right turns from Muharto Street and Ki Ageng Gribig Street. Compared to previous research on the Kedungkandang intersection conducted in early 2022 by [11], the solution offered was to install traffic light signals. **Alternative 3** can also be used especially for Geometric widening so that vehicles are more free to take lanes.

Vol. 4, No. 1, pp. 13-20, March 2023
e-ISSN: 2775-5592

4. Conclusion

From the analysis of existing conditions at the Kedungkandang intersection, it is known that the value of vehicle volume in the first week is 3855.1 smp / hour, and in the second week it is 3510.9 smp / hour.

The degree of saturation (DS) value obtained based on the above traffic performance analysis for the first week is 1.47 and the second week is 1.52 and has an intersection delay of 23.02 in week 1 and 23.92 in Week 2, so based on the intersection delay value, the Kedungkandang intersection is included in the level of service **C** criteria. From the results of gap data processing, the critical gap value at Kedungkandang Unsignalized Intersection is 15.1 seconds for the morning, 16.3 seconds for the afternoon, and 17.2 seconds for the afternoon, thus indicating that the driver's behavior **must wait for a gap** when entering the main road.

The best alternative condition model in this study are prohibition of right turns for vehicles from approach A (Jl. Muharto) and approach D; and Widening of intersection geometrics, and road type changes.

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