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Analysis of the Effect of U-Turn Access Closure on the Performance of Gajah Mada Road, Batam Indonesia

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ABSTRACT

Purpose: Gajah Mada Road, Batam Taman Kota area is a primary collector road 1 that has a U-Turn and dense current if passed by motorists on weekdays in the afternoon. This study aims to analyze road performance due to the closure and opening of U-Turn access.

Design/methodology/approach: The research method used systematic observation is carried out on Mondays and Fridays (weekdays when the U-Turn is closed and opens) at 17.15 - 18.00 WIB in MKJI 1997.

Findings: The volume of vehicles and the average speed of vehicles passing when the U-Turn is closed is higher compared to the U-Turn is opened. Meanwhile, the level of road service (LoS) is classified as good because of the stable current and normal volume even though the vehicle speed is limited and affected by traffic.

Research limitations/implications: The U-Turn closure policy is believed to be a solution to reducing vehicle congestion.

Practical implications: Vehicle buildup factors due to U-Turn access are the main factors hampering road performance.

Originality/value: This paper is an original work.

Paper type: Research papers.

Keywords: Access, U-Turn, Road Performance
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I. INTRODUCTION

Transportation is a very important means of human survival (Andika et al., 2022). Transportation is the greatest need of mankind because it is related to the economy, personal travel, trade, fulfillment of needs, and much more (Garber & Hoel, 2019). The tendency of human beings to often move from one place to another or mobilize is one of the main factors in the importance of the existence and usefulness of the means of transportation (Mufhidin et al., 2022). Mobilization is an attempt to move people or some people to carry out an activity by most individuals themselves (Rogers et al., 2018). Over time, many developing countries in the world such as the Netherlands, Japan, and Malaysia encourage the need for infrastructure facilities, especially highways (Shahu et al., 2020). Highways became the most important means of mobilization used by land transport to travel from one place to its destination. The purpose of building a highway is so that people in an area can mobilize easily.

In Indonesia, the level of population mobilization from year to year has increased significantly. Throughout 2021, Indonesia's population mobility rate was recorded at 6,577,916 times the events of moving and coming to an area (Directorate General of Population and Civil Registration, 2022). This data proves that Indonesia is one of the countries with the largest population in the world. The most important factor that becomes the success of population mobilization is the facilities and facilities used, one of which is the highway. A good highway will

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provide a sense of security and comfort to motorists to get to their destination. However, the increasing population in Indonesia, has also caused an increase in road users. This is one of the problems due to the volume of highways that are no longer able to accommodate many vehicles.

One of the regions in Indonesia that has the largest population is Batam City. Batam City is one of the cities located in the Riau Islands Province and is also one of the industrial cities so its daily industrial activities are quite dense. It is proven that in 2021, Batam City contributed 63.97% to the Gross Regional Domestic Product of Riau Islands Province (BP Batam, 2022). One example of industrial activity in Batam City is the mobilization of heavy vehicles such as trucks. This is one of the obstacles to traffic in Batam City considering that the available road sections are not enough to accommodate various kinds of vehicles. The volume of vehicles in Batam City will increase if the effective time works such as departure in the morning and return in the afternoon. This causes road performance bottlenecks that cannot be avoided every day.

Hampered road performance can be interpreted as a condition when the travel flow on a road is not smooth or hampered due to various things such as small road sections, heavy vehicles passing by, accident tragedies, and so on (Albalate & Fageda, 2019). One of the bad points of road performance in Batam City is Gajah Mada Road, Batam City Park area to the Tiban area. This can happen due to narrow road sections as well as a very large volume of vehicles. Road performance problems in this area occur because motorists from the Tiban and Baloi's directions are very congested so the smooth running of the journey in both directions is hampered. In addition, one of the factors that cause poor road performance to be unavoidable is the traffic sign policy that applies to the area.

Traffic signs are a policy of disciplining road users so that traffic flow can run well. Traffic signs are an important means of communicating with each other, controlling traffic, and safety between drivers (Ben-Bassat et al., 2019). Classification of traffic signs is indispensable for drivers. One of the success factors in classifying traffic signs is the visual appearance to make them easy to understand by road users (Serna & Ruichek, 2018). The existence of traffic signs that should be able to bring order to motorists is one of the factors obstructing road performance in this area. One of the traffic signs in this area that is the cause of the constraints on the flow of road performance is the U-Turn. A U-Turn is a traffic sign that allows traffic movement from two opposite directions (Al-Obaedi, 2019). The existence of U-Turn greatly interferes with the smooth flow of vehicles due to the congested road so motorists who want to turn around have to wait for space so that they can walk. This is what causes the rear driver to have to wait so that there is a buildup in the volume of the vehicle.

Therefore, the police as the party responsible for the smooth flow of traffic issued a temporary policy if congestion occurs in the City Park area. The policy was implemented by closing U-Turn access in the area around City Park so that no motorists would turn around. This can reduce vehicle buildup due to waiting for motorists to access the U-Turn. Motorists can reverse directions on the Gajah Mada Road U-Turn. However, the volume of vehicles in the area is also dense, so this policy reaps pros and cons from some road users. The purpose of this study is to analyze road performance related to policies imposed on U-Turn access closures and the level of effectiveness of these policies.

A. Literature Review

1. U-turn

Traffic signs are a policy that is regulated and compiled in such a way as to regulate road users so that road performance in certain areas can run well. The purpose of traffic signs is to give an overall signal regarding traffic to road users (Babić et al., 2017). Good traffic signs will provide understanding to motorists to determine the level of safety of road users. However, the level of safety also depends on the driver driving his vehicle (Kaplan et al., 2018). The effectiveness of traffic signs is an important role in reducing the number of accidents in population mobility (Wang et al., 2021).

The traffic sign policy that serves as a lane change for road riders by turning vehicles up to 180 degrees is called a U-Turn. One of the weaknesses of U-Turn is that road user who wants to detour in their direction receive a small gap for their movement. So this can cause obstacles to road performance conditions (Pannela & Bhuyan, 2017). The placement of traffic signs greatly affects road performance and traffic management on a road (Konushin et al., 2021). Improper placement of traffic signs can be a major obstacle to smooth road performance. The placement he U-Turn policy should be placed on a fairly wide section of the road. This aims to prevent excessive vehicle buildup (Purnamasari, 2019).

B. Road Performance

The highway became the main medium used to mobilize vehicles from one place to another. The road is certainly used by a variety of vehicles ranging from two-wheeled vehicles, four-wheeled vehicles, and even heavy vehicles (Science, 2018). One of the factors that factor in the good and smooth performance of the road in certain areas is the volume and type of vehicles passing by (He et al., 2020). In addition, it must also be adjusted to the time, the volume of road sections, and traffic sign policies (Rao et al., 2017). Smooth and good road performance

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will greatly determine the welfare of road users. Good road performance will certainly provide a sense of security and comfort for motorists (Albalate & Fageda, 2019).

Road performance can be interpreted as how road conditions work for road users with some of their parameters. Parameters related to road performance are road sections and road flows. The problem of road performance bottlenecks must be something that must be considered by various parties. Another potential that will be problem with road performance is the increasing number of residents which will increase the number of vehicle owners so that the number of road users passing by will increase (Agyapong & Ojo, 2018).

C. Traffic Management

Traffic is one of the basic needs needed by humans because they tend to move from one place to another to meet their needs (Javed et al., 2020). Good traffic, of course, must have good management as well. This is one of the factors for the high number of accidents and deaths on the road (Soehodho, 2017). According to the Regulation of the Minister of Transportation of the Republic of Indonesia KM 14 of 2006, traffic management and engineering is an optimization activity in the use of the entire road network that aims to improve safety, create order, and smooth traffic flow.

Traffic management is one of the factors that can determine the success of motorists in using the road. Traffic cannot be used in the absence of clear management governing and binding road users (Blagojević et al., 2021). Traffic management policies have certainly been considered with road conditions for their application to be effective. Traffic management at a location is very necessary because it concerns the effectiveness and time efficiency of road users. Therefore, traffic management policies include setup, installation, procurement, and planning. This policy certainly aims to provide safety, security, order, and smooth traffic flow in a certain area (Rehena & Janssen, 2018).

II. METHODS

This research uses quantitative methods and systematic observations in the field for data collection based on the MKJI 1997. Data is one of the main strengths in compiling scientific research and modeling (Rifai et al., 2015). Data and information collection is carried out on Gajah Mada Road, Batam City Park area on Mondays and Fridays (weekdays when the U-Turn is closed and opened) at 17.15 - 18.00 WIB by identifying road performance to obtain the required parameter data. The process of systematic scientific research must begin with the identification of appropriate problems (Rifai et al., 2016).

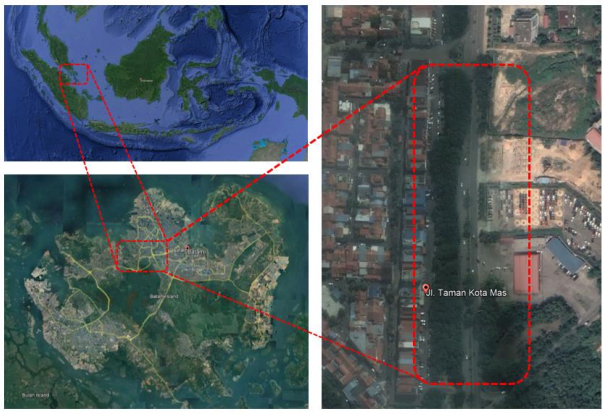

Figure 1 - Research Location on Gajah Mada Road, Batam (Google Earth, 2022)

Information that has been obtained from a case study on Gajah Mada Road, Batam, Taman Kota area will be used as a source of data regarding the consequences caused by the U-Turn access closure policy. The policy will also review the level of road service (LoS). In addition, the data obtained, will be studied whether the policy is the right step in reducing the level of vehicle density. Several parameters are used as a reference in obtaining data to draw the following conclusions.

The calculation of vehicle volume is carried out on weekdays, namely Monday (when the U-Turn is closed) and Friday (when the U-Turn is opened) at the same time at 17.15 - 18.00 WIB. Vehicle type data analyzed in traffic volume calculations include motorcycle (MC), light vehicle (LV), and heavy vehicle (HV). Data analysis was also carried out by calculating vehicles passing from the direction of Baloi towards Tiban and Tiban towards

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Baloi. According to the Presidential Regulation of the Republic of Indonesia Number 87 of 2011 concerning the Spatial Plan for the Batam, Bintan, and Karimun Areas in Article 22 Paragraph (2) states that Gajah Mada Road, Batam is a primary collector road 1 or a road that connects the national activity center with the center of local activities and/or regional activities or between regional activities and local activities.

Figure 2 - Closure of U-Turn Gajah Mada Road, Batam (Observation Results, 2022)

Road capacity is a measure used to accommodate the adequacy and quality of the level of road service (Directorate General of Highways, 1997). The analysis of road capacity in Gajah Mada, Batam is guided by the 1997 MKJI which aims to assess and draw conclusions on the road in accommodating the capacity of passing vehicles. Considering Jalan Gajah Mada, Batam City Park area is often traversed by motorists because it connects the Tiban area where the majority of people live in the area. Road capacity can also be one of the parameters that is an assessment of the policy of the effect of U-Turn access closures on this area.

The calculation of the degree of saturation (DS) aims to see the ratio of the accuracy of certain roads traveled by vehicles (Directorate General of Highways, 1997). According to the 1997 MKJI guidelines, these data are used to determine the level of performance of intersections and road segments. The value of the degree of saturation is closely related to the level of road service (LoS). Road service level (LoS) is a measure used in the 1985 US-HCM to view and assess speed, travel time, freedom of movement, traffic interruptions, comfort, and safety (Directorate General of Highways, 1997). From this data, of course, it will be known regarding the level of effectiveness of the effect of U-Turn closure because it is an indispensable parameter to draw conclusions.

Figure 3 - Opening of U-Turn Gajah Mada Road, Batam (Observation Results, 2022)

In addition to some of the parameters above, there are several other parameters that can be one of the assessments of the U-Turn access closure policy research, namely speed. Free current speed (FV) can be interpreted as the speed of a road user if driving a light vehicle without being influenced by other motorists (Directorate General of Highways, 1997). This data will be a comparison between the speed that a passing vehicle has when the U-Turn access is closed and opened. The effectiveness of this policy can also be measured from the speed of passing vehicles by looking at data on the average speed of vehicles of various types such as two-wheeled vehicles (MC), four-wheeled vehicles (LV), and more than four-wheeled vehicles (HV) when U-Turn access is closed and opened.

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III. RESULTS AND DISCUSSION

The data obtained in systematic observations on Gajah Mada Road, Batam in the Taman Kota area on Mondays and Fridays (weekdays when the U-Turn is closed and opened) at 17.15 - 18.00 WIB is processed based on the MKJI 1997. Some of the parameters studied include the following.

A. Traffic Volume

Traffic volume was found in data from the number of vehicles passing on Gajah Mada Road, Batam, Taman Kota area. The type of road contained in the case study is four lanes divided into 2 directions (4/2 D) with the total current in both directions exceeding 1800 vehicles per hour based on table 1 so that the vehicle equivalent factor according to the MKJI 1997 document is classified as a motorcycle (MC) = 0.25; light vehicle (LV) = 1.0; and heavy vehicle (HV) = 1.2.

Table 1 - Traffic volume when the U-Turn is closed (Source: Observation Results, 2022)

Baloi's direction toward Tiban

Time	*Type*		
	MC	*LV*	*HV*
17.15 - 17.30	*1059*	*459*	*5*
17.30 - 17.45	*841*	*464*	*13*
17.45 - 18.00	*811*	*453*	*6*
Total	*2711*	*1376*	*24*
smp/hour	*677,75*	*1376*	*28,8*
Total smp/hour		*2082,55*	

Tiban direction toward Baloi

Time	*Type*		
	MC	*LV*	*HV*
17.15 - 17.30	*328*	*167*	*12*
17.30 - 17.45	*321*	*159*	*9*
17.45 - 18.00	*341*	*189*	*14*
Total	*990*	*515*	*35*
smp/hour	*247,5*	*515*	*42*
Total smp/hour		*804,5*	

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When viewed from table 1, it can be seen that the number of motorcyclists (MC) who pass is quite high at 17.15 - 17.30 WIB while for the high number of light vehicle riders (LV) and heavy vehicles (HV) passing by occurs at 17.30 - 18.00 WIB. To compare with the degree of effectiveness of road performance can be compared with table 2 on the data of vehicles passing by at the time the U-Turn was opened as follows.

Table 2 - Traffic volume when the U-Turn is opened (Source: Observation Results, 2022)

Baloi direction toward Tiban

Time	*Type*		
	MC	*LV*	*HV*
17.15 - 17.30	*887*	*405*	*4*
17.30 - 17.45	*602*	*407*	*9*
17.45 - 18.00	*665*	*318*	*11*
Total	*2154*	*1130*	*24*
smp/hour	*538,5*	*1130*	*28,8*
Total smp/hour		*1697,3*	

Tiban direction toward Baloi

Time	*Type*		
	MC	*LV*	*HV*
17.15 - 17.30	*288*	*170*	*8*
17.30 - 17.45	*297*	*188*	*5*
17.45 - 18.00	*304*	*169*	*3*
Total	*889*	*527*	*16*
smp/hour	*222,25*	*527*	*19,2*
Total smp/hour		*768,45*	

Based on table 2 of the data obtained from the results of research on the volume of roads when the U-Turn opened, among others, the number of motorcyclists (MC) passing by at 17.15 - 17.30 WIB was relatively high compared to other part-time. For light vehicles (LV) and heavy vehicles (HV), the high number of motorists passing by occurred at 17.30 - 18.00 WIB. This is fairly constant with the data obtained in table 1. However, there is a very significant data difference because the volume of vehicles passing by when the U-Turn is closed is higher than the volume of vehicles when the U-Turn is opened.

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B. Road Capacity

Road capacity is a parameter that serves to determine the level of road service to accommodate the volume of vehicles. There are several equations for calculating the road capacity as follows.

$$C = 4 \times C_O \times FC_W \times FC_{SP} \times FC_{SF} \times FC_{CS} \quad (1)$$

The value of C is multiplied by 4 because it has 4 lanes from 2 different directions. The base capacity value (C_O) according to the MKJI 1997 guidelines table C-1:1 pages 5-50 at 1650 due to 4/2D type roads. The traffic width adjustment factor (FC_W) according to the MKJI 1997 guidelines table C-2:1 pages 5-51 is 1.00 due to the 4/2D type road with a width per lane of 3.5 meters. The directional separation adjustment factor (FC_{SP}) according to the MKJI 1997 guidelines table C-3:1 pages 5-52 is 1.00 because the 2-way road is divided by 50%-50%. The side resistance adjustment factor (FC_{SF}) according to the MKJI 1997 guidelines table C-4:1 pages 5-54 is 0.93 because the class of side resistance in the case study is classified as medium. The city size capacity factor (FC_{CS}) according to the MKJI 1997 guidelines table C-5:1 pages 5-55 is 0.93 because according to data from the Central Statistics Agency in 2022, Batam has around 1.196 million so the value of the city size capacity factor is 1.00.

Then the results of the calculation of road capacity using the following expansion 1 can be obtained:

$C = 4 \times C_O \times FC_W \times FC_{SP} \times FC_{SF} \times FC_{CS}$
$= 4 \times 1650 \times 1.00 \times 1.00 \times 0.93 \times 1.00$
$= 6138$ smp/hour

Table 3 - Capacity Analysis of Gajah Mada Road, Batam (Source: Observation Results, 2022)

Base Capacity	*Lane Width*	*Direction Separator*	*Side Obstacles*	*Population*	*Capacity*
CO	*FCW*	*FCSP*	*FCSF*	*FCCS*	*(smp/hour)*
4/2D	*3.5 m*	*50%-50%*	*Medium*	*1,0 - 3,0*	*6138*
1650	*1,00*	*1,00*	*0,93*	*1,196*	

C. Degree of Saturation (DS)

The degree of saturation is a parameter that is calculated as one of the requirements for determining the level of road service (LoS). As for the calculation, it can be seen in the following equation.

$$DS = Q / C \quad (2)$$

Road volume (Q) is the sum of the traffic volumes of 2 lanes. While capacity (C) is the known capacity value from equation (1).

The value of the degree of saturation (DS) obtained at the time the U-Turn is closed as follows:

DS = 2887.05 / 6138
DS = 0.4703

Meanwhile, the value of the degree of saturation (DS) obtained at the time the U-Turn is opened as follows:

DS = 2465.75 / 6138
DS = 0.4017

Table 4 - Analysis of Saturation Degree Values (Source: Observation Results, 2022)

Day	*Time*	*Volume*
	When U-Turn is closed	
Monday	*17.15 - 18.00*	*2887,05*
	Degree of Saturation	*0,4703*

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When U-Turn is opened		
Friday	*17.15 - 18.00*	*2465,75*
Degree of Saturation		*0,4017*

D. Road Service Level

The level of road service (LoS) is an index that determines the good and bad performance of a road. Some of the parameters used as a reference to determine the type of road performance include road flow, vehicle volume, and vehicle speed. Guided by the US-HCM 1985 and MKJI 1997, it was found that the level of road service (LoS) from the research data at the time the U-Turn was closed was in group C because it had a saturation degree (DS) value of 0.4703. Group C has a stable current with speed influenced by normal traffic and volume. Meanwhile, the level of road service (LoS) at the time the U-Turn opened was in group B because it had a saturation degree (DS) value of 0.4017. This means that the level of road service (LoS) when the U-Turn is opened has a stable current with limited speed and normal volume.

The results of the road service level (LoS) statement were found from previously interconnected parameters, including the volume of vehicles passing on Jalan Gajah Mada, Batam City Park area which was calculated when the U-Turn access was opened and closed. Furthermore, this result was determined by the parameters of calculating road capacity in a case study which showed that Jalan Gajah Mada, Batam could not accommodate more passing vehicles because the road section was not too wide. In addition, the last parameter that determines the results of the level of road service (LoS) is the degree of saturation (DS) which is a calculation found using equation 2 involving the volume and capacity of Jalan Gajah Mada, Batam.

E. Free Current Speed (FV) Analysis of Light Vehicles

The free flow speed (FV) is calculated to be used as a comparison between the average speed of vehicles passing on Gajah Mada Road, Batam Taman Kota area on Monday and Friday (weekdays when the U-Turn is closed and opened) at 17.15 - 18.00 WIB. The equation for determining the speed of the free current is as follows:

$$FV = (FV_O + FV_W) \times FFV_{SF} \times FFV_{CS} \quad (3)$$

The basic free flow speed of the vehicle on the observed road is classified as 4/2D so the FV_O value according to the MKJI 1997 Guidelines Table B-1.1 Pages 5-44 is 57 km/h. The speed adjustment for the road width (km/h) reviewed 4/2D is 3.5 meters so the FV_W value according to the MKJI 1997 guidelines table B-2.1 pages 5-45 is 0. The adjustment factor for side resistance and shoulder width or barrier curb distance is 1 meter with moderate resistance class so that the FFV_{SF} value according to MKJI 1997 Table B-3.1 Pages 5-46 is 0.95. The speed adjustment factor (FFV_{CS}) for Batam City according to data from the Central Statistics Agency in 2020 ranges from 1.196 million people based on MKJI 1997 table B-4.1 pages 5-48, the value is 1.00.

Then the results of the calculation of the free current speed (FV) can be obtained using equation 3 as follows:

$FV = (Fvo + FV_W) \times FFV_{SF} \times FFV_{CS}$

$= (57 + 3.5) \times 0.95 \times 1$

$= 57.475$ km/h

Table 5 - Free Current (FV) Speed Analysis (Source: Observation Results, 2022)

FV_O	FV_W	FFV_{SF}	FFV_{CS}	FV
57	*0*	*0,95*	*1*	*57,475*

F. Vehicle Speed

The calculation of the speed of passing vehicles is aimed at analyzing the effect of U-Turn access closure with benchmarking when U-Turn access is opened. This of course will appear different because when the U-Turn is closed there are no vehicles waiting so there is no buildup. Unlike when the U-Turn is opened, there will be a vehicle that will rotate through the U-Turn so that there is a buildup of vehicles when taking turns to rotate. The distance used to measure the speed of the vehicle speed is a range of 10 meters and time measurement using a stopwatch.

The average speed equation of passing vehicles is as follows:

$$V = L / TT \quad (4)$$

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Speed (L) is a speed value with a unit of meters per second owned by the vehicle at the time of passing. While the vehicle travel time (TT) is the value of time with second units owned by passing vehicles.

Table 6 - Vehicle Speed Calculation (Source: Observation Results, 2022)

Day	*Direction*	*Lowest Speed*		*Top Speed*		*Average (km/h)*
		Time	*km/h*	*Time*	*km/h*	
Monday	*Tiban*	*17.15 - 17.45*	*29,65*	*17.45 - 18.00*	*48,55*	*39,1*
(U-Turn closed)	*Baloi*		*28,17*		*45,94*	*37,055*
Friday	*Tiban*	*17.15 - 17.45*	*17,33*	*17.45 - 18.00*	*32,12*	*24,725*
(U-Turn opened)	Baloi		19,34		33,54	26,44

In calculating the average speed of vehicles, only a few samples of motorcycle (MC), light vehicle (LV), and heavy vehicle (HV) were taken. The data obtained from the analysis using meters per second is then converted into a basic unit of speed, namely km/h to obtain the average speed results of the vehicle. The result of the data obtained is that the average vehicle speed is higher when the U-Turn access is closed than when the U-Turn access is opened.

IV. CONCLUSION

From the data obtained, the U-Turn closure occurred at 17.15 - 17.30 WIB on Monday and there was no U-Turn closing on Friday. Using the MKJI 1997, it can be concluded that the results include based on tables 1 and 2, heavy traffic flow occurs in the direction of Baloi towards Tiban. There is a difference that occurs because the volume of vehicles passing when the U-Turn is closed is higher than when the U-Turn is opened. The road capacity value is 6138 smp / hour and the degree of saturation obtained from the calculation using formula (2) is 0.4703 (when the U-Turn is closed) and 0.4017 (when the U-Turn is opened). Thus, the level of road service (LoS) from the research data when the U-Turn was closed was in group C, which means that the steady flow at speed is influenced by normal traffic and volume. Meanwhile, the level of road service (LoS) when the U-Turn is opened is in group B, which means a stable current with limited speed and normal volume. The free current (FV) speed value of light vehicles was found to be 57.475 km / h which is a comparison with the average speed data of passing vehicles. Based on table 8, the average speed value obtained on Monday (when the U-Turn is closed) is higher than on Friday (when the U-Turn opens). The data obtained proves that the U-Turn access closure policy has had a positive effect on the smooth performance of Gajah Mada Road, Batam, Taman Kota area. This is certainly an alternative to reduce the density of vehicles considering the capacity of the road that cannot accommodate the high volume of vehicles.

REFERENCES

Adiputra, D. S., Rifai, A. I., & Bhakti, S. K. (2022). Design of Road Geometric with AutoCAD® 2D: A Case Wirosari-Ungaran Semarang, Indonesian. *Citizen: Jurnal Ilmiah Multidisiplin Indonesia*, *2*(5), 729-738.

Agyapong, F., & Ojo, T. K. (2018). Managing traffic congestion in the Accra Central Market, Ghana. *Journal of Urban Management*, *7*(2), 85–96. https://doi.org/10.1016/j.jum.2018.04.002

Al-Obaedi, J. (2019). Investigation the Effect of Speed Humps on Merging Time of U-turn Traffic. *Ain Shams Engineering Journal*, *10*(1), 1–4. https://doi.org/10.1016/j.asej.2018.12.001

Albalate, D., & Fageda, X. (2019). Congestion, road safety, and the effectiveness of public policies in urban areas. *Sustainability (Switzerland)*, 11(18), 1–21. https://doi.org/10.3390/su11185092

Almeida, P. R. L. de, Alves, J. H., Parpinelli, R. S., & Barddal, J. P. (2022). A systematic review on computer vision-based parking lot management applied on public datasets. *Expert Systems with Applications*, *198*. https://doi.org/10.1016/j.eswa.2022.116731

ISSN : 2597-4785 (ONLINE)
ISSN : 2597-4750 (PRINTED)

Andika, I., Rifai, A. I., Isradi, M., & Prasetijo, J. (2022). *A Traffic Management System for Minimization of Intersection Traffic Congestion : Case Bengkong Junction , Batam*. 05(05).

Arifin, A., & Rifai, A. I. (2022). Geometric Design of Upper Cisokan Hydroelectric Power Plant Access Road with AutoCAD® Civil 3D (STA 3+ 000-STA. 4+ 800). *Citizen: Jurnal Ilmiah Multidisiplin Indonesia*, *2*(5), 851-858

Asadulhaq, S. P., Rifai, A. I., & Handayani, S. (2022). Passenger Occupancy Phenomena of Trans Jakarta due to COVID-19: A Case Corridor X (2019-2021). *Citizen: Jurnal Ilmiah Multidisiplin Indonesia*, *2*(5), 766-775.

Babić, D., Babić, D., & Macura, D. (2017). Model for Predicting Traffic Signs Functional Service Life – The Republic of Croatia Case Study. *PROMET - Traffic&Transportation*, *29*(3), 343–349. https://doi.org/10.7307/ptt.v29i3.2247

Badue, C., Guidolini, R., Carneiro, R. V., Azevedo, P., Cardoso, V. B., Forechi, A., Jesus, L., Berriel, R., Paixão, T. M., Mutz, F., de Paula Veronese, L., Oliveira-Santos, T., & De Souza, A. F. (2021). Self-driving cars: A survey. *Expert Systems with Applications*, *165*. https://doi.org/10.1016/j.eswa.2020.113816

Bahrami, S., Vignon, D., Yin, Y., & Laberteaux, K. (2021). Parking management of automated vehicles in downtown areas. *Transportation Research Part C: Emerging Technologies*, *126*, 1–23. https://doi.org/10.1016/j.trc.2021.103001

Batam, B. (2022). *Iklim dan Geografis*. https://bpbatam.go.id/tentang-batam/iklim-dan-geografis/

Ben-Bassat, T., Shinar, D., Almqvist, R., Caird, J. K., Dewar, R. E., Lehtonen, E., Salmon, P. M., Sinclair, M., Summala, H., Zakowska, L., & Liberman, G. (2019). Expert evaluation of traffic signs: conventional vs. alternative designs. *Ergonomics*, *62*(6), 734–747. https://doi.org/10.1080/00140139.2019.1567829

Biswas, S., Chandra, S., & Ghosh, I. (2017). Effects of On-Street Parking in Urban Context: A Critical Review. *Transportation in Developing Economies*, *3*(1), 1–14. https://doi.org/10.1007/s40890-017-0040-2

Blagojević, A., Kasalica, S., Stević, Ž., Tričković, G., & Pavelkić, V. (2021). Evaluation of safety degree at railway crossings in order to achieve sustainable traffic management: A novel integrated fuzzy MCDM model. *Sustainability (Switzerland)*, *13*(2), 1–20. https://doi.org/10.3390/su13020832

BP Batam. (2022). *Batam: Industrial Cities and Their Future Development*. https://bpbatam.go.id/batam-kota-industri/

Brown, A., Klein, N. J., Thigpen, C., & Williams, N. (2020). Impeding access: The frequency and characteristics of improper scooter, bike, and car parking. *Transportation Research Interdisciplinary Perspectives*, *4*, 100099. https://doi.org/10.1016/j.trip.2020.100099

Christine, C., Rifai, A. I., & Handayani, S. (2022). Level of Service Evaluation of Pedestrian Facility in Tourism Area: Case Study Jalan Braga, Bandung. *Citizen: Jurnal Ilmiah Multidisiplin Indonesia*, *2*(5), 748-756.

De Ryck, M., Versteyhe, M., & Debrouwere, F. (2020). Automated guided vehicle systems, state-of-the-art control algorithms and techniques. *Journal of Manufacturing Systems*, *54*, 152–173. https://doi.org/10.1016/j.jmsy.2019.12.002

Dewi Haryati. (2017). *Titik Parkir Tepian Jalan Umum Batam Naik 100 Persen, Ini Pemicunya!* https://batam.tribunnews.com/2017/03/26/titik-parkir-tepian-jalan-umum-batam-naik-100-persen-ini-pemicunya

Directorate General of Highways. (1997). Highway Capacity Manual Project (HCM). *Indonesian Road Capacity Manual (MKJI)*, *1*(I), 564.

Directorate General of Population and Civil Registration. (2022). Indonesian Population Mobility 2021, Ministry of Home Affairs Records More Than 6.5 Million Moving Events. https://dukcapil.kemendagri.go.id/berita/baca/1038/mobilitas-penduduk-indonesia-2021-kemendagri-catat-65-juta-lebih-peristiwa-pindah-datang#:~:text=%3A ensikloblogia.com)-,Indonesian Population Mobility 2021%2C Ministry of Home Affairs Records,More Millions of D-Moving Events

Dowling, C., Fiez, T., Ratliff, L., & Zhang, B. (2017). *How Much Urban Traffic is Searching for Parking? Simulating Curbside Parking as a Network of Finite Capacity Queues*. *February*. http://arxiv.org/abs/1702.06156

Fauziawati, R., Rifai, A. I., & Handayani, S. (2022). Passengers Satisfaction Analysis of Quality and Schedule of Commuter Line Service: A Case Citayam-Tebet Route. *Citizen: Jurnal Ilmiah Multidisiplin Indonesia*, *2*(5), 833-842.

Firmansyah, F., Rifai, A. I., & Taufik, M. (2022). The Performance of Roundabouts with Traffic Signals: A Case Kadipaten Intersection, Indonesia A Case Kadipaten Intersection, Indonesia. *Citizen: Jurnal Ilmiah Multidisiplin Indonesia*, *2*(5), 823-832.

Fokker, E. S., Koch, T., van Leeuwen, M., & Dugundji, E. R. (2022). Short-Term Forecasting of Off-Street Parking Occupancy. *Transportation Research Record*, *2676*(1), 637–654. https://doi.org/10.1177/03611981211036373

Garber, N. J., & Hoel, L. A. (2019). *Traffic and highway engineering*. Cengage Learning.

ISSN : 2597-4785 (ONLINE)
ISSN : 2597-4750 (PRINTED)

Gunawan, R. Y., Rifai, A. I., & Irianto, M. A. (2022). AutoCAD® 2D for Geometric Design of Terbanggi Besar–Pematang Panggang Highway (Sta. 28+ 650–Sta. 53+ 650). *Citizen: Jurnal Ilmiah Multidisiplin Indonesia*, *2*(5), 757-765.

Gurbuz, O., & Cheu, R. L. (2020). Survey to Explore Behavior, Intelligent Transportation Systems Needs, and Level of Service Expectations for Student Parking at a University Campus. *Transportation Research Record*, *2674*(1), 168–177. https://doi.org/10.1177/0361198119900169

He, Y., Makridis, M., Fontaras, G., Mattas, K., Xu, H., & Ciuffo, B. (2020). The energy impact of adaptive cruise control in real-world highway multiple-car-following scenarios. *European Transport Research Review*, *12*(1). https://doi.org/10.1186/s12544-020-00406-w

Javed, F. M., Shamrat, M., Majumder, A., Mahmud, I., Rahman, S., Tasnim, Z., & Nobel, N. I. (2020). A Smart Automated System Model For Vehicles Detection To Maintain Traffic By Image Processing Related papers Web Forum And Social Media: A Model For Aut omat ic Removal Of Fake Media Using Mult ilayer... Kingsley E Ukhurebor Det ect ion Of UDP At t acks In . *International Journal of Scientific & Technology Research*, *9*, 2. www.ijstr.org

Kaplan, S., Bortei-Doku, S., & Prato, C. G. (2018). The relation between the perception of safe traffic and the comprehension of road signs in conditions of ambiguous and redundant information. *Transportation Research Part F: Traffic Psychology and Behaviour*, *55*, 415–425. https://doi.org/10.1016/j.trf.2018.03.021

Kazazi Darani, S., Akbari Eslami, A., Jabbari, M., & Asefi, H. (2018). Parking Lot Site Selection Using a Fuzzy AHP-TOPSIS Framework in Tuyserkan, Iran. *Journal of Urban Planning and Development*, *144*(3). https://doi.org/10.1061/(asce)up.1943-5444.0000456

Konushin, A. S., Faizov, B. V., & Shakhuro, V. I. (2021). Road images augmentation with synthetic traffic signs using neural networks. *Computer Optics*, *45*(5), 736–748. https://doi.org/10.18287/2412-6179-CO-859

Kurniawan, A. N., & Rifai, A. I. (2022). Phenomena of Transportation to Work Mode Choice, Due to The Increase of Oil Prices in Indonesia: A Case Light Rail Transit Depot Project Office-Jakarta. *Citizen: Jurnal Ilmiah Multidisiplin Indonesia*, *2*(5), 785-793.

Levin, M. W., Wong, E., Nault-Maurer, B., & Khani, A. (2020). Parking infrastructure design for repositioning autonomous vehicles. *Transportation Research Part C: Emerging Technologies*, *120*(2015), 1–22. https://doi.org/10.1016/j.trc.2020.102838

Małecki, K. (2018). A computer simulation of traffic flow with on-street parking and drivers' behaviour based on cellular automata and a multi-agent system. *Journal of Computational Science*, *28*, 32–42. https://doi.org/10.1016/j.jocs.2018.07.005

Meng, F., Du, Y., Chong Li, Y., & Wong, S. C. (2018). Modeling heterogeneous parking choice behavior on university campuses. *Transportation Planning and Technology*, *41*(2), 154–169. https://doi.org/10.1080/03081060.2018.1407518

Mikusova, M., Abdunazarov, J., Zukowska, J., & Jagelcak, J. (2020). Designing of parking spaces on parking taking into account the parameters of design vehicles. *Computation*, *8*(3). https://doi.org/10.3390/COMPUTATION8030071

Mufhidin, A., Karimah, S., Isradi, M., & Rifai, A. I. (2022). Provision Impact Analysis of Motorcycle Exclusive Lanes on the Performance of Road Sections Using the Method MKJI 1997 and Vissim Software. *IJEBD International Journal Of Entrepreneurship And Business Development EISSN 2597-4785 PISSN 2597-4750*, *5*(2), 395–410. https://jurnal.narotama.ac.id/index.php/ijebd/article/view/1798

Münzel, C., Plötz, P., Sprei, F., & Gnann, T. (2019). How large is the effect of financial incentives on electric vehicle sales? – A global review and European analysis. *Energy Economics*, *84*(xxxx), 104493. https://doi.org/10.1016/j.eneco.2019.104493

Nadia Khaira Ardi, ST, M. (2012). *Batam Congestion and Its Solutions*. https://www.unrika.ac.id/kemacetan-batam-dan-solusinya/

Nurjannah, S. N., Rifai, A. I., & Akhir, A. F. (2022). Geometric Design for Relocation of National Road Sei Duri-Mempawah Section, West Kalimantan using AutoCAD® 2D. *Citizen: Jurnal Ilmiah Multidisiplin Indonesia*, *2*(5), 692-702.

Paidi, V., Fleyeh, H., Håkansson, J., & Nyberg, R. G. (2018). Smart parking sensors, technologies and applications for open parking lots: A review. *IET Intelligent Transport Systems*, *12*(8), 735–741. https://doi.org/10.1049/iet-its.2017.0406

Pannela, S. K., & Bhuyan, P. K. (2017). Modified INAFOGA method for critical gap estimation at u-turn median openings. *International Journal of Civil Engineering*, *15*(7), 967–977. https://doi.org/10.1007/s40999-017-0179-6

Pelangie, K. R., Rifai, A. I., & Yudhistira, P. (2022). Services Analysis of Pedestrian Facility in Office and Business Area: Case Study Jalan Wahid Hasyim, Jakarta. *Citizen: Jurnal Ilmiah Multidisiplin Indonesia*, *2*(5), 804-814.

ISSN : 2597-4785 (ONLINE)
ISSN : 2597-4750 (PRINTED)

Peng, G. C. A., Nunes, M. B., & Zheng, L. (2017). Impacts of low citizen awareness and usage in smart city services: the case of London's smart parking system. *Information Systems and E-Business Management*, *15*(4), 845–876.

Pratama, A., Rifai, A. I., & Thole, J. (2022). The Analysis of Pedestrian Service in Railway Station Area: A Case Tanah Abang Station, Jakarta A Case Tanah Abang Station, Jakarta. *Citizen: Jurnal Ilmiah Multidisiplin Indonesia*, *2*(5), 794-803.

Purnamasari, P. (2019). Motorcyclists' awareness and understanding of traffic signs for traffic safety in Yogyakarta. *IOP Conference Series: Materials Science and Engineering*, *615*(1), 0–8. https://doi.org/10.1088/1757-899X/615/1/012125

Rahayu, A. J., Rifai, A. I., & Akhir, A. F. (2022). The Phenomena of On-Street Parking at Kadipaten Traditional Market, West Java. *Citizen: Jurnal Ilmiah Multidisiplin Indonesia*, *2*(5).

Rao, A. M., Velmurugan, S., & Lakshmi, K. M. V. N. (2017). Evaluation of Influence of Roadside Frictions on the Capacity of Roads in Delhi, India. *Transportation Research Procedia*, *25*, 4771–4782. https://doi.org/10.1016/j.trpro.2017.05.489

Rehena, Z., & Janssen, M. (2018). Towards a Framework for Context-Aware Intelligent Traffic Management System in Smart Cities. The Web Conference 2018 - *Companion of the World Wide Web Conference, WWW 2018*, 893–898. https://doi.org/10.1145/3184558.3191514

Rifai Andri Irfan, & Hafis Khairul. (2021). *Analysis of Road Performance and Vehicle Parking Characteristics in the Halim Perdanakusuma International Airport Area*. *3*(1), 89–98. http://proceedings.worldconference.id.

Rifai, A. I. (2021). *How did the Impact of the 2nd Wave of COVID-19 on Parking Characteristics at Non-Referral Hospitals ? Case Study : Permata Cibubur Hospital , Indonesia*. *3*(5), 481–490.

Rifai, A. I. (2022). Implementasi Building Information Modelling pada Rehabilitasi dan Rekonstruksi Jalan Pasca Bencana Liquefaksi. *Prosiding HPJI (Himpunan Pengembangan Jalan Indonesia)*, 10-10.

Rifai, A. I., Hadiwardoyo, S. P., Correia, A. G., & Pereira, P. (2016). Genetic Algorithm Applied for Optimization of Pavement Maintenance under Overload Traffic: Case Study Indonesia National Highway. *Applied Mechanics and Materials*, *845*, 369–378. https://doi.org/10.4028/www.scientific.net/amm.845.369

Rifai, A. I., Hadiwardoyo, S. P., Correia, A. G., & Pereira, P. (2016). Genetic Algorithm Applied for Optimization of Pavement Maintenance under Overload Traffic: Case Study Indonesia National Highway. *Applied Mechanics and Materials*, *845*, 369–378. https://doi.org/10.4028/www.scientific.net/amm.845.369

Rifai, A. I., Hadiwardoyo, S. P., Correia, A. G., Pereira, P., & Cortez, P. (2015). The data mining applied for the prediction of highway roughness due to overloaded trucks. *International Journal of Technology*, *6*(5), 751–761. https://doi.org/10.14716/ijtech.v6i5.1186

Rifai, A. I., Hadiwardoyo, S. P., Correia, A. G., Pereira, P., & Cortez, P. (2015). The data mining applied for the prediction of highway roughness due to overloaded trucks. *International Journal of Technology*, *6*(5), 751–761. https://doi.org/10.14716/ijtech.v6i5.1186

Rifai, A. I., Nugroho, D. L., Isradi, M., & Mufhidin, A. (2021). Analysis of Impact COVID-19 on Parking Characteristics in the Office Area: Case of Jakarta City. *Proceedings of the International Conference on Industrial Engineering and Operations Management*, 487–495.

Rogers, T., Goldstein, N. J., & Fox, C. R. (2018). Annual Review of Psychology Social Mobilization. *Annual Review of Psychology*, *69*, 357–381. https://doi.org/10.1146/annurev-psych-122414-

Scheck, K., Pfeffer, P. E., & Schick, B. (2022). Detailed analysis and characterization of Subjective Assessment Indicators of manual and automated parking maneuvers. *Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering*, *236*(12), 2557–2571.

Science, S. (2018). *Hulse , L . M., Xie , H . and Galea , E . R . (2018). Perceptions of autonomous vehicles : Relationships with road users , risk , gender and age . Safety Science , Perceptions of Autonomous Vehicles : Relationships with Road Users , Risk , Gender and A*. 1–13.

Serna, C. G., & Ruichek, Y. (2018). Classification of Traffic Signs: The European Dataset. *IEEE Access*, 6, 78136–78148. https://doi.org/10.1109/ACCESS.2018.288482'6

Shahu, J. T., Sivakumar Babu, G. L., & Usmani, A. (2020). Developments in Transportation Geotechnics. *Indian Geotechnical Journal*, *50*(2), 157–158. https://doi.org/10.1007/s40098-020-00436-0

Singh, S. G., & Kumar, S. V. (2022). Side Friction as a Cause of Poor Pavement Maintenance in India—A Study Using Terrestrial Laser Scanner Data. In *Road and Airfield Pavement Technology* (pp. 241–247). Springer.

Soehodho, S. (2017). Public transportation development and traffic accident prevention in Indonesia. *IATSS Research*, *40*(2), 76–80. https://doi.org/10.1016/j.iatssr.2016.05.001

Sony, S., Rifai, A. I., & Handayani, S. (2022). The Effectiveness Analysis of Bus Rapid Transit Services (A Case Trans Semarang, Indonesia). *Citizen: Jurnal Ilmiah Multidisiplin Indonesia*, *2*(5), 712-719.

Stefanus, S., Rifai, A. I., & Nasrun, N. (2022). Implementation Autocad® Civil 3D for Horizontal Alignment Design of Indramayu-Jatibarang Highways. *Citizen: Jurnal Ilmiah Multidisiplin Indonesia*, *2*(5), 739-747.

ISSN : 2597-4785 (ONLINE)
ISSN : 2597-4750 (PRINTED)

Wang, M., Dong, H., Li, X., Song, L., & Pang, D. (2017). A novel parking system designed for smart cities. *Proceedings - 2017 Chinese Automation Congress, CAC 2017*, *2017-Janua*, 3429–3434. https://doi.org/10.1109/CAC.2017.8243373

Wang, X., Jiang, P., Cao, Y., Lyu, N., & Niu, L. (2021). The safety effect of traffic signs for median openings on one-side-widened freeways. *Safety Science*, *144*(August), 105445. https://doi.org/10.1016/j.ssci.2021.105445

Winter, K., Cats, O., Martens, K., & van Arem, B. (2021). Parking space for shared automated vehicles: How less can be more. *Transportation Research Part A: Policy and Practice*, *143*(November 2020), 61–77. https://doi.org/10.1016/j.tra.2020.11.008

Yu, L., Qin, S., Zhang, M., Shen, C., Jiang, T., & Guan, X. (2021). A Review of Deep Reinforcement Learning for Smart Building Energy Management. *IEEE Internet of Things Journal*, *8*(15), 12046–12063. https://doi.org/10.1109/JIOT.2021.3078462

Zhuge, C., Shao, C., & Li, X. (2019). Empirical analysis of parking behaviour of conventional and electric vehicles for parking modelling: A case study of Beijing, China. *Energies*, *12*(16), 3073.

Zulfa, N., Rifai, A. I., & Taufik, M. (2022). Road Geometric Design used AutoCAD® Civil 3D: A Case Study Jalan Campaka-Wanaraja Garut, Indonesia. *Citizen: Jurnal Ilmiah Multidisiplin Indonesia*, *2*(5), 843-850.