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The Effect of Divergent Flow on U-Turn on Traffic Flow Performance (Case Study of A. Yani Road Km. 35 Banjarbaru)

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ABSTRACT

The divergent flow generated on the u-turn when the vehicle makes a u-turn movement can affect traffic performance, especially during peak hours. This problem also occurs on the u-turn of A. Yani Road Km. 35 Banjarbaru. Therefore, it is necessary to conduct research to find out the extent of the influence that divergent flows have on traffic performance. The research was conducted on conditions that were affected by u-turn and which were not affected by u-turn . From the analysis results, the selected model when the u-turn operates normally is the Underwood model with the results of S_m = 16,707 km/hour and F_C = 1392.209 pcu/hour. While the selected model when the u-turn is closed is the Greenshields model with the results of S_m = 26,383 km/hour and F_C = 4576,975 pcu/hour. When affected by u-turn, S_m value decreased by 36.68% and F_C value decreased by 69.58%.

Keywords: Divergent, Traffic Performance, U-Turn

1. INTRODUCTION

Banjarbaru City is one of the cities with heavy traffic flow in the province of South Kalimantan. One of the roads that has a high density level in Banjarbaru City is A. Yani Road Km. 35. This road is a link between cities and between provinces, so it is not surprising that this road segment has a heavy traffic flow.

One way to minimize traffic problems is to have a median so that it can improve safety and traffic flow. In addition, it is necessary to provide a u-turn that can be used by vehicles to make a turning movement at locations deemed necessary. However, the movement of a vehicle making a turning movement can disrupt the flow of traffic.

This is because the number of vehicles that make a turning movement can cause queues. Queues that occur can cause vehicle speed to decrease so that it can cause congestion and longer travel times.

There are two kinds of flow movement when the vehicle makes a turning movement. The two kinds of flow movements are merger flows and divergent flows. The difference in flow that occurs when the vehicle makes a turning movement will produce different behavior.

U-turn facility on A. Yani Road Km. The 35 observed in this study do have a high traffic flow because they are located close to community activity centers such as universities, shopping centers, and other service centers. Therefore, it is necessary to conduct research to determine the extent of the influence caused by divergent flows on traffic performance.

2. THEORITICAL STUDY

2.1 Types of Traffic Flow Movement on U-Turn

In a u-turn facility, there are generally two types of movement, namely diverging and merging (Bina Marga, 1992).

1. Diverging (split), which separates the vehicle from the same flow to another route. Diverging can also be interpreted as the spread of vehicle flow from one lane to several different directions.
2. Merging (joining), namely the merging of vehicles from one lane to the same lane. *Merging* can also be interpreted as the merging of vehicle flows from several different paths to the same direction.

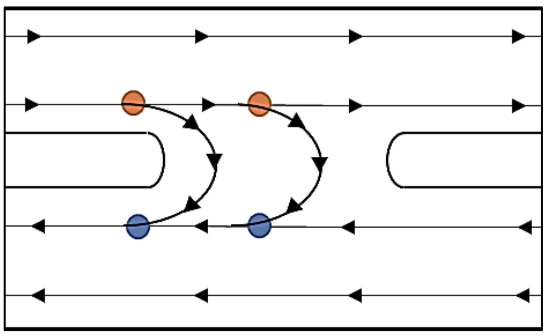

Figure 1. Traffic Flow Movement on U-Turn

Information:
→ = vehicle direction
= diverging flow (separating)
= merging flow (joining)

2.2 Traffic Flow Characteristic Relationship Model

There are three primary characteristics of traffic flow, namely flow, speed, and density. Three types of models to describe the relationship between flow, speed, and density, namely Greenshields, Greenberg, and Underwood (Radam, 2008).

1. Greenshields Model

The relationship between flow, speed, and density according to Greenshields is as follows.

1) Relationship between Speed and Density

$$S = S_f - \frac{S_f}{D_J} . D \quad (1)$$

2) Relationship between Flow and Speed

$$F = D_J . S - \frac{D_J}{S_f} . S^2 \quad (2)$$

3) Relationship between Flow and Density

$$F = S_f . D - \frac{S_f}{D_J} . D^2 \quad (3)$$

4) Maximum Flow (obtained when ∂F/∂D = 0)

$$F_C = D_J . \frac{S_f}{4} \quad (4)$$

Where:

S = speed (km/hour)

D = density (pcu/km)

F = flow (pcu/hour)

S_f = speed at very low traffic flow conditions or at conditions of density or near zero speed or free flow speed (km/hour)

D_J = density when traffic conditions are jammed (pcu/km)

F_C = maximum flow (pcu/hour)

D_m = maximum density

S_m = speed at maximum flow

2. Greenberg Model

The relationship between flow, speed, and density according to Greenberg is as follows.

1) Relationship between Speed and Density

$$S = S_m . ln \frac{D_J}{D} \quad (5)$$

2) Relationship between Flow and Speed

$$F = S . D_J . exp \frac{-S}{S_m} \quad (6)$$

3) Relationship between Flow and Density

$$F = S_m . D . ln \frac{D_J}{D} \quad (7)$$

4) Maximum Flow (obtained when ∂F/∂D = 0)

$$F_C = \frac{D_J . S_m}{e} \quad (8)$$

3. Underwood Model

The relationship between flow, speed, and density according to Underwood is as follows.

1) Relationship between Speed and Density

$$S = S_f . exp \frac{-D}{D_m} \quad (9)$$

2) Relationship between Flow and Speed

$$F = S . D_m . ln \frac{S_f}{S} \quad (10)$$

3) Relationship between Flow and Density

$$F = D . S_f . exp \frac{-D}{D_m} \quad (11)$$

4) Maximum Flow (obtained when ∂F/∂D = 0)

$$F_C = \frac{D_m . S_f}{e} \quad (12)$$

2.3 Correlation Coefficient

According to Radam (2008), the correlation coefficient equation can be calculated using the equation:

1. Linear Equation

$$r = \left| \frac{n \,.\, \sum x_i . y_i - \sum x_i \,.\, \sum y_i}{\sqrt{(n \,.\, \sum (x_i)^2 - (\sum x_i)^2) \,.\, (n \,.\, \sum y_i{}^2 - (\sum y_i)^2)}} \right| \quad (13)$$

2. Logarithmic Equations

$$r = \left| \frac{n \,.\, \sum \ln x_i . y_i - \sum \ln x_i \,.\, \sum y_i}{(n \,.\, \sum \ln x_i{}^2 - (\sum ln x_i)^2) \,.\, (n \,.\, \sum y_i{}^2 - (\sum y_i)^2)} \right| \quad (14)$$

3. Exponential Equation

$$r = \left| \frac{n \,.\, \sum x_i . \log y_i - \sum x_i \,.\, \sum \log y_i}{\sqrt{(n \,.\, \sum x_i{}^2 - (\sum x_i)^2)(n \,.\, \sum \log y_i{}^2 - (\sum \log y_i)^2)}} \right| \quad (15)$$

To see the level of correlation between the independent variable and the dependent variable, guidelines are used to provide an interpretation of the correlation coefficient which can be seen in Table 1.

Table 1. Guidelines for Interpretation of Correlation Coefficients (Radam et al, 2015)

Absolute Value of Correlation Coefficient	Interpretation
0.00 – 0.199	Very Low, Almost Negligible Relationship

Absolute Value of Correlation Coefficient	Interpretation
0.20 – 0.399	Low, Definite but Small Relationship
0.40 – 0.699	Moderate, Substantial Relationship
0.70 – 0.899	Strong, Clear Relationship
0.90 – 1.00	Very Strong, Dependable Relationship

2.4 Degree of Saturation (DS)

Based on PKJI (2014), DS can be calculated using the equation:

$$DS = \frac{F}{C} \quad (16)$$

Where:
DS = degree of saturation
C = capacity (pcu/hour)

3. METHOD

3.1 Research Location

The research was conducted on the u-turn of A. Yani Road Km. 35 Banjarbaru City (in front of the South Kalimantan Regional Police Traffic Directorate). The research was only carried out in one direction, namely from Banjarmasin to Martapura. Vehicle speed is measured 20 m before u-turn. The sketch of the research location can be seen in Figure 2.

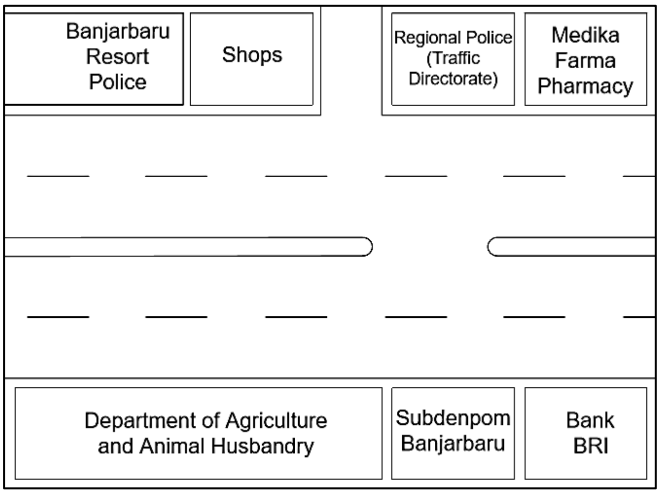

Figure 2. Research Location Sketch

3.2 Data Collection and Processing

Before collecting traffic data, a preliminary survey was conducted to observe the condition of the research location and to find out the busiest days on the road. The data that has been processed will then be analyzed so that it can find the effect based on the results of the analysis. These data are used to obtain the degree of saturation and road performance.

Primary data obtained through a survey for 2 days. The primary data in this study consisted of:

1) Traffic flow data
2) Vehicle speed data
3) Road geometric data

Data logging of traffic flow and speed is divided into 10 minute intervals. The traffic flow that is taken into account is the flow of straight vehicles and the flow of vehicles carrying out turning movements (only when the u-turn operates normally), while the calculated speed is the speed of straight vehicles. Vehicle speed measurement is done with the help of a *speed gun* . Each time interval of 10 minutes, 3 cars and 3 motorcycles are selected to measure their speed.

4. RESULT AND DISCUSSION

4.1 Data Collection Time

From the preliminary survey, it was found that the busiest day at the research site was Saturday. The first survey (when the u-turn operates normally) is carried out on November 6, 2021, while the second survey (when the u-turn *is* closed) is carried out on November 20, 2021. The first survey is carried out for 15 hours starting from 06.00 – 21.00 CIT. After carrying out the first survey, the five busiest hours were determined for the second survey, which was 16.00 – 21.00 CIT.

4.2 Road Geometric Condition

The geometric conditions of the research location can be seen in Figure 3.

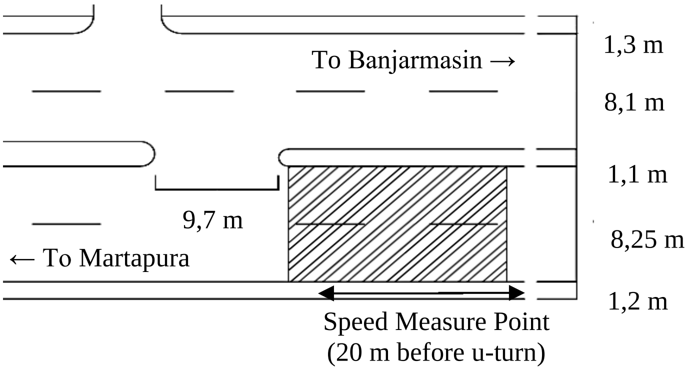

Figure 3. Geometric Conditions of the Research Location

4.3 The Effect of U-Turn on Traffic Performance

From the previous analysis, the right model was chosen to describe the relationship of traffic flow characteristics at the research location. In each condition, a model is chosen where the model has a correlation coefficient that shows the strongest relationship and the most realistic x value. The selected characteristic relationship model must have a correlation coefficient value > 0.7 and the value of the independent variable (x) in the condition (y) = 0 is realistic.

Taking into account the type of road 2/1D with a road width of 8.25 m, the most relevant model when the u-turn is operating normally is the Underwood model, while the most relevant model when the u-turn is closed is the Greenshields model. The effect of u-turn on traffic performance can be seen in Table 2. The results of the selected model in Table 2 can be depicted in the form of a graph of the relationship between traffic flow characteristics which can be seen in Figure 4.

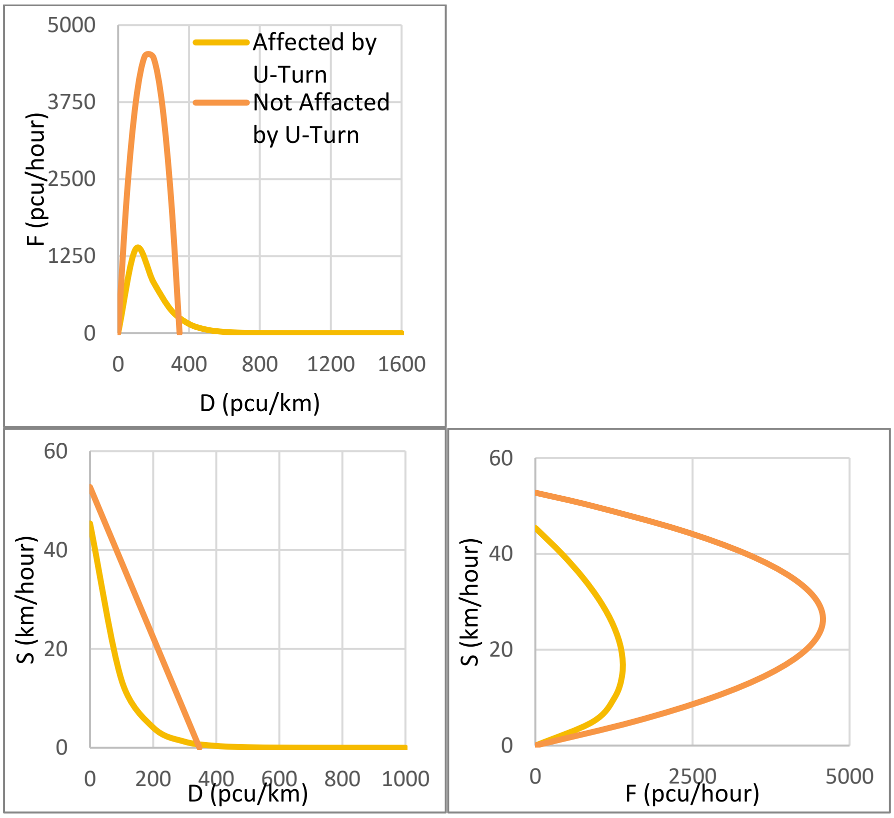

Figure 4. Graph of Relationship Between Traffic Flow Character in Each Condition with Selected Model

From Table 2, it can be seen that the correlation coefficient when the u-turn is operating normally describes a very strong relationship, while the correlation coefficient when the u-turn is closed describes a very strong relationship.

Table 2. The Effect of U-Turn on Traffic Performance

Characteristics	**Condition**		**Percentage Decrease/Increase Due to Influence U-Turn**
	Unaffected U-Turn (*Greenshields* Model)	**Affected U-Turn (*Underwood* Model)**	
S_f (km/hour)	52,767	45.413	(-) 13.94%
S_m (km/hour)	26.383	16.707	(-) 36.68%
D_J (pcu/km)	346.944	~ 600	(+) 72.94%
D_m (pcu/km)	173.472	83.333	(-) 51.96%
F_c (pcu/hour)	4576.795	1392.209	(-) 69.58%
Correlation Coefficient	0.8821	0.9341	(+) 5.90%

4.4 The Effect of U-Turn on the Degree of Saturation

The effect of the presence of a u-turn can also be seen through the relationship between the degree of saturation and the turning flow which can be seen in Figure 5.

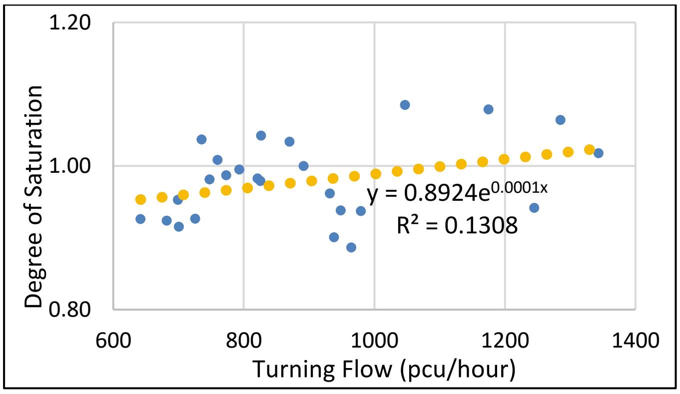

Figure 5. Relationship between DS and Turning Flow

From Figure 5, it can be seen that there is a tendency that the greater the turning flow, the higher the degree of saturation and lower the LoS. However, the relationship between the degree of saturation and the turning flow cannot be described in an equation model because the values obtained show a very low relationship so that there is no significant effect. There are several factors that lead to this condition where LoS is not only influenced by the flow factor of rotation, but is also dominated by other influencing factors.*)*

5.CONCLUSIONS

From the results of the analysis with the limitation of the flow that makes a return of 33.24% - 48.72% of the total traffic flow, it can be concluded that the selected characteristic relationship model when the u-turn is closed is the Greenshields model with S_m of 26.383 km/hour and F_C of 4576,795 smp/hour. When the u-turn operates normally, the selected characteristic relationship model is the Underwood model with S_m of 16.707 km/hour and F_C of 1392.209 smp/hour. When affected by the u-turn, the value of S_m decreased by 36.68% and the value of F_C decreased by 69.58%.

REFERENCES

Directorate General of Highways. 1992. **Tata Cara Perencanaan Persimpangan Sebidang Jalan Perkotaan Number 01/T/BNKT/1992**. Jakarta: Directorate of City Road Development.

Directorate General of Highways. 2014. **Pedoman Kapasitas Jalan Indonesia (PKJI)**. Jakarta: Ministry of Public Works.

Google *Inc.* 2021. ***Google Maps*: Location Map of Ahmad Yani Road Km. 35 Banjarbaru**, http://maps.google.com. Retrieved December 23, 2021 at 20.30.

Radam, Iphan Fitrian. 2008. **Bahan Ajar: Rekayasa Lalu Lintas**. Banjarmasin: Lambung Mangkurat University Press.

Radam, Iphan Fitrian, Mulyono, Agus T., and Setiadji, Bagus H. 2015. **Influence of Service Factors in the Model of Public Transport Mode: a Banjarmasin – Banjarbaru Route Case Study, 5(2), 108-119**. International Journal for Traffic and Transport Engineering.