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Effect of U-Turn Use at Signalized Intersections: A Case of Simpang Frenky, Batam

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ABSTRACT

U-Turn is one of the infrastructures to change direction on the highway. U-Turns also increase access to mobility in the economic growth of the country. U-Turns are allowed at intersections in signalized or unsignalized research if they do not cause potential accidents, of course, taking into account road width, volume, and vehicle speed. In a study conducted at the Simpang Frenky batam center signalized intersection, it was found that U-Turns caused a slowdown in vehicle speed.

1. Introduction

Transportation is an important sector in the development or growth of a nation. Every decade there has been a growth in population in every country, which causes the use of transportation to increase [1]. More and more transportation causes traffic density. This is characterized by congestion at specific points. This causes loss of time, inconvenience to motorists, and affects a nation's economy. As a developing country, traffic congestion in Indonesia causes congestion. Many traffic violations occur because mobility in transportation increases over time. Traffic in Indonesia is regulated by legislation, namely Law Number 22 of 2009 concerning Road Traffic and Transportation, where these regulations are made to ensure security, order, and welfare in a society that needs to be determined regarding prohibited and required actions [2].Traffic violations often occur in the community; teenagers and adults commit violations. These violations include running red lights, violating traffic signs, not wearing driving equipment, and driving recklessly. This is very dangerous for drivers and surrounding people.

Batam with the nickname of an industrial city has a high level of traffic density because many employees come from outside the island of Batam [3]. This causes the intensity of vehicles in Batam city to continue to increase every year; with 930,868 total vehicles, Batam city tops the number of vehicles in the Riau Islands [4]. This volume of vehicles makes the streets in the city of batam, especially on roads that have been widened to 3 to 4 sections, but there are still many traffic violations. Two-wheeled vehicles dominate as the most traffic violations.

Road widening is intensively carried out in the city of Batam. The road around the red light at the industrial Cammo intersection is one of the road-widening locations. At that location, there is also an industrial Camo gate 1 closed due to road widening. Gate 1 Cammo industry is an alternative road for Cammo industry employees who work from the direction of Batu Aji, Piayu, and Sekupang. But after widening the road, gate 1 camo industry was closed and the only road left was gate 2 camo industry. Gate 2 of this industry must go through additional red lights for employees departing from the direction of Batu Aji, Piayu, and Sekupang. At the Franky intersection red light, employees departing from the direction of Batu Aji, Piayu, and Sekupang must make a U-turn, but in its implementation, many employees who drive violate traffic by making a U-turn when the lights are still red. Of course, this endangers motorists who are in the other direction. In the traffic law, it has been stipulated that every driver who violates traffic signs is punished with a maximum imprisonment of 2 months or a maximum fine of IDR 500 thousand [5].

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In this study, the problem is the number of traffic violations turning directions at the red light at the Simpang Frenky due to the closure of gate 1 of the cammo industry. This, of course, becomes interrelated with the initial causes so that there are many traffic violations at the red light at the Simpang Frenky. During work departure hours, traffic violations increase due to the majority of industrial cammo employees being the cause. The delay factor is the cause of traffic violations. Drivers are impatient in waiting for the light to turn green and choose to make a U-turn when the light is still red. This research aims to determine whether the widening of the road makes motorists more orderly in driving and the habits of industrial cammo employees in driving to work. To determine whether a nation's construction's progress reflects its people's behavior [6].

2. Literature Review

2.1 U-Turn

U-Turn is a traffic facility used as a turnaround for vehicles traveling on the road. U-Turns often cause congestion in the form of queues caused by vehicles that will make a U-Turn or intersection (Gunawan, Hermawan, & Tekmono, 2022). U-Turn behavior in driving significantly impacts traffic performance, and it can cause congestion caused by queues of motorists making U-turns. Usually, vehicles traveling straight should be prioritized over those making U-turns. Vehicles traveling straight will suffer more from congestion caused by motorists making a U-turn [7].

In an intersection, motorists are allowed to make a U-turn, but paying attention to the traffic symbols is necessary. Because not all intersections are allowed to make U-turns [8]. There is a slowdown in driving in the process of making a U-Turn movement. This certainly affects the flow of vehicle traffic behind it, which causes congestion [9]

Highways have an essential role in running a country's economy because it is an infrastructure that facilitates accommodation in running a business [10]. U-Turns are one of these infrastructures that participate in running the economy. The role of the U-Turn can also considerably impact driving on the highway because the U-Turn is an accent for motorists to reverse direction, making it easier for motorists.

U-Turns are also allowed by calculating the road section and the vehicle density. On the contrary, U-Turns are not permitted if they can cause accidents [11]. At signalized intersections, U-Turns take many things into account. In general, U-Turns at intersections cause a slowdown in flow which ultimately reduces the effectiveness of the intersection [12]

2.2 Road User Characteristics

Road users have very varied characteristics. The variables can be grouped based on age, gender, driving skills, and experience. Based on these variables, what most affect drivers in driving is time and reaction [13]. Requires a good response in terms of mental and physical. Road planning must pay careful attention to rainwater runoff. The pavement layer is easily damaged by standing water due to the nature of the material forming the asphalt mixture itself. This condition is caused by the fact that asphalt has properties that are not too strong against water immersion [14].

Batam is also known as an industrial city, so the number of people who come to Batam from various regions in Indonesia will also affect how someone drives on the highway [15]. Each region has a different driving style; if in the village, someone in driving tends to be more relaxed because the need for transportation could be better. At the same time, someone from a big city has a driving style that tends to pursue time due to work demands with a definite work schedule. From this the region of origin affects a person's driving style.

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At the research location at Simpang Frenky in Batam Center, the dominant road users are factory workers. During peak hours, the volume of vehicles will be crowded by workers going to work, given its location adjacent to the cammo industrial area. The relationship between traffic volume and time (fluctuation) depends on the location and function of the road. This can determine the peak hours when vehicle volumes peak [16].

Road characteristics also affect road user characteristics. The performance of a road section depends on the road section, volume, and vehicle speed [17]. Congestion can be measured by calculating vehicle volume & rate [18]. Workers with short distances use motorized vehicles, while workers with long distances prefer car vehicles [19].

3. Method

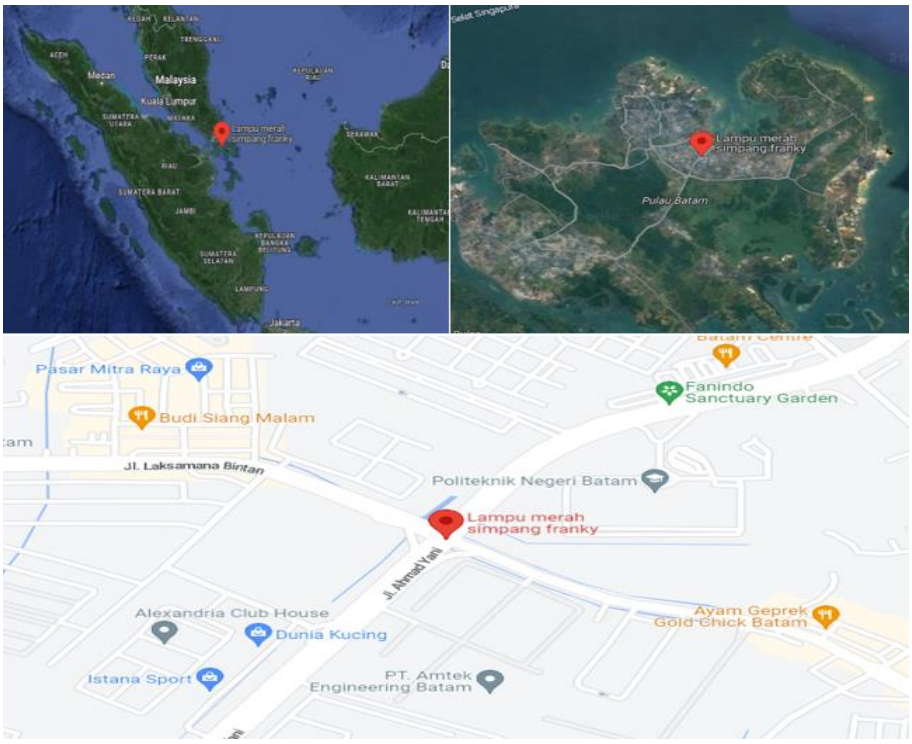

Figure 2. Case Study Location

This research uses a quantitative method, which consists of several stages—starting from data collection to analyzing the data that has been obtained following the 1997 Indonesian Highway Capacity Manual (IHCM) [5]. In this case, data collection must be carried out under the conditions that occur at the location. Determining the survey's purpose is the most crucial thing [14] [4].

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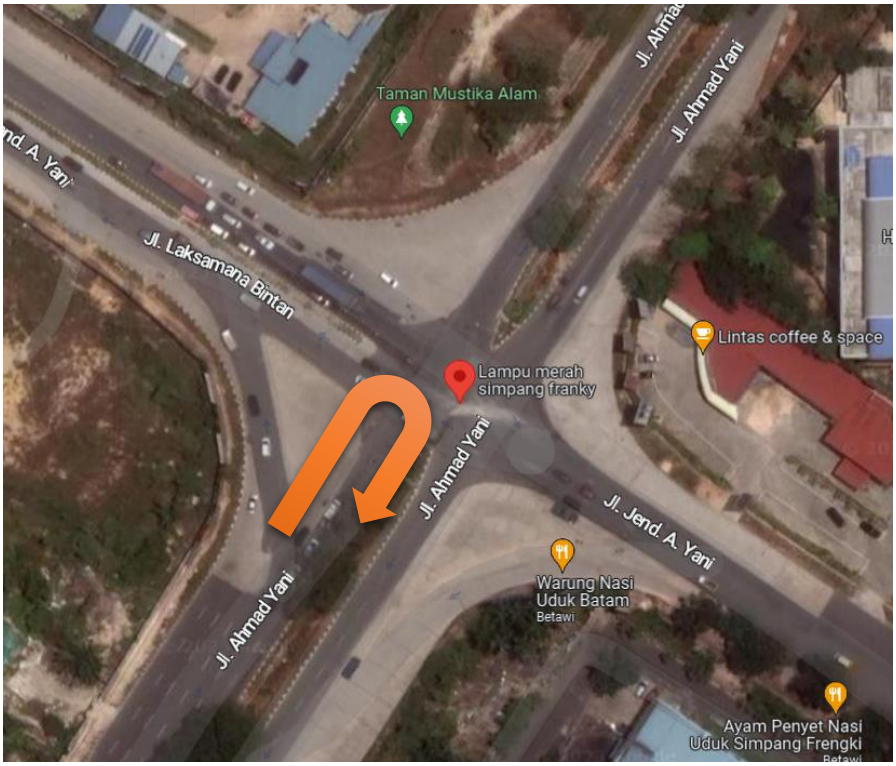

Figure 2. Picture from above

The research location will focus on the U-Turn in the picture above. This research was conducted on Thursday (02/03/2023), at 06.00 - 07.00 hours. The hour of this research is the peak hour for the U-Turn location at Simpang Frenky, Batam Center. Seeing that the survey location is widely used as a turnaround to the Cammo industrial area, this causes opportunities for traffic violations.

4. Result and Discussion

Data collection was conducted at Simpang Frenky, Batam Center. The data collection technique used is the survey method and direct location observation.
The following is the data of the Simpang Frenky Batam Center intersection:

Road type = 4 undivided lanes

Road width = 3.5 meters

Road shoulder width = 1 meter

The survey for this research data was conducted at Simpang Frenky Batam Center intersection from 06.00 - 07.00 WIB. To calculate the volume of traffic flow, vehicles were classified into Light Vehicles (LV) = 1.0; Heavy Vehicles (HV) = 1.2; and Motorized Vehicles (MC) = 0.25 (note: look for quotes from journals with opinions like this). After conducting a survey, the road capacity has been successfully obtained by the author. In determining road capacity, the 1997 IHCM guidelines can be used, which contain the following formula.

$$C = Co \times FCW \times FCSP \times FCSF \times FCSS$$

The Basic Capacity (Co) value at Simpang Frenky Batam Center of 1500 is obtained based on IHCM table. The essential capacity of urban roads can be seen in Table 1. Simpang Frenky Batam Center has four-lane undivided road type.

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Table 1. Urban Road Capacity

Road Type	Base Capacity (pcu/h)	Information
Split four-lane or one-way road	1650	Per lane
Four-lane undivided	1500	Per lane
Two-lane undivided	2900	Total of two

Source: IHCM 1997

The capacity adjustment value (FCw) is obtained as 1.00 with the measured lane width of Simpang Frenky Batam Center of 3.5 meters, which is obtained from Table 2 below.

Table 2. Capacity Adjustment Factor

Road Type	Effective traffic lane width	FCw
Four-lane division or one-way street	Per lane	
	3.00	0.92
	3.25	0.96
	3.50	1.00
	3.75	1.04
	4.00	1.08
Four undivided lanes	Per lane	
	3.00	0.91
	3.25	0.95
	3.50	1.00
	3.75	1.05
	4.00	1.09
Two undivided lanes	Total of two 5	
	6	0.56
	7	0.87
	8	1.00
	9	1.14
	10	1.25
	11	1.29
		1.34

Source: IHCM 1997

The Capacity Adjustment Factor (FCsp) value for a four-lane road type of 50-50 is 1.00, which can be seen in table 3.

Table 3. Table of capacity adjustment values (FCsp) for road types

%-% SP direction separation		50-50	60-40	70-30	80-20	90-10	100-0
FC_{SP}	Two Lane 2/2	1,00	0, 94	0,88	0,82	0,76	0,70
	Four Lanes 4/2	1,00	0,97	0,94	0,91	0,88	0,85

Source: IHCM 1997

The Capacity Adjustment Value (FCsf) for the Sudirman Road location has a side obstacle of 0.96 with a road width of 1.0. The location of Simpang Frenky Batam Center is a residential area that does not have many side obstacles activities of 0.96 can be seen in Table 4 below.

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Table 4. Table of capacity adjustment values (FCsf) for roadside obstructions

Road Type	Roadside nuisance class	Adjustment factor for roadside obstructions and shoulder width ***FCSF***			
		Sidewalk Width WS			
		≤ 0.5 m	1.0 m	1.5 m	≥ 2 m
4/2 D	VL	0,95	0,97	0,99	1,01
	L	0,94	0,96	0,98	1,00
	M	0,91	0,93	0,95	0,98
	H	0,86	0,89	0,92	0,95
	VH	0,81	0,85	0,88	0,92
4/2 UD	VL	0,95	0,97	0,99	1,01
	L	0,93	0,95	0,97	1,00
	M	0,90	0,92	0,95	0,97
	H	0,84	0,87	0,90	0,93
	VH	0,77	0,81	0,85	0,90
2/2 UD or one-way road	VL	0,93	0,96	0,97	0,99
	L	0,90	0,92	0,95	0,97
	M	0,86	0,88	0,91	0,94
	H	0,78	0,81	0,84	0,88
	VH	0,68	0,72	0,77	0,84

Source: IHCM 1997

The city capacity adjustment value (FCcs) with a population of 1.196 million people in 2020, based on data from BPS (Central Bureau of Statistics) obtained an FCcs value of 1.00 which can be seen in Table 5.

Table 5. Table of capacity adjustment values for city groups (FCcs)

City Size (Million people)	Adjustment factor for city size ***FCCS***
<0.1	0,86
0,1 – 0,5	0,90
0,5 – 1,0	0,94
1,0 – 3,0	1,00
>3.0	1,04

Source: IHCM 1997

Based on the data that has been obtained, the road capacity value at the Simpang Frenky Batam Center can be calculated using the 1997 IHCM guidelines as follows

$$C = 4 \times Co \times FCW \times FCSP \times FCSF \times FCCS$$
$$C = 4 \times 1500 \times 1{,}00 \times 1{,}00 \times 0{,}96 \times 1{,}00$$
$$C = 5760 \text{ pcu/hour}$$

Therefore, the capacity value of Jalan Sudirman is 5760 pcu/hour. Degree of saturation (DS) is defined as the ratio of flow to capacity on a road section. It is used as the main factor in determining the performance level of intersections and road sections. Based on IHCM 1997, Jalan Sudirman has a degree of saturation value of 0.28.

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$$DS = \frac{Q}{C}$$
$$DS = \frac{5000}{5760}$$
$$DS = 0{,}87$$

Based on the 1997 IHCM with the US-HCM approach, the level of service of a road is based on the degree of saturation. For example, Sudirman Road, which has a degree of saturation value of 0.28, has a stable traffic flow with vehicle speeds that are influenced by vehicle volume. Therefore, the vehicle speed during traffic flow diversion.

$$V = \frac{s}{t}$$
$$V = \frac{200m}{36{,}9s}$$
$$V = 19{,}51 \text{ km/h}$$

5. Conclusion

The research results found that a U-Turn at Simpang Frenky signalized Batam Center affects the vehicle speed, namely the average speed of 19.51 km/h. This shows that using a U-Turn at Simpang Frenky signalized Batam Center so that it is indicated to cause congestion due to the slowing of the vehicle speed.

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