U-Turn Analysis on Road Performance by Dr. Ir. H. Soekarno Merr (Case Study: West and East Side U-Turn)

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Abstract. Traffic is a system consisting of several key elements, or a headway system. In the median plan, it also has a center opening or U-Turn, but the U-Turn facility does not completely solve these problems and conflicts because the turning vehicle itself does not completely solve them. This is the result of turning in the same direction as vehicles approaching or stopping in high and low speed lanes. Some vehicles are unable to make smooth U-Turns, causing delays for both traffic directions or vice versa. This study aims to determine the traffic performance and performance of the U-Turn facility on Jl. Dr. Ir. Soekarno in the City of Surabaya using the MKJI methodology, 1997. From the results of this study, the peak hours for the south direction (A) are at 16.45-17.45, volume 3480. 6 vehicles per hour, DS (Degree of saturation) 0.73 with service level C, and south to north (B) at 16:45-17.45, volume 3394. 7 vehicles per hour DS 1.07 means the level of service indicates a long queue. The U-Turn movement has the highest volume at 16.45-17.45, with a volume of 656.8 pcu/hour and an intensity ratio greater than 1.0, indicating a vehicle queue.

Keywords: MKJI 1997, Road performance, U-Turn

1. Introduction

In Law No. 22 of 2009 concerning traffic and transportation, as well as being safe and comfortable, it states that traffic is said to be good if traffic can be reached smoothly and there are no problems. A median is a part of road geometry that provides physical lane separation with the aim of eliminating traffic collisions in opposite directions and increasing traffic safety and comfort. [1][2][3] In planning, the median also has a center opening that allows the vehicle to turn in the opposite direction, which is termed a U-Turn. The ability to maintain direction and control the vehicle is usually limited by lane width, center width, and vehicle width, so turning movements are much more complex than turning right or left. The U-Turn facility does not completely solve these problems and conflicts because the turning vehicle itself does not completely solve them. However, the turning vehicle itself causes problems in the form of side obstacles. This is the result of turning in the same direction as vehicles approaching or stopping in high and low speed lanes.

Dr. Street Ir. H Soekarno is an arterial road with a relatively heavy traffic volume during peak hours. The type of road is two-way and divided (using the median). There is a median on each road segment to accommodate the U-Turn movement. It appears that there are some vehicles that cannot perform U-Turn smoothly, resulting in delays for both road users in the same direction or vice versa. Another factor that causes the inhibition of traffic circulation at the research location is that it is influenced by several shopping activities, offices, and so on, so that it can hinder traffic movement in the area.

A study says that with the U-Turn movement, the congestion that occurs is getting worse and the potential for traffic accidents will be even greater, especially at conflict points that have median opening facilities that still meet the safety, smoothness, and performance aspects of the road. with the characteristics of the function of the road, especially on urban arterial roads. [4][5][6][7] The U-Turn direction is very influential on vehicle speed; the performance of traffic flow on the road will be disrupted and is related to traffic volume with changes in road service levels. [8] Then the vehicle will use the segment on the road in the opposite direction, reducing the width of the lane according to the turning time of the vehicle. [9][10][11] This results in vehicles on the opposite current having to reduce their speed and even stop. Vehicle characteristics are also operational characteristics. The performance of the vehicle varies according to vehicle size and weight, which must be taken into account in planning and analysis of road facilities. [12][13]

The purpose of this study was to determine the performance of U-Turn and the performance of roads on Jl. Dr. Ir. H. Soekarno/Merr Surabaya. From this study, it is expected to overcome congestion due to the performance of U-Turn on the performance of roads in urban areas.

2. Materials and Methods

2.1 Road Performance

2.1.1 Capacity

Road capacity is the maximum number of vehicles that can pass on a road per hour under certain conditions. The current is divided by the direction and capacity of each lane. Following equation in determining the capacity:

$$\mathbf{C = Co \times FCw \times FCsp \times FC_{SF} \times FCcs} \quad (1)$$

2.1.2 Degree of Saturation (DS)

The degree of saturation is defined as the percentage of traffic flow Q (vehicles/hour) to capacity C (vehicles/hour) and is used as the key to ensure the performance level of the road segment. The DS value indicates whether there is a capacity problem with the segment. The degree of saturation is formulated as follows:

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$$\mathbf{DS = Q/C} \quad (2)$$

2.1.3 Free Flow Speed

The free flow speed (FV) is defined as the zero current speed, which is the speed drivers would choose if they were to drive unaffected by other motorized vehicles on the road. The free flow speed of light vehicles has been chosen as the basic criterion for road traffic performance at flow = 0. The free flow speed of light vehicles is generally 10% higher than that of heavy vehicles and motorcycles. The free flow velocity is formulated as follows:

$$\boldsymbol{FV = (FVo + FVw)\ FFVsf\ x\ FFVc} \quad (3)$$

2.1.4 Travel Time Speed

As the main measure of road segment performance, travel speed is defined as the average space speed of light vehicles (LV) along the road segment.

$$\mathbf{V = L/TT} \quad (4)$$

2.1.5 Service Level

The level of service, or LOS, shows the method used to assess road performance, which explains one of the indicators of congestion. To find out the LOS, one must compare traffic volume with basic capacity (V/C).

2.1.6 Traffic Volume

Traffic volume describes the number of vehicles that pass at a point or line on a cross section of the road. "Traffic volume" describes the number of vehicles that pass an observation point in one unit of time (days, hours, minutes). [14] Types of vehicles are classified into 3 types of vehicles: light vehicles index of 4-wheeled motorized vehicles; heavy vehicles index of motorized vehicles with more than 4 wheels; motorcycle index (Motor Cycle = MC) for 2-wheeled motorized vehicles; non-motorized vehicles (bicycles, tricycles, and strollers). The data on the number of vehicles is then calculated in vehicles/hour for each vehicle, Passenger car equivalent (PCE) using the correction factors for each vehicle, namely: LV = 1.0; HV = 1.3; MC = 0.50. The total traffic flow in vehicles/hour is:

$$\mathbf{Qvehicles = (pceLV\ x\ LV + pceHV\ x\ HV + pceMC\ x\ MC)} \quad (5)$$

The result of the passenger car unit factor (pcu) is entered into the traffic volume formula.

$$\mathbf{Q = pcu\ x\ Qvehicle} \quad (6)$$

Traffic volume data collection is carried out in the morning, afternoon, and evening by counting heavy, light, and motorcycles. Observation of vehicle speed by taking samples of vehicles running in front of a 50 m observation distance, measuring method using a stop watch and on the way not overtaking other vehicles. with a sample of five vehicles. Observations of vehicles at the time of turning around count the number of vehicles and measurements by calculating the travel time of the turning time to find the length of the turning time.

3. Result and Discussion

3.1 Street Geometry

Table 1. Street Geometry of Dr. Ir. Soekarno Hatta Merr Road
(Source: Field Observation, 2021)

Road Name	Dr. Ir. H. Soekarno
Road Type	4/2 D
Line Width A	13,85 m
Line Width B	10,60 m
Median Width	2,00 m
U – Turn Width	9,15 m
Curb Width	1,90 m

The width of line A is the direction from North to South Merr, and line B is the direction from South to Utas Merr. The research location is back and forth on-line A.

3.2 Traffic Volume on U-turn

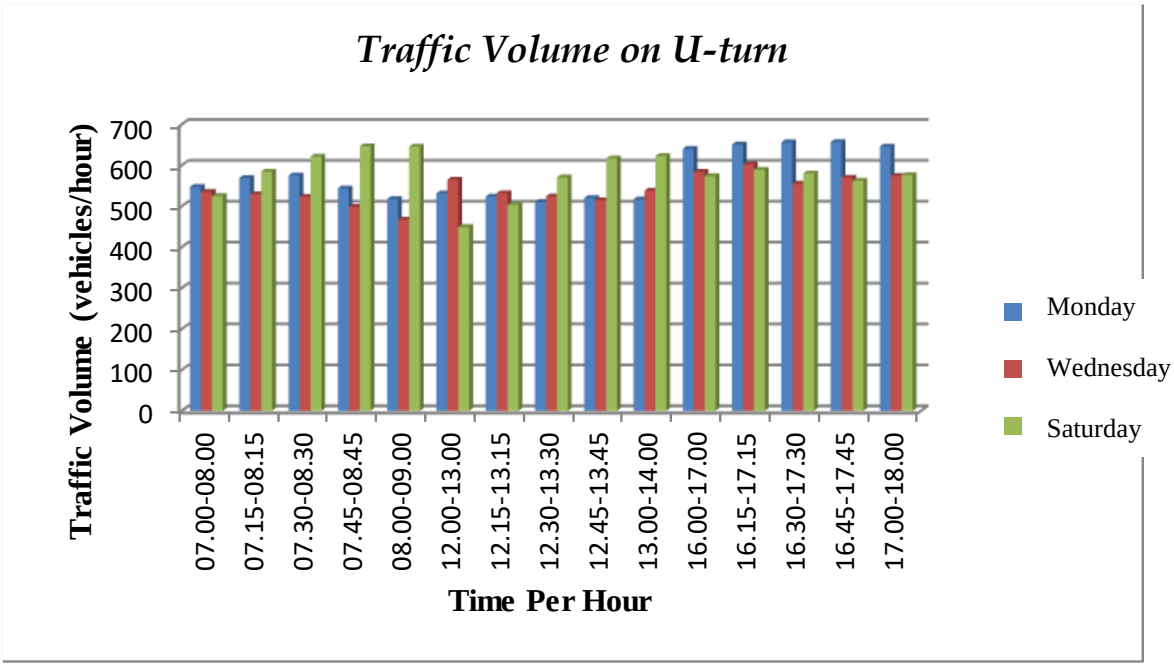

Figure 1. Traffic Volume on U-turn
(Source: Field Observation, 2021)

The graph above shows the peak volume of vehicles carrying out U-Turns on Monday afternoon at 16.45–17.45 with a volume of 656.8 pcu/hour.

3.3 Road Capacity

3.3.1 Dr. Ir. H. Soekarno Road- Line A

From the results of the calculations, the value of the direction capacity from North to South Merr is still within safe limits with C = 4753.46 pcu/hour.

Free flow velocity analysis

- motorcycle (MC) = 47 km/hour according to road function
- light vehicles (LV) = 57 km/hour according to road function
- heavy vehicles (HV) = 43.85 km/hour according to road function

Analysis of the speed of the travel time = 35.97 km/hour. The speed of the travel time is still under control.

Table 2. Service Level of Dr. Ir. H. Soekarno Road- Line A
(Source: Field Observation, 2021)

Day / Date	Direction	Hour	Morning – Afternoon	Traffic volume	Capacity	DS	LOS
Monday, 13-12- 2021	A - B	07.45-08.45	Morning	2913.6	4753,46	0.61	C
		12.45-13.45	Noon	2285.8		0.48	C
		16.45-17.45	Afternoon	3480.6		0.73	C

The results of the analysis show that the level of service for direction A shows category C, which means the flow is stable but the speed and motion of the vehicle are controlled.

Service Level Analysis of U-Turn

Analysis of the U-Turn will use "Queue Theory." Queues will occur if the service time is longer compared to the arrival time. To see the level of intensity of service facilities required by the flow of vehicles that carry out the U-Turn Movement and the duration of the vehicle time in the implementation of the U-Turn Movement.

Table 3. U-turn Analysis for Motorcycle (MC) Line A
(Source: Field Observation, 2021)

		Total traffic (Q) (λ) vehicles/Hour	**Mean**	**Service**	**Queue Ratio (ρ)**
Direction	Hour	A	B	C	D
		A	B	3600 / B	A / C
A - B	07.00 – 08.00	169	9.62	374.22	0.45
	08.00 – 09.00	118.5	11.53	312.23	0.38
	12.00 – 13.00	143.25	9.16	393.01	0.36
	13.00 – 14.00	139.75	12.27	293.40	0.48
	16.00 – 17.00	168	20.10	179.10	0.94
	17.00 – 18.00	182.25	17.36	207.37	0.88
	T O T A L	920.75	80.04	1759.34	3.49

The results of the analysis show that the level of service for area A is such that on line A there is no queue of vehicles in the morning, but in the afternoon, between 16.00 and 17.00, there is a queue but it can move.

3.3.2 Dr. Ir. H. Soekarno Road- Line B

From the results of the calculations, the value of the direction capacity from North to South Merr is still within safe limits with C = 3168.99 pcu/hour.

Free flow velocity analysis

- motorcycle (MC) = 47 km/hour according to road function
- light vehicles (LV) = 57 km/hour according to road function
- heavy vehicles (HV) = 43.85 km/hour according to road function

Analysis of the speed of the travel time shows that the speed of the travel time is smooth and controlled.

Table 4. Service Level of Dr. Ir. H. Soekarno Road- Line B
(Source: Field Observation, 2021)

Day / Date	**Direction**	**Hour**	**Morning – Afternoon**	**Traffic volume**	**Capacity**	**DS**	**LOS**
Monday, 13-12- 2021	A - B	07.45-08.45	Morning	2688.5	3186,99	0.84	E
		12.45-13.45	Noon	2203.3		0.69	C
		16.45-17.45	Afternoon	3394.7		1.07	F

The results of the analysis show that the level of service for direction B is in category C, meaning the flow is stable but the speed and movement of vehicles are controlled. On Monday morning and evening, the flow is forced, the speed is low, the volume is above capacity, and there are long queues (jammed).

Table 5. U-turn Analysis for Motorcycle (MC) Line B
(Source: Field Observation, 2021)

		Total traffic (Q) (λ) vehicles/Hour	**Mean**	**Service**	**Queue Ratio (ρ)**
Direction	Hour	A	B	C	D
		A	B	3600 / B	A / C
A - B	07.00 – 08.00	265	22.73	158.38	1.67
	08.00 – 09.00	297	26.38	136.47	2.18
	12.00 – 13.00	302	15.62	230.47	1.31
	13.00 – 14.00	307	20.68	174.08	1.76
	16.00 – 17.00	344	26.08	138.04	2.49
	17.00 – 18.00	323	21.75	16.52	1.95
	T O T A L	1.838	133.24	1002.96	11.37

The results of the analysis show that the level of service for direction B shows that on line B there are queues of vehicles in the morning at 08.30–09.30 and in the afternoon at 16.00–17.00 because during rush hours in the morning and evening they can move. From south to north, as a result of the U-turn trajectory, there is a queue of vehicles.

4. Conclusion

1. Conditions of traffic flow on Jl. Ir. H. Soekarno Street, City of Surabaya, the largest data was taken from Monday, Wednesday, and Saturday, namely
   - Peak hours in the north-south direction (A) occur at 16.45–17.45 with a volume of 3480.6, a degree of saturation of 0.73, and a LOS C value, which means the flow is stable, but the speed and movement of vehicles are controlled.
   - Peak hours in the south to north direction (B) occur at 16.45–17.45 with a volume of 3394.7, a degree of saturation of 1.08, and a significant LOS F value, indicating that at that hour the flow is forced, the speed is low, the volume is above capacity, and a long queue is formed (congested).
2. For the traffic flow conditions that make a U-Turn on Jl. Dr. Ir. H. Soekarno Street in Surabaya, the largest data was taken from the two U-Turn flow conditions at the observation site, namely on Monday at 16.45 - 17.45 with a vehicle volume of 3394.7 pcu/hour.
   - The queue intensity ratio (ρ) is >1.0, which means there is a queue of vehicles.

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