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Exclusive Stopping Space for Motorcycles (ESSM) technical design at signalized intersections

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Abstract. The growth of motorcycles which continues to increase every year can lead to an increase in the number of accumulation of motorcycles on the approach to the intersection, so it is necessary to plan a Exclusive Stopping Spaces for Motorcycle (ESSM). The purpose of this study is to find out whether the street at the research location meets the requirements for ESSM planning by reviewing the number of motorbikes piled up during the red phase and planning the ESSM design. The method used in this study is an experimental method in accordance with the 2014 Indonesian Highway Capacity Guidelines (PKJI) and the Technical Planning Guidelines for Special Stopping Spaces in urban areas. The results of the study show that ESSM at signalized intersections in urban areas in Merauke City can be implemented in the next 15 years, namely in 2037. Of the four arms of signalized intersections, only 3 approaches can implement ESSM facilities, namely the Brawijaya Street approach, the TMP Street approach, and Parakomando Street approach. While the Angkasa Street approach cannot be applied to ESSM because it does not meet the requirements in the ESSM planning guidelines. The ESSM design on the Brawijaya Street approach uses a 2-lane box type ESSM with an area of 60 m²; on the TMP Street approach using a 2-lane box type ESSM with an area of 60 m²; on the Parakomando Street approach using a 2-lane box type ESSM with an area of 56 m².

Keyword: ESSM, technical design, signalized intersections

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1 Introduction

A signalized intersection is an intersection that has several arms and is equipped with traffic lights, its function is to avoid accidents and congestion due to traffic flow conflicts and to provide an opportunity for vehicles and pedestrians from (small) intersections to cut off the main road [1], [2]. In 2017 the number of motorcycles in the city of Merauke amounted to 92,134 units while in 2021 the number of motorcycles in the city of Merauke increased to 110,626 units. From the above data it is clear that the number of motorbikes has increased and this has resulted in separate transportation problems, especially on urban roads [3]. Traffic junctions regulated by traffic lights are also affected by the existence of these motorcycles [4].

The condition of motorbikes is generally that they are small in size, capable and agile to cross and have flexibility in maneuvering on the highway [5], [6]. However, due to the increasing number of motorized vehicles, this has resulted in motorized vehicle users optimally using all the space at the intersection, causing motorbikes to appear to be scrambling as fast as possible to get out of the intersection arm.

Over time the growth of motorized vehicles increased almost uncontrollably [7]. Especially motorcycles, the growth of motorbikes which continues to increase every year can lead to an increase in the number of motorcycles piled up at the intersection arm in the coming year which will result in less effective performance, namely reducing the volume of vehicles that are passed in the green phase of the traffic control lights [8], [9].

To overcome this problem, it is necessary to do traffic engineering. One of the traffic engineering can be in the form of providing Exclusive Stopping Spaces for Motorcycle (ESSM) facilities by calculating the capacity of ESSM, the average total stacking of motorcycles, the proportion of stacking of motorcycles in each lane, stacking of motorcycles for each phase and then planning an ESSM design based on requirements of traffic conditions and intersection geometric conditions [10], [11].

Research on special parking has been widely studied but tends to only focus on the existing time in the year of research and has weaknesses in forecasting models for the next few years which actually have a long-term impact along with the massive addition of motorized vehicles [10], [12], [13]. For this reason, this research does not only calculate the condition of the vehicles at the time of existing in the research year but also calculates traffic conditions for the future or performs forecasting for the next 15 years.

The purpose of this research is to find out how Exclusive Stopping Spaces for Motorcycle (ESSM) designs are designed at signalized intersections on the Brawijaya Ring Road or Libra intersections.

2 Research Methods

2.1 Research sites

This research is located at a signalized intersection, namely the intersection of four Brawijaya Ring Road, Merauke Regency which consists of Brawijaya Street, Parakomando Street, TMP Street and Angkasa Road. Geographically, this intersection is located at 8°29'40" south latitude and 140°24'07" east longitude. The map and sketch of the research location can be seen in Figure 1.



Fig. 1. The location of the four-signalized intersection

2.2 Data collection technique

The primary data used is related to road geometry surveys which include; road type, lane width, and road separation as well as traffic volume surveys taken to determine the number of vehicles and the buildup of motorcycles at signalized intersections [14]. While secondary data includes data on the number of motorized vehicles for the last 5 years in Merauke district and data on motorcycle dimensions obtained from the Guidelines for Exclusive Stopping Spaces for Motorcycles (ESSM) at Signalized Intersections in Urban Areas [15].

2.3 Analisa data

Calculating ESSM capacity. The ESSM capacity sought can use the formula below [15].

$$C=A/D \quad (1)$$

Calculating the average total accumulation of motorcycles (X1)

$$X1= (\sum RI)/7 \quad (2)$$

Calculating the proportion of motorcycle stacking in each lane (P1)

$$P1= X1/(X1+X2) \times 100\% \quad (3)$$

Calculating Motorcycle Stacking for Each Phase (L1)

$$RL1= X1/(\sum fase) \quad (4)$$

To get the planned buildup of motorcycles, a traffic volume prediction is needed which is calculated using

traffic volume data at the beginning of the year, then projected to the next 15 years according to the plan's forecasting using the following equation:

$$i = \left(\frac{LHR_i}{LHR_n} \right)^{\frac{1}{7}} - 1 \quad (5)$$

Meanwhile, to obtain the number of stacked motorcycles for the planned year, it can be calculated using the forecasting formula with the following equation:

$$P_n = P_0 \times (1 + i)^n \quad (6)$$

3 Results and Discussion

3.1 The condition of the geometry of the Brawijaya Ring Road

In this study geometric data is primary data in the form of existing conditions which can be obtained directly in the field by conducting a survey. Information about the geometric state of the road at the signalized intersection in the Brawijaya circle can be seen in table 1.

Table 1. The geometric conditions of signalized intersections in the Brawijaya Ring Road

	Approach			
	Brawijaya Street	Parakomando Street	TMP Street	Angkasa Street
Street type	4/2D	4/2UD	4/2D	2/2UD
Median width (m)	2	-	2	-
LTOR	Nothing	Nothing	Nothing	Nothing
Enter approach (m)	7.50	7.00	7.50	6.00
Exit approach (m)	6.00	7.50	7.00	7.50
Tilt	1.1%	1.1%	1.1%	1.1%
Pedestrian width (m)	1.4 m	-	1.4 m	-

3.2 Determination of the direction of ESSM

The requirement for ESSM for motorcycles is based on the assumption that there has been an increase in the number of motorcycles as indicated by the volume of motorcycles stacked up and the proportion of motorcycles.

Based on the results of the preliminary survey conducted at the research location, there are 3 intersection approaches that meet the road type and geometric requirements, namely the Brawijaya Street, Parakomando Street and TMP Street approaches. Angkasa Street with a 2-lane 2-way road type does not

meet the road type and geometric requirements, so an analysis of traffic conditions is not carried out. The geometric requirements in question are that the road has a 4-lane 2-way road type with a minimum width of each lane of 3.5 m and a minimum number of stacked motorcycles of 15 motorbikes per lane or 30 motorbikes for 2 lanes. The results of the subsequent traffic analysis can be seen in table 2-4 as follows:

Table 2. The accumulation of motorcycles Brawijaya Street approach

Time	RP	Buildup of motorcycle		The total number of motorcycles
		L1 (3,75 m)	L2 (3,75 m)	
Morning 07.00-09.00	1	7	10	17
	2	6	9	15
	3	8	10	18
	4	8	11	19
	5	9	12	21
	6	9	12	21
	7	9	11	20
	8	8	11	19
	9	9	12	21
	10	15	16	31
Afternoon 13.00-15.00	1	11	13	24
	2	9	12	21
	3	15	15	30
	4	7	11	18
	5	8	11	19
	6	7	11	18
	7	7	11	18
	8	8	11	19
	9	11	9	20
	10	9	11	20
Evening 15.00-17.00	1	10	11	21
	2	9	13	22
	3	7	9	16
	4	9	11	20
	5	8	13	21
	6	9	11	20
	7	9	9	18
	8	9	9	18
	9	8	10	18
	10	9	11	20
Amount		247	267	338
Proportion %		42%	44%	56%
Stacking average		8.9	11.3	20.2

The data in Table 2 explains that the accumulation of motorbikes Brawijaya Street approach has only one Red Phase (RP) which fulfills the requirements for the accumulation of motorbikes in the ESSM planning, namely during the afternoon at the 3rd RP.

Table 3. Accumulation of motorbikes at the Parakomando Street approach

Time	RP	Buildup of motorcycle		The total number of motorcycles
		L1 (3,5 m)	L2 (3,5 m)	
Morning 07.00-09.00	1	8	11	19
	2	9	10	19
	3	9	10	19
	4	10	8	18
	5	9	11	20
	6	7	11	18
	7	9	12	21
	8	8	10	18
	9	8	11	19
	10	7	12	19
Afternoon 13.00-15.00	1	7	11	18
	2	11	9	20
	3	10	11	21
	4	16	15	31
	5	10	9	19
	6	8	12	20
	7	10	8	18
	8	9	11	20
	9	8	10	18
	10	9	9	18
Evening 15.00-17.00	1	7	12	19
	2	7	11	18
	3	8	10	18
	4	7	11	18
	5	7	11	18
	6	9	9	21
	7	9	10	22
	8	9	10	19
	9	8	12	16
	10	9	11	20
Amount		247	262	318
Proportion %		42%	45%	55%
Stacking average		8.7	10.6	19.3

The data in Table 3 explains that the accumulation of motorbikes Parakomando Street approach only has one Red Phase (RP) which fulfills the conditions for stacking motorcycles in the ESSM plan, namely during the afternoon at the 4th RP.

Time	RP	Buildup of motorcycle		The total number of motorcycles
		L1 (3,5 m)	L2 (3,5 m)	
Morning 07.00-09.00	1	9	12	21
	2	8	11	19
	3	9	10	19
	4	7	13	20
	5	10	11	21
	6	14	16	30
	7	8	13	21
	8	10	11	21
	9	9	12	21
	10	9	12	21
Afternoon 13.00-15.00	1	8	13	21
	2	8	12	20
	3	7	12	19
	4	9	13	22
	5	6	11	17
	6	8	12	20
	7	9	9	18
	8	8	11	19
	9	7	9	16
	10	7	16	23
Evening 15.00-17.00	1	8	13	21
	2	7	12	19
	3	6	10	16
	4	8	9	17
	5	7	9	16
	6	6	10	16
	7	9	12	21
	8	9	10	19
	9	8	9	17
	10	9	13	22
Amount		247	346	593
Proportion %		42%	58%	100%
Stacking average		8.2	11.5	19.8

The data in Table 4 explains that the accumulation of motorbikes Parakomando Street approach only has one Red Phase (RP) which fulfills the conditions for stacking motorbikes in the ESSM planning, namely in the morning at the 6th RP.

Looking at the motorcycle stacking data from table 2-4 shows that for now the three approaches are not feasible for ESSM planning because the three approaches have not met the minimum motorcycle stacking requirements, namely there is no minimum stacking that exceeds 50% of 30 red phases, but ESSM can be planned if the calculation of predictions for the next year (forecasting) with a period of 15 years is carried out.

3.3 Predicting the time of the year ahead (forecasting)

The accumulation of motorbikes can be measured based on the increase in the number of vehicles that have increased from year to year. The development of

Table 4. Accumulation of motorbikes at the TMP Street approach

the number of vehicles in Merauke Regency can be seen in Figure 2 as follows:

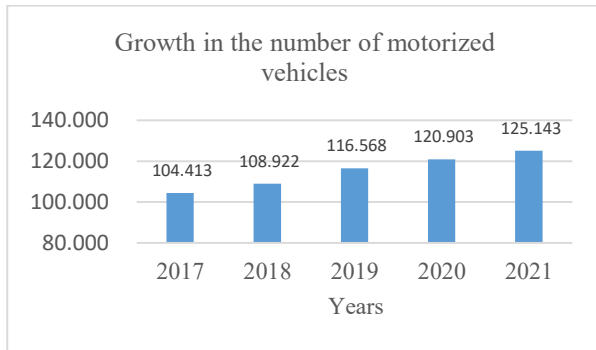


Fig. 2. Development of the number of vehicles for 5 years

From the data in Figure 2, it is known the number of years ($t = 5$ years) so that the rate of growth of motorized vehicle traffic in Merauke Regency can be found using equation 5. The calculation for finding the growth rate of motorized vehicle traffic is as follows:

$$i = \left(\frac{125,143}{104,413} \right)^{\frac{1}{5}} - 1$$

$$= 0.0369 \times 100\%$$

$$= 3.69\%$$

Table 5. Recapitulation of the accumulation of motorbikes in the plan year

Motorcycle Volume for the next 15 years									
Day	Brawijaya Street approach			Parakomando Street approach			TMP Street approach		
	L1	L2	T	L1	L2	T	L1	L2	T
Senin	460	582	1,042	451	548	999	425	596	1,021
Selasa	405	499	904	451	474	925	477	537	1,014
Rabu	389	510	899	434	565	999	372	520	8,92
Kamis	391	522	913	362	513	875	408	532	940
Jumat	379	544	923	381	520	901	498	599	1,097
Sabtu	367	525	892	343	474	816	288	496	784
Minggu	424	532	956	355	499	854	288	418	706

Description: L1 = Lane 1, L2 = Lane 2, T = Total of both lanes

The data in table 5 shows the number of motorcycles stacking for 7 (seven) days consisting of 30 (thirty) phases each day, which have been converted into the plan time. After obtaining data on the accumulation of motorcycles for each lane, then the number of vehicles per lane is averaged. Then the proportion of motorcycles piled up in each lane is calculated and the average number of motorcycles in each lane every time a red light is red.

The average total stacking of motorbikes for lane 1 and lane 2 on Brawijaya Street approach can be calculated using equation 2, while 1 calculation is taken for the Brawijaya Street approach is taken:

$$X1 = \frac{460 + 405 + 389 + 391 + 379 + 367 + 424}{7}$$

$$X1 = 403$$

$$X1 = \frac{460 + 405 + 389 + 391 + 379 + 367 + 424}{7}$$

From these calculations it can be seen that the growth rate of motorized vehicle traffic in Merauke Regency is 3.69%. To determine the value of motorcycle stacking in the planned year ($n = 15$ years) it can be calculated using equation 6. An example of calculation is taken from the TMP Street approach in the morning of the 1st Red Phase (RP) as follows:

$$P_n = 21 \times (1 + 3.69\%)^{15}$$

$$= 36 \text{ vehicle}$$

Furthermore, the data can be calculated as many as 30 RP for each approach using this equation, then totaled and the results divided by 30 (number of RP) in order to get the average value of motorcycle accumulation in the plan year. Detailed forecasting results can be seen in the following table:

$$X1 = 403$$

The proportion of motorcycle stacking can be calculated. One calculation is taken for the Brawijaya Street approach:

$$P1 = \frac{403}{403 + 531} \times 100\% = 43\%$$

$$P2 = \frac{531}{403 + 531} \times 100\% = 57\%$$

The average accumulation of motorbikes for each Red Phase (RP) can be calculated per lane. Meanwhile, 1 calculation is taken for the Brawijaya Street approach:

$$L1 = \frac{403}{30} = 14$$

$$L2 = \frac{403}{30} = 18$$

From several examples of calculations, the following shows the average and proportion of motorcycle stacking for each approach arm.

3.4 Brawijaya Street approach

Based on the existing condition of Jalan Brawijaya approach, the number of lanes for the approach is 2 (two) lanes, if using ESSM.

The following is the technical design requirement for Exclusive Stopping Spaces for Motorcycles (ESSM) with an average number of total stacking motorcycles of 32 which has been adjusted according to the ESSM area design selection table.

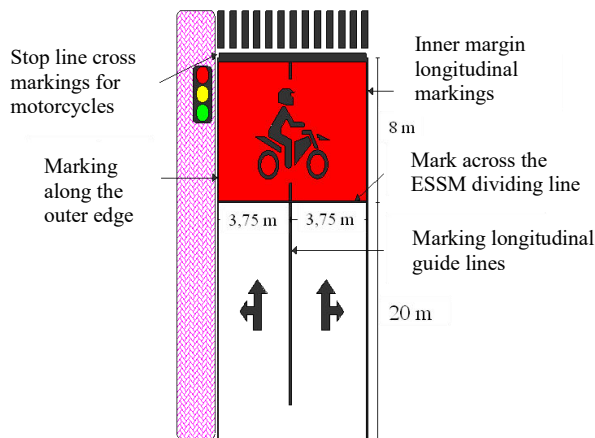


Fig. 3. ESSM technical design Brawijaya Street approach

3.5 TMP Street approach

Based on the existing conditions of the TMP Street approach, the number of incoming approach lanes is 2 (two) lanes, the same is the case with the Brawijaya Street approach, if using ESSM with 2 approach lanes, the average number of motorbikes stacking for each phase on the TMP Street approach does not exceed 37 motorbikes then the space requirement is sufficient for the number of motorbikes that have piled up.

The following is the technical design for Exclusive Stopping Spaces for Motorcycle (ESSM) requirements according to the ESSM area design selection table.

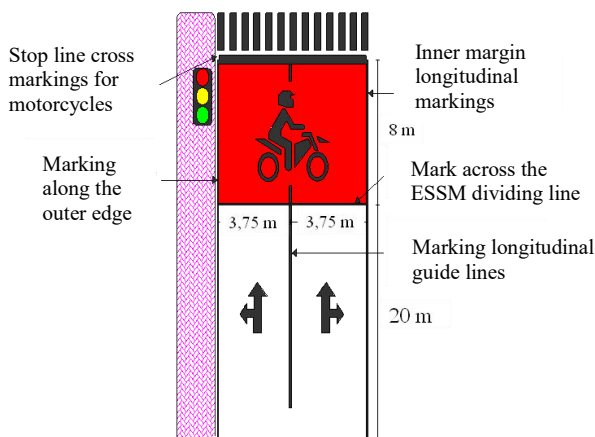


Fig. 4. ESSM technical design TMP Street approach

3.6 Parakomando Street approach

Based on the existing condition of the Parakomando Road approach, the number of lanes for the approach is 2 (two) lanes. If using an ESSM with 2 approach lanes, the average number of motorcycles stacked up for each phase on the Parakomando Street approach does not exceed 37 motorcycles, so the space requirements are sufficient for the number of motorcycles piled up.

The following is the technical design requirement for Exclusive Stopping Spaces for Motorcycles (ESSM) for an average total stacking value of 32 motorcycles.

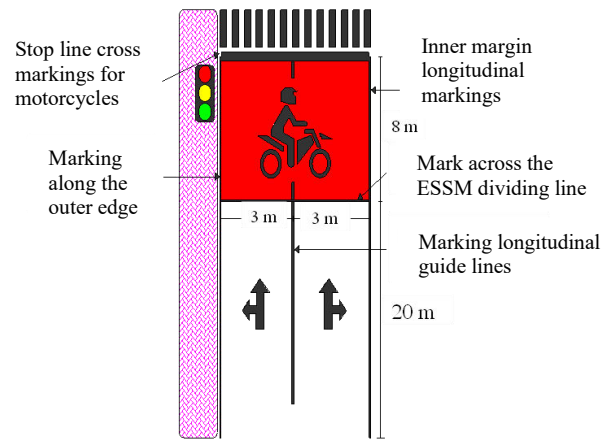


Fig. 5. ESSM technical design Parakomando Street approach

4 Kesimpulan

Based on the results of research conducted with reference to the Exclusive Stopping Spaces for Motorcycle (ESSM) Technical Planning Guidelines at Signalized Intersections in Urban Areas, it can be concluded that the planned ESSM can be implemented in 2037. From the forecasting results the average number of motorcycles builds up, it can be seen that only 3 approaches require ESSM facilities, namely the Brawijaya Street approach, the TMP Street approach, and the Parakomando Street approach. Meanwhile, the Angkasa Street approach does not meet the requirements for applying the ESSM.

The ESSM design planning is as follows; Brawijaya Street approach has a box type ESSM model with 2 lanes without approach lanes, 7.5 m wide, 8 m long and 60 m² wide; TMP Street approach has a box type ESSM model with 2 lanes without approach lanes, 7.5 m wide, 8 m long and 60 m² wide; Parakomando Street approach has a box type ESSM model with 2 lanes without approach lanes, 7 m wide, 8 m long and 56 m² wide.

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