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# Performance Analysis Of Tugu Pancasila Roundabout In Putussibau City Kapuas Hulu District

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## ABSTRACT

Tugu Pancasila Roundabout in Putussibau City is a 5-arm roundabout that organizes traffic in 5 directions of movement. Poor traffic management at this roundabout, such as the lack of roundabout signs and no separation island or median on roads other than the main road, makes motorists who should pass through the roundabout instead choose not to cross the roundabout and go against the flow because they want to reach their destination faster. In addition, due to the increasing population and the volume of vehicles traveling, it is anticipated that in the future, the Tugu Pancasila roundabout will have increasingly heavy traffic flows. The performance analysis of Tugu Pancasila Roundabout was calculated using MKJI 1997 and VISSIM software. The performance analysis of Tugu Pancasila Roundabout was carried out by taking roundabout geometric data, manually taking side obstacle data, and traffic volume data for three days using survey aids in the form of CCTV starting at 06.00 - 18.00 WIB. Analysis of the existing conditions in 2023, the highest degree of saturation is 0.62 with the level of service B; in the 2028 projection conditions, the highest degree of saturation is 0.73 with the level of service B; and in the 2033 projection conditions, the highest degree of saturation is 0.86 with the level of service E. With a poor level of service, the volume of vehicles and the roundabout capacity could be more balanced, so improvements are needed for the Tugu Pancasila Roundabout in Putussibau City. The improvement solution is to re-plan the roundabout following the Roundabout Planning Guidelines for Intersections (2004). For the results of the MKJI 1997 analysis of the roundabout re-planning solution, the 2028 projection obtained the highest degree of saturation of 0.54 with level of service B, and in the 2033 projection obtained the highest degree of saturation of 0.63 with level of service B. for the results of the VISSIM software simulation, the roundabout re-planning solution for the 2028 projection obtained a delay of 13.14 seconds with level of service B, and the 2033 projection obtained a delay of 15.60 seconds with level of service C.

**Keywords:** *Roundabout, Performance Analysis, Putussibau*

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## 1. Introduction

An intersection can be defined as the general area where 2 or more roads join or intersect, including the road and roadside facilities for the movement of traffic therein (Khisty and Lall, 2005; Lo et al., 2023). Roundabout is a type of directional traffic intersection control that circles an island in the

centre of the intersection. Roundabout intersection planning is a very important part of highway planning. At roundabouts, there is a meeting between vehicles from various directions (Osei et al., 2021; Sukmawati, et. al., 2022).

Tugu Pancasila Roundabout is a 5-arm intersection roundabout that regulates traffic in 5 directions of movement. Connecting office areas, educational institutions, residential areas, and economic areas, as well as serving traffic flows in and out of the city to the north, makes this roundabout possible for conflict flows because it serves essential flows.

In this research, the Tugu Pancasila Roundabout is modeled using VISSIM software. VISSIM (Verkher In Stadten Simulation Model) software is a multi-modal traffic flow microscopic simulation software that can analyze the operation of private vehicles and public transport with problems such as lane configuration, vehicle composition, traffic signals, and others, making VISSIM a valuable tool for the evaluation of various alternative measures based on transportation engineering measures and planning effectiveness (PTV VISION, 2011).

## 2. Materials and Methods

### 2.1. Study Area/ Research Location

This research was conducted at the Tugu Pancasila Roundabout which connects D. I. Panjaitan Street, W. R. Supratman Street, Gajah Mada Street, Pancasila Street, and Jeranding Abdurahman Street.


**Fig 1.** Research Location

### 2.2. Data

The data used in the research are primary data and secondary data. Primary data is data obtained or collected by researchers directly from the source of the data or in the form of original data (Siyoto and Sodik, et. al., 2015). The following primary data is needed in this study:

- Geometrics Data
- Traffic Volume Data
- Vehicle Speed Data
- Side Obstacle Data
- Data on Existing Buildings around the Roundabout

Secondary data is data obtained or collected from various existing sources, such as books, reports, journals, etc. The following secondary data is needed in this study:

- Research Location Map
- Total Population Data
- Total Vehicle Data

### 2.3. Analysis Method

Data analysis is carried out using the 1997 Indonesian Road Capacity Manual (MKJI) method and using VISSIM Software, then evaluated, then given a planning solution for the improvement of the Tugu Pancasila Roundabout in Putussibau City.

#### 2.3.1 Capacity

According to MKJI 1997, the total capacity of the braided section of the roundabout is the product of the basic capacity (Co), which is the capacity under certain (ideal) conditions and the adjustment factor (F), taking into account the effect of actual field conditions on capacity.

$$C = 135 \times WW1{,}3 \times (1 + WE/WW)1{,}5 \times (1 + PW/3)0{,}5 \times (1 + WW/LW) - 1{,}8 \times FCS \times FRSU \quad (1)$$

#### 2.3.2 Degree of Saturation

According to MKJI 1997, the degree of saturation is the ratio of traffic flow to capacity, which is usually calculated per hour. The traffic behaviour of the braided section is closely related to the degree of saturation.

$$DS = \frac{Q_{SMP}}{C} \quad (2)$$

#### 2.3.3 Delay

According to MKJI 1997, delays in the braided section can occur due to traffic delays (DT) that result from the interaction of traffic with other movements in the intersection, and geometric delays (DG) that result from the deceleration and acceleration of traffic.

$$D = DT + DG \quad (3)$$

$$DG = (1 - DS) \times 4 + DS \quad (4)$$

$$DT_R = \sum \frac{(Q_i \times DT_i)}{Q_{in}}; i = 1 \ldots n \quad (5)$$

$$DR = DT_R + 4 \quad (6)$$

#### 2.3.4 Queuing Opportunities

The chance of queuing with more than 2 vehicles on any approach, at an unsignalised intersection. This queuing probability is calculated from the empirical relationship between queuing probability and the degree of saturation.

$$QPR\% = maks\,(QPi\%); i = 1 \ldots n \quad (7)$$

#### 2.3.5 Level of Service

Level of service are categorised from A to F with level of service A representing the best service operating conditions and level of service F representing the worst service operating conditions.

**Table 1.** Level of Service based on Degree of Saturation

| Level of Service | Degree of Saturation |
|---|---|
| A | 0,00 – 0,20 |
| B | 0,21 – 0,44 |
| C | 0,45 – 0,74 |
| D | 0,75 – 0,84 |
| E | 0,85 – 1,00 |
| F | > 1,00 |

**Table 2.** Level of Service based on Delay

| Level of Service | Delay (sec/smp) |
|---|---|
| A | 0 – 5 |
| B | 5 – 15 |
| C | 15 – 25 |
| D | 25 – 40 |
| E | 40 – 60 |
| F | > 60 |

## 3. Result and Discussion

### 3.1 Performance Analysis of Roundabout in Existing Conditions in 2023

Traffic performance analysis of roundabouts in existing conditions is carried out based on primary data processing of road geometric survey results, traffic volume, vehicle speed, and side obstacles on the braid section and road sections studied. Analysis of geometric parameter calculations, capacity calculations, and traffic behaviour of the braid section aims to determine the capacity value, degree of saturation, delay and queuing opportunities of the roundabout.
The geometric parameters of the roundabout braided section can be seen in Figure 2.

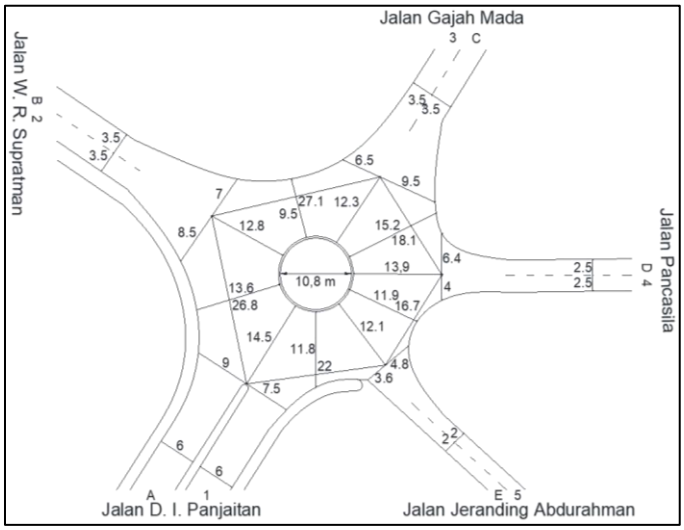


**Fig 2.** Braid Section Geometric Parameter of Roundabout in Existing Condition

The results of the braid section geometric parameters calculation of the existing condition can be seen in Table 3.

**Table 3.** Braid Section Geometric Parameter Calculation Results of The Existing Condition

| No | Braid Section | Entry Width | | Average Entry Width | Braid Width | WE/WW | Braid Length | WW/LW |
|---|---|---|---|---|---|---|---|---|
| | | Approach 1 (m) | Approach 2 (m) | WE (m) | WW (m) | | LW (m) | |
| 1 | AB | 9 | 14,5 | 11,75 | 13,6 | 0,864 | 26,8 | 0,507 |
| 2 | BC | 7 | 12,8 | 9,9 | 9,5 | 1,042 | 27,1 | 0,351 |
| 3 | CD | 9,5 | 12,3 | 10,9 | 15,2 | 0,717 | 18,1 | 0,840 |
| 4 | DE | 4 | 13,9 | 8,95 | 11,9 | 0,752 | 16,7 | 0,713 |
| 5 | EA | 3,6 | 12,1 | 7,85 | 11,8 | 0,665 | 22 | 0,536 |

The results of the braid section capacity calculation of the existing condition can be seen in Table 4.

**Table 4.** Braid Section Capacity Calculation Results of The Existing Condition

| No | Braid Section | WW Factor | WE/WW Factor | PW Factor | WW/LW Factor | Base Capacity C0 | Adjustment Factor | | Capacity C smp/hour |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | City Size | Street Environment (FRSU) | |
| 1 | AB | 4017,301 | 2,545 | 0,523 | 0,478 | 2555,606 | 0,88 | 0,95 | 2136,486 |
| 2 | BC | 2519,849 | 2,918 | 0,526 | 0,582 | 2253,120 | 0,88 | 0,95 | 1883,608 |
| 3 | CD | 4642,270 | 2,250 | 0,558 | 0,334 | 1943,988 | 0,88 | 0,95 | 1625,174 |
| 4 | DE | 3377,107 | 2,319 | 0,682 | 0,380 | 2028,663 | 0,88 | 0,95 | 1695,962 |
| 5 | EA | 3340,261 | 2,149 | 0,449 | 0,462 | 1488,790 | 0,88 | 0,95 | 1244,628 |

The results of the braid section traffic behaviour calculation for the existing condition can be seen in Table 5.

**Table 5.** Braid Section Traffic Behaviour Calculation Results of The Existing Condition

| No | Braid Section | Flow of Braid Section Q smp/hour | Degree of Saturation DS | Traffic Delay DT sec/smp | Total Traffic Delay DTOT = Q x DT | Queue Opportuniy QP% |
|---|---|---|---|---|---|---|
| 1 | AB | 727 | 0,34 | 1,6 | 1160,498 | 3 - 7 |
| 2 | BC | 781 | 0,41 | 1,9 | 1517,518 | 5 - 9 |
| 3 | CD | 740 | 0,46 | 2,1 | 1578,520 | 5 - 11 |
| 4 | DE | 714 | 0,42 | 2,0 | 1410,127 | 5 - 9 |
| 5 | EA | 766 | 0,62 | 3,0 | 2258,382 | 10 - 21 |
| 6 | Degree of Saturation (DS) | | | | | 0,62 |
| 7 | Average Traffic Delay (DTR) sec/smp | | | | | 5,8 |
| 8 | Average Roundabout Delay DR (DTR+4) sec/smp | | | | | 9,78 |
| 9 | Roundabout Queue Opportunity QPR% | | | | | 10 - 21 |

The results of the VISSIM software simulation of existing conditions can be seen in Table 6.

**Table 6.** VISSIM Simulation Results of The Existing Condition

| Code | From | Towards | Queue Length (m) | Maximum Queue Length (m) | Delay (sec) | Level of Service |
|---|---|---|---|---|---|---|
| A1 | D. I. Panjaitan | D. I. Panjaitan | 4,02 | 26,66 | 13,10 | B |
| A2 | D. I. Panjaitan | W. R. Supratman | 4,02 | 26,66 | 8,21 | A |
| A3 | D. I. Panjaitan | Gajah Mada | 4,02 | 26,66 | 13,42 | B |
| A4 | D. I. Panjaitan | Pancasila | 4,02 | 26,66 | 7,07 | A |
| A5 | D. I. Panjaitan | Jeranding Abdurahman | 4,02 | 26,66 | 7,51 | A |
| B1 | W. R. Supratman | D. I. Panjaitan | 2,67 | 17,82 | 15,40 | C |
| B2 | W. R. Supratman | W. R. Supratman | 2,67 | 17,82 | 0,00 | A |
| B3 | W. R. Supratman | Gajah Mada | 2,67 | 17,82 | 9,97 | A |
| B4 | W. R. Supratman | Pancasila | 2,67 | 17,82 | 17,84 | C |
| B5 | W. R. Supratman | Jeranding Abdurahman | 2,67 | 17,82 | 17,41 | C |
| C1 | Gajah Mada | D. I. Panjaitan | 33,54 | 114,94 | 40,91 | E |
| C2 | Gajah Mada | W. R. Supratman | 33,54 | 114,94 | 13,63 | B |
| C3 | Gajah Mada | Gajah Mada | 33,54 | 114,94 | 0,00 | A |
| C4 | Gajah Mada | Pancasila | 33,54 | 114,94 | 7,75 | A |
| C5 | Gajah Mada | Jeranding Abdurahman | 33,54 | 114,94 | 35,18 | E |
| D1 | Pancasila | D. I. Panjaitan | 4,69 | 39,45 | 13,85 | B |
| D2 | Pancasila | W. R. Supratman | 4,69 | 39,45 | 13,19 | B |
| D3 | Pancasila | Gajah Mada | 4,69 | 39,45 | 11,57 | B |
| D4 | Pancasila | Pancasila | 4,69 | 39,45 | 0,00 | A |
| D5 | Pancasila | Jeranding Abdurahman | 4,69 | 39,45 | 14,32 | B |
| E1 | Jeranding Abdurahman | D. I. Panjaitan | 15,93 | 82,44 | 29,82 | D |
| E2 | Jeranding Abdurahman | W. R. Supratman | 15,93 | 82,44 | 31,66 | D |
| E3 | Jeranding Abdurahman | Gajah Mada | 15,93 | 82,44 | 26,32 | D |
| E4 | Jeranding Abdurahman | Pancasila | 15,93 | 82,44 | 39,57 | E |
| E5 | Jeranding Abdurahman | Jeranding Abdurahman | 15,93 | 82,44 | 0,00 | A |
| Roundabout | | | 12,17 | 114,94 | 17,81 | C |

### 3.2 Performance Analysis of Roundabout in Projection Conditions for 2028

Traffic performance analysis of the roundabout under the 2028 projection conditions, to determine the performance of the roundabout in 2028. This analysis uses the compound interest formula to project the peak hour volumes that have been analysed.

The results of the braid section traffic behaviour calculation of the 2028 projection conditions can be seen in Table 7.

**Table 7.** Braid Section Traffic Behaviour Calculation Results of The 2028 Projection Condition

| No | Braid Section | Flow of Braid Section Q smp/hour | Degree of Saturation DS | Traffic Delay DT sec/smp | Total Traffic Delay DTOT = Q x DT | Queue Opportuniy QP% |
|---|---|---|---|---|---|---|
| 1 | AB | 860 | 0,40 | 1,9 | 1624,220 | 4 - 9 |
| 2 | BC | 924 | 0,49 | 2,3 | 2124,802 | 6 - 13 |
| 3 | CD | 875 | 0,54 | 2,5 | 2209,744 | 7 - 15 |
| 4 | DE | 845 | 0,50 | 2,3 | 1975,968 | 6 - 13 |
| 5 | EA | 906 | 0,73 | 4,2 | 3830,209 | 15 - 32 |
| 6 | Degree of Saturation (DS) | | | | | 0,73 |
| 7 | Average Traffic Delay (DTR) sec/smp | | | | | 7,2 |
| 8 | Average Roundabout Delay DR (DTR+4) sec/smp | | | | | 11,25 |
| 9 | Roundabout Queue Opportunity QPR% | | | | | 15 - 32 |

The results of the VISSIM software simulation of the 2028 projection conditions can be seen in Table 8.

**Table 8.** VISSIM Simulation Results of The 2028 Projection Condition

| Code | From | Towards | Queue Length (m) | Maximum Queue Length (m) | Delay (sec) | Level of Service |
|---|---|---|---|---|---|---|
| A1 | D. I. Panjaitan | D. I. Panjaitan | 10,61 | 63,68 | 27,25 | D |
| A2 | D. I. Panjaitan | W. R. Supratman | 10,61 | 63,68 | 18,23 | C |
| A3 | D. I. Panjaitan | Gajah Mada | 10,61 | 63,68 | 24,34 | C |
| A4 | D. I. Panjaitan | Pancasila | 10,61 | 63,68 | 21,77 | C |
| A5 | D. I. Panjaitan | Jeranding Abdurahman | 10,61 | 63,68 | 23,00 | C |
| B1 | W. R. Supratman | D. I. Panjaitan | 2,02 | 17,65 | 18,43 | C |
| B2 | W. R. Supratman | W. R. Supratman | 2,02 | 17,65 | 0,00 | A |
| B3 | W. R. Supratman | Gajah Mada | 2,02 | 17,65 | 11,48 | B |
| B4 | W. R. Supratman | Pancasila | 2,02 | 17,65 | 16,03 | C |
| B5 | W. R. Supratman | Jeranding Abdurahman | 2,02 | 17,65 | 20,23 | C |
| C1 | Gajah Mada | D. I. Panjaitan | 13,68 | 61,22 | 31,23 | D |
| C2 | Gajah Mada | W. R. Supratman | 13,68 | 61,22 | 35,83 | E |
| C3 | Gajah Mada | Gajah Mada | 13,68 | 61,22 | 0,00 | A |
| C4 | Gajah Mada | Pancasila | 13,68 | 61,22 | 14,19 | B |
| C5 | Gajah Mada | Jeranding Abdurahman | 13,68 | 61,22 | 40,51 | E |
| D1 | Pancasila | D. I. Panjaitan | 15,28 | 57,85 | 33,19 | D |
| D2 | Pancasila | W. R. Supratman | 15,28 | 57,85 | 46,26 | E |
| D3 | Pancasila | Gajah Mada | 15,28 | 57,85 | 26,49 | D |
| D4 | Pancasila | Pancasila | 15,28 | 57,85 | 0,00 | A |
| D5 | Pancasila | Jeranding Abdurahman | 15,28 | 57,85 | 25,07 | D |
| E1 | Jeranding Abdurahman | D. I. Panjaitan | 50,70 | 182,76 | 49,07 | E |
| E2 | Jeranding Abdurahman | W. R. Supratman | 50,70 | 182,76 | 55,52 | F |
| E3 | Jeranding Abdurahman | Gajah Mada | 50,70 | 182,76 | 50,24 | F |
| E4 | Jeranding Abdurahman | Pancasila | 50,70 | 182,76 | 79,40 | F |
| E5 | Jeranding Abdurahman | Jeranding Abdurahman | 50,70 | 182,76 | 0,00 | A |
| Roundabout | | | 18,46 | 182,76 | 28,21 | D |

### 3.3 Performance Analysis of Roundabout in Projection Conditions for 2033

Traffic performance analysis of the roundabout under the 2033 projection conditions, to determine the performance of the roundabout in 2033. This analysis uses the compound interest formula to project the peak hour volumes that have been analysed.

The results of the braid section traffic behaviour calculation of the 2033 projection conditions can be seen in Table 9.

**Table 9.** Braid Section Traffic Behaviour Calculation Results of The 2033 Projection Condition

| No | Braid Section | Flow of Braid Section Q smp/hour | Degree of Saturation DS | Traffic Delay DT sec/smp | Total Traffic Delay DTOT = Q x DT | Queue Opportuniy QP% |
|---|---|---|---|---|---|---|
| 1 | AB | 1018 | 0,48 | 2,2 | 2276,514 | 6 - 12 |
| 2 | BC | 1094 | 0,58 | 2,7 | 2979,258 | 8 - 18 |
| 3 | CD | 1036 | 0,64 | 3,2 | 3279,772 | 10 - 23 |
| 4 | DE | 1001 | 0,59 | 2,8 | 2772,567 | 9 - 19 |
| 5 | EA | 1073 | 0,86 | 6,9 | 7415,125 | 24 - 51 |
| 6 | Degree of Saturation (DS) | | | | | 0,86 |
| 7 | Average Traffic Delay (DTR) sec/smp | | | | | 9,7 |
| 8 | Average Roundabout Delay DR (DTR+4) sec/smp | | | | | 13,75 |
| 9 | Roundabout Queue Opportunity QPR% | | | | | 24 - 51 |

The results of the VISSIM software simulation of the 2033 projection conditions can be seen in Table 10.

**Table 10.** VISSIM Simulation Results of The 2033 Projection Condition

| Code | From | Towards | Queue Length (m) | Maximum Queue Length (m) | Delay (sec) | Level of Service |
|---|---|---|---|---|---|---|
| A1 | D. I. Panjaitan | D. I. Panjaitan | 21,17 | 53,56 | 28,14 | D |
| A2 | D. I. Panjaitan | W. R. Supratman | 21,17 | 53,56 | 28,21 | D |
| A3 | D. I. Panjaitan | Gajah Mada | 21,17 | 53,56 | 33,23 | D |
| A4 | D. I. Panjaitan | Pancasila | 21,17 | 53,56 | 32,63 | D |
| A5 | D. I. Panjaitan | Jeranding Abdurahman | 21,17 | 53,56 | 33,81 | D |
| B1 | W. R. Supratman | D. I. Panjaitan | 27,45 | 131,37 | 50,76 | F |
| B2 | W. R. Supratman | W. R. Supratman | 27,45 | 131,37 | 67,07 | F |
| B3 | W. R. Supratman | Gajah Mada | 27,45 | 131,37 | 60,23 | F |
| B4 | W. R. Supratman | Pancasila | 27,45 | 131,37 | 56,68 | F |
| B5 | W. R. Supratman | Jeranding Abdurahman | 27,45 | 131,37 | 45,50 | E |
| C1 | Gajah Mada | D. I. Panjaitan | 70,60 | 218,04 | 50,24 | F |
| C2 | Gajah Mada | W. R. Supratman | 70,60 | 218,04 | 144,49 | F |
| C3 | Gajah Mada | Gajah Mada | 70,60 | 218,04 | 0,00 | A |
| C4 | Gajah Mada | Pancasila | 70,60 | 218,04 | 2,50 | A |
| C5 | Gajah Mada | Jeranding Abdurahman | 70,60 | 218,04 | 39,45 | E |
| D1 | Pancasila | D. I. Panjaitan | 26,50 | 106,65 | 44,04 | E |
| D2 | Pancasila | W. R. Supratman | 26,50 | 106,65 | 47,64 | E |
| D3 | Pancasila | Gajah Mada | 26,50 | 106,65 | 32,87 | D |
| D4 | Pancasila | Pancasila | 26,50 | 106,65 | 0,00 | A |
| D5 | Pancasila | Jeranding Abdurahman | 26,50 | 106,65 | 56,10 | F |
| E1 | Jeranding Abdurahman | D. I. Panjaitan | 95,69 | 239,30 | 132,92 | F |
| E2 | Jeranding Abdurahman | W. R. Supratman | 95,69 | 239,30 | 122,45 | F |
| E3 | Jeranding Abdurahman | Gajah Mada | 95,69 | 239,30 | 123,30 | F |
| E4 | Jeranding Abdurahman | Pancasila | 95,69 | 239,30 | 144,54 | F |
| E5 | Jeranding Abdurahman | Jeranding Abdurahman | 95,69 | 239,30 | 0,00 | A |
| | Roundabout | | 48,28 | 239,30 | 48,31 | E |

### 3.4 Classification of Performance Analysis Results of Existing Conditions, Projection Conditions in 2028 and 2033

The class classification of the highest degree of saturation and average delay of existing conditions in 2023, and projection conditions in 2028 and 2033, based on MKJI 1997 calculations can be seen in Table 11.

**Table 11.** Class Classification of Degree of Saturation and Average Delay of Existing Conditions, Projection Condition for 2028, and 2033

| No | Classification | Result | Level of Service |
|---|---|---|---|
| | $DS_R$ Existing Result (2023) | 0,62 | C |
| 1 | $DS_R$ Projection Result (2028) | 0,73 | C |
| | $DS_R$ Projection Result (2033) | 0,86 | E |
| | $DT_R$ (sec) Existing Result (2023) | 9,78 | B |
| 2 | $DT_R$ (sec) Projection Result (2028) | 11,25 | B |
| | $DT_R$ (sec) Projection Result (2033) | 13,75 | B |

After simulation in VISSIM software. Class classification on the value of delay based on simulation results for existing conditions in 2023, and projection conditions in 2028 and 2033, can be seen in Table 12.

**Table 12.** Class Classification of Delays Based on VISSIM Software Simulations of Existing Conditions, Projection Condition for 2028, and 2033

| No | Classification | Result | Level of Service |
|---|---|---|---|
| 1 | Delay Existing Result (2023) | 17,81 | C |
| 2 | Delay Projection Result (2028) | 28,21 | D |
| 3 | Delay Projection Result (2033) | 48,31 | E |

### 3.5 Improvement Solutions for Tugu Pancasila Roundabout Putussibau City

The performance of the Tugu Pancasila Roundabout in Putussibau City results in the existing condition in 2023 in the highest degree of saturation value of 0.62 with level of service C, for the projection condition in 2028 resulted in the highest degree of saturation value of 0.73 with level of service C, and for the projection condition in 2033 resulted in the highest degree of saturation value of 0.86 with level of service E. The performance of the Tugu Pancasila Roundabout in Putussibau City for the 2033 projection with a degree of saturation value of DS 0.85 - 1.00 resulted in a decrease in the level of performance at the roundabout such as the occurrence of high traffic density causing congestion. Based on the analysis results, it is necessary to have an improvement solution in the future for the Tugu Pancasila Roundabout in Putussibau City, to reduce density and traffic violations so that traffic movements reach a good level of service where the final result gets a DS value <0.75. The improvement solution to be carried out is to re-plan the roundabout following the Roundabout Planning Guidelines for Level Crossing (2004).

### 3.6 Tugu Pancasila Roundabout Re-planning Solutions

The solution attempted at the Tugu Pancasila roundabout in Putussibau City, Kapuas Hulu District is to re-plan the roundabout following the Roundabout Planning Guidelines for Level Crossings (2004). The re-planning of the roundabout can be seen in Figure 3.

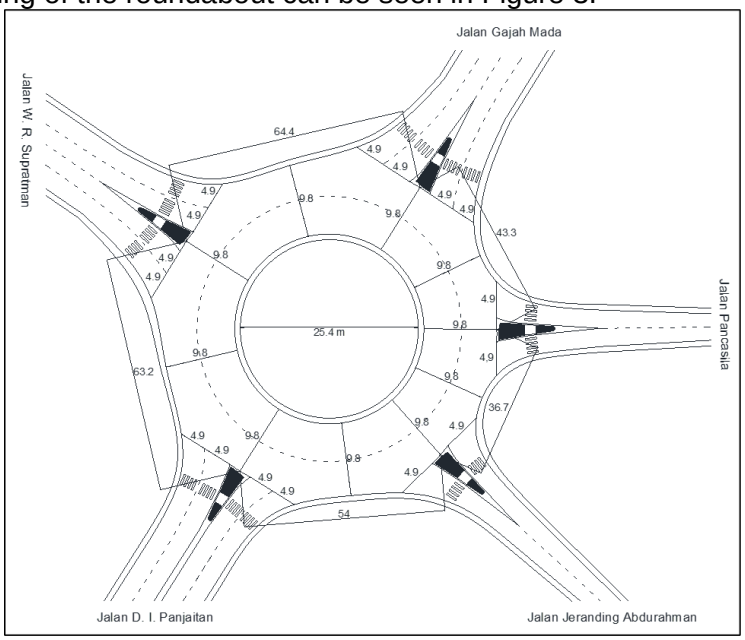


**Fig 3.** Roundabout Re-planning

The results of the braid section geometric parameters calculation of the roundabout re-planning solution for 2028 projection conditions can be seen in Table 13.

**Table 13.** Braid Section Geometric Parameter Calculation Results of The Re-planning Solution for 2028 Projection Condition

| No | Braid Section | Entry Width | | Average Entry Width | Braid Width | WE/WW | Braid Length | WW/LW |
|---|---|---|---|---|---|---|---|---|
| | | Approach 1 (m) | Approach 2 (m) | WE (m) | WW (m) | | LW (m) | |
| 1 | AB | 9,8 | 9,8 | 9,8 | 9,8 | 1,000 | 63,2 | 0,155 |
| 2 | BC | 9,8 | 9,8 | 9,8 | 9,8 | 1,000 | 64,4 | 0,152 |
| 3 | CD | 9,8 | 9,8 | 9,8 | 9,8 | 1,000 | 43,3 | 0,226 |
| 4 | DE | 4,9 | 9,8 | 7,35 | 9,8 | 0,750 | 36,7 | 0,267 |
| 5 | EA | 4,9 | 9,8 | 7,35 | 9,8 | 0,750 | 54 | 0,181 |

The results of the braid section capacity calculation of the re-planning solution for 2028 projection conditions can be seen in Table 14.

**Table 14.** Braid Section Capacity Calculation Results of The Re-planning Solution for 2028 Projection Condition

| No | Braid Section | WW Factor | WE/WW Factor | PW Factor | WW/LW Factor | Base Capacity C0 | Adjustment Factor | | Capacity C smp/hour |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | City Size | Street Environment (FRSU) | |
| 1 | AB | 2623,782 | 2,828 | 0,523 | 0,771 | 2995,965 | 0,88 | 0,95 | 2504,627 |
| 2 | BC | 2623,782 | 2,828 | 0,526 | 0,775 | 3026,440 | 0,88 | 0,95 | 2530,104 |
| 3 | CD | 2623,782 | 2,828 | 0,558 | 0,693 | 2867,780 | 0,88 | 0,95 | 2397,464 |
| 4 | DE | 2623,782 | 2,315 | 0,682 | 0,653 | 2707,438 | 0,88 | 0,95 | 2263,418 |
| 5 | EA | 2623,782 | 2,315 | 0,449 | 0,741 | 2021,264 | 0,88 | 0,95 | 1689,777 |

The results of the braid section traffic behaviour calculation of the re-planning solution for 2028 projection conditions can be seen in Table 15.

**Table 15.** Braid Section Traffic Behaviour Calculation Result of The Re-Planning Solution For 2028 Projection Condition

| No | Braid Section | Flow of Braid Section Q smp/hour | Degree of Saturation DS | Traffic Delay DT sec/smp | Total Traffic Delay DTOT = Q x DT | Queue Opportuniy QP% |
|---|---|---|---|---|---|---|
| 1 | AB | 860 | 0,34 | 1,6 | 1385,486 | 3 - 7 |
| 2 | BC | 924 | 0,37 | 1,7 | 1581,870 | 4 - 8 |
| 3 | CD | 875 | 0,36 | 1,7 | 1497,924 | 4 - 8 |
| 4 | DE | 845 | 0,37 | 1,8 | 1480,578 | 4 - 8 |
| 5 | EA | 906 | 0,54 | 2,5 | 2277,786 | 7 - 15 |
| 6 | Degree of Saturation (DS) | | | | | 0,54 |
| 7 | Average Traffic Delay (DTR) sec/smp | | | | | 5,1 |
| 8 | Average Roundabout Delay DR (DTR+4) sec/smp | | | | | 9,07 |
| 9 | Roundabout Queue Opportunity QPR% | | | | | 7 - 15 |

The results of the VISSIM software simulation of the roundabout re-planning solution for 2028 projection conditions can be seen in Table 16.

**Table 16.** VISSIM Simulation Results of The Roundabout Re-planning for 2028 Projection Condition

| Code | From | Towards | Queue Length (m) | Maximum Queue Length (m) | Delay (sec) | Level of Service |
|---|---|---|---|---|---|---|
| A1 | D. I. Panjaitan | D. I. Panjaitan | 3,53 | 25,87 | 7,96 | A |
| A2 | D. I. Panjaitan | W. R. Supratman | 3,53 | 25,87 | 8,78 | A |
| A3 | D. I. Panjaitan | Gajah Mada | 3,53 | 25,87 | 7,15 | A |
| A4 | D. I. Panjaitan | Pancasila | 3,53 | 25,87 | 7,90 | A |
| A5 | D. I. Panjaitan | Jeranding Abdurahman | 3,53 | 25,87 | 5,86 | A |
| B1 | W. R. Supratman | D. I. Panjaitan | 2,07 | 16,42 | 14,58 | B |
| B2 | W. R. Supratman | W. R. Supratman | 2,07 | 16,42 | 0,00 | A |
| B3 | W. R. Supratman | Gajah Mada | 2,07 | 16,42 | 16,27 | C |
| B4 | W. R. Supratman | Pancasila | 2,07 | 16,42 | 11,27 | B |
| B5 | W. R. Supratman | Jeranding Abdurahman | 2,07 | 16,42 | 14,48 | B |
| C1 | Gajah Mada | D. I. Panjaitan | 2,78 | 12,45 | 13,77 | B |
| C2 | Gajah Mada | W. R. Supratman | 2,78 | 12,45 | 12,23 | B |
| C3 | Gajah Mada | Gajah Mada | 2,78 | 12,45 | 0,00 | A |
| C4 | Gajah Mada | Pancasila | 2,78 | 12,45 | 9,12 | A |
| C5 | Gajah Mada | Jeranding Abdurahman | 2,78 | 12,45 | 14,74 | B |
| D1 | Pancasila | D. I. Panjaitan | 4,04 | 27,62 | 16,54 | C |
| D2 | Pancasila | W. R. Supratman | 4,04 | 27,62 | 20,05 | C |
| D3 | Pancasila | Gajah Mada | 4,04 | 27,62 | 13,51 | B |
| D4 | Pancasila | Pancasila | 4,04 | 27,62 | 0,00 | A |
| D5 | Pancasila | Jeranding Abdurahman | 4,04 | 27,62 | 10,60 | B |
| E1 | Jeranding Abdurahman | D. I. Panjaitan | 3,71 | 23,36 | 26,23 | D |
| E2 | Jeranding Abdurahman | W. R. Supratman | 3,71 | 23,36 | 16,38 | C |
| E3 | Jeranding Abdurahman | Gajah Mada | 3,71 | 23,36 | 27,45 | D |
| E4 | Jeranding Abdurahman | Pancasila | 3,71 | 23,36 | 17,45 | C |
| E5 | Jeranding Abdurahman | Jeranding Abdurahman | 3,71 | 23,36 | 0,00 | A |
| Roundabout | | | 3,22 | 27,62 | 13,14 | B |

The results of the braid section traffic behaviour calculation of the re-planning solution for 2033 projection conditions can be seen in Table 17.

**Table 17.** Braid Section Traffic Behaviour Calculation Result Of The Re-Planning Solution For 2033 Projection Condition

| No | Braid Section | Flow of Braid Section Q smp/hour | Degree of Saturation DS | Traffic Delay DT sec/smp | Total Traffic Delay DTOT = Q x DT | Queue Opportuniy QP% |
|---|---|---|---|---|---|---|
| 1 | AB | 1018 | 0,41 | 1,9 | 1941,902 | 4 - 9 |
| 2 | BC | 1094 | 0,43 | 2,0 | 2217,994 | 5 - 10 |
| 3 | CD | 1036 | 0,43 | 2,0 | 2099,647 | 5 - 10 |
| 4 | DE | 1001 | 0,44 | 2,1 | 2077,464 | 5 - 10 |
| 5 | EA | 1073 | 0,63 | 3,1 | 3368,504 | 10 - 22 |
| 6 | Degree of Saturation (DS) | | | | | 0,63 |
| 7 | Average Traffic Delay (DTR) sec/smp | | | | | 6,1 |
| 8 | Average Roundabout Delay DR (DTR+4) sec/smp | | | | | 10,09 |
| 9 | Roundabout Queue Opportunity QPR% | | | | | 10 - 22 |

The results of the VISSIM software simulation of the roundabout re-planning solution for 2033 projection conditions can be seen in Table 18.

**Table 18.** VISSIM Simulation Results of The Roundabout Re-planning for 2033 Projection Condition

| Code | From | Towards | Queue Length (m) | Maximum Queue Length (m) | Delay (sec) | Level of Service |
|---|---|---|---|---|---|---|
| A1 | D. I. Panjaitan | D. I. Panjaitan | 9,34 | 49,41 | 9,50 | B |
| A2 | D. I. Panjaitan | W. R. Supratman | 9,34 | 49,41 | 8,30 | B |
| A3 | D. I. Panjaitan | Gajah Mada | 9,34 | 49,41 | 9,31 | B |
| A4 | D. I. Panjaitan | Pancasila | 9,34 | 49,41 | 8,03 | B |
| A5 | D. I. Panjaitan | Jeranding Abdurahman | 9,34 | 49,41 | 8,28 | A |
| B1 | W. R. Supratman | D. I. Panjaitan | 4,53 | 16,23 | 15,94 | C |
| B2 | W. R. Supratman | W. R. Supratman | 4,53 | 16,23 | 19,28 | F |
| B3 | W. R. Supratman | Gajah Mada | 4,53 | 16,23 | 6,84 | B |
| B4 | W. R. Supratman | Pancasila | 4,53 | 16,23 | 9,75 | C |
| B5 | W. R. Supratman | Jeranding Abdurahman | 4,53 | 16,23 | 12,28 | B |
| C1 | Gajah Mada | D. I. Panjaitan | 2,81 | 15,38 | 14,21 | C |
| C2 | Gajah Mada | W. R. Supratman | 2,81 | 15,38 | 18,04 | E |
| C3 | Gajah Mada | Gajah Mada | 2,81 | 15,38 | 0,00 | A |
| C4 | Gajah Mada | Pancasila | 2,81 | 15,38 | 12,29 | A |
| C5 | Gajah Mada | Jeranding Abdurahman | 2,81 | 15,38 | 10,30 | B |
| D1 | Pancasila | D. I. Panjaitan | 5,19 | 19,94 | 15,28 | F |
| D2 | Pancasila | W. R. Supratman | 5,19 | 19,94 | 20,14 | D |
| D3 | Pancasila | Gajah Mada | 5,19 | 19,94 | 38,70 | D |
| D4 | Pancasila | Pancasila | 5,19 | 19,94 | 0,00 | A |
| D5 | Pancasila | Jeranding Abdurahman | 5,19 | 19,94 | 13,93 | C |
| E1 | Jeranding Abdurahman | D. I. Panjaitan | 10,61 | 33,54 | 33,98 | D |
| E2 | Jeranding Abdurahman | W. R. Supratman | 10,61 | 33,54 | 54,27 | D |
| E3 | Jeranding Abdurahman | Gajah Mada | 10,61 | 33,54 | 30,26 | D |
| E4 | Jeranding Abdurahman | Pancasila | 10,61 | 33,54 | 33,92 | D |
| E5 | Jeranding Abdurahman | Jeranding Abdurahman | 10,61 | 33,54 | 0,00 | A |
| Roundabout | | | 6,49 | 49,41 | 15,60 | C |

### 3.7 Classification of Performance Analysis Results of Existing Conditions, Projection Conditions in 2028 and 2033

After the analysis for the roundabout re-planning, the following class classification on the highest degree of saturation value and average delay for existing conditions, projection conditions in 2028 and 2033, based on MKJI 1997 calculations can be seen in Table 19.

**Table 19.** Class Classification of Degree of Saturation and Average Delay of Roundabout Re-planning Solution for 2028 and 2033 Projection Condition

| No | Classification | Result | Level of Service |
|---|---|---|---|
| 1 | $DS_R$ Projection Result (2028) | 0,54 | C |
| | $DS_R$ Projection Result (2033) | 0,63 | C |
| 2 | $DT_R$ (sec) Projection Result (2028) | 9,07 | B |
| | $DT_R$ (sec) Projection Result (2033) | 10,09 | B |

After simulation for Roundabout Re-planning Solution in VISSIM software. Class classification on the value of delay based on simulation results for 2028 and 2033 projection conditions, can be seen in Table 20.

**Table 20.** Class Classification of Delays Based on VISSIM Software Simulations of Roundabout Re-planning Solution for 2028 and 2033 Projection Condition

| No | Classification | Result | Level of Service |
|---|---|---|---|
| 1 | Delay Projection result (2028) | 13,14 | B |
| 2 | Delay Projection result (2033) | 15,60 | C |

### 3.8 Comparison of MKJI 1997 and VISSIM Software Results

#### 3.8.1 Comparison of MKJI 1997 Queue Opportunity Results and VISSIM Software Queue Lengths

The results of queuing opportunities in the braided section using MKJI 1997 are obtained in units of per cent, while the results of queue length using VISSIM software are obtained in units of metres, which can be seen in Table 21.

**Table 21.** Comparison of MKJI 1997 Queue Opportunity and VISSIM Software Queue Length Results

| Condition | Braid Section | MKJI 1997 Queue Opportunity QP% | Software VISSIM Queue Length (m) |
|---|---|---|---|
| Existing 2023 | AB | 3 - 7 | 4,02 |
| | BC | 5 - 9 | 2,67 |
| | CD | 5 - 11 | 33,54 |
| | DE | 5 - 9 | 4,69 |
| | EA | 10 - 21 | 15,93 |
| Projection 2028 | AB | 4 - 9 | 10,61 |
| | BC | 6 - 13 | 2,02 |
| | CD | 7 - 15 | 13,68 |
| | DE | 6 - 13 | 57,85 |
| | EA | 15 - 32 | 50,7 |
| Projection 2033 | AB | 6 - 12 | 21,17 |
| | BC | 8 - 18 | 27,45 |
| | CD | 10 - 23 | 70,6 |
| | DE | 9 - 19 | 26,5 |
| | EA | 24 - 51 | 95,69 |
| Roundabout Re-planning Solution Projection 2028 | AB | 3 - 7 | 3,53 |
| | BC | 4 - 8 | 2,07 |
| | CD | 4 - 8 | 2,78 |
| | DE | 4 - 8 | 4,04 |
| | EA | 7 - 15 | 3,71 |
| Roundabout Re-planning Solution Projection 2033 | AB | 4 - 9 | 9,34 |
| | BC | 5 - 10 | 4,53 |
| | CD | 5 - 10 | 2,81 |
| | DE | 5 - 10 | 5,19 |
| | EA | 10 - 22 | 10,61 |

#### 3.8.2 Comparison of MKJI 1997 and VISSIM Software Delay Results

A comparison of delay results using MKJI 1997 and VISSIM software can be seen in Table 22.

**Table 22.** Comparison of Delay Results Using MKJI 1997 And VISSIM Software

| Condition | Delay (sec) | | Level Of Service | |
|---|---|---|---|---|
| | MKJI 1997 | Software VISSIM | MKJI 1997 | Software VISSIM |
| Existing 2023 | 9,78 | 17,81 | B | C |
| Projection 2028 | 11,25 | 28,21 | B | D |
| Projection 2033 | 13,75 | 48,31 | B | E |
| Roundabout Re-planning Solution Projection 2028 | 9,07 | 13,14 | B | B |
| Roundabout Re-planning Solution Projection 2033 | 10,09 | 15,6 | B | C |

## 4. Conclusion

From the research that has been done, it can be concluded that based on the Indonesian Road Capacity Manual (1997), in the existing conditions of 2023, the performance of the roundabout has the highest degree of saturation of 0.62, and in the projection conditions of 2028 and 2033 the highest

degree of saturation is 0.73 and 0.86. Furthermore, by re-planning the roundabout using the results of the 2028 and 2033 projections, the highest degree of saturation is obtained at 0.54 and 0.63. So, there is a decrease in the degree of saturation value in 2028 and 2033. The results of the roundabout performance analysis using VISSIM software show that in 2023, the roundabout performance has a roundabout delay value of 17.81 seconds, while in the projected conditions of 20028 and 2033, it is 28.21 seconds and 48.28 seconds, respectively. By re-planning the roundabout, the delay value significantly decreases, namely in 2028 to 13.14 seconds and in 2033 to 19.71 seconds. Thus, planning a roundabout by following the Roundabout Planning Guidelines for Level Crossings (2004) has a better level of service.

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## 6. Author's Note

The author declares that this article is an original work and does not contain plagiarism of any research, because it has passed the examination to obtain a bachelor of engineering degree at the Faculty of Engineering, Tanjungpura University, on December 22, 2023.

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