Traffic Engineering At The Kim Ii Roundabout

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Abstract.

As the manager of the industrial area, currently PT. KIM has problems related to traffic jams that occur around the KIM roundabout and to reduce the number of traffic accidents at KIM due to collisions between vehicles from opposite directions, it is necessary to carry out traffic engineering in the area. Traffic engineering is related to the implementation of repair work Roundabouts are not only road construction improvements but also include traffic engineering before, during and after construction. Simulation of traffic conditions to provide alternative solutions to traffic problems that occur at the KIM II Roundabout using VISSIM software. From the results of the simulations that have been carried out, it can be seen that almost all road sections have a level of service F, which means they have a VCR value > 1. This is included in the oversaturated category, side obstacles and delays increase, stopping and moving events increase, if the flow increases, the vehicle speed is equal to zero (complete stop). This condition causes delays on one of the sections of 151 vehicle seconds and this condition is not very good because it will lengthen the queue of vehicles crossing the roundabout. In accordance with the simulation that has been carried out, and based on several applicable regulations regarding the traffic system at roundabouts, several alternatives for handling traffic problems in the KIM II Roundabout area are provided.

Keywords: *Traffic Engineering, PT. KIM and Roundabout.*

I. INTRODUCTION

As the manager of the industrial area, currently PT. KIM has problems facing traffic jams that occur around the KIM roundabout with the number of vehicles passing through the roundabout intersection area Jl. P. Sumbawa, Jl. P.Nias -1 Selatan is quite numerous and crowded when entering work hours and leaving work at KIM. And to reduce the number of traffic accidents at KIM due to collisions between vehicles from opposite directions, it is necessary to carry out traffic engineering at the roundabout.To ensure this and the appropriate method for emgineering this roundabout, research is needed in road planning at the KIM II Roundabout. Traffic in the roundabout area is quite congested, especially during morning, afternoon and evening rush hours.

II. OBJECTIVES

The objectives of carrying out traffic engineering at the KIM II Roundabout are as follows:

1. To determine the condition of the level of road service at the KIM II Roundabout so that it can be linked to the traffic management that will be carried out;
2. To carry out traffic impact analysis according to existing conditions;
3. To carry out management planning and traffic engineering for the KIM II Roundabout Road as a form of handling the congestion that occurs.

III. RESEARCH LIMITATIONS

This research only discusses traffic engineering management planning on roads around the KIM II Roundabout.

IV. THEORETICAL BASIS

Transportation is very important in relation to the economic growth of a region. As the population grows increasingly dense and the development of society becomes more advanced, the movement of goods and services will also increase, which must then be balanced with improvements in transportation facilities and infrastructure, including planning good road conditions and traffic management.The aim of traffic engineering is to obtain or provide traffic conditions that are as smooth and safe as possible without large costs for the movement of people, goods and services with existing geometric or network and traffic conditions through a system of management, structuring and regulation. One alternative that can be done in designing a road network system is to carry out a traffic survey which is intended to obtain input materials for predicting the volume and type of motorized vehicles that will pass through a road section during the design life.The role of roads and road networks is to provide access to homes and mobility. Road infrastructure is used to serve transportation traffic involving goods and people/passengers from the place of origin to the destination. Road infrastructure functions as a driving force for the development of other sectors as a supporter or link at the city level. Road network infrastructure is still a basic requirement for distribution services for trade and industrial commodities. In the era of decentralization, the road network is also the glue that binds the interests of the nation and state in all social, cultural, economic, political and security aspects. So the existence of a road network system that reaches all regions of the country is a demand that must be met.

For this reason, integration is needed in planning the development of transportation facilities and infrastructure in the context of the intermodal transportation system.Road infrastructure includes road areas, intersections and terminals as well as road networks. Road characteristics include cross section, capacity, design speed and road class. The condition of road infrastructure greatly influences the smooth flow of transportation, especially goods transportation. Good road conditions will result in faster travel times and cheaper transportation costs compared to damaged roads. Road infrastructure to support increasing development in all fields requires the availability of a road network that can be relied upon in terms of its structural stability and the length of the available sections. The available road infrastructure must be of high quality, capable of supporting traffic in accordance with the planned load and capable of remaining in good condition for the life of the plan.The good condition of road infrastructure is also influenced by the load of vehicles crossing the road. The dimensions, weight of the vehicle and load will cause a compressive force on the vehicle axle. The axial compressive force is then transmitted to the pavement surface and will contribute to road damage. Road classification in accordance with the travel characteristics and vehicle characteristics of road users in terms of vehicle dimensions, road function represented through vehicle travel speed, and vehicle weight. This classification is basically a minimum standard measure for realizing the safety of land transportation using roads, as well as for realizing transportation infrastructure. A certain class of road has a maximum axle weight limit in accordance with applicable laws and regulations summarized in Table 1 below.

Table 1. Road Classification in class, function, axle load and car dimensions

Road Class	Road Function	Axle Load (tons)	Car Dimension (m)		
			width	length	height
Special	Arterial	≥ 10	≥2.5	≥18	≤ 4.2
I	Arterial, Collector	≤ 10	≤ 2.5	≤ 18	≤ 4.2
II	Arterial, Collector,Local, neighborhood	≤ 8	≤ 2.5	≤ 12	≤ 4.2
III	Arterial, Collector,Local, neighborhood	≤ 8	≤ 2.1	≤ 9	≤ 3.5

(Source: Republic of Indonesia Law No. 22 of 2009, Minister of Public Works Regulation No.5/PRT/M/2018)

From Table 1 it can be concluded that there are 4 categories of vehicles with a "permit" to operate on public roads as follows (Iskandar, 2007):

1. "Small vehicles" with a maximum length and width of 9000 x 2100mm, with a Heaviest Axle Load (MST) ≤ 8 tons, are permitted to use roads in all road function categories, namely environmental roads, local roads, collector roads and arterial roads.

2. "Medium vehicles" with a maximum length and width of 18000 x 2500mm, and MST ≤ 8 tons, are permitted to operate only on roads that function as collectors and arteries; Vehicles are prohibited from entering local roads and neighborhood roads.
3. "Large vehicles" with a maximum length and width of 18000 x 2500 mm, and MST ≤10 tonnes, are permitted to operate on arterial roads only; And
4. "Special large vehicles" with a maximum length and width of 18000 x 2500mm, and an MST >10 tons, are permitted to operate strictly on roads that function as arterial and class I (one) only. Both large vehicles and special large vehicles are prohibited from entering neighborhood roads, local roads and collector roads.

A round-about is a type of intersection control that is generally used in urban and out-of-town areas. The traffic that has priority is traffic that is already at the roundabout, so vehicles entering the roundabout must first give opportunity to traffic that is already at the roundabout.A roundabout consists of a directed traffic lane around a central island which can be raised or flat. This type of traffic circle creates a rotational movement of traffic flow, replacing intersecting movements with a series of intersection sections. In general, roundabouts with right-of-way arrangements (priority from left) are used in urban and inland areas for intersections between roads with moderate traffic flow. In high traffic flows and congestion at the intersection exit area, the roundabout is easily blocked, which may cause capacity to be disrupted in all directions.Roundabouts are most effective when used at intersections between roads of the same size and traffic level. Therefore roundabouts are very suitable for intersections between two-lane or four-lane roads. For intersections between larger roads, interlocking areas easily occur and roundabout safety decreases. Although the traffic impact of roundabouts in the form of delays is always better than other types of intersections such as signalized intersections, the installation of signals is still preferable to ensure a certain capacity can be maintained, even in peak hour traffic conditions.

The implementation of traffic roundabouts has several benefits in improving safety and smooth traffic because:

1. Forcing the vehicle to reduce speed, because the vehicle is forced to turn to follow the road that surrounds the roundabout;
2. Eliminate crossing conflicts, and replace them with weaving conflicts which can proceed more smoothly, without having to stop if the current is not so large; And
3. It is easy to increase intersection capacity by widening the intersection legs.

For planning and operational analysis of existing roundabouts, the objective of the analysis is usually to make minor improvements to the intersection geometry in order to maintain the desired traffic behavior, along the route or road network. In high traffic flows and congestion at the intersection exit area, the roundabout is easily blocked, which may cause capacity to be disrupted in all directions.

The following are several alternatives that can be provided to solve problems at roundabouts in accordance with research that has been carried out regarding problems at roundabouts:

1. Regulate traffic with signs;
2. Socialization and supervision by the authorities;
3. Widening road sections to reduce the degree of roundabout saturation due to high traffic volumes;
4. Geometric re-planning of roundabouts; And
5. Physical improvements in the form of building new roads at different levels (not at one level).

The impacts of traffic regulation on roundabouts are:

1. Setting the "give way" sign on approaches, which gives priority to vehicles in the roundabout reduces the accident rate when compared with priority from the left (not regulated). If enforced, this method is also effective in avoiding roundabout blockages;
2. Traffic signal settings should not be applied to roundabouts, because they can reduce safety and capacity;
3. The lane closest to the kerb should be wider than usual to provide space for non-motorized vehicles and make it easier for left-turning vehicles to pass without weaving into the roundabout.

The sequence of calculations for the performance analysis of intersections with roundabouts used is:
1. Input data (number of vehicles, type of vehicle, road geometric conditions);
2. Capacity calculation;
3. Degree of saturation (determinant of road service level);
4. Delay of the roundabout mesh section; And
5. Chances of queuing for the interwoven part of the roundabout.

Level of Service is a quantitative measure that reflects the driver's perception of the quality of driving a vehicle. Analysis of the level of traffic congestion is obtained from the process of calculating road service levels. The greater the value of the volume capacity ratio, the worse the level of road service. On the other hand, if the value of the volume capacity ratio is lower, the level of road service will be better.Traffic behavior in the form of a degree of saturation > 0.75 during peak hours is recommended to be avoided. The degree of saturation is used as one of the main factors in determining the level of performance of an intersection or road segment. Theoretically, the degree of saturation cannot be more than 1, if it is close to or more than one, it means that traffic conditions are approaching saturation.Service level is the ability of roads and / or intersections to accommodate traffic in certain circumstances (the Ministry of Public Works Regulations No. 14 Year of 2006 concerning Management and Engineering of Road Traffic, 2006). The level of road service can be seen in Table 2 below.

Table 2. Level of Road Service

Service Level	Related Operating Characteristic
A	▪ Free flow ▪ Traffic velocity > 100km/h ▪ There must always be clear visibility to overtake ▪ Traffic volume up to 20% of capacity (400 pcu/h, 2 way) ▪ About 75% of the overtaking action can be done with little or no delay
B	▪ The beginning of stable flow ▪ Traffic velocity ≥ 80 km/h ▪ Traffic volume up to 45% of capacity (900 pcu/h, 2 way)
C	▪ Traffic flow is still stable ▪ Traffic velocity ≥ 65 km/h ▪ Traffic volume up to 70% of capacity (1400 pcu/h, 2 way)
D	▪ Approaching instability flow ▪ Traffic velocity decreased up to 60 km/h ▪ Traffic volume up to 85% of capacity (1700 pcu/h, 2 way)
E	▪ Reached capacity condition with volume 2000 pcu/h, 2 way ▪ Traffic velocity is about 50 km/h
F	▪ Restrained flow condition ▪ Traffic velocity < 50 km/h ▪ Volume below 2000 pcu/h

(Source: Minister of Public Works Regulation No. 14 of 2006)

V. VISSIM

VISSIM is an abbreviation of Verkehr in Stadten SIMulations Model is a transportation modeling software used to analyze traffic and movement with boundaries, namely lane geometry, traffic signals, vehicle composition, driver behavior and others (PTV Planung Transport Verkehr GmbH , 2023).VISSIM is used to evaluate various alternatives based on transportation engineering in making more effective and efficient decisions. The VISSIM program was developed based on the car following model method by Wiedimann (PTV Planung Transport Verkehr GmbH, 2023).The basic concept of the Wiedimann model is that the driver of a faster moving vehicle begins to reduce speed when it reaches the individual's perception threshold for the slower moving vehicle. Since he couldn't exactly determine the vehicle's speed, his speed would drop below that vehicle's speed until he began to accelerate slightly again after reaching another perception threshold. Different driver behaviors are considered with speed and distance behavior distribution functions(PTV Planung Transport Verkehr GmbH, 2023).

The Wiedemann traffic flow model is based on the assumption that there are basically four different driving states for a driver(PTV Planing Transport Verkehr GmbH, 2023):
• Free driving
• Approaching
• Following
• Braking

The following are the calibration parameters in Vissim (PTV Planing Transport Verkehr GmbH, 2023):

- Desired Position at free flow, is a change in the driver's freedom to drive the vehicle on the network path;
- Overtaking on the same lane, is a change in driver behavior to overtake vehicles in the same lane;
- Distance Standing, is determining the distance of a vehicle when it is not moving;
- Distance Driving, is determining the distance of each vehicle when driving on the road network;
- Average standstill distance (ax), in this parameter determines the average distance between two consecutive vehicles or following each other;
- Additive part of safety distance (bx_add), is the value of the safe distance used for abnormal conditions when driving such as sudden braking and sudden stopping d;
- Multiplicative part of safety distance (bx_mult), is the value of the additional safe distance used during abnormal conditions while driving with adjustment by the Value of range in Vissim 0.1.

The stages of Vissim operation are as follows (Purba, Herianto, Pinggungan, & Putra, 25 OCTOBER 2019):

- Input Background, enter an image that has been taken first from Google Earth;
- Perform Network Settings;
- Create a road network, create links and connectors according to existing road conditions;
- Determine the type of vehicle, match the type of vehicle surveyed with the vehicle entered into the VISSIM software. Fill in vehicle classes, classify vehicle types into vehicle categories;
- Input overall traffic flow volume;
- Determine the origin and destination routes in Static Vehicle Routing Decisions;
- Data processing, Vissim software is run.

VI. RESULT AND DISCUSSION

The traffic survey method is carried out manually using surveyors to calculate the traffic flow through a section of road. The aim and purpose of manual traffic calculation surveys is to obtain data about the number and type of vehicles passing on a road section. Apart from that, a survey was also carried out on the geometric condition of the roundabout, to obtain data regarding the approach width, diameter of the roundabout, and the condition of the width of small islands or other parts of the road around the survey location. The activities carried out mainly consist of:

- Carrying out a preliminary survey (viewing the location) as a basis for determining surveyor posts;
- Dividing surveyors into 5 planned posts. The following is the distribution of traffic survey posts:
  - Post A: Nias Island Road towards Mabar Toll Gate, Rawe Martubung Road, South Nias Island Road;
  - Post B: Mabar Toll Gate towards Jalan Rawe Martubung and Jalan Pulau Nias Selatan;
  - Post C: Jalan Rawe Martubung towards Jalan Pulau Nias Selatan, which enters through the roundabout, and exits from the roundabout;
  - Post D: Jalan Pulau Nias Selatan towards Jalan Rawe Martubung, Mabar Toll Gate, Jalan Pulau Nias, Jalan Pulau Batam, U Turn, and towards entering the roundabout;
  - Post E: Batam Island Road towards Nias Island Road, Mabar Toll Gate, Rawe Martubung Road and South Nias Island Road.
- Preparing traffic volume survey equipment requirements. The main equipment is enumeration forms, stationery, hand boards, enumeration aids such as counters, or other enumeration applications. Meanwhile, for supporting equipment such as raincoats or lighting;
- Conduct briefings to the surveyor team;

- Carry out a traffic survey for 2 days (Monday and Wednesday) with conditions for 12 hours starting at 06.00 WIB – 18.00 WIB. Enumeration is grouped by time period (15 minutes);
- The vehicle groups that pass through the survey posts are heavy vehicles, light vehicles, motorbikes and non-motorized vehicles;
- After collecting all the data, road service levels will be calculated so that analysis and recommendations for handling road conditions can be provided. The calculation of service levels in this case was carried out using Vissim software.

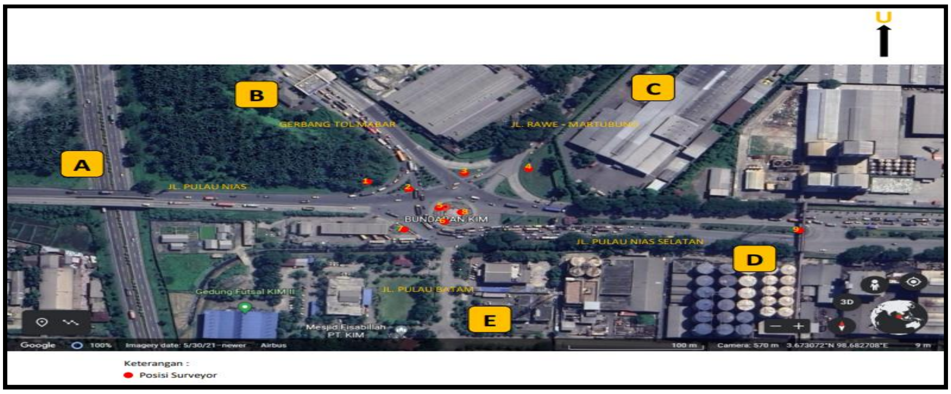

Fig 1. Survey post point

After getting the traffic survey results, data processing was carried out using VISSIM software. From processing this data, it can be concluded that the level of service conditions of the roundabout section. The following is a view of the existing conditions in VISSIM:

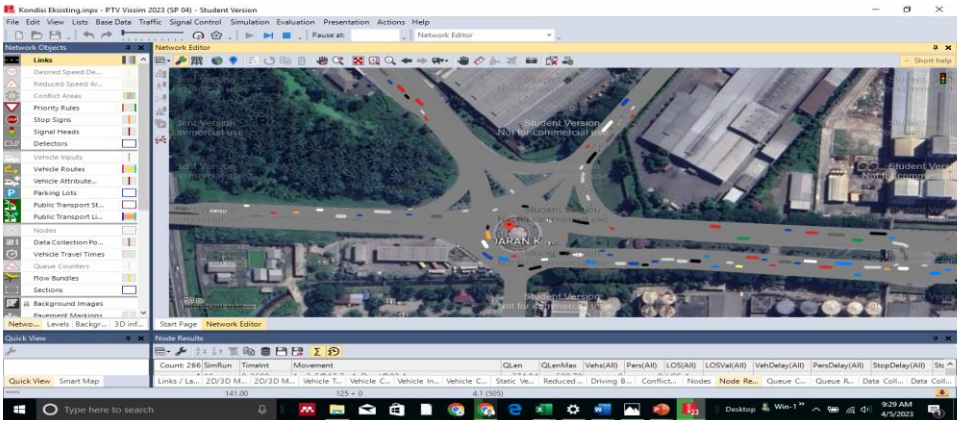

Fig 2. Existing Condition of the KIM II Roundabout

Table 3. Level of Service at KIM II Roundabout Existing Conditions

Direction	Level of Service	Delay (minutes)
E-D	LOS A	0.00
E-A	LOS B	10.73
E-B	LOS F	86.42
E-C	LOS A	0.00
A-D	LOS F	79.83
A-B	LOS F	55.90
A-C	LOS E	41.35
B-D	LOS F	115.04
B-C	LOS A	6.26
C-D	LOS F	91.37
D-E	LOS A	0.00
D-A	LOS E	46.63
D-B	LOS F	130.64
D-C	LOS F	52.21
LOS Boundary	LOS F	67.93

Based on the results of the table above, the following are several conditions that can be applied to existing traffic conditions:

- There are several road sections around the roundabout that have a level of service F, which means they have a VCR value > 1. This is included in the oversaturated category, obstacles and delays increase, stopping and moving events increase, if the flow increases then the vehicle speed is equal to zero (complete stop).
- The road sections are the KIM Office to the Toll Gate, all traffic from the direction of the bridge to each arm surrounding the roundabout, from the Toll Gate to the KIM II Gate, all road sections related to the roundabout arms located at the KIM II Gate.
- With these conditions, it can be said that the existing condition of the roundabout has very saturated traffic which can cause traffic conditions to stop.
- The biggest delay occurred from the KIM II Gate towards the Toll Gate at 131 seconds per vehicle. This will make the queue of vehicles even longer. The maximum vehicle queue length can reach 512 meters when the vehicle is stopped. This will result in paralyzed traffic in the roundabout area if it is not handled properly. The following is a table of vehicle queues in existing conditions:

Table 4. Existing congestion

Intersection Arm	Queue Length (M)	Max. Queue Length (M)
A	152.75	320.80
B	23.18	59.99
C	95.12	130.62
D	205.16	512.30
E	0.00	0.00

Based on these results, it can be said that it is necessary to handle traffic conditions at the roundabout so that the flow crossing the roundabout does not experience problems or delays.

In accordance with the simulation that has been carried out, and based on several applicable regulations regarding the traffic system at roundabouts, the following recommendations can be given as an alternative for handling traffic problems in the KIM II Roundabout area:

1. Reducing the diameter of the roundabout;
2. Reduce the diameter of the roundabout and extend the existing barrier on the exit arm of the KIM II Gate to the bridge;
3. Reducing the diameter of the roundabout, extending existing barriers, and narrowing the road median at the entrance and exit areas of KIM II Gate;
4. Reducing the diameter of the roundabout, lengthening existing barriers, narrowing the road median at the entrance and exit areas of KIM II Gate, and adding traffic signals at the roundabout to block traffic from the KIM II Gate area and the bridge.

These four alternatives have been carried out in the form of traffic simulations in VISSIM using existing traffic data. For these four alternatives, directional separation signs have been provided in both directions on the roundabout arm of KIM II Gate and a change in the position of the KIM II entrance ticket post where the post will be moved backwards and between ticket posts the position will be swapped to avoid traffic making a U-turn. at the KIM II Entrance. What will determine the choice of this alternative is the condition of the road service level and vehicle delays according to the simulation results in VISSIM.The alternative chosen was the second alternative with the roundabout reduced and the barrier extended to the bridge. For the diameter of the roundabout, it will be reduced to the width of the strip with the median also extended to the roundabout. In this alternative condition, the roundabout is reduced to the width of the line to create a new lane so that it can increase vehicle volume capacity at the same time. Apart from that, the position of the post at the KIM II entrance will also be changed to avoid the U-Turn in the KIM II Entrance/Exit lane.

Additionally, there are direction separation signs installed in these lanes. Simultaneously with these conditions, the existing barrier was extended at the KIM II exit to the bridge. This is recommended to separate vehicles heading towards the bridge and the KIM II Office (Jl. Batam). The right side of the road only applies to vehicles heading to the Toll Gate, while the left side of the road is for vehicles heading to the bridge and the KIM office. Conditions like this will be directed through directional separation signs which will be installed at the KIM II Entrance/Exit section. The following are the simulation conditions that have been carried out:

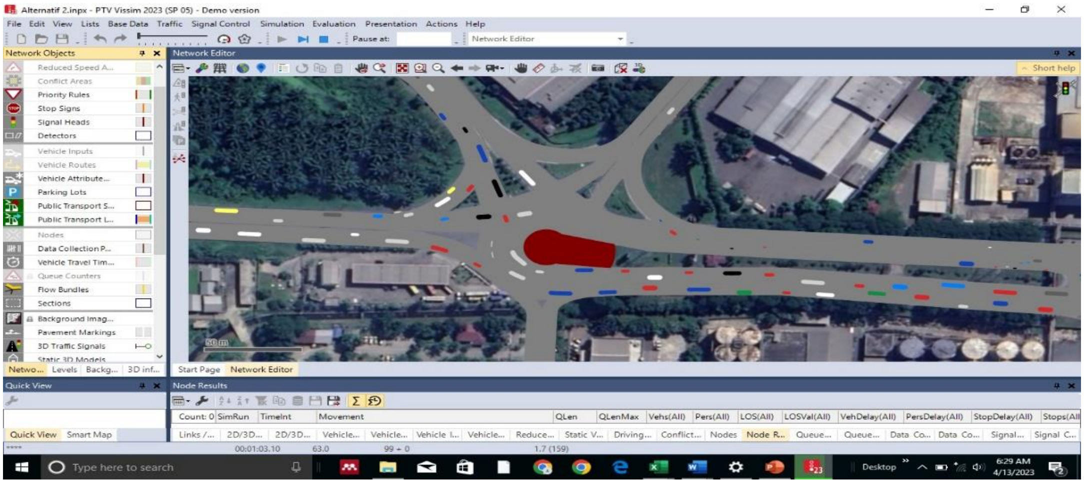

Fig 3. Selected Alternative KIM II Roundabout Simulation

In accordance with the results of the simulation that has been carried out, the following is the level of road service on the selected alternative with the conditions of delays and length of vehicle queues as follows:

Tabel 5. Selected Alternative Queue Length

Intersection Arm	Queue Length (M)	Max. Queue Length (M)
A	0.00	0.00
B	0.00	0.00
C	0.00	0.00
D	82.46	336.73
E	0.00	0.00

Tabel 6. Selected Alternative KIM Roundabout Level of Service

Direction	Level of Service	Delay (minutes)
E-D	LOS A	0.00
E-A	LOS A	0.00
E-B	LOS A	0.00
E-C	LOS A	2.19
A-D	LOS A	4.85
A-B	LOS A	1.17
A-C	LOS C	20.38
B-D	LOS A	1.49
B-C	LOS D	0.00
D-B	LOS F	32.48
D-C	LOS A	0.00
D-E	LOS A	46.63
D-A	LOS A	130.64
C-D	LOS A	52.21
LOS Boundary	LOS C	18.43

Based on the results of the selected alternative, here are several things that need to be considered:

- The average level of service in this condition is C (VCR 0.4 – 0.7). As a result of the increase in traffic flow, obstacles continue to increase, causing delays or congestion but still within acceptable limits for motorists. With a delay of around 19 seconds per vehicle. This condition is reduced from the results of the previous simulation in the second condition.
- The worst level of service is at the KIM II gate towards Martubung (Jl. Rawe), namely F with the largest delay condition, namely 57 seconds per vehicle.
- This condition is almost close to saturation flow but there is still visible traffic movement and this condition is better when compared to the four alternative simulations that have been stiffened.

VII. RECOMMENDATION

The following are several suggestions that can be given to avoid traffic spills on the KIM II Roundabout Road for the long term:

1. The turning method is carried out at the roundabout location;
2. Relocation of gas stations around roundabouts because this can increase vehicle delays and lengthen traffic queues;
3. Adding entrances at toll gates to reduce vehicle queues;
4. Increase the lane width on the KIM II Entrance/Exit road to accommodate more vehicles;
5. Conditioning the mains at the KIM II entrance/exit median so that it can increase road capacity;\
6. And others that can influence the flow at the roundabout location.

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REFERENCES

[1] E. K. Morlok, **Introduction to Transportation Engineering and Planning**, Jakarta: Erlangga, 1991.

[2] A. Munawar, **Dasar-dasar Teknik Transportasi**, 2005.

[3] M Trueblood ; J Dale, "**Simulating Roundabouts With Vissim**," 2nd Urban Street Symposium: Uptown, Downtown, or Small Town: Designing Urban Streets That Work, 2003.

[4] **Pedoman Kapasitas Jalan Indonesia**, Kementerian Pekerjaan Umum dan Perumahan Rakyat, 2014.

[5] Pd. T-19-2004-B **Survai Pencacahan Lalu Lintas dengan cara Manual**, Departemen Permukiman dan Prasarana Wilayah, 2004.

[6] **PP No 30 Tahun 2021 Bidang Lalu Lintas dan Angkutan Jalan**, Peraturan Pemerintah, 2021.

[7] UU Nomor 38 Tahun 2004 Tentang **Jalan**, Kementerian PUPR, 2004.

[8] A. A. Alamsyah, **Rekayasa Lalu Lintas**, Malang: UMM Press, 2005.

[9] Permenhub KM 14 Tahun 2006 Tentang **Manajemen dan Rekayasa Lalu Lintas Di Jalan**, 2006.

[10] PP No 32 Tahun 2011 Tentang **Manajemen Dan Rekayasa, Analisis Dampak, Serta Manajemen Kebutuhan Lalu Lintas**, 2011.

[11] PP No 34 Tahun 2006 Tentang **Jalan**, 2006.

[12] A. Purba, D. Herianto, F. R. Pinggungan dan S. Putra, "**Analisis Kinerja Simpang Tak Bersinyal Jalan Suprapto -Jalan S. Parman Bandar Lampung**," dalam Seminar Nasional SINTA FT UNILA Vol. 2 Tahun 2019, Bandar Lampung, 25 OKTOBER 2019.