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PERFORMANCE ANALYSIS OF UNSIGNALIZED INTERSECTIONS AND ROAD SECTIONS USING VISSIM SOFTWARE

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Abstract

The Kodim intersection is one of the intersections at Jalan Raya Sawangan. Identifying vehicle traffic, performance, and potential remedies at the Kodim intersection and Jalan Raya Sawangan was the goal of this study. The information gathered from the survey results, the research technique employs a strategy from the PKJI (Pedoman Kapasitas Jalan Indonesia) and a simulation utilizing the PTV Vissim program. Based on the results of data analysis and processing, the busiest traffic flow at the Kodim intersection occurred on Weekday at 17.30–18.30 WIB with a degree of saturation value of 1,391 and the LoS value is F. Analysis of the road section also obtained the largest volume of vehicles on Weekday at 17.15–18.15 WIB, the degree of saturation value is 1.49, so the Los value is F. By carrying out several repair solutions, the best service level value is obtained for the repair solution by making a flyover. The solution of making a flyover produces a degree of saturation value of 0.382, so that the Level of Service (Los) value of the intersection is obtained at level B. The resulting degree of saturation value is below 0.85, as required in the PKJI 2014.

Keywords: Intersection, PKJI 2014, Vissim Modelling

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Introduction

Research Background

An intersection is a part of the road that brings together two or more road segments. So that at intersections, road flows can join, cross, or intersect. Good transportation is when the factors of safety, high accessibility, sufficient capacity, and comfort are met.

The increase in road sections and capacity in Depok City was 0.7%, while the vehicle growth rate in 2014 was 9% per year for the last 5 years. The increase in private vehicles continues to increase every year. The number of motorcycles in 2010 was 613,487 units, then jumped in 2014 to 817,850 units. As for private cars, in 2010, there were 87,503 units and that increased to 155,510 units in 2014. (Depok City Department of Transportation, 2010 and 2014). Based on these data, there will be an increase in population activity. Vehicles were also observed to be congested on several roads in Depok City, one of which was Jalan Raya Sawangan. Jalan Raya Sawangan connects traffic between Depok City, Bogor Regency, South Jakarta, and Tangerang Regency.

Traffic congestion often occurs at one of the intersections located on Jalan Raya Sawangan, namely the Kodim Intersection, which is a level intersection connecting four road sections, namely those heading to and leaving the cities of Depok, Cinere, and Bojong Gede. Based on observations, there is often congestion at the intersection both during rush hour (going to and from work) or on holidays (Saturday and Sunday) due to shopping flows or residents driving to spend the day off. Therefore, an analysis is needed at the intersection to find out whether it is still feasible to use as well as provide solutions to overcome problems at the intersection.

Research Problems

The formulation of the problem in this final project's research is as follows:

1. How is the volue of vehicles during rush hour at the Simpang Kodium, Depok, West Java?
2. How is the performance of the Kodim Intersection and Jalan Raya Sawangan during rush hour?
3. How are the alternative solutions that can provide comfort for road users?

Research Purposes

Based on the formulation of the research problem, the purposes of this research are as follows:

1. Knowing the volume of vehicles passing through the Kodim intersection during rush hour.
2. Analyze the performance of the Kodim Intersection and Jalan Raya Sawangan around the Kodim Intersection.
3. Provide alternative solutions that can make road users more comfortable.

Literature Review

Intersection Definition

An intersection is a place where two or more roads meet, so that an intersection is a critical place or area that becomes a point of conflict that causes road congestion. Road intersections are an essential component of the network of roads. Another definition of an intersection is the overall area where two roads meet and intersect, which includes the road and any facilities that are located along the side of it. To get to their purpose drivers might choose to go straight, turn, or change roads (Castañeda et al., 2021; Susilo, 2015)

Intersections are points on the network the street where streets meet and where intersecting vehicle trajectories intersect (Rorong et al., 2015). Intersection can be defined as general area where two or more roads join or intersections, including roads and edge facilities road for the movement of traffic therein. Crossroads consist of two main categories, namely intersections at grade and non-level intersections (Ratnaningsih, 2016; Wu et al., 2021). Making intersections serves the dual purposes of minimizing the possibility of incidents between vehicles (including pedestrians) and increasing vehicle comfort and ease of movement (Iyataan, 2015; Olayode et al., 2021). In order for the intersection to be a place where two roads meet or intersect as well as road facilities intended to improve comfort for drivers and pedestrians and reduce the chance of accidents. However, given that the intersection is where two routes merge, it is possible for vehicular accidents to happen. The type of intersection in this study is an intersection that combines four roads.

Intersection Type

According to Morlok (1998), there are several types of intersections based on how they are arranged and can be grouped into two types, namely as follows:

1. Intersection without signal
2. Intersection with APILL (signalized)

This study examines the Kodim Intersection, Depok, West Java, which is an unsignalized.

Traffic Maneuvering at Intersections

There are several maneuvers at the intersection (Fazlurahman, 2019), namely:

1. Diverging. The event of separating a vehicle from other vehicles from the same traffic to a different path.
2. Merging. Events joining vehicles from different lanes to the same lane.
3. Crossing. Intersection events between the flow of vehicles from one lane to another at the intersection.
4. Weaving. The confluence of two or more traffic flows moving in the same direction along a highway lane without the aid of traffic signs.

Traffic Volume

Traffic volume is a number vehicles passing through a road at a certain time period (Lestari, 2014). In this study, the number of vehicles will be obtained by counting in the field. So that the vehicle volume data will be analyzed to determine the performance of the Kodim Intersection.

Traffic Densities

The volume of vehicles using a given lane or section of road is called the traffic density. Unit vehicle/km is the standard unit of density. According to Morlok (1991), the number of vehicles occupying a segment of a given road or lane, which is typically stated as the number of vehicles per kilometer per lane, is referred to as traffic density (Sondakh Marunsenge James Timboeleng & Elisabeth, 2015). So that later the traffic density level will act as an indicator of the level of service of the Kodim Intersection.

Traffic Speed

There are several definitions used to explain speed in relation to vehicle movement on the motion path (Harianto, 2004), namely:

1. Space Mean Speed. The vehicle's average speed is calculated by dividing the entire distance traveled by the required length of time.
2. Time mean speed. the typical speed of vehicles as they pass a particular spot in the road for a predetermined amount of time.
3. Running speed. regardless of obstructions that cause delays, including as intersection barriers and pedestrian crossings. Therefore, the ratio of the distance traveled to the journey time less the halting time is the speed of movement.

The speed of this vehicle can be affected by how many vehicles are at an intersection or on a road segment. So that the greater the speed of the vehicle, the higher the performance of the intersection and the road section. Whereas if the speed is slower, it means that the level of service value is also getting smaller, even the roads can be in a saturated condition, where there are long queues of vehicles.

Vehicle Speed Gauge

To measure the speed of the vehicle Motorists can use the speed tool gun radar. This tool is a tool used in law enforcement and traffic problem research. Device it can be held by hand, placed on a traffic police patrol car, or placed on the road. Ways of working speed radar gun based on the Doppler effect, where the tool emits something Radar waves directed at a moving object (car) and reflected back to the tool for then by this device measured the speed of the object (Cindy Irene Kawulur, T.K. Sendow, E. Lintong, 2013).

Capacity (C)

Capacity is the capacity of the intersection to accommodate traffic flow maximum per unit time is stated in smp/hour green. Capacity on intersection is calculated at each approach or groups of lanes within a approach (Wikrama., 2011)

The capacity at an intersection can be calculated for the total inflow from all arms of the intersection and is defined as follows: (Kementerian Pekerjaan Umum, 2014)

$C = C_0 \times F_{LF} \times F_M \times F_{UK} \times F_{HS} \times F_{Bki} \times F_{Bka} \times F_{Rmi}$ ...(1)

C = Intersection Capacity (skr/hour)

C_0= base capacity of the intersection (skr/hour)

F_{LP}= Road width adjustment factor

FM= Main Road median adjustment factor

F_{UK}= City size adjustment factor

F_{HS}= Side barrier adjustment factor

F_{BKi}= Left turn ratio adjustment factor

F_{BKa}= Right turn ratio adjustment factor

F_{Rmi}= Minor Road flow ratio adjustment factor

Degree of Saturation (D_1)

Degree of Saturation (D_J) is the ratio of traffic flow to capacity (skr/hour). Calculation of the degree of saturation (D_J) is as follows

$$D_J = \frac{q}{C} \quad \ldots(2)$$

D_J= Degree of Saturation

C = Capacity (skr/hour)

q = traffic flow (skr/hour)

$q = q_{vehicles} \times F_{skr}$

F_{skr}= skr Factor

F_{skr}= ekr_{KR} x $\%q_{KR}$*ekr_{KS} x $\%q_{KS}$ + ekr_{SM} x $\%q_{SM}$ ...(3)

Free flow speed depends on the vehicle type (motorcycle, car or heavy vehicle) and road type (number of lanes and with/without divider). The average space mean speed can be calculated by using IHCM graphically by inputting the free flow speed and the degree of saturation (Munawar et al., 2017).

Vehicle Delays (D)

The analysis and modeling for road links was primarily concerned with developing speed-flow correlations for various road types and researching the impact of geometric, traffic, and environmental factors on these relationships. Speed reduction in urban areas is largely dependent on the surroundings and activities along the side of the road (also known as "side frictions"). Numerous activities on the side of the road might drastically slow down traffic (Munawar, 2011).

1. Traffic Delays (T_{LL}) due to traffic interaction with other movements at the intersection.
2. Geometric Delays (T_G) due to the undisturbed deceleration and acceleration of vehicles.

$T = T_{LL} + T_G$ … (4)(PKJI, 2014)

Queue Opportunity (PA)

The queue probability with upper and lower bounds can be obtained by using the following formula (PKJI,2014):

Upper limit opportunity, PA:

$47.71\, D_J - 24.68\, D_J^2 + 56.47\, D_J^3$ ... (5)

Lower limit opportunity, PA:

$9{,}02 D_J + 20{,}66 D_J^2 + 10{,}59\, D_J^3$ … (6)

Traffic Management

A better traffic situation can be accomplished through traffic management. The first step in effective traffic management is to create the ideal circumstance. The complexity of carrying out actual traffic engineering, however, occasionally restricts the realization of this traffic situation. Directly applied traffic engineering typically has drawbacks, including the necessity for road user socialization, a lack of available time, high expenditures, and the danger of failure that could result in severe congestion (Ramadhan et al., 2019). So that traffic management must be carried out in such a way so that all road users can feel the benefits.

The US Department of Transportation (DoT) claims that there are three main causes of traffic congestion. The first one has to do with things that affect traffic, like accidents, construction zones, and severe weather. The second one has to do with traffic demand, which includes changes in both regular traffic and unique events. The transportation infrastructure, which consists of physical bottlenecks and traffic-control equipment, is the final source (de Souza et al., 2017).

A construction of infrastructure will bring both positive and negative impacts on its surrounding including the impacts on traffic around the construction site. The phenomenon's impact on traffic will contribute significantly to the volume of traffic in areas like office buildings, shopping malls, bus terminals, etc (Saleh et al., 2017).

Traffic congestion is a burning issue in many cities due to an exponential growth of running vehicles. In general, there are two kind of traffic congestion. The first is recurrent traffic congestion, which occurs every day at the same time and same location. The second type is irregular traffic congestion, which appears haphazardly as an unanticipated incident. An unexpected spike in traffic flow may result from this one-time effect. Contrary to recurrent traffic congestion, detecting non-recurring congestion is crucial since it calls for the examination of real-time traffic data in order to make the proper traffic management decisions (Nellore & Hancke, 2016).

Based on some of the opinions above, it can be concluded that there are two types of traffic congestion. These involve daily recurring traffic congestion and irregular traffic delays brought on by unexpected occurrences. Traffic accidents, construction projects, inclement weather, traffic changes, and outdated traffic control technology are just a few of the many factors that contribute to traffic congestion. So, to solve the problem of traffic jams it takes several solutions. In this study an experiment will be carried out for traffic management at the Kodim intersection with several conditions applied.

Road

Through traffic management and traffic engineering, the government seeks to make road traffic and transportation safe, secure, quick, smooth, and efficient (Porat, 2009). The growth of a city is influenced by how well a road network performs. A performance-good road network provides the community with a number of benefits. These benefits lead to higher income and regional income. If people and things are moved efficiently, then society's direct economic income will rise (Koloway, 2009). For road planning well, the geometric shape has to be defined in such a way that the road can provide services optimally to the appropriate traffic with its function (Firdaus, 2013). Thus, good quality of road geometric planning, traffic management, and safe, efficient and comfortable traffic engineering can indirectly improve the economy of a city.

The performance value of the road segment is determined by knowing the value of:

1. Side Barrier Class (KHS)

Side Barriers are the many obstacles to traffic performance fromactivity beside the 200 meter long road segment that can affect traffic. (Mudiyono & Anindyawati, 2017)

Parking activities on the road can reduce road capacity, the losses experienced by road users due to congestion is not proportional to the income received from the sector parking (Harry Patmadjaja, Julius Urbanus, Paul Tjahjaputra, 2003).

2. Free flow speed

Free current speed (FV) is defined as the speed at zero current level, is the speed that the driver would choose if driving a motorized vehicle without affected by other motorized vehicles on the road. Light vehicle free flow speed selected as the basic criterion for road segment performance at flow=0 (Cindy, 2016)

The free flow speed of light vehicles can be calculated with the following formula (Pedoman Kapasitas Jalan Indonesia, 2014):

$$\mathrm{V_{BKR}} = (\mathrm{V_{B0}} + \mathrm{V_{BL}}) \times \mathrm{FV_{HS}} \times \mathrm{FV_{UK}} \quad \dots (7)$$

Information:

V_{BKR} = free flow speed
V_{B0} = Base free flow speed
V_{BL} = Speed adjustment lane width
FV_{HS} = Speed adjustment factor due to side barrier
FV_{UK} = Speed adjustment factor due to city size

3. Capacity (C)

The capacity of a road section is defined as the maximum number of vehicles that can cross a road segment uniform per hour, in one direction for a two-lane two-way street with a median or two-way total for a walk two lanes without a median, for a certain unit of time under certain road and traffic conditions (Gea & Harianto, 2011). The capacity of one road section in a highway system is the maximum number of vehicles who have sufficient probability to pass that way (in one or both directions) over a specified period of time and under typical road and traffic conditions (Vikri et al., 2018). The capacity value of the road section can be calculated using the following formula (PKJI, 2014):

$$C = C_0 \times FC_{LJ} \times FC_{PA} \times FC_{HS} \times FC_{UK} \dots (7)$$

Speed limits are rarely enforced in urban areas in Indonesia and hence has little effect on the current velocity free. Other traffic rules are effect on traffic performance parking restrictions and stops along side roads, restrictions on access to certain types of vehicles, access restrictions from roadside land and etc (Lalenoh et al., 2015).

Level of Service

According to KM 14, 2006 Level of Service (Los) is the ability of roads and/or intersections to accommodate traffic under certain conditions (Peraturan Menteri Perhubungan, 2006). Meanwhile according to PM 96 Tahun 2015, Level of Service (Los) is a quantitative and quality measure that describes traffic operational conditions (Peraturan Menteri Perhubungan, 2015). These levels are denoted by the letter A which is the highest level of service to F which is the level of service the lowest (Indrayana et al., 2013)

Service Level Stated Quality Level of Traffic Flow

Actually, happened on a segment way, feasible or not a carrying capacity of the road the volume of traffic that occurs in standardization according to the Manual Indonesian Road Capacity (MKJI) 1997. To find out the level our own road service as well must first know characteristics, capacity and volume the road itself then calculated the degree of saturation (Imarianto et al., 2017). MKJI divides the level of road service into 6 conditions (A, B, C, D, E, F) by plotting the speed and volume (V/C) data points we can determine the level of service that exists on the road section being reviewed, in addition to plot the results of the relationship between velocity and volume (Haryati & Najid, 2021).

PTV Vissim

Typical simulation models include a selection of common vehicle types, including cars, buses, trucks, and motorcycles. However, there are a number of non-standard vehicle kinds in mixed traffic, such as motorized and non-motorized three-wheelers, and these can have a big impact on the simulation results. As a result, the first stage in the simulation is to precisely specify the static and dynamic properties of each type of vehicle in terms of its length, width, rate of acceleration and deceleration, and speed ranges. For each type of vehicle, one may take into account variables like axle design, turning radius, etc. for a more accurate modeling (Manjunatha et al., 2013).

In practice, traffic modeling is frequently used to support the design and validation of newly created control techniques. Users have a wide variety of road traffic simulators to pick from. Most of them are commercial pieces of software. Additionally, open-source simulators created by academic institutions or research centers are also accessible. Depending on the specific needs of the user, each of them has benefits or drawbacks (Tettamanti & Varga, 2012). So, in order to get good simulation results, input adjustments must be made in advance for vehicle types that are not found in the vissim software.

There are two different programs that make up the Vissim simulation system. The traffic flow model (Vissim's core) is the first program, while the signal control model is the second. The signal control program (slave) receives detector values from the master program, Vissim, every second. The detector readings are used by the signal control to determine the current signal characteristics. As soon as Vissim receives the signal aspects, the subsequent cycle of traffic flow begins. The simulation is stochastic, microscopic (single vehicle modeling), and has fixed time slices of one second. An online animation of the traffic flow and offline reports of the distributions of waiting and travel times are the simulation's outputs (Fellendorf, 1994).

Then, the calibrated models are assessed using fresh field data that includes input volumes, traffic mix, and other necessary information. It is calculated what the mean absolute percentage difference is between the exit flows derived from the model and those obtained from the field. If this error is contained within the necessary bounds, the model is considered to be validated (Siddharth & Ramadurai, 2013). So that the input that will be used for the simulation must be taken directly from the field so that later an accurate simulation will be produced.

The psychophysical car-following model created by Wiedemann (1974) is used by Vissim. The idea behind this model is that when approaching slower moving vehicles, faster moving vehicle drivers begin to slow down once they reach their own personal perception threshold. However, due to the driver's error in estimating the lead vehicle speed, the speed may end up being lower than the lead vehicle speed. This implies that after crossing another threshold, the driver will gradually increase the speed again. Due to the flaws of the drivers, this causes an iterative process of acceleration and deceleration to calculate the precise speeds of the lead vehicles (Aghabayk et al., 2013).

The paths of the merging vehicles in the Vissim simulation model should go beyond the entire weaving area, which was designated as the merge link. In order to make sure that vehicles coming from freeway could properly complete the merging process, this was done. Vehicles in the Vissim simulation model would exit the network from the lane. The Vissim user manual further stipulates that the downstream connector's lane-change distance must be greater than the merge link's overall length (Fan et al., 2013)

In this study, PTV Vissim was used as a tool for analyzing the performance of the Kodimintersection, and then the results of the analysis would be compared using the manual method using the PTV Vissim software.

Research Methodology

The four-arm unsignalized intersection, namely the Kodim intersection, Depok, West Java, which connects Jalan Raya Sawangan, Jalan Pramuka Raya, and Jalan Pramuka II. The research location can be seen in Figure 1.

Figure 1. Map of the research location: Kodim Intersection, Depok, West Java

The flowchart for this research can be seen in Figure 2 as follows:

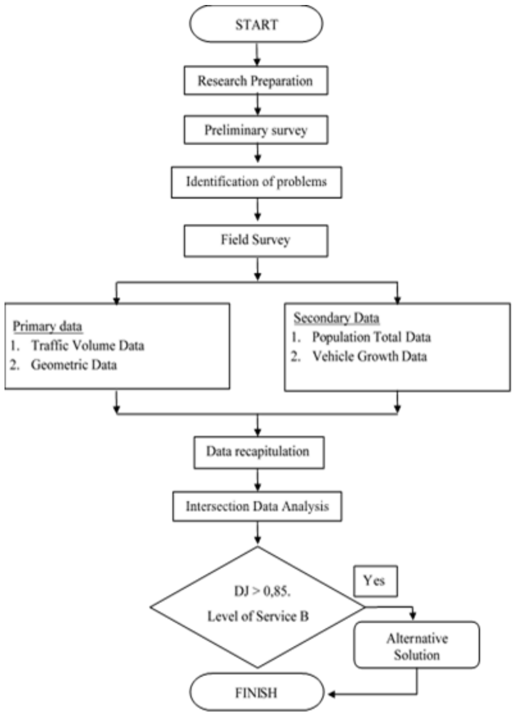

Figure 2. Research flowchart

Research Results and Discussion

Survey Results

The survey results at the intersection can be seen in table 1 as follows.

Table 1. Data traffic counting

	Weekend		Weekday	
Survey Time	11.00 - 13.00	17.00-19.00	07.00-09.00	17.00-19.00
Peak Hour	11.45-12.45	17.00-18.00	07.15-08.15	17.30-18.30
Q (Veh/ Hour)	8182	9230	9288	**10.137**

Based on the vehicle traffic survey data that has been carried out, the largest vehicle volume value was obtained on Weekday, 17.15–18.15 WIB, with the number of vehicles 10137 vehicles/hour. So, this data is considered to represent other data because it has the highest volume of traffic flow.

Intersection Performance Analysis

After analyzing the intersection survey data, the results of the analysis can be seen in table 2 below.

Table 2. Intersection analysis result data

Intersection Data Analysis	
Traffic Flow	4072 skr/hour
Capacity	2927 skr/hour
Degree of Saturation	1.3
Vehicle Delays	111.04 second
Level of Service	F

Based on the results of the analysis using the 2014 PKJI, the traffic flow results were 4072 cur/hour, the vehicle capacity was 2927 cur/hour, the degree of saturation was 1.3 and vehicle delays were 111.04 seconds. So that the level of service F is obtained, where a value like this, it means that the intersection is in a saturated state, resulting in congestion or queues of vehicles at the intersection. So a solution is needed to obtain a minimum level of service value at level B, and a degree of saturation below 0.85. A degree of saturation below 0.85 means that the vehicle can move comfortably without a queue of vehicles.

First of all, an experiment is carried out to carry out traffic engineering as in Solution A, Solution B, and Solution C. Then, if the traffic engineering does not meet the minimum level of service value B, a solution experiment is carried out by changing the intersection geometry. As in Solution D, road widening was carried out so that the intersection geometry became symmetrical, and in Solution E, a non-level intersection was made by building a flyover at the intersection.

Alternative Solution A (Prohibited Right Turns of the Major and Minor Arms)

Alternative Solution A is traffic engineering with a sign prohibiting right turns from the major and minor arms. This alternative solution was chosen because there are lots of vehicles turning right on major and minor roads. So, it is hoped that this traffic engineering can describe the traffic density at the Kodim Intersection. A traffic engineering sketch for an alternative solution A can be seen in figure 3 as follows.

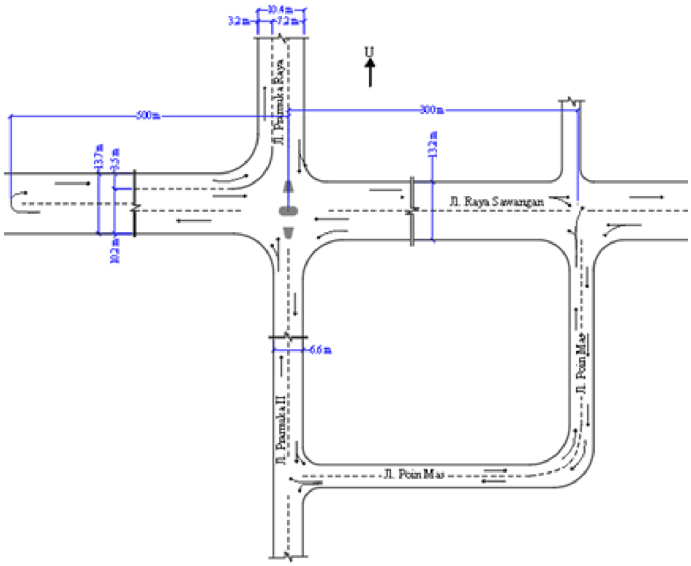

Figure 3. Sketch alternative solution A

Figure 3 illustrates the traffic engineering actions in alternative solution A, which can be described as follows.

a) Drivers from the north who will turn west can first turn left for about 300 m, then turn right via Jalan Poinmas.
b) For drivers from the east who will turn north, you can go straight first, then look for a U-turn about 500 m from the intersection and turn left directly to the west.
c) Drivers from the south who will turn east from Jalan Pramuka II can return south via Jalan Poinmas, which is 400 m long and will appear at the intersection between Jalan Raya Sawangan and Jalan Poinmas.
d) Drivers from the west who will turn south can go straight for 300 meters first, then go via Jalan Poinmas.

Alternative Solution B (Prohibited Right and Straight Turns of the Minor Arm)

Alternative solution B is traffic engineering with a prohibition sign for turning right and straight from the minor arm. This alternative solution was chosen because there are a lot of vehicles turning right and going straight on minor roads. So, it is hoped that this traffic engineering can describe the traffic density at the Kodim Intersection. A traffic engineering sketch for alternative solution B can be seen in Figure 4 as follows.

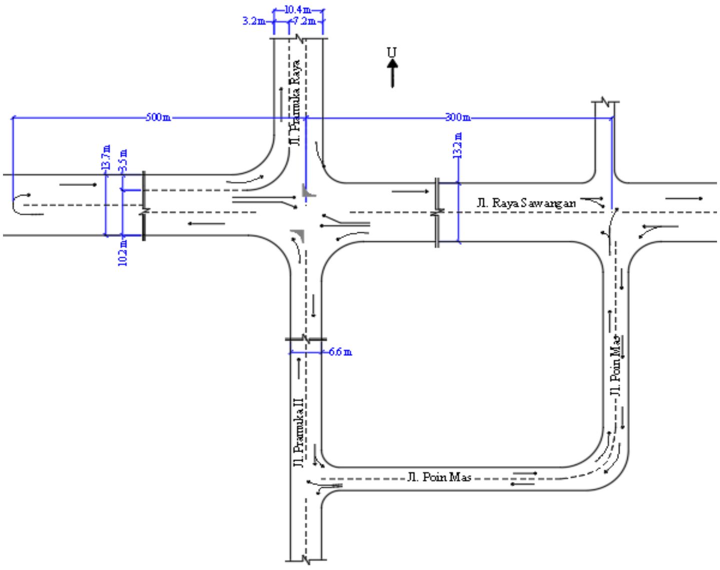

Figure 4. Sketch alternative solution B

Figure 4 illustrates traffic engineering actions in alternative solution B which can be described as follows:

a) Drivers from the north who are heading south and west can turn left after 300 meters and then enter Jalan Poinmas.
b) Drivers from the south heading north can first turn left, then look for a 500 m u-turn and turn left directly from the west.
c) Drivers from the south who are heading east, can first turn left to find a roundabout or return south and then pass Jalan Poinmas.

Alternative Solution C (Installation of Traffic Signals at Intersections)

Alternative solution C is a solution with the addition of a traffic signaling tool (APILL) at the intersection. This alternative solution is carried out because in Solution A and Solution B, just doing traffic engineering does not have much effect on increasing the value of the level of service. So it will be analyzed if the Kodim intersection uses a traffic signaling tool. Data width of each intersection approach in table 3 as follows.

Table 3. Intersection analysis result data

	U	S	T	B
L	3.6 m	3.3 m	6.6 m	8.6 m
L_M	3.6 m	3.3 m	6.6 m	5.1 m
L_{BKIJT}	0 m	0 m	0 m	3.5 m
L_K	3.6 m	3.3 m	6.6 m	5.1 m

L = width of the road
L_M = driveway width
L_{BKIJT} = width of continuous turn left.
L_K = exit width

Based on the results of the phase analysis at the intersection, it can be seen in table 4 as follows.

Table 4. Signal time traffic phase alternative C

		Green	Red	Yellow	All Red	Phase Time
Phase 1	E&W Green	50	39	3	2	94
Phase 2	N&S Green	30	55	3	1	89

So, it is described, the signal phase at the Kodim intersection can be seen in figure 5.

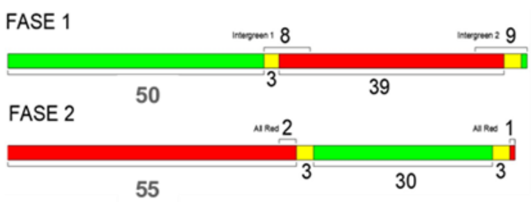

Figure 5. Signal phase

Alternative Solution D (Symmetrical Intersection Geometry)

Making the intersection geometry symmetrical is expected to increase vehicle capacity on roads and intersections. The intersection is made symmetrical by widening the major roads to 2x (2x4) and the minor roads to 2x5 which can be seen in figure 6.

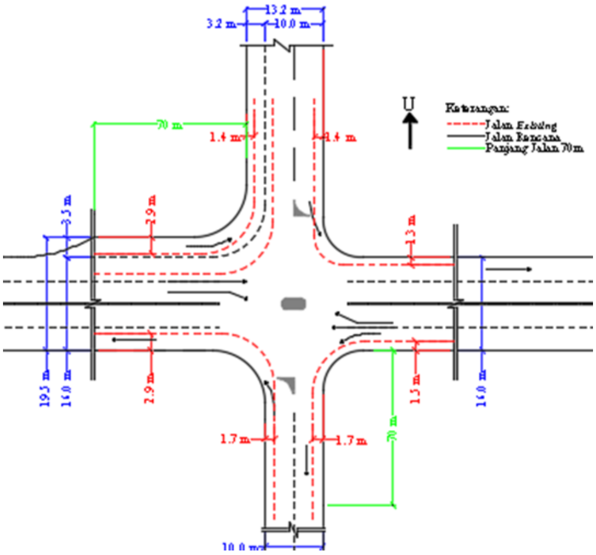

Figure 6. Dimension Widening

Each road section is widened by 70 m, so this improvement solution requires land acquisition. The amount of land acquisition includes:

a) North : 196 m^2 (Shops)
b) East : 196 m^2 (Shops)
c) West : 406 m^2 (Mosque)
d) South : 238 m^2 (Mosque)

Traffic engineering is also carried out such as alternative solutions B.

Alternative Solution E (Selection of the Type of Intersection)

Selection of the type of intersection can be used as an alternative solution by looking at the graph of the volume comparison of the major arm and the minor arm. The volume of vehicles on the graph is in units of vehicles/day.

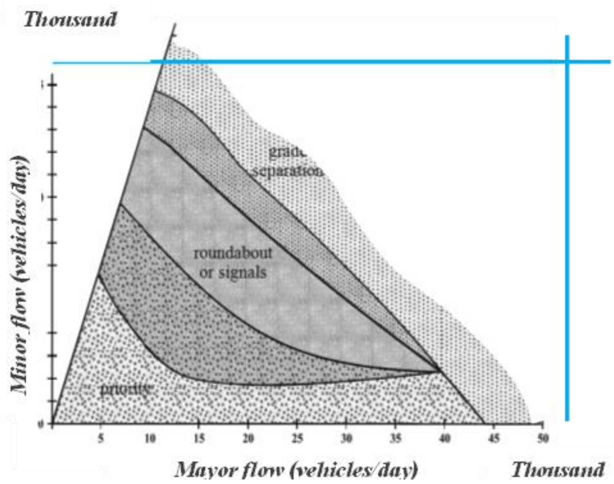

Figure 7. Intersection type selection graph

Based on the graph in figure 7 above, it can be concluded that the type of intersection that is suitable for the Kodim Intersection is a non-level intersection; therefore, an alternative solution will be made to change the geometric intersection to be symmetrical and make a flyover on the minor arm. So that the sketch of the intersection can be seen in figure 8.

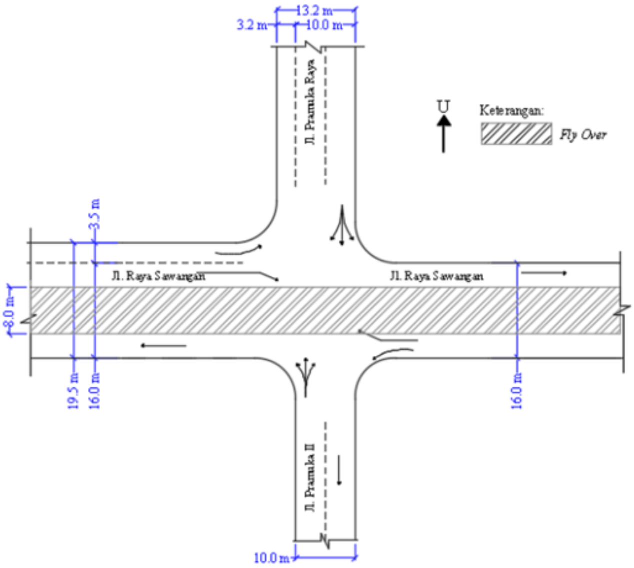

Figure 8. Flyover sketch

Comparison of Results of Analysis of Actual Conditions with Alternative Solutions

Comparison of the results of the analysis of actual conditions with alternative solutions can be seen in table 5 as follows.

Table 5. Comparison of alternative solution analysis result

Analysis	**Actual (Peak Hour)**	**A**	**B**	**C**	**D**	**E**
Q(veh/hour)	9288					
q_{mi}(veh/hour)	3588	3588	3588	N:1252 S: 691 E: 1944 W:1511	3588	3588
q_{mi}(skr/hour)	1450	1450	1450		1450	1450
q_{ma}(veh/hour)	6219	6219	6219		6219	6219
q_{ma}(skr/hour)	2623	2623	2623		2623	2623
Q_{total}(veh/hour)	9807	9807	9807		9807	9807
Q_{total}(skr/hour)	4072	4072	4072		4072	4072
Type	422	422	422	422	424	424
C(skr/hour)	2928	3231	4009	N :660 S: 408 E:2118 W:1314	3789	3775
Dj	1.39	1.26	1.02	N :1.89 S:1.69 E:0.91 W:1.15	1.70	0.51
T(s)	111.0	66.53	19.7	N:271 S:297 E:29.6 W:67.4	23.18	10.6
LoS	F	F	C	F	C	B

Based on Table 5, it can be seen that, when compared, the solution for making a flyover produces a Level of Service value with a B value, which is the best Los value compared to alternative solutions A, B, C, and D.

Prediction of Intersection Traffic Performance for the Next 5 Years

Then the prediction of intersection volume for the next 5 years can be seen in table 6.

Table 6. Calculation of vehicle flow (Q) 2022 – 2027

Years	n	Vehicles flow (skr/hour)			Amount
		SM	KR	KS	
2022	0	1506	1917	650	4073
2023	1	1605	1972	700	4277
2024	2	1710	2028	755	4493
2025	3	1821	2086	813	4721
2026	4	1941	2146	876	4963
2027	5	2068	2207	945	5219

So that the results of calculating the flow of vehicles and the degree of saturation for the next 5 years are in table 7 as follows.

Table 7. Calculation 2022 – 2027 intersection performance prediction

	Vehicles Flow (Q)	Capacity (C)	Degree of Sturation (Dj)
	(skr/hour)	(skr/hour)	
2022	4073	2927.98	1.391
2023	4277	2927.98	1.461
2024	4493	2927.98	1.534
2025	4721	2927.98	1.612
2026	4963	2927.98	1.695
2027	5219	2927.98	1.783

Table 7 is the data from the analysis of capacity calculations and the degree of saturation of intersections for the next 5 years. So that the prediction of intersection performance for 2027 is obtained with a degree of saturation of 1.783. This value exceeds the provisions for Degree of Saturation (DJ) < 0.85 based on the PKJI 2014. So that the intersection is in a saturated state and it is certain that there will be long queues of vehicles.

Road Section Survey Data

Data from the survey results on the Jalan Raya Sawangan section can be seen in table 8.

Table 8. Vehicle flow survey data

	Weekend		Weekday	
Survey Time	11.00-13.00	17.00-19.00	07.00-09.00	17.00-19.00
Peak Hour	11.45-12.45	17.00-18.00	07.15-08.15	17.15-18.15
Q (vehicles/hour)	5769	6438	6583	7185

Based on the survey data, the volume of vehicles on Jl. The biggest Raya Sawangan occurred on Monday at 17.15–18.15 with a total of 7185 vehicles/hour. So that the largest volume value will be used for road performance analysis.

Road Segment Analysis Results

The results of the analysis of Jalan Raya Sawangan can be seen in table 9.

Table 9. Road segment analysis results

	Actual (2/2TT)
Road width 1	3.3
Road width 2	3.3
Total Flow (Q)	3764.9
KHS	Low
FV_0 (km/hour)	42
FV_L (km/hour)	-1.2
FV_{HS} (km/hour)	0.96
FV_{UK} (km/hour)	1
V_B (km/hour)	39.168
C_0 (skr/hour)	2900
FC_{LJ} (skr/hour)	0.948
FC_{PA} (skr/hour)	1

	Actual (2/2TT)
FC_{HS} (skr/hour)	0.92
FC_{UK} (skr/hour)	1
Kapasitas (skr/hour)	2529.26
Derajat Kejenuhan (D_J)	1.49
V_T (km/hour)	24
L (km)	0.2
W_T (s)	30
LoS	F

Prediction of Road Traffic Performance for the Next 5 Years

Calculation results for prediction of vehicle traffic in the next 5 years can be seen in table 10.

Table 10. Calculation of vehicle flow (Q) for 2022 – 2027

Years	n	Vehicles Flow (skr/Hour)			TOTAL
		SM	KR	KS	
2022	0	1864	1548	352.8	3765
2023	1	1986	1592	380	3959
2024	2	2116	1638	410	4164
2025	3	2255	1685	441	4381
2026	4	2402	1733	476	4611
2027	5	2559	1782	513	4854

Based on Table 10, it can be seen that the value of vehicle traffic will continue to increase every year, with predictions that it will be 4854 cur/hour in 2027. Then the degree of saturation and intersection capacity for the next 5 years can be seen in table 11.

Table 11. Calculation of prediction of road performance 2022 – 2027

Years	Vehicles Flow (Q)	Capacity (C)	Degree of Saturation (Dj)
	(skr/hour)	(skr/hour)	
2022	3765	2529.26	1.489
2023	3959	2529.26	1.565
2024	4164	2529.26	1.646
2025	4381	2529.26	1.732
2026	4611	2529.26	1.823
2027	4854	2529.26	1.919

Table 11 is data from the analysis of capacity calculations and the degree of saturation of intersections for the next 5 years. So that the prediction of intersection performance for 2027 is obtained with a degree of saturation of 1.919, where this value exceeds the provisions for Degree of Saturation (DJ) < 0.85. So that the intersection is in a state of saturation and it is certain that there will be long queues of vehicles.

Modeling Results with PTV Vissim

Figure 9 is a road network that has been modeled on PTV Vissim. Then the road network is displayed in wireframe mode so that the road network can be seen clearly.

Figure 9. Modelling Vissim

Then the road network that has been modeled will be added by vehicles based on survey volume in the field, so that the intersection can be simulated as show in figure 10 as follows.

PTV Vissim Analysis Results

After simulating the intersection using PTV Vissim, queue values and stopped vehicles can be generated, which can be seen in table 12 as follows.

Table 12. Results of intersection analysis using Vissim Modelling

	QLen (m)	QLen Max (m)	VehDelay(s)
A-C (East-West)	144	183	64
A-D (East-South)	144	183	18
A-B (East-North)	144	183	89
C-A (West-East)	137	170	59
C-D (West-South)	137	170	18
D-A (South-East)	671	83	10
D-C (South-West)	671	83	13
D-B (South-North)	671	83	1
B-A (North-East)	54	68	26
B-C (North-West)	54	68	39
B-D (North-South)	54	68	10

Based on the data presented in table 12, it can be seen that the longest queue of vehicles is from the south with a value of 671m. While the highest value of stopping vehicles occurs in the east-to-north direction with a value of 89 seconds, So that a comparison between the results of the analysis with the 2014 PKJI and the analysis using PTV Vissim can be seen in table 13, as follows.

Table 13. Intersection analysis

	Analysis Actual Conditions with PKJI 2014	Analysis Actual Conditions with PTV Vissim
Delays	111.044 second/skr	89 second/skr
Level of Service	F	F

So it can be seen from Table 13 that the analysis of the intersection using PKJI 2014 and PTV Vissim produces the same Level of Service which is class F, where in this condition the value of vehicle volume far exceeds the capacity of the intersection, resulting in long queues of vehicles on each approach to the intersection.

Conclusion

Based on the results of the analysis of the performance of the Kodim intersection and Jalan Raya Sawangan section that has been carried out, several things can be concluded as follows:

1. Analysis from the Kodim Intersection resulted in the largest volume of vehicles on Weekday at 17.15-18.15 WIB with a vehicle volume of 4072 skr/hour and a capacity of 2927 skr/hour. So that it produces a degree of saturation value of 1.391. Then in the analysis of the road sections, the largest volume of vehicles was obtained on Weekday at 17.15-18.15 WIB with a total volume of 3764 skr/hour and a road capacity of 2529 skr/hour. So that the degree of saturation value is 1.49. So, if based on the DJ requirement < 0.85, the Kodim intersection and Jalan Raya Sawangan still need solutions for repair solutions to produce a degree of saturation below 0.85, which will cause long queues of vehicles at peak hours.
2. Based on the analysis results, a delay value of 111 seconds is obtained which causes the Level of Service (Los) to be categorized at service level F. As for the results of the analysis of the performance of Jalan Raya Sawangan, the results of the analysis are restrained flow, traffic speed less than 50 km / hour, and the value of the traffic volume is more than 100% of the capacity value, the Sawangan Highway Section is included in the service level F.
3. Because the Kodim Intersection and the Jalan Raya Sawangan section analyzed still produce a degree of saturation exceeding 0.85, a solution must be found to improve the performance of the intersection. Based on several alternative solutions that have been presented, namely traffic engineering, road widening, and making flyovers. So it can be concluded that the most effective alternative solution is to make a flyover. The solution of making a flyover produces a degree of saturation value of 0.382, so that the Level of Service (Los) value of the intersection is obtained at level B. The resulting

degree of saturation value is below 0.85, as required in the PKJI 2014.

References

Aghabayk, K., Sarvi, M., Young, W., & Kautzsch, L. (2013). A novel methodology for evolutionary calibration of vissim by multi-threading. *Australasian Transport Research Forum, ATRF 2013 - Proceedings*, *October*, 1–15.

Castañeda, K., Sánchez, O., Herrera, R. F., Pellicer, E., & Porras, H. (2021). BIM-based traffic analysis and simulation at road intersection design. *Automation in Construction*, *131*, 103911. https://doi.org/https://doi.org/10.1016/j.autcon.2021.103911

Cindy Irene Kawulur, T.K. Sendow, E. Lintong, A. L. E. R. (2013). Pengemudi (Studi Kasus Ruas Jalan Manado-Bitung). *Jurnal Sipil Statik*, *1*(4), 289–297.

Cindy, N. (2016). Analisa dan Solusi Kemacetan Lalu Lintas di Ruas Jalan Kota (Studi Kasus Jalan Imam Bonjol - Jalan Sisingamangaraja). *Jrsdd*, *4*(ISSN:2303-0011), 153–162.

de Souza, A. M., Brennand, C. A. R. L., Yokoyama, R. S., Donato, E. A., Madeira, E. R. M., & Villas, L. A. (2017). Traffic management systems: A classification, review, challenges, and future perspectives. *International Journal of Distributed Sensor Networks*, *13*(4). https://doi.org/10.1177/1550147716683612

Fan, R., Yu, H., Liu, P., & Wang, W. (2013). Using VISSIM simulation model and Surrogate Safety Assessment Model for estimating field measured traffic conflicts at freeway merge areas. *IET Intelligent Transport Systems*, *7*(1), 68–77. https://doi.org/10.1049/iet-its.2011.0232

Fazlurahman, I. (2019). ANALISIS KEMACETAN LALU LINTAS PADA SIMPANG BERSINYAL (Studi Kasus : Simpang Ir. H. Juanda – Raya Bogor). *Prosiding Seminar Intelektual Muda*, *1*(1), 284–289. https://doi.org/10.25105/psia.v1i1.5962

Fellendorf, M. (1994). VISSIM: A microscopic Simulation Tool to Evaluate Actuated Signal Control including Bus Priority. *64th Institute of Transportation Engineers Annual Meeting*, *January*, 1–9.

Firdaus, O. (2013). Analisis Tingkat Pelayanan Jalan Pada Ruas Jalan Utama Kota Pangkalpinang. *Forum Profesional Teknik Sipil*.

Gea, M. S. A., & Harianto, J. (2011). Analisis Kinerja Ruas Jalan Akibat Parkir Pada Badan Jalan. *Universitas Sumatera Utara*, *1*, 1–10.

Harianto, J. (2004). Perencanaan Persimpangan tidak Sebidang pada Jalan Raya. *Universitas Sumatera Utara*, 1–16.

Harry Patmadjaja,Julius Urbanus,Paul Tjahjaputra, R. S. (2003). Pengaruh Kegiatan Perparkiran Di Badan Jalan Terhadap Kinerja Ruas Jalan Studi Kasus Jalan Kertajaya. *Civil Engineering Dimension*, *5*(2), 63–74.

Haryati, S., & Najid, N. (2021). Analisis Kapasitas Dan Kinerja Lalu Lintas Pada Ruas Jalan Jenderal Sudirman Jakarta. *JMTS: Jurnal Mitra Teknik Sipil*, *4*(1), 95. https://doi.org/10.24912/jmts.v0i0.10460

Imarianto, G., Pandulu, G. D., & Arifianto, A. K. (2017). Analisis Tingkat Pelayanan Jalan Pada Ruas Jalan Gajayana Kecamatan Lowokwaru Kota Malang. *Program Studi Teknik Sipil, Fakultas Teknik, Universitas Tribhuwana Tunggadewi Malang*, *1*(2), 64–74.

Iyataan, P. (2015). *Peningkatan Arus Lalu Lintas (Studi Kasus Simpang Tiga Lengan Gamping Yogyakarta dan Simpang Empat Lengan Pelemgurih Yogyakarta).*

Jurusan, D., Sipil, T., Teknik, F., & Udayana, U. (2011). *ANALISIS KINERJA SIMPANG BERSINYAL (Studi Kasus Jalan Teuku Umar Barat – Jalan Gunung Salak) A.A.N.A. Jaya Wikrama*. *15*(1).

Kementerian Pekerjaan Umum. (2014). Kapasitas Simpang. *Panduan Kapasitas Jalan Indonesia*, 68.

Kinerja, A., Jalan, R., Biaya, D. A. N., Akibat, P., Ngurah, I. G., Agung, G., Wedagama, D. M. P., & Suparsa, I. G. P. (2013). Analisis kinerja ruas jalan dan biaya perjalanan akibat tundaan pada ruas jalan (Studi kasus : Segmen Simpang Gunung Soputan-Simpang Teuku Umar Barat). *Jurnal Ilmiah Elektronik Infrastruktur Teknik Sipil*, *2*(2), 1–7.

Koloway, B. S. (2009). Kinerja Ruas Jalan Perkotaan Jalan Prof Dr. Satrio, DKI Jakarta. *Journal of Regional and City Planning*, *20*(3), 215–230.

Lalenoh, R. H., Sendow, T. K., & Jansen, F. (2015). Analisa Kapasitas Ruas Jalan Sam Ratulangi Dengan Metode Mkji 1997 Dan Pkji 2014. *Jurnal Sipil Statik*, *3*(11), 737–746.

Lestari, F. A. (2014). Analisis Dampak Lalu Lintas Akibat Adanya Pusat Perbelanjaan Dikawasan Pasar Pagi Pangkalpinang Terhadap Kinerja Ruas Jalan. *Jurnal Fropil*, *2*(1), 32–44.

Manjunatha, P., Vortisch, P., & Mathew, T. (2013). Methodology for the Calibration of VISSIM in Mixed Traffic. *Transportation Research Board 92nd Annual Meeting*, 11.

Mudiyono, R., & Anindyawati, N. (2017). Analisis Kinerja Jalan Majapahit Kota Semarang (Studi Kasus: Segmen Jalan Depan Kantor Pegadaian Sampai Jembatan Tol Gayamsari). *Prosiding Seminar Nasional Inovasi Dalam Pengembangan SmartCity*, *1*(1), 345–354.

Munawar, A. (2011). Speed and capacity for urban roads, Indonesian experience. *Procedia - Social and Behavioral Sciences*, *16*, 382–387. https://doi.org/10.1016/j.sbspro.2011.04.459

Munawar, A., Irawan, M. Z., & Fitrada, A. G. (2017). Development of urban road capacity and speed estimation methods in Indonesia. *Lecture Notes in Engineering and Computer Science*, *2230*, 564–567.

Nellore, K., & Hancke, G. P. (2016). A survey on urban traffic management system using wireless sensor networks. *Sensors (Switzerland)*, *16*(2). https://doi.org/10.3390/s16020157

Olayode, I. O., Tartibu, L. K., & Okwu, M. O. (2021). Prediction and modeling of traffic flow of human-driven vehicles at a signalized road intersection using artificial neural network model: A South African road transportation system scenario. *Transportation Engineering*, *6*, 100095. https://doi.org/https://doi.org/10.1016/j.treng.2021.100095

Peraturan Menteri Perhubungan. (2006). C:lg depan\ mrll tgl 13/2/066 /usb kepmen 1. *Peraturan Menteri Perhubungan*.

PKJI. (2014). Kapasitas Jalan Perkotaan. *Direktorat Jenderal Bina Marga*, 1–63.

Porat, D. F. (2009). *Analisis Simpang Bersinyal Pada Simpang Tiga Maguwoharjo Yogyakarta*.

Ramadhan, S. A., Joelianto, E., & Sutarto, H. Y. (2019). Simulation of Traffic Control Using Vissim-COM Interface. *Internetworking Indonesia Journal*, *11*(1), 55–61.

Ratnaningsih, D. (2016). Analisis Kinerja Simpang Ciliwung Kota Malang. *Prokons: Jurnal Teknik Sipil*, *10*(2), 127–131.

Rorong, N., Elisabeth, L., & Waani, J. E. (2015). Di Ruas Jalan S.Parman Dan Jalan Di.Panjaitan Di Ruas Jalan S.Parman Dan Jalan Di.Panjaitan. *Jurnal Sipil Statik*, *3*(11), 747–758.

Saleh, S. M., Sugiarto, S., Hilal, A., & Ariansyah, D. (2017). A study on the traffic impact of the road corridors due to flyover construction at Surabaya intersection, Banda Aceh of Indonesia. *AIP Conference Proceedings*, *1903*, 1–7. https://doi.org/10.1063/1.5011559

Siddharth, S. M. P., & Ramadurai, G. (2013). Calibration of VISSIM for Indian Heterogeneous Traffic Conditions. *Procedia - Social and Behavioral Sciences*, *104*, 380–389. https://doi.org/10.1016/j.sbspro.2013.11.131

Sondakh Marunsenge James Timboeleng, G. A., & Elisabeth, L. (2015). Pengaruh Hambatan Samping Terhadap Kinerja Pada Ruas Jalan Panjaitan (Kelenteng Ban Hing Kiong) Dengan Menggunakan Metode Mkji 1997. *Jurnal Sipil Statik*, *3*(8), 571–582.

Susilo, B. H. (2015). Dasar-dasar rekayasa transportasi. In *Buku Dosen-2014*.

Tettamanti, T., & Varga, I. (2012). Development of road traffic control by using integrated VISSIM-MATLAB simulation environment. *Periodica Polytechnica Civil Engineering*, *56*(1), 43–49. https://doi.org/10.3311/pp.ci.2012-1.05

Vikri, M., Septiansyah, M., & Wulansari, dwi novi. (2018). Analisa Kinerja Ruas Jalan Medan Merdeka Barat, DKI JAKARTA. *Jurnal Kajian Teknik Sipil* , *3*(2), 110–115.

Wu, L., Zhang, R., Zhou, R., & Wu, D. (2021). An edge computing based data detection scheme for traffic light at intersections. *Computer Communications*, *176*, 91–98. https://doi.org/https://doi.org/10.1016/j.comcom.2021.05.014