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Analysis of Service Levels at Signalized Intersections Using Vissim 2023: Case Study of the Road Sultan Hamid I– Tanjung Raya I– Sultan Hamid II– Tanjung Raya II Intersection

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ABSTRACT:

Rapid population growth urges an efficient transportation system to be developed, particularly at the intersection of Jalan Sultan Hamid I, Jalan Tanjung Raya II, Jalan Sultan Hamid II, and Jalan Tanjung Raya I. To tackle congestion, a microscopic traffic simulation using VISSIM 2023 was conducted, incorporating field data, model validation, and driver behavior analysis. The simulation revealed that existing conditions resulted in a Level of Service (LOS) of F, with an average queue length of 206 meters and a queue time of 105 seconds. The first alternative solution, which added one alternative road, also achieved LOS F, showing an average queue length of 209 meters and a queue time of 101 seconds. Conversely, the second alternative, which included two additional roads, improved the service level to LOS E, with an average queue length of 222 meters and a reduced queue time of 66 seconds.

Keywords: Intersection Service, Traffic, Congestion, Vissim

1. Introduction

East Pontianak is a sub-district within Pontianak City, West Kalimantan that has undergone significant development in recent years. The region has experienced rapid population growth, now reaching substantial numbers, alongside an increase in economic and social activities. Consequently, the demand for an efficient transportation system has become increasingly pressing. In this context, traffic congestion represents a primary challenge for both government authorities and local communities.

A particular area of concern is the intersection at the confluence of Jalan Sultan Hamid I, Jalan Tanjung Raya II, Jalan Sultan Hamid II, and Jalan Tanjung Raya I. This intersection serves as a crucial connector among various locales, including residential zones, shopping centers, and educational institutions. With a high volume of vehicles traversing this area, particularly during peak hours, it frequently experiences severe congestion. Prolonged queues and inefficient travel times pose significant issues for road users, adversely impacting both community productivity and comfort.

Traffic congestion at this intersection not only hinders the flow of vehicles but may also impede local economic growth. The resultant inconvenience for road users can diminish the area's appeal as a hub for economic and social activities. Thus, conducting a comprehensive analysis of road service levels at this signalized intersection is imperative. Addressing the congestion problem necessitates an examination of road service quality as a critical initial step. Utilizing VISSIM 2023 software facilitates microscopic traffic simulations, which can yield a clearer understanding of the traffic flow conditions at the intersection. This tool enables researchers to analyze various traffic scenarios and assess the effects of potential interventions. It is anticipated that this research will generate actionable recommendations to enhance traffic efficiency and safety at the signalized intersections of Jalan Sultan Hamid I, Jalan Tanjung Raya II, Jalan Sultan Hamid II, and Jalan Tanjung Raya I.

According to the Directorate General of Highways (2023), the Level of Service (LOS) serves as a key indicator to assess the quality of service provided by transportation facilities, particularly roads and intersections. This assessment considers multiple factors, including vehicle speed, traffic density, waiting time, and user comfort. Evaluating LOS is crucial for planners, as it aids in identifying traffic issues and devising appropriate solutions. Various classification systems, ranging from A to F, are utilized to represent differing levels of service quality, with LOS A signifying excellent service and LOS F indicating very poor conditions. The degree of saturation, defined as the ratio of road flow to capacity, is a primary factor in assessing the performance of intersections and road segments (Faritzie, 2021).

Budiman et al. (2016) note that signalized intersections possess distinctive characteristics that influence traffic flow efficiency. The design of traffic signals at these intersections aims to allocate equitable time to all road users, including both vehicles and pedestrians. However, peak traffic flow during certain hours can result in prolonged queues and increased waiting times, ultimately compromising service quality. Consequently, a thorough analysis of signal timing and traffic flow arrangements at signalized intersections is essential for enhancing efficiency and safety.

Traffic characteristics emerge from the interactions of individual drivers within a given roadway section and its surrounding environment. Due to the varying perceptions and capabilities of drivers, traffic behavior cannot be standardized, nor can it be uniformly regulated based on driver characteristics or habits (Akbar et al., 2018).

Arisandi (2015) defines an intersection as the meeting or branching of roads, either at the same or different levels. In essence, an intersection comprises two or more converging road segments, including associated road and roadside facilities. Based on their configuration, intersections can be categorized into different types:

1) Unsignalized intersections are intersections that do not utilize traffic signals. At these intersections, road users must determine whether it is safe to proceed or whether they must stop before crossing.

2) Signalized intersections are those where road users can navigate through the intersection based on the operation of traffic signals. In this case, road users are permitted to proceed only when the traffic signal indicates green for their respective direction..

Intersections can be classified into two primary categories: at-grade intersections and non-grade intersections. At-grade intersections are those where two or more roads converge at the same level, with each road connecting at the intersection and referred to as an intersection leg, intersection arm, or approach. In contrast, non-grade intersections facilitate the separation of traffic across different levels, allowing vehicle lanes to intersect only at designated points where vehicles either merge into or diverge from the same travel lane, such as in the case of flyovers (Elisabeth & Timboeleng, 2015).

In the context of VISSIM, a traffic simulation software, various types of traffic can be modeled, including vehicles such as cars, buses, and trucks, as well as public transport options like trams and buses. The software also accommodates simulations of bicycles, motorcycles, pedestrians, and rickshaws. Users of VISSIM have the capability to simulate a wide range of geometric configurations and road user behaviors present within the transportation system (Aryandi & Munawar, 2014).

2. Method

The research survey was conducted at the intersection of Jalan Tanjung Raya I, Jalan Sultan Hamid I, Jalan Tanjung Raya II, and Jalan Sultan Hamid II. A map of the research location, along with photographs depicting the road conditions, is provided in Figure 1.

Figure 1. Research Site

The first survey measured various aspects of road geometry, including road length, road width, intersection conditions, markings, road types, functions, and other relevant characteristics. The second survey focused on vehicle volume, with observations divided into three sessions: Session I from 06:00 to 08:00 WIB, Session II from 11:00 to 13:00 WIB, and Session III from 16:00 to 18:00 WIB. Additionally, a third survey was conducted to assess traffic cycle times using a stopwatch. This survey measured four key time intervals that will be utilized as input data for the VISSIM software: green time, red time, and amber time (the duration between red and green), as detailed in Table 1.

Table 1. Survey Schedule

Survey Schedule	Survey Activities
Saturday, 20 July 2024	Initial survey of intersection location
Thursday, 25 July 2024	Vehicle volume survey of vehicle volume
Thursday, 1 August 2024	Traffic signal cycle time survey
Tuesday, 06 August 2024	Road Geometric Survey

The data collected encompass intersection geometric data, environmental condition data surrounding the intersection, and traffic volume data. Observations for traffic volume at the Tanjung Raya I, Sultan Hamid I, Tanjung Raya II, and Sultan Hamid II intersection were conducted over a single day—specifically, Thursday—for a total of six hours. The results of the geometric road survey data are presented in Table 2.

Table 2. Road Geometric Data

Road Geometric	Intersection Arm			
	Tanjung Raya II	Tanjung Raya I	Sultan Hamid I	Sultan Hamid II
Road Function	Artery	Artery	Local	Local
Number of Lanes	2	1	1	2
Number of Lines	4	2	2	4
Number of Directions	2	2	2	2
Lane Width	6 m	9 m	6 m	8 m

The existing intersection data includes detailed dimensions of the road, lanes, medians, and sidewalks for each approach to the intersection. This intersection is a signalized one, situated at the junction of Jalan Tanjung Raya I, Jalan Sultan Hamid I, Jalan Tanjung Raya II, and Jalan Sultan Hamid II. The geometric conditions of the intersection are shown in Figure 3 below.

Figure 2. Geometric Condition of the Intersection

The data on traffic flow, indicating the number of vehicles crossing the road within a specified time period are presented in Table 3. while Table 4 presents the traffic signal timing data.

Table 3. Traffic Volume

Time Period	Location			
	North	East	South	West
06:00 – 08:00	12.326	8.751	7.419	5.727
11:00 – 13:00	4.850	4.850	5.484	3.498
16:00 – 18:00	9.427	9.427	7.019	2.787

Remarks;

North : Heading to Jalan Sultan Hamid I

East : Heading to Jalan Tanjung Raya II

South : Heading to Jalan Sultan Hamid II

West : Heading to Jalan Tanjung Raya I

Table 4. Traffic Volume

Traffic Wait Duration (seconds)	Location			
	North	East	South	West
Red Light	171	171	120	183
Amber Light	3	3	3	3
Green Light	40	40	91	28
Amber Light	3	3	3	3

Fase 1	Utara	40	3	171				3	
Fase 2	Timur		3		40	3	171		
Fase 3	Selatan	120				3	91	3	
Fase 4	Barat	3	183					3	28

Travel time is derived from the speed observation method conducted over a specific time period. This method aims to measure vehicle speed characteristics under the prevailing traffic and environmental conditions at the road location. To achieve statistically valid results, multiple speed measurements are necessary as presented in Table 5.

Table 5. Vehicle Speed Data

No	**Time dan Distance Motor Cycles (MC)**		**Time dan Distance Light Vehicles (LV)**		**Time dan Distance *Heavy Vehicles* (HV)**		**Time dan Distance Non-Motorized Vehicles (UM)**	
	Time (s)	**Distance (m)**	**Time (s)**	**Distance (m)**	**Time (s)**	**Distance (m)**	**Time (s)**	**Distance (m)**
1	7.48	100	9.14	100	8.50	100	24.97	100
2	6.69	100	10.29	100	8.36	100	16.63	100
3	8.43	100	8.66	100	10.51	100	19.98	100
4	6.63	100	7.97	100	8.99	100	13.98	100
5	7.92	100	7.17	100	9.86	100	11.92	100

Vehicle speed for use in the VISSIM 2023 simulation was measured at a reference distance of 100. which results are presented in Table 6.

Table 6. Vehicle Speed

No	**Time dan Distance Motor Cycles (MC)**			**Time dan Distance Light Vehicles (LV)**			**Time dan Distance *Heavy Vehicles* (HV)**			**Time dan Distance Non-Motorized Vehicles (UM)**		
	Time (s)	**Distance (m)**	**Speed (Km/H)**	**Time (s)**	**Distance (m)**	**Speed (Km/H)**	**Time (s)**	**Distance (m)**	**Speed (Km/H)**	**Time (s)**	**Distance (m)**	**Speed (Km/H)**
1	7.48	100	48.13	9.14	100	39.39	8.50	100	42.35	24.97	100	14.42
2	6.69		53.81	10.29		34.99	8.36		43.06	16.63		21.65
3	8.43		42.7	8.66		41.57	10.51		34.16	19.98		17.99
4	6.63		54.3	7.97		45.17	8.99		40.04	13.98		25.75
5	7.92		45.45	7.17		50.21	9.86		36.51	11.92		30.20
Average speed			48.88	Average speed		42.26	Average speed		39.23	Average speed		22

Vehicle volume calculations for the VISSIM 2023 simulation involved summing survey data and selecting maximum values from peak hours. For example, the calculation for the northbound of Jalan Sultan Hamid I focused on the busiest morning hours:

Total PCU = Σ MC + Σ LV + Σ HV + Σ UM

Traffic Volume = Σ Total PCU (Left Turn+ Straight + Right Turn)

Dimana;

MC = Motor Cycles (unit./jam)

LV = Light Vehicles (unit/hour)

HV = Heavy Vehicles (unit/hour)

UM = Non-Motorized Vehicles (unit/hour)

Calculation Example:

Total PCU (Left Turn) = Σ MC + Σ LV + Σ HV + Σ UM = 1.375 + 44 +13 + 1 = 1.433 unit/hour

Total PCU (Straight) = Σ MC + Σ LV + Σ HV + Σ UM = 10.016 + 744 + 40 + 0 = 10.800 unit/hour

Total PCU (Right Turn) = Σ MC + Σ LV + Σ HV + Σ UM = 85 + 8 + 0 + 0 = 93 unit/hour

Volume = Σ Total PCU (Left Turn + Straight + Right Turn) = 1.433 + 10.800 + 93 = 12.326 unit/hour

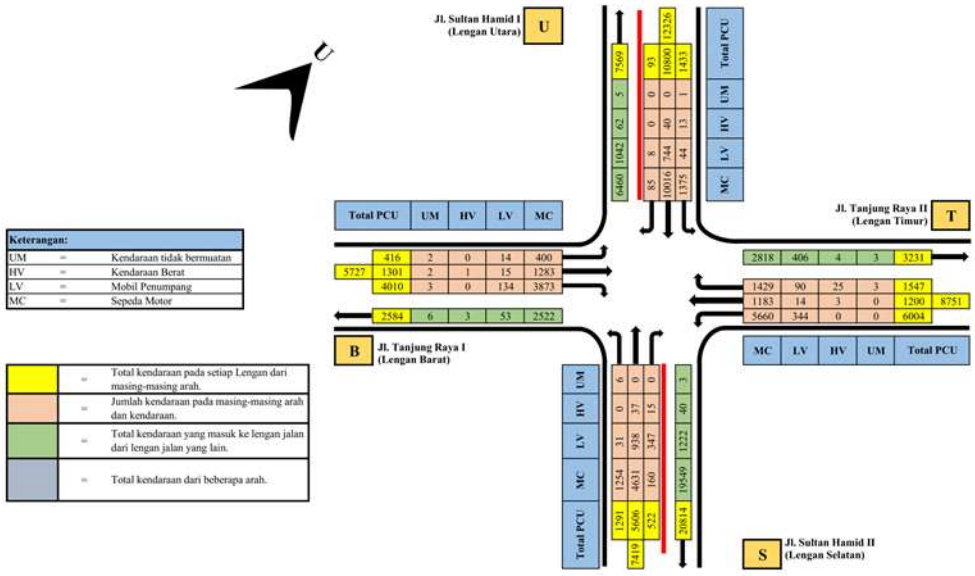

Figure 1. Data Volume Kendaraan

3. Results and Discussions

Modeling Outcome

The modeling results for the original (existing) conditions at the intersection of Jalan Sultan Hamid I, Jalan Tanjung Raya II, Jalan Sultan Hamid II, and Jalan Tanjung Raya I yielded data from the VISSIM 2023 software, with the following averages:

a) Qlen : 206 meter

b) Qlen Max : 507 meter

c) LOS (All) : LOS_F

d) Veh Delay : 105 seconds

First Alternative

The average vehicle queue length (QLen) for each time interval is measured at 206 meters, while the average maximum vehicle queue length (QLen Max) is recorded at 507 meters. Under current conditions, the VISSIM 2023 simulation indicates that the service level at the intersection falls within category "F" (very unstable), with a service level value of 6. The average duration of the queues is approximately 105 seconds. The graphical representation of the relationship between the average queue lengths is illustrated in Figure 4.

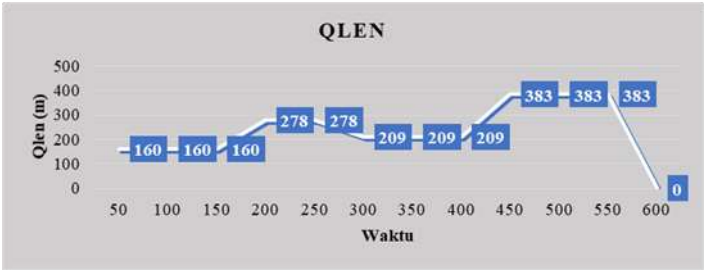

Figure 4. Existing Queue Length (m)

Simulations performed under existing conditions yield data indicating that the majority of service level results fall within LOS_F and LOS_D categories. The overall vehicle delay (VehDelay) is recorded at 105 seconds. These findings suggest that the service level condition is highly unstable, corresponding to Level of Service F. According to Ministerial Regulation No. 96 of 2015. a Level of Service F is characterized by a delay exceeding 60 seconds per vehicle.

Second Alternative

The second alternative or solution involves utilizing an alternative road to alleviate congestion originating from the South arm. The details of this approach are illustrated in the sketch provided in Figure 3.89. In this scenario, traffic direction control will allocate 25% of vehicles traveling south to proceed straight along the alternative road, while another 25% will continue straight on the road at the signalized intersection.

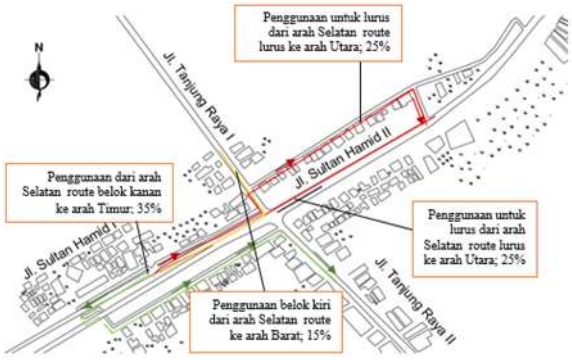

Figure 5. Second Alternative Use of Alternative Roads

The implementation of alternative road arms has resulted in a slight reduction in the speed at the intersection compared to the existing configuration. The results of the third simulation yielded the following average outcomes:

a. Qlen : 222 meter

b. Qlen Max : 505 meter

c. LOS (All) : LOS_F

d. Veh Delay : 62 seconds

The average vehicle queue length (QLen) for each time interval is recorded at 222 meters, while the average maximum vehicle queue length (QLen Max) measures 505 meters. Under alternative condition one, the VISSIM 2023 simulation indicates that the service level at the intersection is categorized as "E" (very poor), with a service level value of 5. in contrast to the existing condition, which is classified as "F" (very unstable). The average queue duration observed is approximately 62 seconds. The graphical representation of the relationship between the average queue lengths is shown in Figure 6.

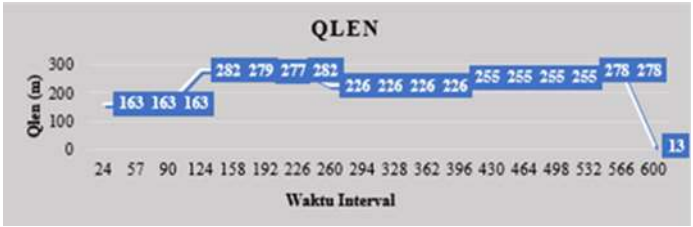

Figure 8. Second Alternative Queue Length

The results of the simulation conducted on the second alternative for the route system arrangement on the southern arm of Jalan Sultan Hamid II indicate a modest improvement, with a service level transitioning from LOS_F to LOS_E based on existing data. The discussion surrounding this second alternative suggests a slight reduction in queue lengths. The overall vehicle delay (VehDelay) is recorded at 62 seconds, reflecting a very poor service

level condition (Level of Service E). According to Ministerial Regulation No. 96 of 2015. Level of Service E is characterized by delays ranging from 40.1 seconds to 60 seconds per vehicle.

4. Conclusion

The primary factors influencing the level of service at the intersection of Jalan Sultan Hamid I, Jalan Tanjung Raya II, Jalan Sultan Hamid II, and Jalan Tanjung Raya I in Pontianak East include geometric conditions, environmental conditions, traffic volume, traffic flow, and road user behavior. The VISSIM 2023 simulation under existing conditions reveals an average vehicle queue length (QLen) of 206 meters and an average maximum vehicle queue length (QLen Max) of 507 meters. The overall vehicle delay (VehDelay) is recorded at 105 seconds, categorizing the level of service as "F" (very unstable) with a value of 6.

In the first alternative route arrangement, which involves directing traffic on the Sultan Hamid II road arm toward Jalan Tanjung Raya II (left turn condition) with 50% using alternative roads and 100% in the direction of Jalan Sultan Hamid I (straight condition), the simulation yields an average vehicle queue length (QLen) of 209 meters and an average maximum vehicle queue length (QLen Max) of 510 meters. The overall vehicle delay (VehDelay) is 101 seconds, resulting in a level of service categorized as "F" (very poor), with a value of 6. identical to the existing condition.

The second alternative route arrangement directs traffic on the Sultan Hamid II road arm toward Jalan Tanjung Raya II (left turn condition) with 35% utilizing alternative roads and 50% in the direction of Jalan Sultan Hamid I (straight condition). This configuration includes 25% of vehicles proceeding straight through the intersection and 25% using the alternative road without passing through the intersection. The simulation produces an average vehicle queue length (QLen) of 222 meters and an average maximum vehicle queue length (QLen Max) of 505 meters. The overall vehicle delay (VehDelay) is recorded at 62 seconds, resulting in a level of service categorized as "E" (very poor) with a value of 5. indicating an improvement of one level from the initial condition.

The second alternative exhibits a queue time of 39 seconds longer than that of the first alternative. According to Ministerial Regulation No. 96 of 2015. Level of Service E is characterized by delays exceeding 40.1 seconds but not exceeding 60 seconds per vehicle.

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