ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

Available online at
https://jurnalteknik.unisla.ac.id/index.php/CVL

https://doi.org/10.30736/cvl.v2i2

Evaluation of Alternative Traffic Engineering Management with the Use of Microscopic Simulation Software Vissim

Setyadi Gunawan[1], Yogi Oktopianto[2*], Tri Susila Hidayati[3]
[1, 2*,3]*Road Transportation System Engineering, Politeknik Keselamatan Transportasi Jalan*
*Corresponding Author: *yogi.oktopianto@pktj.ac.id*

A R T I C L E I N F O

Article History :
Article entry : 07-14-2024
Article revised : 07-16-2024
Article received : 06-08-2024

Keywords :
Intersection, VISSIM, MAPE, GEH, SSAM

IEEE Style in citing this article:
S. Gunawan, Y. Oktopianto, and T. Susila Hidayati, "Evaluation of Alternative Traffic Engineering Management with the Use of Microscopic Simulation Software Vissim", *civilla*, vol. 9, no. 2, pp. 189–200.

A B S T R A C T

The population of Makassar City has grown by 30,965 people in the last year and represents an annual change of 1.89% from 2022. Road growth in Makassar City has only experienced growth of 0.8% - 2% per year, while vehicle growth has reached 15% - 16% per year. Congestion at unsignalized intersections of the A.P Pettarani which is the Central Business District area of Makassar City which has activities ranging from offices, economy and education. The study aims to analyze the performance and existing at the unsignalized intersection A.P Pettarani - Sultan Alauddin Makassar City as well as traffic engineering management with queue length and delay due to u-turn using VISSIM Software. The results of the existing show the current performance with a traffic delay of 30.4 seconds, a queue length of 225 meters with LOS D and traffic conflicts that crossing of 1749 and lane changes of 6264. After the alternative is implemented, the delay and queue time at the A.P Pettarani - Sultan Alauddin Intersection are significantly reduced. The delay time when the existing conditions are at 30.4 seconds drops to 16.61 seconds, the delay time at the intersection drops by 13.79 seconds or 45.36%. As well as a decrease in queue length in the existing condition of 225 m to 151 m with a decrease of 74 meters or 32.89%.

1. Introduction

The population of Makassar City in 2023 is estimated to be 1,673,094 people [1]. The population of Makassar City has grown by 30,965 people in the past year and represents an annual change of 1.89% from 2022[2]. This dynamic demographic condition indicates the need for serious efforts to provide better traffic infrastructure [3]. An increase in population can certainly have implications for traffic density, and Makassar City needs to be able to prioritize road construction, intersection management, and an efficient transportation system [4]. Road growth in Makassar City only grows by 0.8% - 2% per year, while vehicle growth reaches 15% - 16% per year [5]. The issues caused by traffic congestion necessitate ongoing observation of vehicle movement on the road network [6]. The strategy to address this problem is to use traffic management and engineering to improve traffic flow and maximize the use of road and

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

intersection space [7]. This requires a lot of data from traffic surveys to assess and analyze various factors [8].

According to [9] Article 1 Paragraph 24 on Road Traffic and Transportation defines that a traffic accident is an incident on the road that is unexpected and unintentional. Involving vehicles with or without other road users resulting in human casualties and / or property damage [10]. Traffic accidents can be based on several contributing factors such as people, vehicles, roads, and the surrounding environment [11].

Accident data according to [12] shows a significant increase in 2020-2022. In 2020 the number of traffic accident cases in Makassar City was 973 cases, in 2021 it was 1090 cases, and in 2022 it was 1484 cases [13]. There was an increase in accident cases in 2020-2021 [14]. A one-year period has increased accidents in Makassar City by 117 accident cases or as much as 12%, while in 2021-2022 there was a very high increase in the number of traffic accident cases in Makassar City with a difference of 394 or as much as 36.1% [15].

Congestion at unsignalized intersections cannot be separated from the effect of the A.P Pettarani road which is the Central Business District (CBD) area of Makassar City which has various types of community activities ranging from offices, economy, and education [16]. The high movement of vehicle traffic on A.P Pettarani road often causes motorized vehicle users who park their vehicles on the shoulder of the road or on-street and some street vendors who sell their merchandise on the sidewalks around A.P Pettarani [17].

VISSIM software based on traffic simulation is available for civil engineering transportation [18]. Modeling and simulation of transportation systems is becoming increasingly popular due to the ease of switching between different scenarios while still considering the possibilities for use in the field [19]. The PTV VISSIM program facilitates the simulation of actual city traffic, the formulation of effective traffic management plans, and the testing of various intersection constructions [20]. One of the advantages of this software is the ability to simulate transportation conditions in the field with fairly complete parameters by modeling various types of vehicles such as motorcycles and non-motorized vehicles [21]. Simulation models are often used to assess how well new traffic modeling techniques and various traffic facilities work to create effective and sustainable transportation networks [22]. The key to ensuring that the microsimulation model reflects local conditions well is to calibrate and validate it [23]. This study has differences with previous studies on traffic conflicts at the intersection in access to the adjacent u-turn 200 m from the intersection which is below the minimum technical standard. The purpose of this study is to analyze the existing performance of the intersection and appropriate alternative treatments.

2. Research Method

Based on the objectives and problems that exist in this research, it is included in quantitative research. This study aims to analyze the existing performance of three unsignalized intersections. This research was conducted at the case study location of the three unsignalized intersections A.P Pettarani - Sultan Alauddin in Makassar City. Data collection was carried out using field observations. Observation data collection is done by surveying intersection geometry, traffic volume, vehicle speed, traffic conflicts, and driver behavior. after data collection, data processing will be carried out which includes analysis using PKJI 2023, SSAM to determine traffic conflicts, and VISSIM software as a traffic simulator at the intersection.

3. Description and Technical

3.1 Population and Samples

In this study, the sampling technique used the Slovin formula. The Slovin formula has an error tolerance limit with an error rate of 1%, 5%, and 10% which is used to calculate the number of samples that will be affected by the error rate, the greater the number of samples close to the population size, the smaller the error rate, while the smaller the number of samples,

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

the greater the chance of error. As a result, the tolerance limit used in the study was 5% for the sample of vehicles in the existing speed survey.

$$n = \frac{N}{1+N(e)^2} \quad (1)$$

Description: n: Many Samples; N = Population Size; e = Error Tolerance

3.2 Sampling Techniques

Vehicle Speed Sample Technique with Time-Distance Calculation Method. The Time-Distance Calculation method is a simple and effective way to measure vehicle speed. The basic principle of this method is to measure the time required by the vehicle to cover a certain distance. The following are the steps:

a. Determine the known distance: Determination of two fixed and measured distance points (50 m).
b. Timing device preparation: Timing device using a stopwatch or Spot Speed App.
c. Measurement: When the vehicle passes the starting point (Point A) the time measurement starts until the vehicle passes the end point (Point B).

3.3 Instrument Analysis Tool

Intersection geometric data and traffic volume are analyzed using PKJI 2023, PKJI 2023 is a guideline for analyzing the degree of saturation at the intersection to determine the level of service of the intersection. Calculation of speed based on sampling techniques using the Slovin Method to determine the 85% percentile of the type of vehicle passing through the intersection. Data that has been analyzed using PKJI 2023, data input is carried out in the VISSIM Software to carry out the running process with adjustments to vehicle speed and driver behavior. The results of the VISSIM Software running are then validated using GEH & MAPE to get the most optimal running. The most optimal VISSIM Software running results are processed using SSAM to analyze the level of traffic conflicts that exist in existing conditions and alternatives.

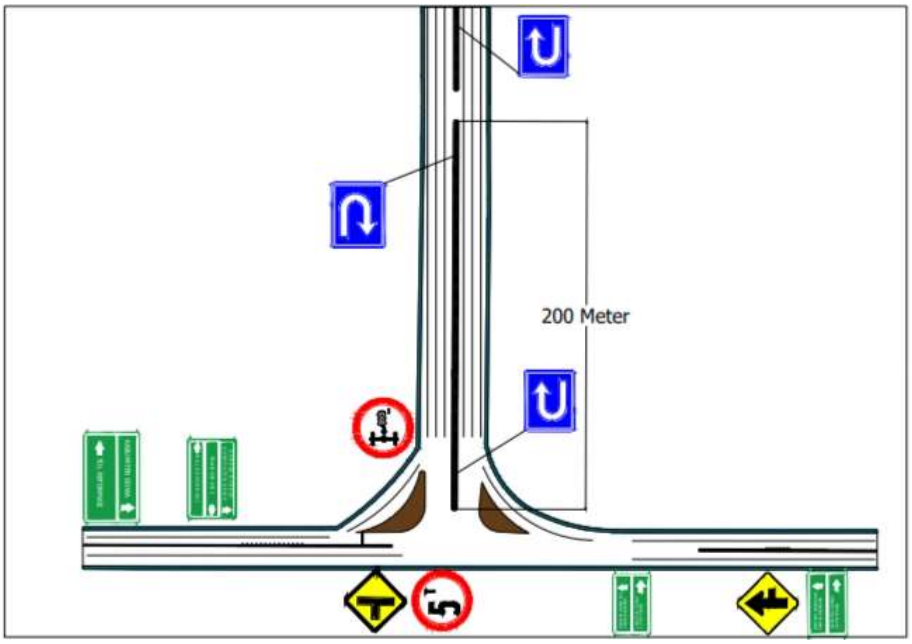
3.4 Data Analysis Techniques

a. Intersection Geometrics: Data analysis is carried out by taking notes related to the data obtained by the intersection inventory survey. Furthermore, it can be processed and displayed in visual form using AutoCAD.
b. Vehicle Speed Analysis: Field data in meters per second was converted to kilometers per hour through conversion and 85% Percentile speed search by classifying each vehicle type using Microsoft Excel.
c. Queue Length and Delay Time: Queue length can be calculated directly in the field by observing the length of the queue generated by vehicles passing through the intersection. Delay time can be calculated by observing how long it takes for vehicles to pass through the intersection.
~~d.~~ Driving Behavior: Driver behavior that occurs directly while driving is referred to as driver behavior. Since the driving behavior in each place is very different, a behavioral study was conducted to calibrate the parameters before modeling to obtain more accurate results [24]. Every driver-behavior model has pre-defined parameters that allow users to enter values within a range determined by the current traffic conditions in their area [25].
e. Microscopic Simulation Software Vissim: This stage begins with creating an existing model by doing calibration and validation to match the actual conditions. If the model is valid, it will be continued with the analysis of alternative traffic engineering management of the intersection conditions.

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

4. Results and Discussions

4.1 Geometrics Data



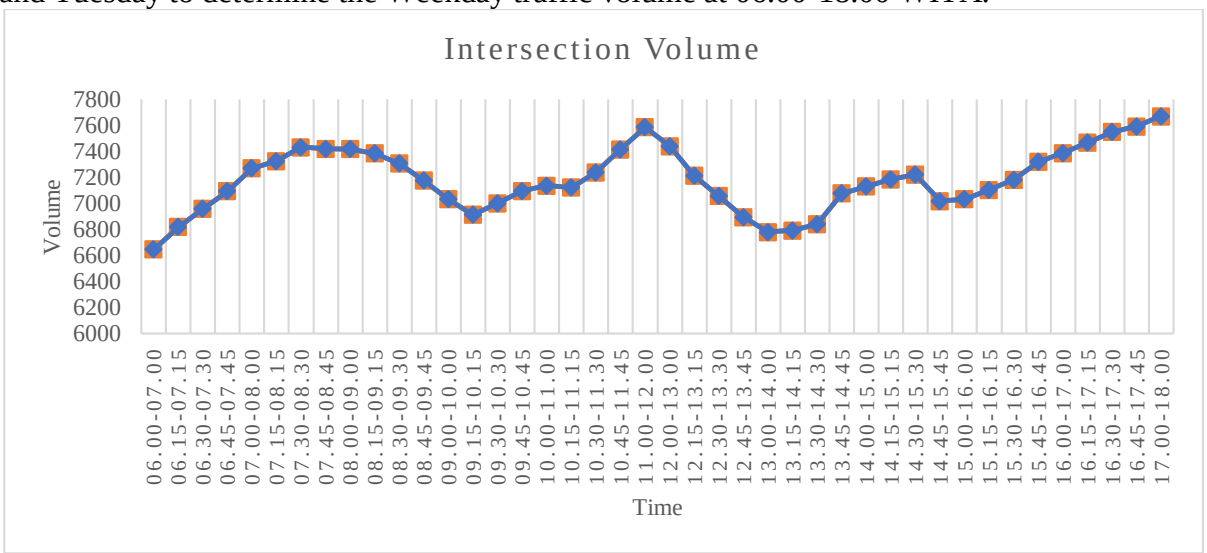
Source: Research Data (2024)

Figure 1. Intersection Geometrics

Major Road Width (north approach lane width of 31 meters). Minor Road Width (west approach lane width of 14.95 meters and east approach lane width of 15.6 meters). The pavement condition is made of Flexible Pavement in good condition. Separating the direction of the minor road from the major in the form of road markings in the form of dotted lines.

4.2 Traffic Volume

Traffic volume can be calculated in 15 minutes from each arm entering the intersection. The calculation of traffic volume is calculated by counting the number of vehicles passing through the intersection area. The division of vehicle classes is divided according to the Indonesian Road Capacity Guidelines (PKJI) 2023, namely Motorcycles (SM), Passenger Cars (MP), Medium Vehicles (KS), Large Buses (BB), and Large Trucks (TB). The survey was conducted on Saturday and Sunday to determine the Weekend traffic volume and on Monday and Tuesday to determine the Weekday traffic volume at 06.00-18.00 WITA.



Source: Research Data (2024)

Figure 2. Tuesday Intersection Volume Diagram

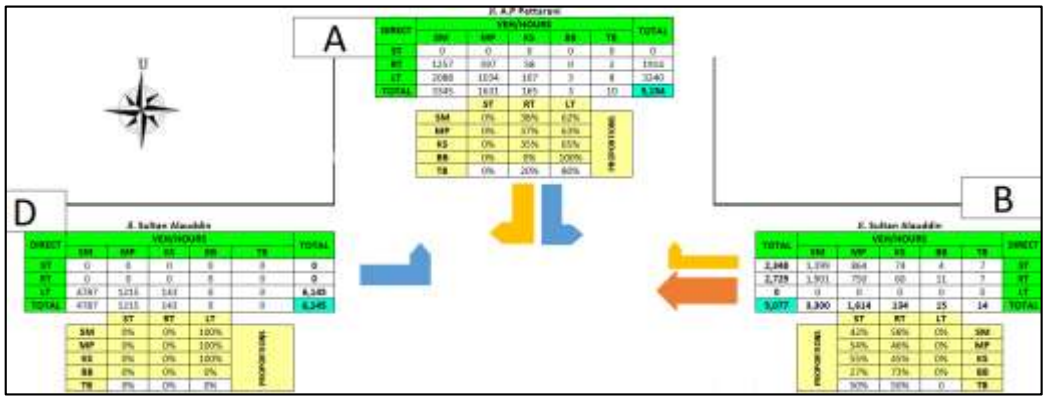
ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

Table 1. Peak Hour Intersection Traffic Volume.

Vehicle Type	East		West		North		Total	
	Veh/ Hours	PCE/ Hours	Veh/ Hours	PCE/ Hours	Veh/ Hours	PCE/ Hours	Veh/ Hours	PCE/ Hours
SM	3300	660	4787	957	3345	669	11432	4962
MP	1614	1614	1215	1215	1631	1631	4460	4460
KS	134	241	143	257	165	297	442	795
BB	15	27	0	0	3	5	18	32
TB	14	25	0	0	10	18	24	43
Total	5077	2567	6145	2430	5154	2620	16376	7617

Source: Research Data (2024)

The number of vehicles crossing the intersection is highest on the west leg of the intersection with 6145 vehicles, the traffic volume on the north leg of the intersection with 5154 volumes, while for the east leg of the intersection traffic volume with 5077. During peak hours, 16376 vehicles crossing the A.P Pettarani – Sultan Alauddin Unsignalized Triple Intersection, Makassar City. The direction of vehicle movement on each approach to the intersection for each type of vehicle is shown in the following Cartograph diagram:



Source: Research Data (2024)

Figure 3. Cartograph Diagram Tuesday

4.3 Calibration of Driving Behavior

Table 2. Calibration of Driving Behavior.

Parameter	Period		
	Default	Reference	Calibration
Average Standstill Distance	2	0.6	0.5
Additive Part of Safety Distance	2	0.5	0.5
Multiplicative Part of Safety Distance	3	1	1
Standstill Distance for Static Obstacles	0.5	-	0.2
Desired Lateral Position	Middle of Lane	Any	Any
Lateral Distance Driving	1	0.2	0.1
Lateral Distance Standing	1	0.5	0.3
Lane Change Rule	Slow Lane Rule	Free Lane	Free Lane
Observe Adjacent Lane	Truk	-	Yes
Consider Next Turn	Truk	-	Yes
Waiting Time Before Diffusion	60	-	180
Motorcycle	0.2 and 1	-	0.1 and 0.3
Car	0.2 and 1	-	0.3 and 0.4
Medium Vehicle	0.2 and 1	-	0.3 and 0.4
Big Bus	0.2 and 1	-	0.4 and 0.7
Big Truck	0.2 and 1	-	0.4 and 0.7
Minimum Clearance	0.5	0.5	0.2

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

Source: Research Data (2024)

4.4 Validation GEH and MAPE

Table 3. GEH Test Calibration Results Traffic Volume.

Destination	Vehicle Volume		GEH	
	Observation	VISSIM	Results	Description
Sultan Alauddin (West)	6145	6140	0.07%	Accepted
A.P Pettarani	5858	5824	0.45%	Accepted
Sultan Alauddin (East)	5077	5064	0.18%	Accepted
Average	5693	5676	0.23%	Accepted

Source: Research Data (2024)

The results of the GEH validation test for the intersection modeling simulated using VISSIM on each approach to the intersection resulted in a value of ≤ 5. Thus, the modeling is considered valid and acceptable if it gets a value of ≤ 5.

Table 4. MAPE Validation Test Results Queue Length.

Destination	Queue Length (m)		MAPE	
	Observation	VISSIM	Results	Description
Sultan Alauddin (West)	60	55	9.05%	Accepted
A.P Pettarani	165	180	8.09%	Accepted
Sultan Alauddin (East)	400	442	9.05%	Accepted
Average	208	225	8.86%	Accepted

Source: Research Data (2024)

The results of the MAPE validation test using the queue length at the foot of the intersection simulated using VISSIM show a value of less than 10%, these results are considered valid and accepted with the description of the modeling capability is very good.

Table 5. MAPE Validation Test Results Delay Length.

Intersection A.P Pettarani – Sultan Alauddin	Delay Length (s)		MAPE		Level of Service (LOS)
	Observation	VISSIM	Results	Description	
	29	30.4	4.6 %	Accepted	D

Source: Research Data (2024).

The results of the MAPE Delay validation test simulated using VISSIM show a result value of 4.6% having a very good modeling capability description. The results of the length of delay at the A.P Pettarani – Sultan Alauddin intersection were obtained at 29 seconds with a Level of Service (LOS) value based on the Highway Capacity Manual (2001) getting D with a vehicle flow that began to be unstable and low speed.

4.5 Alternative

The following are some alternatives that can be given as a result of the analysis of the three unsignalized intersections A.P Pettarani – Sultan Alauddin by the Short Term and Long Term Alternatives.

4.5.1 Addition of U-Turn Spacing

According to the Minister of PUPR of the Republic of Indonesia, Number 5 of 2023 concerning Road Technical Requirements and Road Technical Planning states that the distance between the closest lane separation openings on arterial roads is at least 1 KM and on collector roads at least 0.5 KM. With the existing conditions, the distance between the opening of the separation lane and the intersection is at a distance of 200 m, therefore it is necessary to have

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

an alternative that involves moving or increasing the U-Turn distance by adjusting field conditions by 300 meters to 500 meters from the intersection on the arterial road function.

Source: Research Data (2024)

Figure 4. West Intersection Alternative

Table 6. Results Performance of Alternative Intersection.

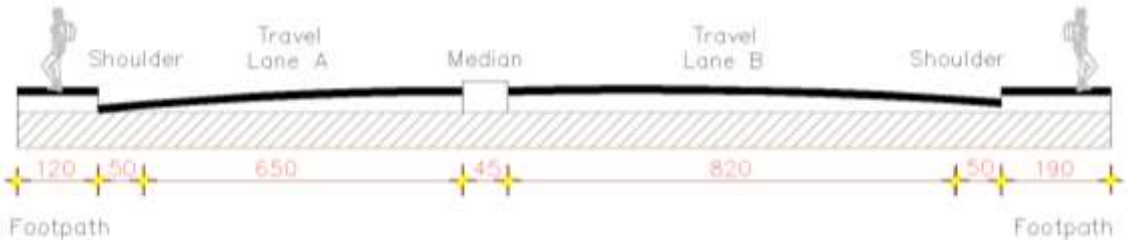
Intersection	VISSIM		Level of	Traffic Conflicts	
A.P Pettarani –	Queue (m)	Delay (s)	Service (LOS)	Lane Change	Crossing
Sultan Alauddin	189	17.58	C	4810	1650

Source: Research Data (2024)

The results of the alternative performance of the intersection in traffic conditions when after the additional u-turn distance is applied with a traffic delay of 17.58 seconds and a queue length of 189 m with LOS (Level of Service) level C. At the intersection, there are traffic conflicts that intersect (crossing) 1650 and lane changes of 4810.

Per the Minister of PUPR Republic of Indonesia Number 5 of 2023 concerning Road Technical Requirements and Road Technical Planning to 500 meters. The delay time when the existing conditions are at 30.4 seconds drops to 17.58 seconds, the delay time at the intersection drops by 12.82 seconds or 42.17% at the intersection. As well as a decrease in queue length in the existing condition of 225 m to 189 m with a decrease of 36 meters or 16% at the intersection.

4.5.2 Addition of U-Turn Spacing and Widening of Intersection Approaches

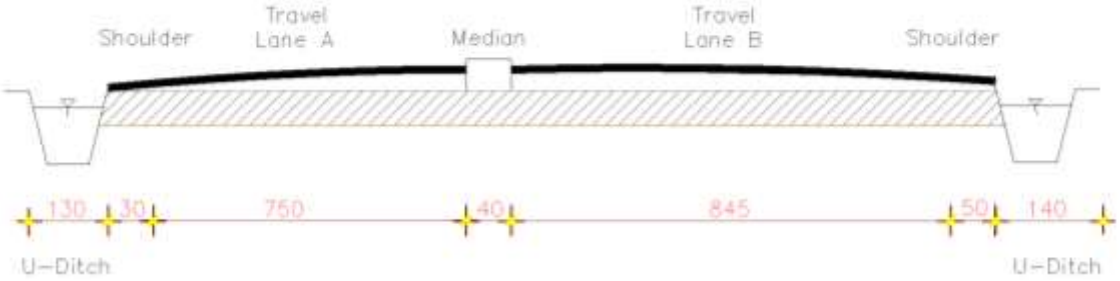


Source: Research Data (2024)

Figure 5. West Intersection Alternative

Widening the approach to the western intersection by reducing the width value of the road shoulder with a minimum value of 50 cm, so there is an increase in Lane A by 30 cm and Lane B by 70 cm.

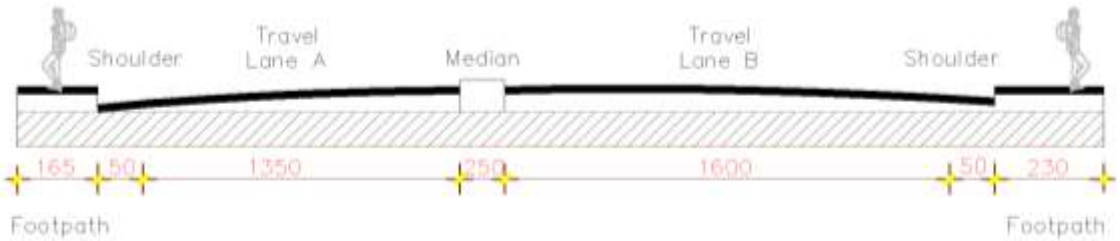
ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399



Source: Research Data (2024)

Figure 6. East Intersection Alternative

Widening the approach to the eastern intersection by reducing the width value on the shoulder with a minimum value of 50 cm, so there is an addition to Lane A by 50 cm and Lane B by 125 cm.



Source: Research Data (2024).

Figure 7. North Intersection Alternative.

Widening the approach to the north intersection by reducing the width value of the road shoulder with a minimum value of 50 cm, so there is an addition to Lane A by 100 cm and Lane B by 80 cm.

Table 7. Results Performance of Alternative Intersection.

Intersection	VISSIM		Level of	Traffic Conflicts	
A.P Pettarani – Sultan	Queue (m)	Delay (s)	Service (LOS)	Lane Change	Crossing
Alauddin	151	16.61	C	5290	1875

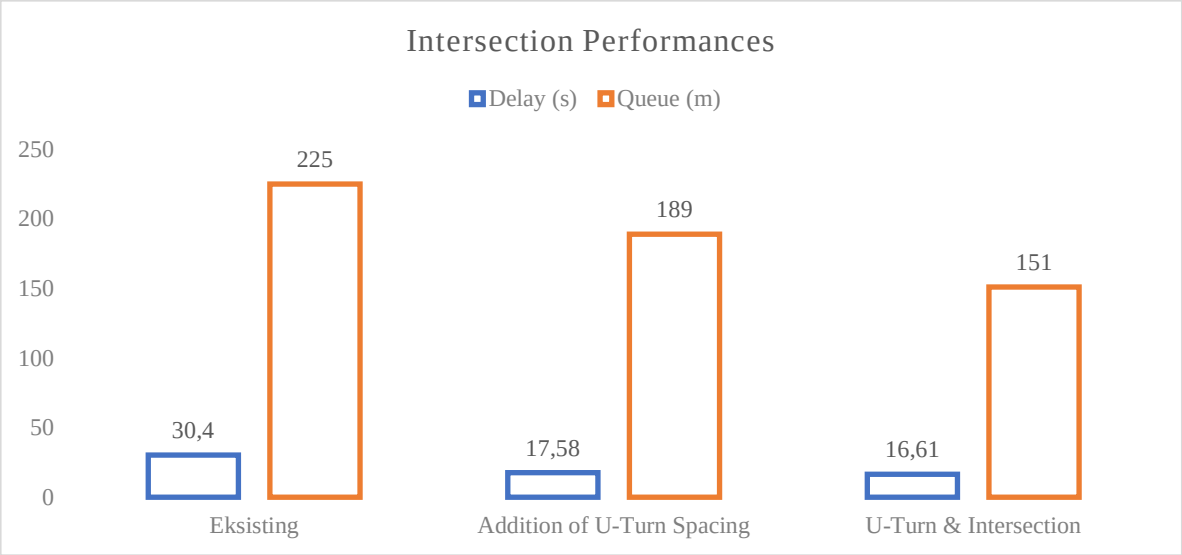
Source: Research Data (2024)

The results of the alternative performance of the intersection in traffic conditions when after implementing the addition of u-turn distance and widening the intersection approach with a traffic delay of 16.61 seconds and a queue length of 151 m with LOS (Level of Service) level C. At the intersection, there are traffic conflicts that intersect (crossing) 1875 and lane changes of 5290.

Under the Minister of PUPR Republic of Indonesia Number 5 of 2023 concerning Road Technical Requirements and Road Technical Planning to 500 meters and according to Law No. 38 of 2004 concerning Road Width. The delay time when the existing conditions are at 30.4 seconds drops to 16.61 seconds, and the delay time at the intersection drops by 13.79 seconds or 45.36% at the intersection. As well as a decrease in queue length in the existing condition of 225 m to 151 m with a decrease of 74 meters or 32.89% at the intersection.

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

4.6 Alternative Discussion



Source: Research Data (2024).

Figure 8. Recapitulation of Alternative Intersection Performances.

To address the traffic problems at the A.P Pettarani-Sultan Alauddin intersection, Makassar City, the following 2 alternatives have been evaluated. The following alternatives are based on the intersection performance results:

4.6.1 Short Term Alternative

The selection of alternative 1 at the A.P Pettarani - Sultan Alauddin intersection involves the removal of u-turns, this alternative can provide the best solution to overcoming traffic problems in the area. With a delay of 17.58 seconds and a queue of 189 meters, as well as a reduction in traffic conflicts of lane changes of 4810 and crossing of 1650 with an intersection level of service C.

4.6.2 Long Term Alternative

The selection of alternative 2 at the A.P Pettarani - Sultan Alauddin intersection, which involves adding width to each leg of the intersection and moving the u-turn which requires time and cost to make geometry changes, this alternative can provide the best solution in overcoming traffic problems in the area. With a delay of 16.61 seconds and a queue of 151 meters, as well as a reduction in traffic conflicts of 5290 lane changes and 1875 crossings with an intersection service level of C.

5. Conclusion and Suggestion

5.1 Conclusion

This research concludes that alternatives are chosen to be able to overcome traffic problems at the A.P Pettarani - Sultan Alauddin intersection with short-term and long-term recommendations based on the results of alternative intersection performance and improve traffic performance. This choice is based on the SE Minister of PUPR Republic of Indonesia Number 5 of 2023 concerning Road Engineering Requirements and Road Technical Planning and according to Law No. 38 of 2004 concerning Road Width with Entry Control. The selection of alternatives at the A.P Pettarani - Sultan Alauddin intersection involves widening the approach to the foot of the intersection and increasing the distance of the u-turn. With the results of a delay of 16.61 seconds and a queue of 151 meters, as well as a reduction in lane change conflicts of 5290 and crossing of 1875 with an intersection level of service C. Taking the lowest delay as the optimal objective as has been done in research [26]. After the alternative is implemented, the delay and queue time at the A.P Pettarani - Sultan Alauddin Intersection are

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

significantly reduced. The delay time when the existing conditions are at 30.4 seconds drops to 16.61 seconds, and the delay time at the intersection drops by 13.79 seconds or 45.36%. As well as a decrease in queue length in the existing condition of 225 m to 151 m with a decrease of 74 meters or 32.89%.

5.2 Suggestion

Suggestions obtained from this research are addressed to the government or related agencies to implement alternative proposals by short-term or long-term recommendations, namely by increasing the distance between the opening of the separation lane from the approach to the intersection and increasing the width at the foot of the intersection. In this study, it is still necessary to conduct comparative research to find out the results of the optimal alternative proposal.

References

[1] Badan Pusat Statistik Kota Makassar, "Badan Pusat Statistik Kota Makassar," BPS KOTA MAKASSAR. [Online]. Available: https://makassarkota.bps.go.id/

[2] N. I. Tutu, "Analisis Pola Pertumbuhan Ekonomi dan Pengaruh Penduduk Terhadap Pendapatan Asli Daerah di Kota Makassar," *Jurnal Linears*, vol. 5, no. 2, pp. 87–96, 2022, doi: 10.26618/j-linears.v5i2.8503.

[3] I. M. Suraharta, N. P. W. Andreyani, and I. Hardiansyah, "Manajemen dan rekayasa lalu lintas pada hari pasar di pasar koto baru kabupaten tanah datar," pp. 52–62.

[4] A. Sahri, E. Purwanto, and A. Budiharjo, "Kajian Manajemen Lalu Lintas Kawasan Central Business District (CBD) di Kota Tegal," vol. 8, no. 1, pp. 38–52, 2021, doi: 10.46447/ktj.v8i1.291.

[5] H. Halim, "Analisis Deskriptif Kecelakaan Sepeda Motor," no. October, pp. 11–13, 2016.

[6] M. M. Bandi and V. George, "Microsimulation Modelling in VISSIM on Short-term and Long-term Improvements for Mangalore City Road Network," in *Transportation Research Procedia*, 2020. doi: 10.1016/j.trpro.2020.08.243.

[7] S. Hadi, S. A. R. Hanida, and R. Aprianto, "JURMATEKS Peningkatan Kinerja Simpang Ciceri , Kota Serang dengan Model," vol. 7, pp. 1–13, 2024, doi: 10.30737/jurmateks.v7i1.5619.

[8] K. Jepriadi, "Kalibrasi dan Validasi Model Vissim untuk Mikrosimulasi Lalu Lintas pada Ruas Jalan Tol dengan Lajur Khusus Angkutan Umum (LKAU)," vol. 9, no. 2, pp. 110–118, 2022, doi: 10.46447/ktj.v9i2.439.

[9] T. L. Undang-Undang No.22, "UU 22 Th 2009," *JDIH Kementerian Perhubungan*, vol. 5, no. August. pp. 12–42, 2009.

[10] Y. Oktopianto, R. P. Marwanto, and R. Rukman, "Pemodelan Kondisi Geometrik Jalan Terhadap Potensi Kecelakaan Lalu Lintas," *Borneo Engineering : Jurnal Teknik Sipil*, vol. 7, no. 3, pp. 352–362, 2023, doi: 10.35334/be.v7i3.4671.

[11] P. Rusmandani, E. P. Anggana, and A. Sasmito, "Mikrosimulasi Kinerja Simpang Bersinyal Dengan Menggunakan Software Surrogate Safety Assessment Model (Ssam) Di Kota Malang (Studi Kasus : Simpang Terusan Sulfat)," vol. l, no. 2, pp. 120–128, 2020.

[12] P. K. Makassar, "Kepolisian Negara Republik Indonesia." Kota Makassar, 2023.

[13] Wahab. Syahrir, *Kota Makassar Dalam Angka 2023*. Kota Makassar, 2023.

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

[14] Y. Oktopianto, W. Y. Hastuti, and R. Phahlevi Marwanto, "Traffic Accident Cost Analysis Using The Gross Output (Human Capital) Method Approach," *Civilla : Jurnal Teknik Sipil Universitas Islam Lamongan*, vol. 9, no. 1, pp. 1–10, 2024, doi: 10.30736/cvl.v9i1.1169.

[15] H. A. Apriawal, "Tugas akhir evaluasi kinerja simpang tiga tak bersinyal di kota makassar," 2019.

[16] Bucek, "Pertigaan Jalan Sultan Alauddin - AP Pettarani Macet Parah," Celebes Media. [Online]. Available: https://celebesmedia.id/celebes/artikel/1009050322/pertigaan-jalan-sultan-alauddin-ap-pettarani-macet-parah

[17] S. Hadi and R. P. Marwanto, "Penataan Pedagang Kaki Lima, Arus Lalu Lintas Dan," pp. 75–88, 2018.

[18] A. Budiharjo *et al.*, "Dampak Junction Metering dalam Meningkatkan Kinerja Simpang Menggunakan Piranti Lunak Vissim," vol. 27, no. 2, pp. 187–194, 2021.

[19] N. S. Kusumastutie, P. Rusmandani, and M. K. Pradana, "SIMULASI PENERAPAN CHICANE DENGAN MENGGUNAKAN," vol. 7, no. 1, pp. 26–39, 2020.

[20] T. Kučera and J. Chocholáč, "Design of the city logistics simulation model using PTV VISSIM software," in *Transportation Research Procedia*, 2021. doi: 10.1016/j.trpro.2021.02.033.

[21] M. W. Indryady, "Evaluasi Simpang Tidak Bersinyal Dengan Penggunaan Software Vissim (Studi Kasus Simpang Tiga Monumen Emmy Saelan)," 2023.

[22] J. Fabianova, P. Michalik, J. Janekova, and M. Fabian, "Design and evaluation of a new intersection model to minimize congestions using VISSIM software," vol. 10, no. 1, pp. 48–56, 2020, doi: doi:10.1515/eng-2020-0019.

[23] M. A. R. Abdeen, S. Farrag, M. Benaida, T. Sheltami, and Y. El-Hansali, "VISSIM calibration and validation of urban traffic: a case study Al-Madinah City," *Personal and Ubiquitous Computing*, vol. 27, no. 5, pp. 1747–1756, 2023, doi: 10.1007/s00779-023-01738-9.

[24] D. Lin, X. Yang, and C. Gao, "VISSIM-based Simulation Analysis on Road Network of CBD in Beijing, China," *Procedia Soc Behav Sci*, vol. 96, 2013, doi: 10.1016/j.sbspro.2013.08.054.

[25] H. Al-Msari, S. Koting, A. N. Ahmed, and A. El-shafie, "Review of driving-behaviour simulation: VISSIM and artificial intelligence approach," *Heliyon*, vol. 10, no. 4, 2024, doi: 10.1016/j.heliyon.2024.e25936.

[26] M. Yun and J. Ji, "Delay Analysis of Stop Sign Intersection and Yield Sign Intersection based on VISSIM," *Procedia Soc Behav Sci*, vol. 96, 2013, doi: 10.1016/j.sbspro.2013.08.228.

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

This page is intentionally left blank