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Study of Signalized Intersection on Prof. Moh Yamin Road – Dr. Abdurrahman Saleh Road with PKJI Method and Vissim Software

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Abstract: Traffic congestion frequently occurs at intersections due to conflicting vehicle movements from each approach. One such location in the city of Palu is the intersection of Jalan Prof. Moh Yamin and Jalan DR. Abdurrahman Saleh, which experiences high traffic volumes, particularly during peak hours. Its proximity to public facilities and direct access to the airport contribute significantly to traffic intensity. This study evaluates the operational performance of the intersection using the PKJI 2023 method and microscopic simulation with VISSIM. The parameters analysed include queue length, delay, and level of service. Results from the PKJI indicate that all approaches operate at level of service F. In contrast, the VISSIM simulation yields results that better reflect actual conditions. Three improvement scenarios were assessed: signal timing optimisation, road widening and modal shift to private vehicles. The scenario involving a modal shift from private vehicles to public transport produced the most substantial improvement, reducing delays and queues while elevating the level of service to between B and D across the approaches.

Keywords: *Signalized Intersection, PKJI 2023, VISSIM, Queue Length, Delay.*

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I. INTRODUCTION

Transportation is one of the important infrastructures that is needed to support all community activities. Transportation problems that occur in urban areas due to the lack of public transportation have caused private vehicle users to increase, resulting in integration between road capacity and traffic volume which causes congestion. Congestion often occurs at intersections, due to conflicting movements between vehicles coming from each leg of the intersection. One of the intersections in Palu City that often experiences congestion is the intersection of Jalan Prof. Moh Yamin - Jalan DR. Abdurrahman Saleh. The movement of vehicles at this intersection is very high, especially during rush hour, because this intersection is close to several public facilities such as offices, hotels, shopping centers, restaurants and is a route to Mutiara Sis Aljufri Palu Airport, so that it attracts a lot of traffic activity that greatly affects the smooth flow of traffic and the performance of road sections at this intersection.

Based on this background, it is necessary to evaluate the performance of the intersection in order to obtain the current performance conditions of the intersection. This study used the 2023 PKJI analysis and traffic simulation using Vissim software. The purpose of the study was to determine the performance of the intersection and determine alternative solutions to problems at the intersection of Jalan Prof. Moh Yamin – Jalan DR. Abdurrahman Saleh in Palu City.

II. METHOD

The data analysis in this study is based on two different references: the Indonesian Highway Capacity Guidelines (PKJI), which is used to process the results of traffic survey data, and the PTV Vissim software, which serves as a traffic simulation modeling tool that produces 2D or 3D animations.

➢ *Analisys PKJI (2023)*

Performance analysis of the signalized intersection of Jalan Prof. Moh Yamin – Jalan DR. Abdurrahman Saleh includes:

- *Saturated Flow (J)*

$J = J_0 \times F_{HS} \times F_{UK} \times F_G \times F_P \times F_{BKi} \times F_{BKa}$

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Description:
- ✓ J = Saturated flow (smp/hour)
- ✓ J_0 = Basic saturated flow (smp/hour)
- ✓ F_{HS} = Correction factor J0 due to side obstacles
- ✓ F_{UK} = Correction factor J0 related to city size
- ✓ F_G = Correction factor J0 due to longitudinal slope of the approach
- ✓ F_P = Correction factor J0 due to the distance of the stop line at the mouth of the approach
- ✓ to the first parked vehicle
- ✓ F_{BKa} = Correction factor J0 due to traffic flow turning to the right
- ✓ F_{BKi} = Correction factor J0 due to traffic flow turning to the left

- *Capacity (C)*

$$C = J \times \frac{WH}{s}$$

Description:
- ✓ C = Capacity of APILL intersection (smp/hour)
- ✓ J = Saturated flow (smp/hour)
- ✓ WH = Total green time in one cycle (seconds)
- ✓ s = Cycle time (seconds)

- *Degree of Saturation (DJ)*

$$D_J = q/C$$

Description:
- ✓ D_J = Degree of saturation
- ✓ q = Traffic volume, smp/hour
- ✓ C = Capacity smp/hour

- *Queue Length ((PA)*

$$N_q = N_{q1} + N_{q2}$$

Description:
- ✓ N_q = Average number of vehicles in queue (smp) at the start of the green signal
- ✓ N_{q1} = Number of queues (smp) remaining from the previous green phase
- ✓ N_{q2} = Number of queues (smp) arriving during the red phase

If $D_J \leq 5$; then $N_{q1} = 0$ and If $D_J > 5$; then N_{q1}:

$$N_{q1} = 0.25 \times s \times \left[(Dj - 1) - \sqrt{(Dj-1)^2 + \frac{8x(DJ-0,5)}{S}}\right]$$

$$N_{q2} = s \times \left[\frac{1-RH}{1-RH \times DJ} \times \frac{q}{3600}\right]$$

- *Queue length (PA)*

$$PA = \frac{Nq \times 20}{LM}$$

Description :
- ✓ PA = Queue length
- ✓ N_q = Number of queues
- ✓ L_M = Entry width

- *Average traffic delay (T_{LL})*

$$T_{LL} = s \times \frac{0,5x(1-RH)^2}{(1-RHxDJ)} + \frac{NQ1x3600}{C}$$

Description :
- ✓ TL = Average traffic delay (seconds)
- ✓ S = Adjusted cycle time (seconds)
- ✓ RH = Green ratio (g/c)

➢ *Vissim Software*

The modeling process of the Prof. Moh. Yamin road Intersection – DR. Abdurrahman Saleh road is summarized in Figure 1 below:

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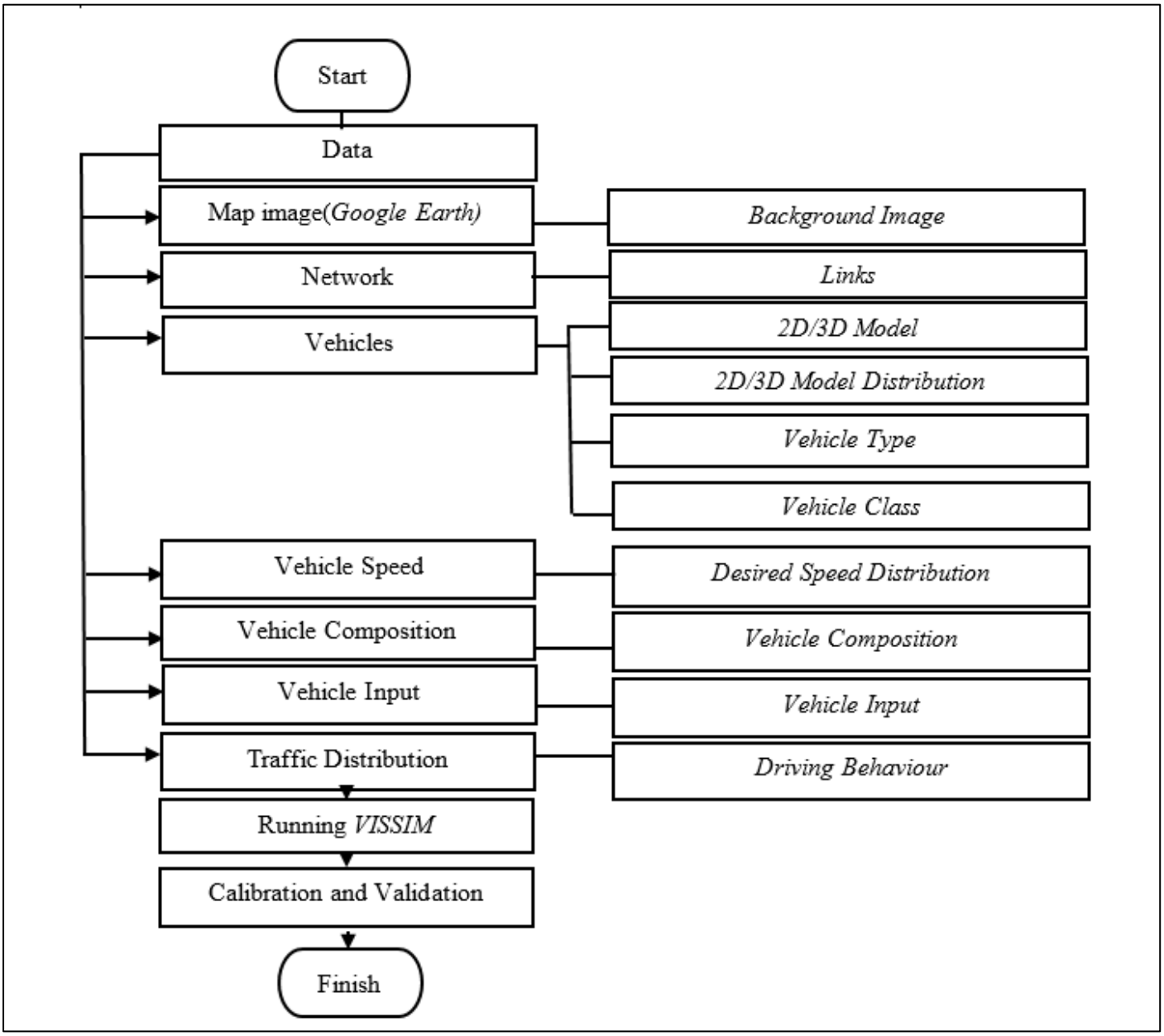

Fig 1 Research Flowchart

III. RESULT AND DISCUSSION

➢ *Geometric Characteristics of Intersections*

The intersection of Prof. Moh Yamin Street – Dr. Abdurrahman Saleh Street is an APILL intersection with 4 (four) intersection legs located in Palu City.

Table 1 Characteristics of the Intersection Oo Prof. Moh Yamin Road - DR. Abdurrahman Saleh Road

No	Description	Characteristics	Information	
1	Intersection Type	424		
2	Approach Width U	13 m	Prof Moh. Yamin Street	Provincial Road
3	Approach Width S	11 m	Dewi Sartika Street	
4	Approach Width B	14 m	Basuki Rahmat Street	National Road
5	Approach Width T	14 m	DR. Abdurrahman Saleh Street	
6	Land Use Around Intersection	Office, Education and Trade		

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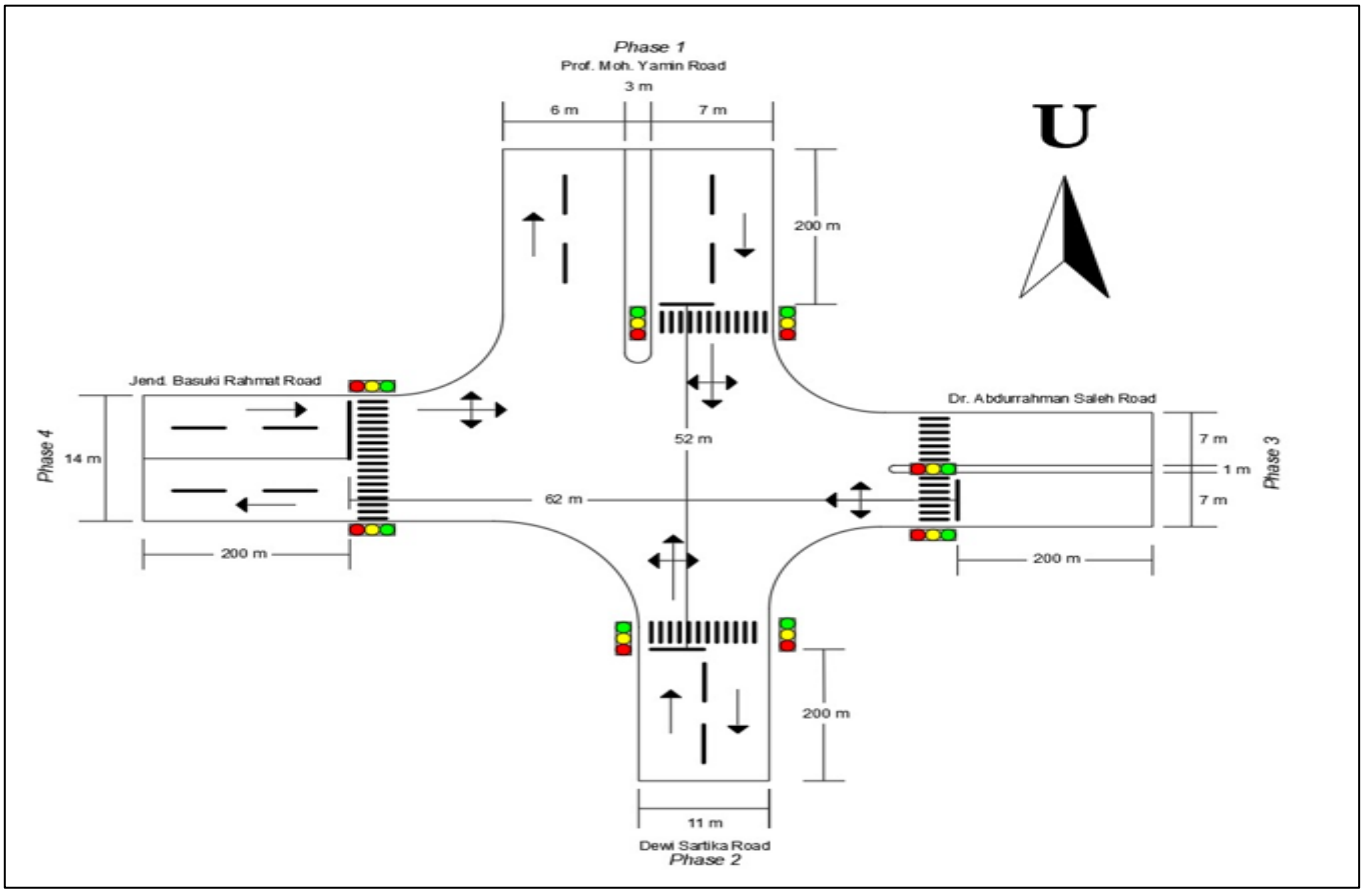

Fig 2 Geometric Intersection of Prof. Moh Yamin Road – DR. Abdurrahman Saleh Road

➢ *Cycle Time*

The intersection of Prof. Moh. Yamin Street – DR. Abdurrahman Saleh Street uses a 4-phase system arrangement, namely phase 1 of the intersection arm of Prof. Moh. Yamin Street, phase 2 of the intersection arm of Dewi Sartika Street, phase 3 of the intersection arm of DR. Abdurrahman Saleh Street and phase 4 of the intersection arm of Basuki Rahmat Street.

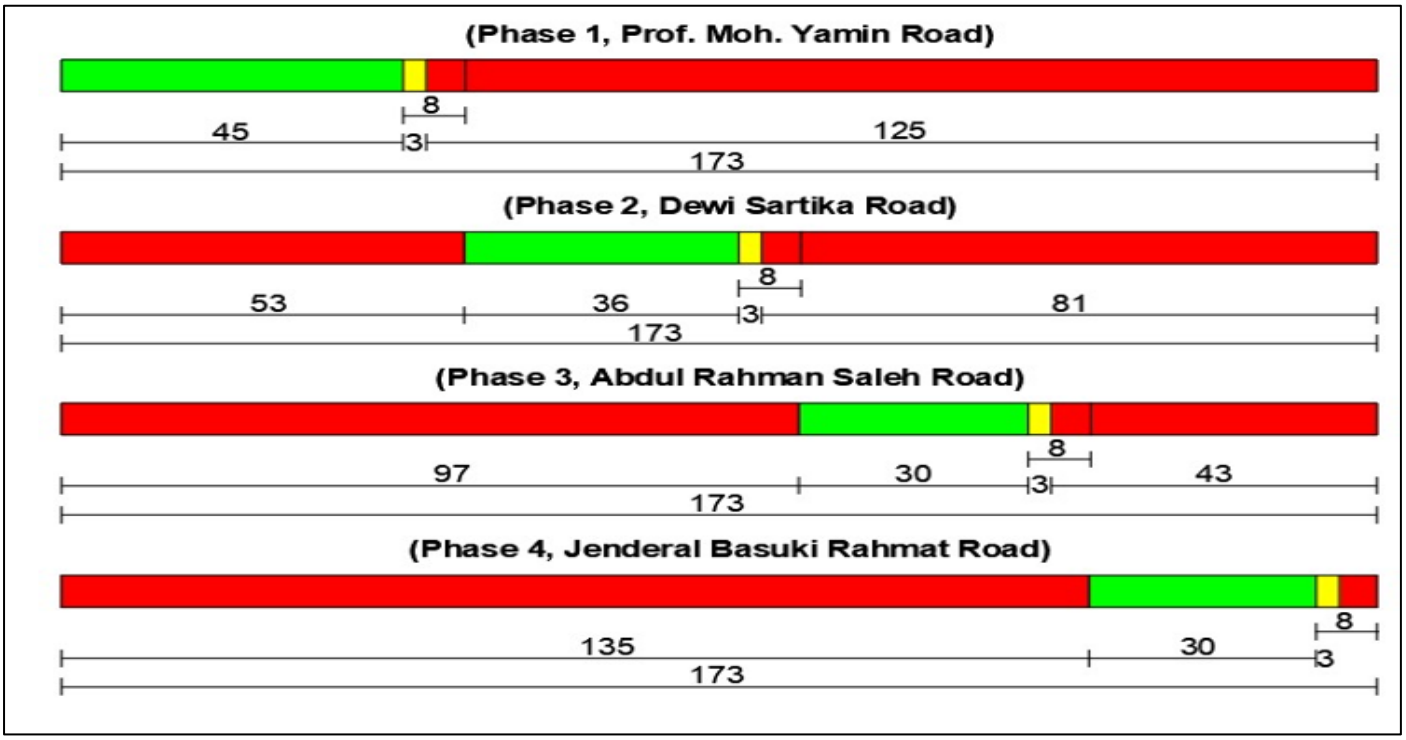

Fig 3 Cycle Time Phase Diagram

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➢ *Traffic Flow Volume*

Traffic volume data was obtained from direct observations in the field. The survey was conducted on Tuesday, September 24, 2024 using CCTV camera recordings. Traffic flow volume data collection was carried out during peak hours of the time period, namely in the morning at 06.00 - 08.00 WITA, during the day at 11.00 - 13.00 WITA and in the evening at 16.00 - 18.00 WITA. For analysis using PKJI 2023, survey data in the form of vehicle units per hour were converted into passenger car units (smp/hour).

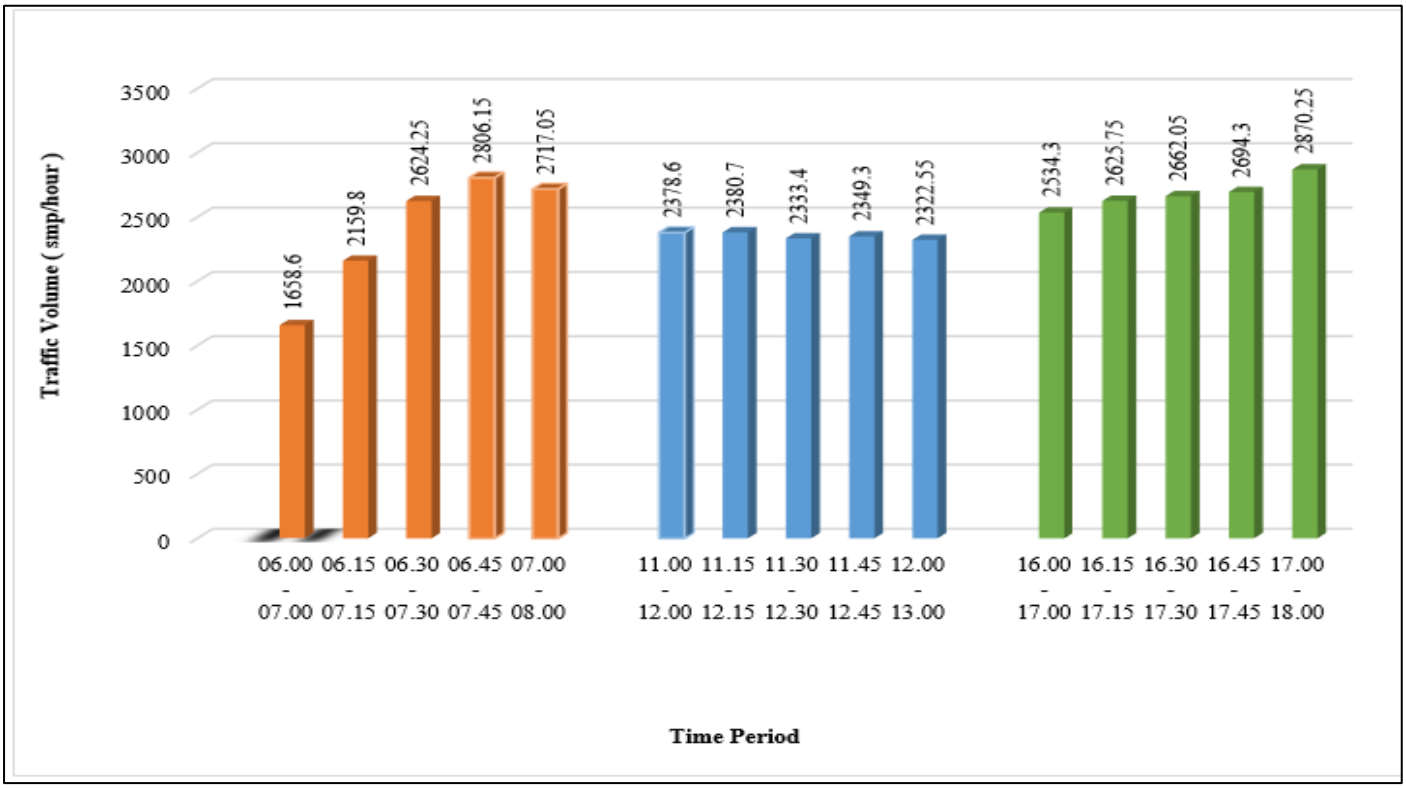

Fig 4 Intersection Traffic Volume

From the results of traffic volume data analysis, the peak hours and maximum vehicle volume at the intersection were obtained at 17.00 – 18.00 WITA with a maximum volume of 2870.25 smp/hour.

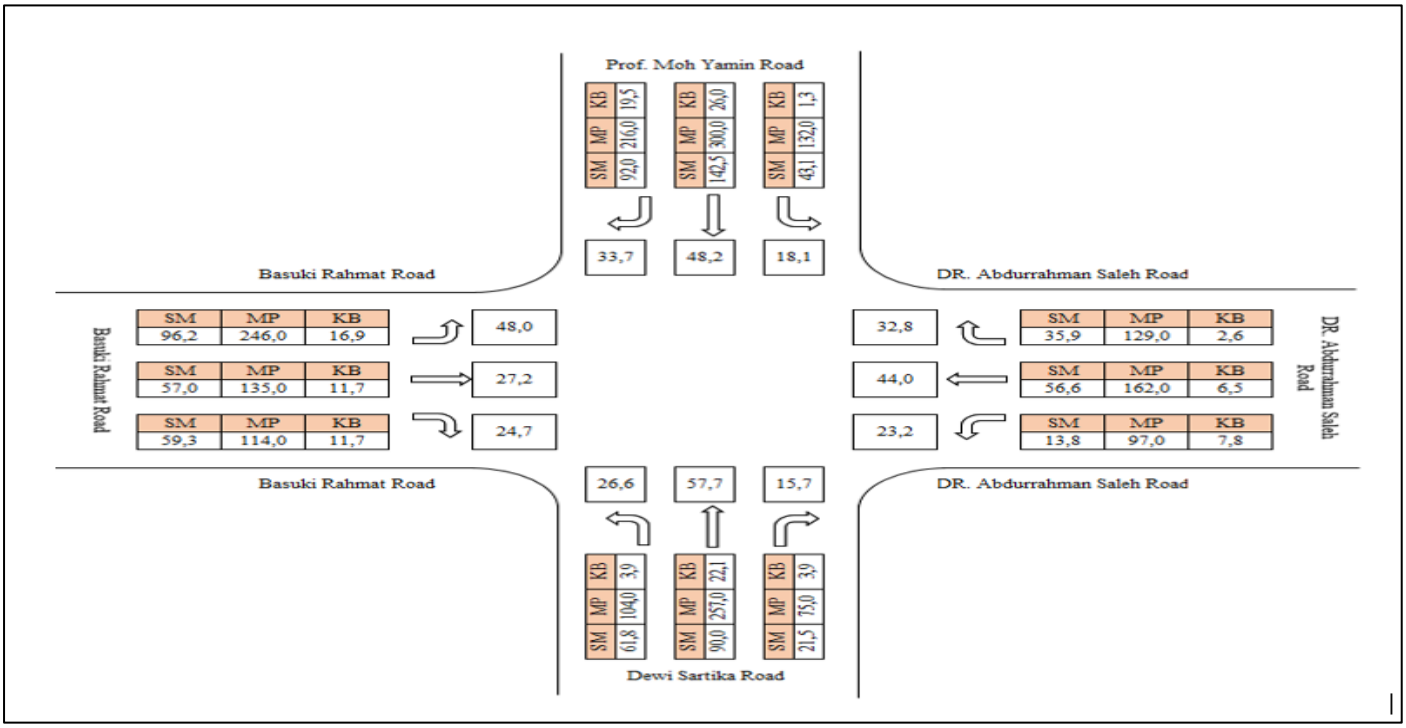

Fig 5 Traffic Flow Distribution During Afternoon Peak Hours (17.00 – 18.00)

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The afternoon peak hour which occurs at 17.00 – 18.00 WITA is influenced by the large number of vehicle movements heading to their original destination after activities such as going home from work, going home from campus, in addition to the existence of shopping centers and commercial areas around the intersection also affecting the movement activity at the intersection.

➢ *Signalized Intersection Analysis Using PKJI 2023*

Based on the results of the field survey and data analysis, the highest traffic volume value for each intersection arm was obtained during the afternoon peak period, then to determine the capacity and level of service of the Prof. Moh. Yamin Road - DR. Abdurrahman Saleh Road intersection, the data was analyzed using the SA-I form, SA-II form, SA-III form, SA-IV form and SA-V form contained in the Indonesian Road Capacity Guidelines (PKJI) 2023. The results of data analysis using the PKJI 2023 method analyzed using Microsoft Excel software can be seen in Table 2.

Table 2 Results of PKJI 2023 Analysis

Approach	Fase	Saturated Flow (J) (smp/hour)	Traffic Flow (q) (smp/hour)	Capacity (C) (smp/hour)	Degree of Saturation (DJ)	Queue Length (PA) (meters)	Delay (T) (second/smp)	Level of Service (PM 96) 2015
North	1	2365,5	795,95	615,3	1,29	383,78	238,5	F
South	2	1747,88	469,45	363,72	1,29	409,62	352,14	F
East	3	3188,74	511,1	552,96	0,92	113,75	97,91	F
West	4	2658,18	388,65	460,96	0,84	118,3	88,35	F

Based on the results of the 2023 PKJI analysis, the highest queue length occurred in the south (Dewi Sartika road) at 409.63 meters with a delay of 352.14 seconds/smp. The lowest queue length was in the west (Basuki Rahmat road) with a queue length of 118.3 meters and a delay of 88.35 seconds/smp. The level of intersection service on all arms based on PM 96 (2015) is in category F (delay value> 60 seconds/smp)

➢ *Analysis Using VISSIM Software*

Simulation modeling at the research location using PTV Vissim software based on direct observation data at the research location.

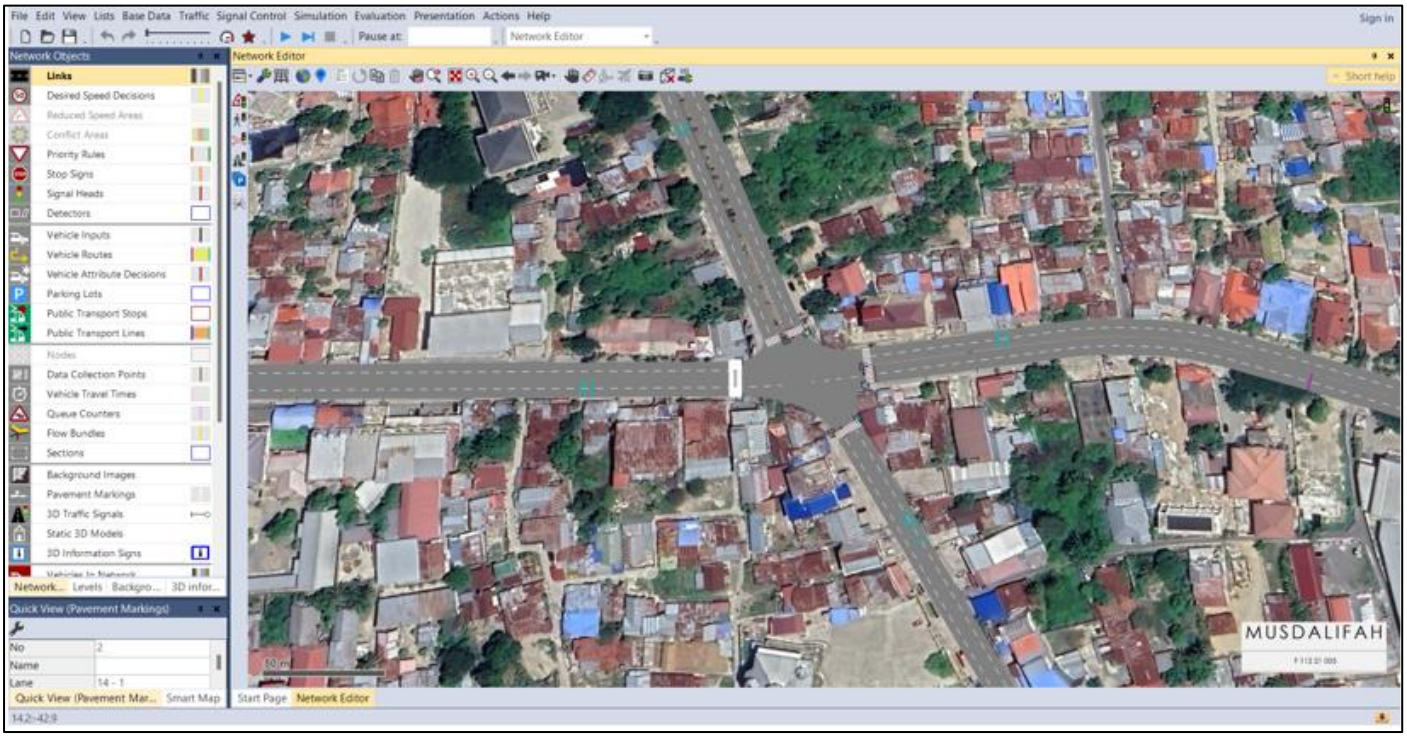

Fig 6 Vissim Modeling at the Research Location

The data that will be inputted into the VISSIM Software are: intersection geometric data, peak hour vehicle volume of 7199 vehicles/hour by dividing 4 (four types of vehicles, namely motorcycles, light vehicles and heavy vehicles, vehicle speed data, vehicle composition data, travel routes, travel route composition, signal time data and driver behavior data.

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➢ *Calibration and Validation*

The calibration process in simulation modeling is carried out by adjusting the driver behavior parameters through a trial and error approach until the simulation results in VISSIM represent real conditions at the research location. This study uses the Wiedemann 74 driver behavior model which is considered the most appropriate for traffic characteristics in urban areas. The initial calibration stage begins with setting the car following parameters, namely the behavior of maintaining distance between vehicles, then adjustments are made to the lateral components, such as changing the desired position at free flow from "middle of lane" to "any", and setting the distance standing and distance driving values (at 0 km / h) to reflect the distance of the vehicle when in a stopped condition.

Table 3 *Trial and Error* in Calibration

Trial	**Changed Parameters**	**Value**	
		Before	**After**
1	a. *Desired position at free flow*	*Middle of lane*	*Any*
	b. *Observe adjacent lane*	*Off*	*On*
	c. *Overtake on same lane: on left & on right*	*Off*	*On*
2	(Continued from trial 1)		
	a. *Minimum lateral distance standing (at 0 km/h) (m)*	1	0,2
	b. Minimum lateral distance driving (at 50 km/h) (m)	1	0,5
3	(Continued from trial 2)		
	a. *Average standstill distance*	2	1
	b. *Additive part of savety distance*	2	1
	c. *Multiplicative part of savety distance*	3	1
4	(Continued from trial 3)		
	a. *Average standstill distance*	1	0,75
	b. *Additive part of savety distance*	1	1
	c. *Multiplicative part of savety distance*	1	1
5	(Continued from trial 4)		
	a. *Average standstill distance*	0,75	0,45
	b. *Additive part of savety distance*	1	1
	c. *Multiplicative part of savety distance*	1	1

Table 4 Changes in Driver Behavior Components

No	**Changed Parameters**	**Value**	
		Before	**Sesudah**
1	*Has Overtaking lane*	*Off*	*On*
2	*Reduce Speed*	*No*	*Yes*
3	*Average standstill distance*	*2*	*0,45*
4	*Additive part of safety distance*	2	1
5	*Multiplicative part of safety distance*	3	1
6	*Desired position at free flow*	*Middle of Lane*	*Any*
7	*Overtake on same lane: on left & on right*	*Off*	*On*
8	*Distance standing* (at 0 km/h) (m)	1	0,2
9	*Distance driving* (at 50 km/h) (m)	1	0,5

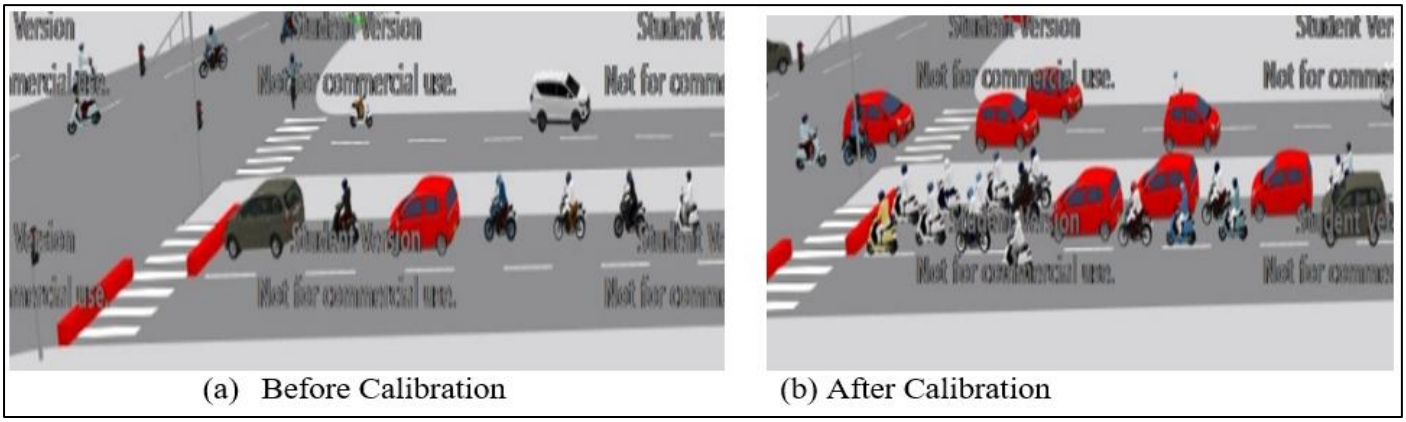

Fig 7 3D View of Intersection Calibration

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Validation in this study is based on the GEH (Geoffrey E. Havers) test for traffic volume variables and the MAPE (Mean Absolute Percentage Error) test for queue length.

$$GEH = \left[\sqrt{\frac{(qsimulated - q\ observated)^2}{0{,}5\ x\ (q\ simulated + q\ Observated)}}\right]$$

q = traffic volume (vehicles/hour)

The calculation of the GEH equation for GEH values < 5.0 is considered an acceptable simulation, a value of 5.0 ≤ GEH ≤ 10.0 requires a re-examination and a GEH value > 10 is likely an incorrect data input.

Table 5 GEH Test Results after Calibration

Location	Intersection approach	Vehicle Volume (vehicles/hour)		GEH	Results
		Observation	Vissim		
Prof. Moh. Yamin Road – DR. Abdurrahman Saleh Road	North	2534	2341	3,9	Accepted
	South	1614	1538	1,9	Accepted
	East	1109	1109	0,0	Accepted
	West	1942	1928	0,3	Accepted

Based on Table 5, validation for the GEH value using the traffic volume variable at each approach meets the requirements, namely <5, so that the results of the Vissim modeling in this study can be accepted. The GEH value presents the number of vehicles at the time of modeling close to the actual at the research location.

$$MAPE = \frac{1}{n}\sum_{t=1}^{n} \frac{At - Ft}{At} + \cdots x\ 100\%$$

n = Number / Amount of data
At = Data in the field
Ft = Simulation data

The range of values for MAPE < 10% indicates very good forecasting ability, 10 - 20% for good forecasting ability, 20 - 50% for reasonable forecasting ability and > 50% indicates poor forecasting ability.

Table 6 MAPE Test Results after Calibration

Intersection approach	**Queue Length**							**MAPE (%)**	**Results**
	Observation	Running Simulation					Average		
		1	2	3	4	5			
North	225	227	211	265	220	257	236	4,9	Accepted
South	150	161	113	118	188	135	143	4,7	Accepted
East	70	60	80	68	62	63	67	4,9	Accepted
West	100	110	59	117	64	125	95	5,0	Accepted

Table 6 shows the validation value for the MAPE value using the queue length variable on each approach which is said to be valid because the MAPE value is less than 10%. This indicates accurate prediction results.

Fig 8 3D View of Intersection Validation on Dewi Sartika Road

➢ *VISSIM Simulation Results*

The results of the Simpang performance analysis using Vissim software can be seen in Table 7.

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Table 7 VISSIM Simulation Output Results

Location	Intersection approach	Traffic Volume (vehicles/hour)	Queue Length (meters)	Delay (second)	LOS (HCM) 2010
Simpang Jalan Emi Saelan – Jalan Basuki Rahmat	North	2341	236	157	F
	South	1538	143	85	F
	East	1109	67	79	E
	West	1928	95	71	E

Table 7 shows the largest queue length occurred on the north arm, which was 236 meters with a delay value of 157 seconds, the lowest queue length occurred on the east arm with a queue length of 67 meters and a delay of 71 seconds. The level of road service based on HCM 2010 on the north and south arms is in category F (delay > 80 seconds) which means saturated flow, very low speed and congestion) while on the east and west arms the level of service is in category E (delay > 55 seconds - 80 seconds)

➢ *Comparison of PKJI 2023 Analysis and VISSIM Modeling*

The following is a comparison of the results of the performance analysis of the intersection of Prof. Moh. Yamin Road – DR. Abdurrahman Saleh Road using PKJI 2023 and PTV VISSIM.

Table 8 Comparison of PKJI 2023 Analysis Results and VISSIM Simulation Results

Intersection approach	PKJI 2023			PTV VISSIM		
	Queue Length	Delay	LOS PM 96 (2015)	Queue Length	Delay	LOS (HCM) 2010
	(m)	(Second)		(m)	(detik)	
North	384	238	F	236	157	F
South	410	352	F	143	85	F
East	114	98	F	67	79	E
West	118	88	F	95	71	E

Based on the data in Table 8, there is a difference between the queue length of the PKJI 2023 analysis results and the Vissim simulation results, where the queue length values obtained from the PKJI 2023 analysis on all arms show a larger number than the queue length of the Vissim simulation results. Comparison of the delay of the PKJI 2023 analysis and the Vissim simulation shows that the delay value obtained from the calculation based on PKJI is greater than the Vissim simulation results.

➢ *Alternative Intersection Handling*

- *Alternative 1 (Green Time Optimization)*

Green Time Optimization is carried out by adjusting the total cycle time based on the provisions of PKJI 2023, which is 130 seconds, changing all red to 2 seconds and the time between green to 5 seconds. Adjustments are made by redividing the green time in each phase based on the existing traffic volume.

- *Alternative 2 (Road Widening)*

The second alternative is by widening the road on all arms. The northern approach is initially 7 meters wide to 9 meters, the southern arm is initially 5.5 meters wide to 8 meters, the eastern arm is initially 7 meters wide to 8 meters and the southern arm is initially 7 meters wide to 8 meters.

- *Alternative 3 (Diversion of Private Vehicles to Public Vehicles)*

Diversion of private vehicles to public transportation is carried out to reduce the use of private vehicles, so that it is expected to be able to reduce traffic congestion caused by the density and length of vehicle queues, especially on the Prof. Moh. Yamin - Dewi Sartika Road. Trans Palu Bus has a capacity of 35 passengers with 21 seats. The Trans Palu Bus service route for the intersection of Prof. Moh. Yamin - DR. Abdurrahman Saleh is:

✓ Corridor 03 M: Basuki Rahmat Road- DR. Abdurrahman Saleh Road
✓ Corridor 03 Y: Moh. Yamin Road - DR. Abdurrahman Saleh Road

The alternative of switching private vehicles to public transportation is carried out by assuming that 50% of motorized vehicle users and 30% of private car users switch to Trans Palu Bus. This strategy is supported by the addition of one new corridor for the route to Dewi Sartika road. For the estimation of transportation capacity, a load factor value of 70% of the maximum capacity of the Trans Palu Bus is used, which is 35 passengers, so that the effective capacity per bus calculated is 25 passengers.

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Table 9 Comparison of Queue Lengths for Existing and Alternative Conditions

Intersection approach	Queue Length (meters)				Delay (second)				Level of Services			
	Existing	Alternatives			Existing	Alternatives			Existing	Alternatives		
		1	2	3		1	2	3		1	2	3
North	236	198	123	136	157	73	75	54	F	E	E	D
South	143	145	53	95	85	79	33	34	F	E	C	C
East	67	81	56	58	79	92	59	20	E	F	E	B
West	95	68	59	78	71	34	35	42	E	C	C	D

Based on Table 9, Alternative 1, the queue length decreases on the north and west arms. In contrast, the east and south arms actually experience an increase in queue length compared to existing conditions. Alternative 2, the queue length decreases on all intersection arms, with the largest decrease occurring on the north and south arms. In Alternative 3, the queue length on all intersection approach arms decreases compared to existing conditions. A significant decrease is seen on the north and south arms, while on the east and west arms a decrease also occurs although not as large as the decrease on the other arms

Delays on alternative 1, alternative 2 and alternative 3 on all arms show a decrease compared to existing conditions. The level of road service on alternative 1 provides a slight improvement, especially on the west approach to C (delay> 20 - 35 seconds), but does not change on other approaches. Alternative 2 provides similar results to alternative 1, namely an improvement on the south and west arms to C (delay> 20 - 35 seconds). Alternative 3 shows the best improvement overall, with an increase in the index to B in the east and C in the south and D in the north and west.

IV. CONCLUSION

Based on the evaluation results of the intersection of Jalan Prof. Moh. Yamin - Jalan DR. Abdurrahman Saleh, it was concluded that the 2023 PKJI analysis showed that all intersection arms were at service level F (delay > 60 seconds/smp) based on PM 96 of 2015, with high delays and queue lengths exceeding existing conditions, while the Vissim Simulation on the east and west arms showed an increase in the level of road service to E with lower delays and queue lengths and approaching existing conditions. The intersection handling alternatives in the three alternatives showed improved performance compared to existing conditions, the green time optimization alternative is suitable for the short term because it is cheap and quick to implement even though it is not yet effective on the east arm, the alternative of vehicle diversion and road widening is more ideal for the long term because it can reduce congestion as a whole.

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