Microscopic Simulation Analysis of The Fatmawati Intersection in Jakarta

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Abstract. The average growth of motor vehicles in Jakarta reaches 3.6% per year triggers congestion, especially when intersections lack proper design and signal settings. The Fatmawati intersection is linking primary arterials and secondary collectors vital for business mobility, but often experiences delays due to geometric inconsistencies and increased traffic from toll ramp exits. This study aims to analyse the existing performance of the Fatmawati intersection based on the 2023 Indonesian Road Capacity Guidelines (PKJI 2023) and to propose optimization through microscopic simulation using PTV VISSIM software validated with the GEH statistical test. Results indicate that the intersection is in poor condition, with a degree of saturation of 0.86, maximum queue length of 271.1 meters, and average delay of 84.88 sec/SMP. The model is considered valid with GEH values below 5, indicating alignment be-tween simulated and observed vehicle volumes and queue lengths with PKJI 2023 analysis, with lateral queue diamond parameters adjusted specifically for motorcycles. Optimization scenarios involving cycle time reduction, right-turn restrictions, geometric widening, and signal coordination resulted in queue length reductions of up to 59% and delay reductions of up to 53%. This study confirms that simple geometric modifications combined with adaptive signal settings can improve the performance of urban intersections.

Keywords: Microsimulation, Intersection Performance, PTV VISSIM, PKJI 2023

1. Introduction

The rapid annual growth of motorized vehicles in Jakarta, averaging 3.6% from 2019 to 2023. The rapid growth that has not been matched by proportional improvements in road infrastructure, leading to increasingly congested conditions across the city [1]. Intersections, as critical components of the road network, significantly influence overall traffic performance [2]. A poorly managed intersection can lead to severe delays and long queues [3]. The Fatmawati intersection, which connects major arterial and secondary collector roads in a key residential, business, and commercial district of South Jakarta based on Jakarta Governor Regulation No. 31 of 2022, is one such example. It has been identified as one of the 200 major congestion points in the city due to geometric inconsistencies, merging conflicts due to the entry and exit ramps JORR toll by national news. The theoretical analysis by highlighting the bottleneck effect due to lane-changing in the merging/diverging area, which is relevant to the phenomenon of queues near ramps [4]. In addition, congestion can form in locations of changes in road conditions such as ramps, both localized and widespread [5]. The studies have rated the Fatmawati intersection's performance at Level of Service F, indicating saturated conditions with high delays [6]

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To address these issues, the Indonesian government has issued a series of policies and technical guidelines. Despite various policies and guidelines such as the Indonesian Highway Capacity Manual (PKJI 2023), Ministerial Regulation No. 96/2015, and Jakarta's Transportation Master Plan (Presidential Regulation No. 55/2018), effective intersection management remains a challenge, especially in the context of Jakarta's heterogeneous traffic. Therefore, this study aims to evaluate the operational performance of the Fatmawati Intersection under existing conditions using the PKJI 2023 framework and to validate a microscopic simulation model built in PTV VISSIM through GEH statistical testing. The originality of this research lies in its combination of Indonesian-specific traffic characteristics with advanced microsimulation calibration, focusing on driver behaviour adjustments for realistic modeling. Furthermore, the study proposes optimized signal and geometric scenarios to enhance performance. The results of the study are expected to provide a solution to the optimization of intersection performance by reducing queue lengths, decreasing delay times, and improving the level of service (LOS).

2. Related Work

The intersection is the meeting point where vehicle lanes intersect [7]. Intersections are places where vehicles make changes in traffic which caused varied movement patterns as a form of effort to change lanes where there are diverging, merging, crossing, and weaving [8]. The intersection of traffic at a point can cause intersection conflicts [9]. One of the intersection arrangements is a signaled intersection [10]. A signaled intersection is an intersection governed by traffic signals where road users have the opportunity to pass through the intersection according to the time distribution of intersections from various approaches to allow the flow of traffic to run regularly [11].

2.1. Intersection Performance Indicators

Based on PKJI 2023 there are several indicators to evaluate intersection performance

- Capacity (C) is the ability to channel the highest traffic flow in crossing the stop line and exiting without being hampered by disturbances such as traffic flow delays, lane conditions and certain traffic flow management
- Saturation Degree (Dj) is ratio between volume and capacity
- Queue Length (PA) is the length of a queue of vehicles queuing along an approach that is controlled by movement in front of it or that vehicle is stopped by another component of the traffic system
- Delay (T) is of additional time used by motorists to overtake an intersection due to the geometry and condition of the crossing

Minister of Transportation Regulation No. 96 of 2015 defines the Intersection Level of Service Index based on the average intersection delay time. According to the Highway Capacity Manual (2010), the planning and evaluation of signalized intersections, acceptable performance is generally considered to be no worse than LOS D or delay time less than 55 s before the junction enters a condition of unstable current and approaches capacity.

Table 1. LOS Criteria for Signalized Intersections

Level of Service (LOS)	Average Control Delay (seconds/vehicle)	Descriptions
A	≤ 10	Free flow, very low delay
B	$> 10 - 20$	Stable flow, low delay
C	$> 20 - 35$	Stable flow, acceptable delays
D	$> 35 - 55$	Approaching unstable flow, tolerable delays
E	$> 55 - 80$	Unstable flow, at or near capacity
F	> 80	Forced or breakdown flow, excessive delays and queuing

2.2. The Concept of Microsimulation

Microscopic simulation is a model that describes the behavior and interaction of each driver in a traffic system, where the modeling is made in more detail for each movement of the vehicle. Microscopic modeling leads to the development of driver and vehicle behavior to produce realistic simulations [12].

Microsimulation Parameters Using VISSIM. In the VISSIM software, there is a default parameter value, but it does not describe conditions that are suitable for heterogeneous traffic in Indonesia, so it requires adjustments [13]. The parameters that are commonly adjusted are standstill distance, observed vehicle, minimum headway, additive Factor Security, Multiplicative Factor Security, Lane Change Result, Overtake on same line, desired lateral position, and lateral minimum distance [14].

Validation and Calibration. Validation in VISSIM is a stage of checking the results of parameter calibration by comparing observation data in the field with modeling results to accurately represent the model [9]. GEH is a standard statistical test commonly used in traffic engineering, prediction, and modeling by comparing simulation results with observation results [10]. GEH scores have special conditions that indicate whether validation is acceptable or not. A GEH value of < 5 is said to be an acceptable model, on the other hand, the GEH value > 5 model is rejected, while a GEH value between 5 and 10 is said to be an error model or bad data [11]. GEH equation is shown in equation (1).

$$GEH = \sqrt{\frac{(Simulated - Observed)^2}{0.5\ x\ (Simulated - Observed)}} \tag{1}$$

3. Material and Method

This Research was conducted at the four-signal Fatmawati intersection which connect Jalan RS Fatmawati Raya, Jalan TB Simatupang, and Jalan R. A. Kartini, that are not affected by entry-exit ramps and nearby intersections during weekday peak hours.

3.1 Material

The data used in this study is divided into primary and secondary data. Primary data was obtained through field surveys and includes traffic volumes and vehicle speed. Secondary data refers to pre-existing information relevant to the research collected through literature studies and data information from the Dinas Perhubungan Jakarta.

Geometry Intersection. Geometric data were collected through field observations and measurements, as well as by utilizing the Google Earth measurement function to obtain wider coverage. The measurements include surrounding environmental conditions, road widths, and the number of lanes, which are summarized in **Table 2** and the geometry shown in **Fig. 1**.

Table 2. Geometric Data and Environmental Conditions of the Fatmawati Intersection Approach

Description	Jl. RS. Fatmawati (N)	Jl. RS. Fatmawati (S)	Jl. TB. Simatupang	JL. R.A. Kartini
Approach	North	Sout	East	West
Road Type	Arterial	Arterial	Collector	Collector
Environmental Condition	Commercial	Commercial	Commercial	Commercial
Side Barriers	Moderate	Moderate	Moderate	Moderate
Number of lanes per approach	2	4	4	3
Left-turn Lane width (m)	4	7	6	4
Exit lane width (m)	6	14	14	10,5
Entry lane width (m)	7	6	14	10,5

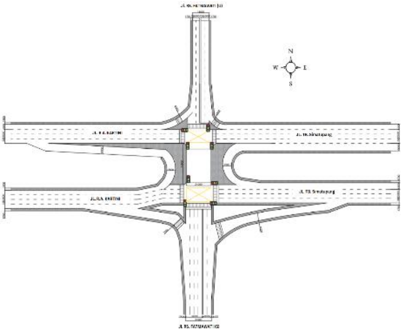

Fig. 1. Geometry of Fatmawati Intersection

Signal Timing and Phase. Signal Timing and phase data was obtained by Jakarta Department of Transportation where the composition of signal time and signal phase doing one cycle was shown in **Table 3**.

Table 3. Static Signal Time of Fatmawati Intersection

Signal Phase	Signal Time	Cycle Time (s)
West - East (Phase 1)	80 | 2 | 2 | 169	253
East - West (Phase 1 and 2)	84 | 12 | 2 | 2 | 153	253
East - North (Phase 2)	84 | 12 | 2 | 2 | 153	253
North – South and North - West (Phase 3)	100 | 78 | 2 | 2 | 49	253
South – North and South - East (Phase 4)	204 | 45 | 2 | 2	253

East approach is controlled by two traffic signal phases. The first phase governs the through movement heading west, which starts with an earlier green signal. The second phase controls both the through and right-turn movements, allowing vehicles to proceed westbound and northbound after the first phase from the westbound approach ends as shown in **Fig. 2**.

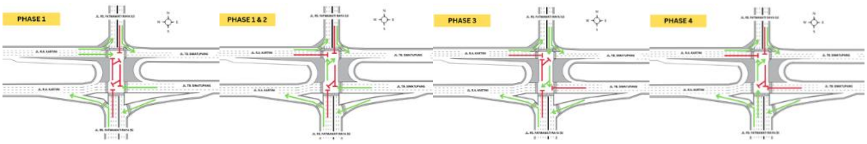

Fig. 2. Signal Phase of Fatmawati Intersection

Traffic Volume. Traffic volume data were obtained through a traffic counting survey using CCTV cameras installed to monitor vehicle movements at the intersection's entry points and queue legs. The cameras were used to capture and count vehicle movements and incoming traffic volumes on each approach. The survey time was determined based on secondary data of daily traffic volumes by Dinas Perhubungan Jakarta which show the peak traffic. The day of observation was selected based on the TomTom Traffic Index, which showed that travel times in Jakarta.

Vehicle Speed. Vehicle speed data was obtained by doing spot speed survey using speed gun. The desired speed is assigned for each approach based on the road classification, primary arterial roads are used to represent speed conditions on the approaches from Jl. TB Simatupang and Jl. R.A. Kartini, while secondary collector roads represent the approach from Jl. RS Fatmawati Raya. The reduced speed area is defined for each turning movement, including right turns, left turns, and U-turns. The data also obtained classified by vehicle types, motorcycle, cars, big vehicle (truck and bus). The data also obtained classified by vehicle types, motorcycle, cars, big vehicle (truck and bus). For, quantities analysis, the minimum sampel obtained is 30 for each type [18].

3.2 Analysis Method

The analyses using two different conditions, existing and scenario. The Existing conditions was evaluated using PKJI 2023 to see how the intersection performance using PKJI 2023 and the queue length result was used to validate microsimulation using VISSIM. The optimalization scenario was evaluated using existing model that been validated using statical method GEH by calibrating the driving behavior parameter.

Calibration. The calibration using trial and error method based on the range for several studies that conducted on Indonesia

1. Tugu Intersection in Yogyakarta [19]
2. Wlingi Market in Blitar [20]
3. Pendopo Intersection, Abdulrahman Saleh Intersection, and Hutama Karya Intersection in Semarang [21]
4. Cebongan Intersection and Taman Ringin Interscetion in Yogyakarta [22]
5. Unsignaled Intersection on Jalan Yos Sudarso Surakarta [23]

Running. The simulation was run minimal 5 times using different random seed and the output was average to validate [16]. Tbe simulation must be run for 4500 s with 900 as a warm up period to stabilise the traffic network and 3600 for evaluation [24].

Validation. The validation based on observed variables, namely traffic volume and queue length [12] [13]. Additional validation was carried out by visually comparing the queues on the model and the real conditions in the field.

4. Result and Discussion

4.1 Fatmawati Intersection Performance Using PKJI 2023

Table 4. Recapitulation of Fatmawati Intersection Performance Based on PKJI 2023

Approach	Volume (q) SMP/hour	Capacity (C) SMP/hour	Saturation Degree (Dj)	Queue Length (PA) m	Delay (T) sec
Jl. RS. Fatmawati (North)	1224	1418	0,86	271,1	79,8
Jl. RS. Fatmawati (South)	1242	1573	0,79	121,1	106,3
Jl. TB. Simatupang (East)	2013	2362	0,85	188,4	78,7
Jl. R.A. Kartini (West)	1214	1873	0,65	140,6	78,3

Table 4 shows that the largest degree of saturation occurs at the northern approach, which is 0.86 which indicates poor intersect performance. The longest queue length occurred on the northern approach with a queue of 271.1 m. The highest delay time occurred on the southern approach with a delay time of 106.3 seconds. The overall average intersection delay time is 84.88 sec/veh which shows an F or poor service level indicating an excessive delays and queueing.

4.2 Microsimulation Fatmawati Intersection Existing Scenario

The microsimulation was built by input the traffic data as network, vehicle volume, vehicle composition, desired speed, route, traffic signal, and set the driving behavior [25]. The model was calibrated by adjusting driving behavior parameter through trial and error until the model was valid by GEH test [26].

First Calibration. The first calibration of Parameter Following, Car Following Model, and Minimum Lateral Distance refers to research [21]. Lateral Parameters refers to research [20]. The output vehicle volume and queue length meet the accepted criteria or the GEH value is less than 5. However, visually the simulation shows an anomaly where vehicle stacked on top of each other as shown in **Fig. 3**. This condition causes the queue to shorten because in the same space there is more than one vehicle. In reality, vehicles lining up in the available spaces and gaps without sharing with other vehicles. This condition does not indicate the real conditions that may occur in the field.

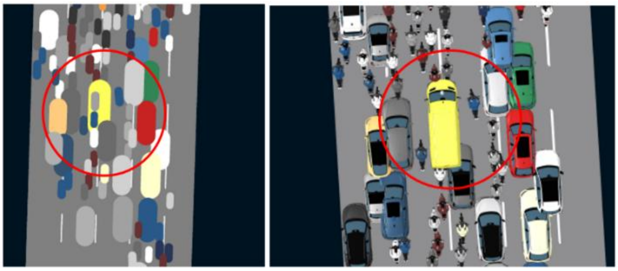

Fig. 3. Visualization of Overlapping Vehicles

Second Calibration. The lateral parameters are important parameters to describe tight traffic conditions, especially in queues where vehicles tend to take gaps between other vehicles to get the position of the queue in front as possible [14]. This parameter that causes vehicles to visually stack on top of each other so that adjustments need to be made. The minimum longitudinal speed (km/h) was changed to 0 km/h which allowed the driver to make movements between vehicles that stopped at low speeds [15]. The left and right overtake parameters are specifically for motorcycles and passenger cars so that large vehicles such as buses or trucks cannot position themselves to take the lanes of other vehicles from both the left and right directions. Observing adjacent lanes affects the position of the vehicle which will change its lane more carefully and pay attention to the surrounding vehicles so that there are no sharp movements that cause vehicles to intersect with each other. The diamond shape queueing parameter is not used so that the vehicle does not queue offset from the lateral position but is specifically for motorcycles so that they can position themselves to fill the empty space laterally either in a line or in a diamond form. This shape makes better use of free space so that the modelled queue length is closer to the field result.

Table 5. Vehicle Volume and Queue Length Validation with Second Calibration

Vehicle Movement	Existing Volume	Volume Output (Veh/hour)					Avg	GEH	Information
		S(42)	**S(43)**	**S(44)**	**S(47)**	**S(50)**			
N Straight	3135	2977	3061	2995	3011	2919	2992,60	2,57	ACCEPTED
N Right	1254	1203	1218	1080	1188	1223	1182,40	2,05	ACCEPTED
N Left	1067	1025	1031	1010	1075	1008	1029,80	1,15	ACCEPTED
S Straight	1495	1422	1362	1375	1373	1421	1390,60	2,75	ACCEPTED
S Right	2174	2106	2075	2160	2148	2066	2111,00	1,36	ACCEPTED
S Left	963	978	897	934	924	924	931,40	1,03	ACCEPTED
E Straight	5607	5298	5344	5389	5405	5443	5375,80	3,12	ACCEPTED
E Right	858	886	869	919	834	881	877,80	0,67	ACCEPTED
E Left	1226	1222	1247	1202	1219	1220	1222,00	0,11	ACCEPTED
E U-Turn	1764	1729	1760	1830	1706	1803	1765,60	0,04	ACCEPTED
W Straight	3271	3264	3188	3284	3245	3218	3239,80	0,55	ACCEPTED
W Left	1215	1202	1191	1201	1228	1257	1215,80	0,02	ACCEPTED
W U-Turn	1848	1903	1773	1960	1797	1915	1869,60	0,50	ACCEPTED
Approach	PKJI Queue Length 2023 (m)	Qlenmax (m)					Avg	GEH	Information
		S(42)	**S(43)**	**S(44)**	**S(47)**	**S(50)**			
N Straight	3135	2977	3061	2995	3011	2919	2992,60	2,57	ACCEPTED
N Right	1254	1203	1218	1080	1188	1223	1182,40	2,05	ACCEPTED
N Left	1067	1025	1031	1010	1075	1008	1029,80	1,15	ACCEPTED
S Straight	1495	1422	1362	1375	1373	1421	1390,60	2,75	ACCEPTED

Table 5 shows vehicle volume and queue length meet the accepted criteria or the GEH value is less than 5. Visually the simulation shows the motorcycle queue in diamond just like the actual queue as shown in **Fig. 4**.

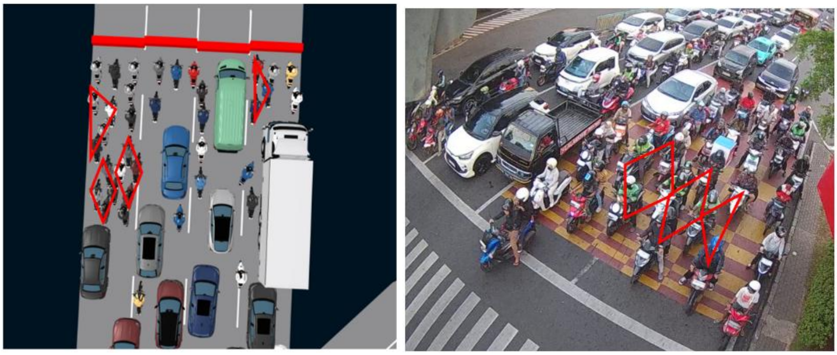

Fig. 4. Comparison of the Visual Condition of the Model and The Actual Queue

Therefore, the calibration value that used in this calibration show on **Table 6**.

Table 6. Driving Behavior Parameter Used

Parameter	Driving Behavior Parameter	Default	Used Calibration
Following	Look Ahead Distance Max. (m)	200	200
	Number of Interaction Objects	4	8 (AllVeh) and 10 (MC)
	Look Back Distance Min. (m)	0	15
	Look Back Distance Max. (m)	150	100
Car Following Model	Average standstill distance (ax)	2	0,2 m
	Additive part of safety distance (bx_add)	3	0,25
	Multiple part of safety distance (bx_mult)	3	0,25
Lane Change	Waiting Time	60	210
	Min. Clearance	0,5	0,3
Lateral	Desired Posistion at Free Flow	Middle	Any
	Minimum Longitudinal Speed (km/h)	3,6	0
	Overtake Left & Right	No	Left and Right (MC & MP)
	Diamond shape queuing	No	Yes (MC) & no (All Veh)
	Minimum Lateral Distance Standing (m)	0,2	0,1 (SM); 0,2 (MP); dan 0,5 (KB dan BB)
	Minimum Lateral Distance Driving (m)	1	0,3 (SM); 0,3 (MP); dan 0,8 (KB dan BB)

4.3 Microsimulation Fatmawati Intersection Optimization Scenario

Scenario 1. Optimization scenario 1 reduces the green time of each approach as shown on **Table 7** with the goal of reducing the time of one cycle so that vehicles do not have to wait too long in the queue. Too large a green time can lead to longer queues and longer delay times on other approaches because it is directly proportional to the wait time in red signals [29].

Table 7. Controlling Signal Scenario 1

Signal Phase	Signal Time							Cycle Time (s)
West - East (Phase 1)	50	2	2	134				188
East - West (Phase 1 and 2)	54			7	2	2	123	188
East - North (Phase 2)	54			7	2	2	123	188

Signal Phase	Signal Time					Cycle Time (s)
North – South & North - West (Phase 3)	65	78	2	2	41	188
South – North & South - East (Phase 4)	147	37	2	2		253

This suggests that reducing green time on all approaches to shortening cycle times can reduce queue lengths and delay times as shown at the **Table 10**. However, the delay time in straight and right turns on the East, West, and South approaches still show a delay time more than 80 s or considered as level of service F, namely saturated conditions, very long queues, and too high delay times, so it is necessary to carry out further optimization scenarios.

Scenario 2. Scenario 2 prohibits right turn movements from the easterly approach to the northbound approach with the goal of reducing signal phases and reducing cycle times to reduce delay times and queue lengths. This scenario changes signal phase 4 to 3 where the western and eastern approaches have a green signal in one protected and non-intersecting phase as shown on **Table 8**. This prohibition will increase the volume of straight motion assuming all vehicles that will turn right from the Eastern approach are directed to be straight.

Table 8. Controlling Signal Scenario 2

Signal Phase	Signal Time					Cycle Time (s)
West - East (Phase 1)	52	2	2	108		164
East - West (Phase 1)	52	2	2	108		164
North – South & North - West (Phase 3)	56	70	2	2	164	188
South – North & South - East (Phase 4)	130	30	2	2		164

As the **Table 10**, the Eastern approach has seen a decrease in queue length although the straight movement has experienced an increase in volume due to the right turn ban. This happens because the ban on right turn movement reduces the barrier to straight movement so that no queue is held back due to the right turn movement regulated by the signal phase itself. The intersection performance shows an improvement from the existing conditions, but the overall level of service does not show any difference from the first scenario. As for the South, East and West approaches still have the worst delay time more than 55 s, namely LOS E with near-saturated capacity and unstable currents, so it is necessary to carry out other optimization scenarios

Scenario 3. Scenario 3 uses optimization setting time scenario 2 and changing the road geometry as shown on **Table 9** intended to increase capacity and provide more space so that vehicle movement when entering and exiting intersections is freer, thereby reducing delay time due to geometry.

Table 9. Geometric Data and Environmental Conditions for Scenario 3

Description	Jl. RS. Fatmawati (N)	Jl. RS. Fatmawati (S)	Jl. TB. Simatupang	JL. R.A. Kartini
Approach	North	South	East	West
Road Type	Arterial	Arterial	Collector	Collector

Environmental Condition	Commercial	Commercial	Commercial	Commercial
Side Barriers	Moderate	Moderate	Moderate	Moderate
Number of lanes per approach	2	4	4	3
Left-turn Lane width (m)	4	7	7	4
Exit lane width (m)	8	15	15	11,3
Entry lane width (m)	7,5	8	15	11,3

The results of the third scenario as can be seen on **Table 10** shows a drastic decrease in the length of the northern approach queue, even though it uses the same signal time, the decline in this scenario is much greater than in the second optimization scenario due to the expansion of the lanes. The enlargement of the lane causes the approach capacity to output a greater traffic flow [16] so that the queue formed is shorter. The South, East, and West approaches showed no significant difference in queue length compared to optimization 2 because the geometric change was not as significant as the northern approach. However, scenario 3 resulted in an average delay time on LOS D category with traffic flow conditions was almost unstable and the delay was still within tolerable limits. As for the West and South approaches, they have the worst service level, namely LOS E with capacity conditions close to saturated and unstable currents. This result is not much different from scenario 2 even though lane widening has been carried out cause scenario 3 uses the same time signal as scenario 2.

Scenario 4. Signal optimization scenario 4 applies signal coordination between the north and south approaches with geometric conditions according to scenario 3. This scenario is intended so that the last vehicle has enough green time to pass through the connecting part between intersections so that there is no need to wait for the next red time [31] for one cycle considering that the geometry of Fatmawati Intersection has a middle section along 28 m which requires travel time to reach the opposite intersection and will help to reduce delay time and improve service performance at least LOS D to obtain intersections with near-unstable traffic flow conditions with tolerable delay times according to HCM 2010 at each movement. This scenario utilizes travel time between the south and north approaches, measured using travel time counters in VISSIM.

By using a total cycle time of 127 seconds and adjusting the green time again so that signal coordination that matches the travel time of the platoon's movements, **Fig. 5** obtained, which shows the signal coordination scenario.

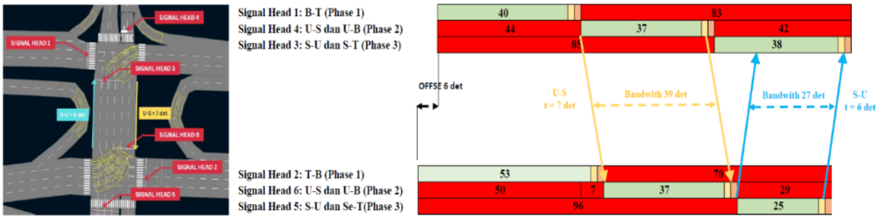

Fig. 5. Scenario 4 Coordination Signal of Fatmawati Intersection

The queue length is reduced by up to 59% on the Northern approach as shown on **Table 10**, resulting in a reduction in queue length that tends to be evenly distributed across all approaches with the smallest 49% reduction in queue length occurring on the Western approach. The longest queue length occurred on the North approach, which was 119.74 m, while the shortest queue occurred on the South approach, which was 79.53 m. The results of running optimization scenario 4 showed an average reduction of delay time of up to 53%, which was 31.69 seconds compared to the existing conditions. Overall, the movement of Fatmawati Intersection has improved, namely LOS C with stable flow conditions and a reasonable amount of delay. The worst level of service occurred at the North, South, and West approaches, namely LOS D. The worst service conditions have met the minimum limit of feasibility of the signaled intersection with delay less than 50 s or namely LOS D with near-unstable traffic flow conditions with tolerable delay times. Scenario 4 has become the best optimization scenario for improving Fatmawati Intersection performance.

Table 10. Recapitulation Intersection Performance for Each Scenario

Scenario	Existing	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
Approach	Qlenmax (m)	Qlenmax (m)	(%)	Qlenmax (m)	(%)	Qlenmax (m)	(%)	Qlenmax (m)	(%)
Jl. RS. Fatmawati (North)	289,48	204,96	-29%	166,32	-43%	123,43	-57%	119,74	-59%
Jl. RS. Fatmawati (South)	166,56	99,92	-40%	92,50	-44%	89,96	-46%	75,15	-55%
Jl. TB. Simatupang (East)	238,95	189,76	-21%	150,00	-37%	156,36	-35%	103,63	-57%
Jl. R.A. Kartini (West)	155,45	116,51	-25%	106,50	-31%	94,66	-39%	79,53	-49%
Movement	VehDelay (s)	VehDelay (s)	(%)	VehDelay (s)	(%)	VehDelay (s)	(%)	VehDelay (s)	(%)
Intersection Fatmawati - East - West	84,68	72,14	-15%	56,24	-34%	54,78	-35%	33,16	-61%
Intersection Fatmawati - East - East	33,03	16,40	-50%	10,22	-69%	9,36	-72%	6,73	-80%
Intersection Fatmawati - East - North	137,27	96,87	0	0	0	0	0	0	0
Intersection Fatmawati - East - South	6,98	4,23	-39%	4,17	-40%	3,88	-44%	3,90	-44%
Intersection Fatmawati - North - West	70,94	54,49	-23%	43,57	-39%	40,70	-43%	49,70	-30%
Intersection Fatmawati - North - East	48,46	33,49	-31%	21,67	-55%	11,15	-77%	12,25	-75%
Intersection Fatmawati - North - South	72,61	55,20	-24%	44,58	-39%	41,56	-43%	52,01	-28%
Intersection Fatmawati - South - West	20,74	5,79	-72%	5,31	-74%	4,23	-80%	3,88	-81%
Intersection Fatmawati - South - East	112,61	75,81	-33%	70,60	-37%	69,09	-39%	53,45	-53%
Intersection Fatmawati - South - North	114,30	73,89	-35%	67,86	-41%	68,96	-40%	48,52	-58%
Intersection Fatmawati - West - West	9,50	9,45	-1%	17,92	89%	9,55	1%	9,66	2%
Intersection Fatmawati - West - East	79,57	69,91	-12%	58,32	-27%	55,18	-31%	42,85	-46%
Intersection Fatmawati - West - North	18,04	13,73	-24%	12,44	-31%	6,82	-62%	4,62	-74%
Intersection Fatmawati	67,40	51,29	-24%	42,28	-37%	39,42	-42%	31,69	-53%
Movement	LOS	LOS Scenario 1		LOS Scenario 2		LOS Scenario 3		LOS Scenario 4	
Intersection Fatmawati - East - West	LOS_F	LOS_E		LOS_E		LOS_D		LOS_C	
Intersection Fatmawati - East - East	LOS_C	LOS_B		LOS_B		LOS_A		LOS_A	
Intersection Fatmawati - East - North	LOS_F	LOS_F							
Intersection Fatmawati - East - South	LOS_A	LOS_A		LOS_A		LOS_A		LOS_A	
Intersection Fatmawati - North - West	LOS_E	LOS_D		LOS_D		LOS_D		LOS_D	
Intersection Fatmawati - North - East	LOS_D	LOS_C		LOS_C		LOS_B		LOS_B	
Intersection Fatmawati - North - South	LOS_E	LOS_E		LOS_D		LOS_D		LOS_D	
Intersection Fatmawati - South - West	LOS_C	LOS_A		LOS_A		LOS_A		LOS_A	
Intersection Fatmawati - South - East	LOS_F	LOS_E		LOS_E		LOS_E		LOS_D	
Intersection Fatmawati - South - North	LOS_F	LOS_E		LOS_E		LOS_E		LOS_D	
Intersection Fatmawati - West - West	LOS_A	LOS_A		LOS_B		LOS_A		LOS_A	
Intersection Fatmawati - West - East	LOS_E	LOS_E		LOS_E		LOS_E		LOS_D	
Intersection Fatmawati - West - North	LOS_B	LOS_B		LOS_B		LOS_A		LOS_A	
Intersection Fatmawati	LOS_E	LOS_D		LOS_D		LOS_D		LOS_C	

5. Conclusion

1. The performance of Fatmawati Intersection shows poor conditions on the North approach, namely Jl. RS. Fatmawati Raya with a degree of saturation that does not meet the 2023 PKJI standards and service performance of all approaches are included in category F or very poor.
2. The microsimulation model meets the accepted category with a GEH validation value of < 5 which shows the suitability of the vehicle volume in the model with the results of field surveys and queue lengths with the results of the PKJI 2023 analysis using lateral adjustment parameters, especially on motorcycles that can form a diamond queue.
3. The best optimization scenario to improve the performance of the Fatmawati intersection is optimization scenario 4 by changing the 4 signal phases to 3 signal phases by prohibiting right turns on the East approach, reducing the green time and

cycle time, widening the geometry for the exit and entering lanes of the intersection, and applying signal coordination. Optimization scenario 4 was able to reduce the queue length proportionately on all approaches by up to 59% and there was an average delay reduction of up to 53% which is included in the LOS C category.

This study was limited by resources and the availability of primary data, requiring the use of secondary data from previous studies, official websites, and indirect sources. Future research is encouraged to conduct more comprehensive field surveys to improve the accuracy of simulation models with direct empirical observations. Since microsimulation depends heavily on local driving behaviour parameters, future studies should calibrate key variables like car-following, lane-changing, and lateral movement based on site-specific data rather than relying solely on literature or trial and error. Additionally, further research should examine the broader traffic management system, including signal phase adjustments, geometric configurations, and the influence of surrounding road networks to optimize intersection performance more holistically.

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