Indonesian Journal of Advanced Research (IJAR)
Vol. 4, No. 7, 2025: 1633-1652

Microsimulation-Based Traffic Management on Urban Roads in Indonesia

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A R T I C L E I N F O

Keywords:
Traffic Management, U-Turn, Road Cipto Mangunkusumo, PTV VISSIM, PKJI 2023

Received : 15, June
Revised : 30, June
Accepted: 31, July

A B S T R A C T

Congestion in urban areas is not only influenced by the high volume of vehicles, but also by U-Turn maneuver activities that can cause conflicts and reduce traffic performance. This study aims to evaluate the effect of U-Turn facilities on road performance and provide recommendations for handling them. The method used is microscopic simulation using PTV VISSIM software, with reference to evaluation parameters based on the 2023 Indonesian Road Capacity Guidelines (PKJI), namely the degree of saturation (DJ), delay, and Level of Service. The results of the study indicate that in the next 10 years there will be a decline in the performance of the analyzed U-Turn. This study analyzes 3 (three) alternative handling solutions in the form of traffic management on U-Turns and produces the best recommendations in the form of full opening of U-Turns 1 and 4, partial closure of U-Turns 2, and full closure of U-Turns 5 and 6 which can improve traffic performance on U-Turns to be more optimal (reducing delay values and increasing Level of Service values).

DOI prefix: https://doi.org/10.55927/ijar.v4i7.15071
ISSN-E: 2986-0768
https://journal.formosapublisher.org/index.php/ijar

INTRODUCTION

Traffic congestion is a phenomenon that often occurs in urban areas, especially during rush hours such as when people are going to and from work, weekends, and national holidays. (Astati Sukawati et al., 2023). This condition is caused by an imbalance between the increasing number of private vehicles and inadequate road infrastructure capacity. (Aufa Fadhil et al., 2024).

Traffic congestion is influenced by road width, vehicle volume, and the proximity of intersections or traffic lights. Each vehicle contributes significantly to congestion, especially as vehicle growth far exceeds road expansion (Sriwati, 2019). In addition to this imbalance, on-street parking also plays a major role by reducing road capacity and disrupting traffic flow (Masrul & Utami, 2021). Moreover, U-turns combined with roadside parking further contribute to congestion (Ariyanto, 2021).

A U-turn is a traffic facility that allows vehicles to reverse direction without using intersections, improving travel efficiency. However, poorly designed U-turns can cause traffic conflicts, slowdowns, and even stoppages, especially during peak hours (Hafidhoh Halim, 2022). These conflicts reduce road capacity, increase queues, and lower the Level of Service. A case study on Jalan R.W. Monginsidi, Manado, showed that high traffic volumes and poorly executed U-turns led to congestion, worsened by nearby access points (Maer et al., 2019). Thus, proper design and arrangement of median openings and U-turn facilities are crucial to reducing traffic conflicts.

Effective U-turn management on urban roads improves traffic flow by reducing conflicts between turning and through vehicles, increasing speed, and shortening queues (Hafidhoh Halim, 2022). Improved U-turn geometry also reduces congestion and enhances safety. It minimizes collision risks and lowers delays at bottlenecks, making driving more convenient. A solid understanding of U-turn maneuvers helps traffic managers develop strategies to reduce conflicts and optimize flow (Siregar, 2021).

This study aims to develop effective traffic control methods to manage vehicle flow, focusing on Jalan Cipto Mangunkusumo, Cirebon City. It evaluates the impact of U-Turns on road performance by analyzing vehicle volume, delay, queue length, speed, V/C ratio, and other key parameters. The study also assesses road geometry and level of service. VISSIM simulations were conducted at U-Turn points to propose strategic measures for reducing traffic congestion.

This study was conducted to develop a traffic management strategy focused on Jalan Cipto Mangunkusumo, Cirebon City, aiming to assess the impact of U-turns on road efficiency and propose regulatory solutions to reduce negative effects. Traffic performance at existing U-turns was analyzed using parameters such as volume, delay, queue length, speed, and V/C ratio through microscopic simulations, based on PKJI 2023 evaluation standards.

LITERATURE REVIEW

Several prior studies, such as Azka et al. (2025), examined U-turn impacts on congestion using VISSIM simulations. However, they did not apply the latest evaluation standards like PKJI 2023. Most focused more on signalized intersection control, on-street parking effects, or public transport planning (e.g., Farhan et al., 2023; A.S. et al., 2023), rather than U-turns as the main subject.

This study analyzes traffic congestion caused by U-turns on Jalan Cipto-Mangunkusumo using a quantitative approach based on the 2023 PKJI method and PTV VISSIM microscopic simulation. This represents an update from previous studies, which mostly relied on the 2014 PKJI (Gara & Idham, 2023)(Azka et al., 2025)), and emphasizes the importance of using current standards to evaluate road capacity and service levels.

In summary, this study addresses a gap in previous research by analyzing U-turn impacts on arterial roads using the latest methods and visual simulations. Recommendations - such as removing certain U-turns, rerouting traffic, and widening medians - were based on multiple VISSIM scenarios and evaluated using PKJI 2023 standards for saturation and service levels. This combination of data and simulation enhances the validity and applicability of the findings. The study's uniqueness lies in integrating PKJI 2023 with VISSIM, tailored to Jalan Cipto-Mangunkusumo's local conditions, providing a more comprehensive basis for traffic planning and policy.

METHODOLOGY

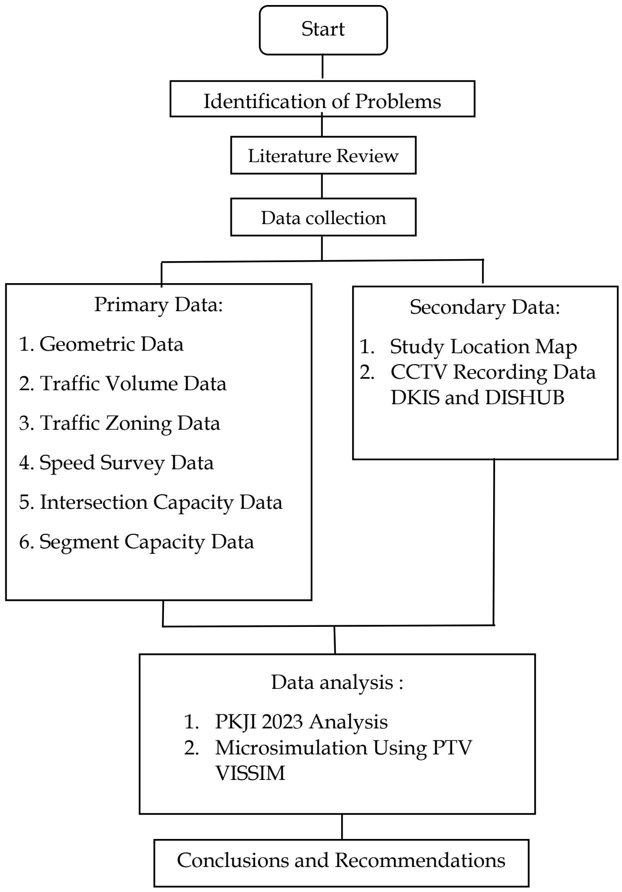

Figure 1. Research Method

Data Collection

Primary data were obtained from the results of a field survey which included geometric data, traffic flow for one day on Saturday at 15:00-24:00 WIB, the flow of vehicle entry and exit zones on Jalan Cipto Mangunkusumo, speed survey data, signalized intersection capacity data and unsignalized intersections (U-Turn), and data on the varying capacity of Cipto Mangunkusumo road segments. Secondary data were obtained from the Communication, Informatics and Statistics Office and also the Cirebon City Transportation Office.

Data Analysis

Data Analysis Using a form in Microsoft Excel by following the analysis of the 2023 Indonesian Road Capacity Guidelines. The calculation results are obtained in the form of capacity (C), vehicle flow (q), degree of saturation (Dj), queue probability (Pa), and delay (T) to determine traffic services (Level of Service). While the analysis using PTV VISSIM produces speed data, average queue length, maximum queue length and delay (T) which can classify the level of traffic service "LOS" (Level of Service). Based on the Characteristics of Service Levels according to Permendag No. 96/2015 can be seen in Table 1.

Table 1. Service Level Based on Delay (T)

Service level	Average Vehicle Delay (seconds)	Notes.
A	< 5.0	Very good
B	> 5.1 -15.0	Good.
C	> 15.1 - 25.0	Maintain
D	> 25.1 - 40.0	Less
E	> 40.1 - 60.0	Bad
F	> 60.1	Very Bad

Vehicle Growth Rate Factors

The vehicle growth rate factor (projection) is used to determine the situation in the coming year in order to have alternative solutions that can be done to avoid congestion. Based on data from the Central Statistics Agency (BPS) of West Java, vehicle growth in Cirebon City has increased every year, proving that the increase in vehicles will affect the volume of vehicles on U-turn maneuvers on the road. The steps to calculate the growth rate factor for each vehicle are by using the Compound Annual Growth Rate (CAGR) method with the following equation.

$$\textbf{CAGR \%} = \left(\left(\frac{\text{Value}_{2024}}{\text{Value}_{2020}}\right)^{\frac{1}{n}} - 1\right) \times 100$$

Microscopic Simulation Modeling

The projected traffic volume can be modeled in the VISSIM application which aims to obtain the Delay value in producing the traffic level of service (LOS), so that it can compare the performance of the U-Turn with the reference standard Guideline No: 06/BM/2005 concerning U-Turn Planning. The input data are geometric, traffic volume based on incoming zoning flow, speed, vehicle route, intersection, conflict area, and driver behavior on Jl. Cipto Mangunkusumo.

Research Location

Figure 2. Research Location

This research took place along Cipto Mangunkusumo Street, Cirebon City, West Java Province. The road is 2.73 km long, it has coordinates Latitude 6° 43.028' S Longitude 108° 33.036' E, Cirebon City, West Java.

RESULTS AND DISCUSSION

Figure 3. Road Segment, Location U-Turn, and Traffic Zoning Data

Table 2. Road Zoning

TRAFFIC ZONE OF JL. DR. CIPTO MANGUNKUSUMO		
Zone	Road Name	Information
1	Tuparev	Signalized Intersection
2	Wahidin	Signalized Intersection
3	Kartini	Signalized Intersection
4	Tentara Pelajar	Eastern Approach Location 1
5	Sutawinangun	Western Approach Location 2
6	Arya Kemuning	Eastern Approach Location 3
7	Sasana Budaya	Western Approach Location 3
8	Terusan Cipto	Western Approach Location 3
9	Pembangunan Raya	Western Approach Location 4
10	Dr. Sutomo	Eastern Approach Location 4
11	Pemuda Raya	Signalized Intersection
12	Dr. Sudarsono	Signalized Intersection
13	Karang Sari Indah	Western Approach Location 6
14	Karang Jalak Mekar	Western Approach Location 8
15	Sunyaragi	Western Approach Location 10
16	Kesambi (from the direction Kuningan)	Signalized Intersection
17	Pangeran Drajat	Signalized Intersection
18	Kesambi	Signalized Intersection

Based on Figure 3, Jalan Cipto Mangunkusumo is a 4/2 T toll road with 14 U-turns (12 open, 2 closed), 3 signalized intersections, and on-street parking. This study focuses on U-turn points to assess their impact on traffic performance. Traffic flow data, from Table 2, covers 18 inflow and outflow zones. The survey was conducted on Saturday (Sunday night) from 15:00 to 24:00 in both northbound and southbound directions.

Geometric Road Data

Road geometric data was acquired by a direct survey using a walking distance meter along Jalan Citpo Mangunkusumo.

Table 3. Road Segment

Road Segment	Wide (m)			Long (m)
	South direction	Median	North direction	
Segment A	13	1,0	9,5	140
Segment B	11	1,0	9,5	275
Segment C	11	1,0	9,5	460
Segment D	11	1,0	9,5	225
Segment E	16,5	1,5	6	380
Segment F	6,5	1,5	6,5	175
Segment G	6,5	1,5	6,5	160
Segment H	6,5	1,5	6,5	200
Segment I	6,5	1,5	6,5	150
Segment J	6,5	1,5	6,5	160
Segment K	6,5	1,5	6,5	135
Segment L	6,5	1,5	6,5	270
			Quantity :	2730

Source: Direct Observation in the Field on April 30, 2025

Table 4. Location U-Turn

Location	Road Segment	Wide (m)	Description of U-Turn		
			Long (m)	Open (m)	Closed (m)
U-Turn 1	Segment A Segment B	9,5 11	21,5	7	14,5
U-Turn 2	Segment B Segment C	9,5 11	21,5	12,5	9
U-Turn 3	Segment C Segment D	9,5 11	18	-	18
U-Turn 4	Segment D Segment E	9,5 16,5	27	17,5	9,5
U-Turn 5	Segment E Segment F	6 6,5	14,5	14,5	-
U-Turn 6	Segment F Segment G	6,5 6,5	7	7	
U-Turn 7	Segment H Segment I	6,5 6,5	7,5	7,5	-
U-Turn 8	Segment H Segment I	6,5 6,5	10,5	10,5	-
U-Turn 9	Segment I Segment J	6,5 6,5	6	6	-
U-Turn 10	Segment I Segment J	6,5 6,5	8,5	8,5	-
U-Turn 11	Segment J Segment K	6,5 6,5	8	8	-
U-Turn 12	Segment K Segment L	6,5 6,5	9	9	-
U-Turn 13	Segment L Segment L	6,5 6,5	14,5	14,5	-
U-Turn 14	Segment L Segment L	6,5 6,5	12,5	-	12,5

Source: Direct Observation in the Field on April 30, 2025

Table 3 shows Segment C as the longest at 460 m. From the north, Segments A–D have the widest roads at 9.5 m, while from the south, Segment E is widest at 16.5 m. The total length of Jalan Cipto Mangunkusumo is 2,730 m. Table 4 shows the largest median opening at U-Turn 4, with a width of 27 m, an opening length of 17.5 m, and a closing length of 9.5 m. U-Turns 1 and 2 follow with 21.5 m widths; U-Turn 1 has an opening of 7 m and closing of 14.5 m, while U-Turn 2 has an opening of 12.5 m and closing of 9 m. U-Turn 3 ranks third with an 18 m opening and 14.5 m closing.

Traffic Flow

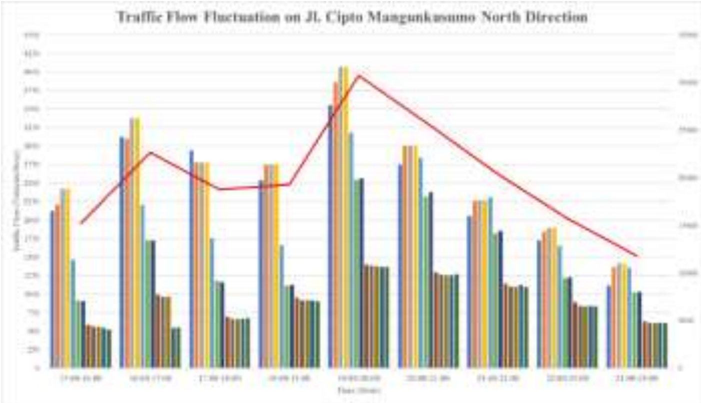

Figure 4. Traffic Flow Fluctuation on Jl. Cipto Mangunkusumo North Direction

Table 5. Number of Vehicles from the North

TIME HOUR	15:00-16:00	16:00-17:00	17:00-18:00	18:00-19:00	19:00-20:00	20:00-21:00	21:00-22:00	22:00-23:00	23:00-24:00
Segment A	2124	3123	2939	2539	3551	2747	2056	1725	1117
Segment B	2206	3098	2780	2754	3862	3005	2256	1845	1368
Segment C	2419	3378	2780	2754	4072	3007	2274	1896	1416
Segment D	2419	3378	2780	2754	4072	3007	2274	1896	1416
Segment E	1463	2206	1757	1660	3182	2847	2307	1651	1357
Segment F	911	1728	1183	1115	2542	2318	1819	1214	1023
Segment G	906	1721	1161	1121	2565	2374	1854	1229	1031
Segment H	587	994	697	954	1396	1297	1142	892	635
Segment I	560	967	670	911	1385	1265	1100	841	610
Segment J	563	964	663	919	1378	1257	1100	837	608
Segment K	542	542	669	914	1368	1253	1123	840	610
Segment L	520	552	677	904	1365	1269	1096	838	605
TOTAL	15222	22650	18756	19300	30739	25645	20402	15705	11798

Figure 4. and Table 5. show that peak hour traffic flow on Jl. Cipto Mangukusumo Northbound occurs at 19:00-20:00. The highest flow occurs in segments C and D at 4072 vehicles/hour. The total number of vehicles during peak hour passing through Jl. Cipto Mangunkusumo from the Northbound is 30739 vehicles.

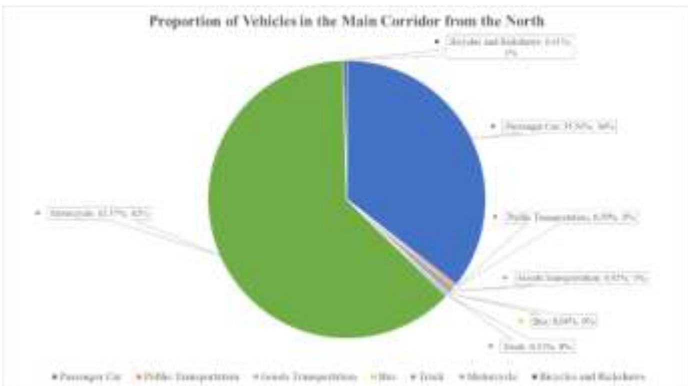

Figure 5. Proportion of the Number of Vehicles from the North

From the data in Figure 5, it shows the proportion of vehicle types passing through Jl. Cipto Mangunkusumo from the north with Motorcycles at 62.37%, Passenger Cars at 35.56%, Goods Transport at 0.92%, Public Transport at 0.39%, Trucks at 0.31%, Buses at 0.04% and Pedicabs at 0.41%.

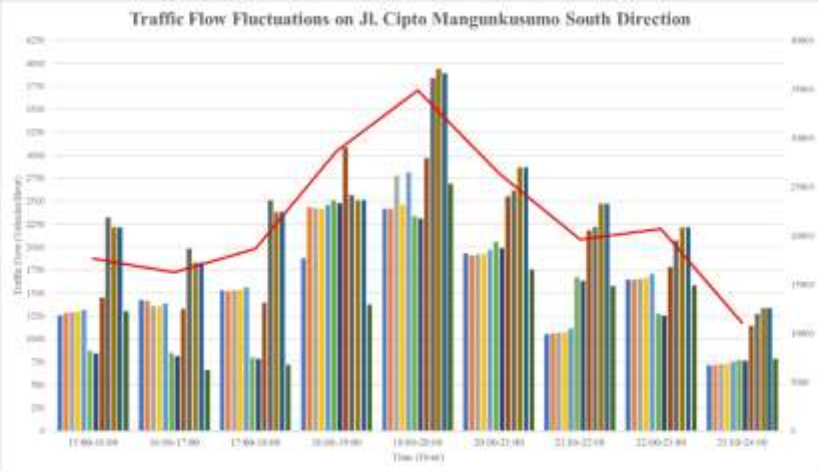

Figure 6. Traffic Flow Fluctuations on Jl. Cipto Mangunkusumo South Direction

Table 6. Number of Vehicles from the South

TIME HOUR	15:00-16:00	16:00-17:00	17:00-18:00	18:00-19:00	19:00-20:00	20:00-21:00	21:00-22:00	22:00-23:00	23:00-24:00
Segment L	1259	1424	1527	1878	2416	1928	1053	1643	715
Segment K	1281	1414	1519	2432	2420	1912	1062	1646	720
Segment J	1294	1357	1527	2421	2778	1919	1070	1654	726
Segment I	1291	1360	1535	2413	2460	1927	1070	1658	728
Segment H	1315	1384	1562	2460	2813	1967	1115	1709	753
Segment G	871	850	802	2508	2338	2056	1669	1274	773
Segment F	843	814	786	2478	2313	1990	1632	1252	759
Segment E	1447	1328	1393	3087	2971	2554	2180	1780	1144
Segment D	2321	1982	2508	2570	3838	2615	2218	2069	1271
Segment C	2217	1835	2381	2508	3941	2867	2472	2214	1334
Segment B	2217	1835	2381	2508	3893	2867	2472	2214	1334
Segment A	1303	664	717	1373	2691	1753	1580	1581	783
TOTAL	17659	16247	18638	28636	34872	26355	19593	20694	11040

Figure 6. and Table 6. show that peak hour traffic flow on Jl. Cipto Mangunkusumo southbound occurs between 7:00 PM and 8:00 PM. The highest flow occurs in segment C, with 3,941 vehicles per hour. The total number of vehicles passing through Jl. Cipto Mangunkusumo southbound during peak hour is 34,872 vehicles.

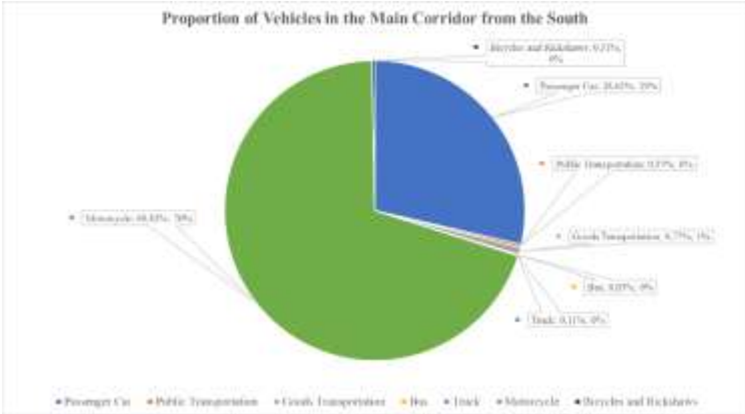

Figure 7. Proportion of the Number of Vehicles from the South

From the data in Figure 7, it shows the proportion of vehicle types passing through Jl. Cipto Mangunkusumo from the south with Motorcycles at 69.82%, Passenger Cars at 28.62%, Goods Transport at 0.77%, Public Transport at 0.35%, Trucks at 0.11%, Buses at 0.03% and Pedicabs at 0.31%.

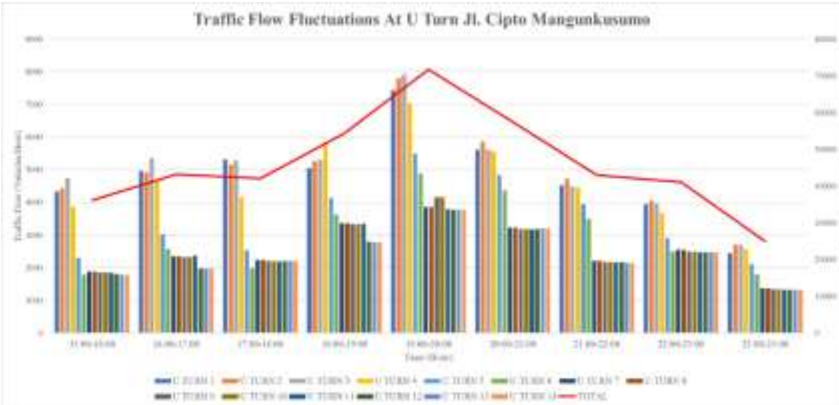

Figure 8. Traffic Flow Fluctuations At U-Turn Jl. Cipto Mangunkusumo

Table 7. Values For Graphics

VALUES FOR GRAPHICS									
TIME	15:00-16:00	16:00-17:00	17:00-18:00	18:00-19:00	19:00-20:00	20:00-21:00	21:00-22:00	22:00-23:00	23:00-24:00
U-TURN 1	4341	4958	5320	5047	7444	5614	4528	3939	2451
U-TURN 2	4423	4933	5161	5262	7803	5872	4728	4059	2702
U-TURN 3	4740	5360	5288	5324	7910	5622	4492	3965	2687
U-TURN 4	3866	4706	4173	5841	7043	5561	4454	3676	2560
U-TURN 5	2306	3020	2543	4138	5495	4837	3939	2903	2116
U-TURN 6	1782	2578	1985	3623	4880	4374	3488	2488	1796
U-TURN 7	1878	2354	2232	3367	3856	3224	2212	2550	1363
U-TURN 8	1878	2354	2232	3367	3856	3224	2212	2550	1363
U-TURN 9	1854	2324	2197	3332	4163	3184	2170	2495	1336
U-TURN 10	1854	2324	2197	3332	4163	3184	2170	2495	1336
U-TURN 11	1844	2378	2182	3351	3798	3169	2162	2483	1328
U-TURN 12	1801	1966	2196	2792	3784	3181	2176	2483	1325
U-TURN 13	1779	1976	2204	2782	3781	3197	2149	2481	1320
U-TURN 14	1779	1976	2204	2782	3781	3197	2149	2481	1320
TOTAL	36127	43206	42113	54341	71759	57439	43031	41049	25006

Figure 8. And Table 7. Show that the traffic flow during peak hours at the U-turn occurs at 7:00 PM - 8:00 PM. U-turn 3 recorded the highest vehicle flow, namely 7,910 vehicles/hour. However, U-turn 3 was known to have experienced a total closure so that it was not fully functional. The highest performance was at U-turn 2 with 7,803 vehicles/hour. In addition to U-turn 2 and U-turn 3, U-turn 1 recorded a flow of 7,444 vehicles/hour, U-turn 4 with 7,043 vehicles/hour, U-turn 5 with 5,495 vehicles/hour, and U-turn 6 with 4,880 vehicles/hour. The number of vehicles during peak hours was 71,759 vehicles. This analysis focuses on the handling of U-Turn 1-6, which shows that the performance of the U-Turn has the highest level of flow squeezed by signalized intersections (Tuparev, Wahidin and Kartini) and signalized intersections (Pemuda Raya and Dr. Sudarsono).

U-Turn Performance

In the 2023 Indonesian Capacity Guidelines, U-turns are categorized as conflict movements and are not regulated by the Traffic Signaling Device (APILL), so the approach used uses an unsignalized intersection analysis because this maneuver occurs without traffic light regulation, involves waiting vehicles, and turns against traffic flow. Adjustments to the unsignalized intersection capacity calculation formula add a U-turn factor (FPBa) based on actual conditions in the field, where the U-turn maneuver significantly affects the capacity and performance of the intersection, with the following adjustments (Jenderal et al., n.d.).

C = C0 x FLP x FM x FUK x FHS x FBKi x FBKa x FPBa x FRmi

Information:

C	=	Intersection Capacity	FHS	=	Side Obstacle Correction Factor
C0	=	Intersection Basic Capacity	FBKi	=	Left Turn Flow Ratio Correction Factor
FLP	=	Average Approach Width Correction Factor	FBKa	=	Right Turn Flow Ratio Correction Factor
FM	=	Median Type Correction Factor	FPBa	=	U-Turn Flow Ratio Correction Factor
FUK	=	City Size Correction Factor	FRmi	=	Minor Road Flow Ratio Correction Factor

Table 8. U - Turn Performance 2025

U-TURN PERFORMANCE 2025												
	U-Turn 1		U-Turn 2		U-Turn 3		U-Turn 4		U-Turn 5		U-Turn 6	
	V/H	SMP/Hour	V/H	SMP/Hour	V/H	SMP/Hour	V/H	SMP/Hour	V/H	SMP/Hour	V/H	SMP/Hour
Passenger Car	3416	3416	3409	3409	-	-	3403	3403	2269	2269	1981	1981
Medium Vehicles	10	18	9	16	-	-	8	14	7	13	7	13
Motorcycle	6732	1346	6151	1230	-	-	5665	1133	4016	803	3088	618
Total	10158	4780,4	9569	4655,4	-	-	9076	4550,4	6292	3085	5076	2611
Capasity	4824		3297		-		4406		2957		3022	
Degree of Saturation	0,99		1,41		-		1,03		1,04		0,86	
Intersection Delay (T)	18,62		-		-		20,59		21,17		14,61	
Vehicle Level of Service	**C**		**F**		**(CLOSED)**		**C**		**C**		**B**	

Based on table 8. It shows that U-Turn 2 does not issue a delay time due to the limitations of the 2023 PKJI formula in issuing a delay time when DJ reaches 1.41, this exceeds the validity limit of the delay calculation therefore, cases like this should be carried out using a microsimulation method such as VISSIM. So the highest delay value is at U-Turn 5 at 21.17 seconds with LOS C, the second value is at U-Turn 4 at 20.59 seconds with LOS C, the third value is at U-Turn 1 at 18.62 seconds with LOS C, and the last value is at U-Turn 6 at 14.61 seconds with LOS B.

Operational Performance Projections for the Next 10 Years

The projection analysis uses vehicle growth analysis, assuming that traffic growth is directly proportional to vehicle growth. Vehicle volume growth is calculated using the compound annual growth rate (CAGR) method, which has the same principle as the Compound Annual Growth Rate (CAGR). This method allows for more accurate and stable traffic growth projections over the next 10 years, thus supporting effective road capacity planning and infrastructure management. (Source: Directorate General of Highways, 2012; Road Performance Study, 2022).

Table 9. Cirebon City Vehicle Growth Data

Cirebon City Vehicle Growth Data					
Year	Vehicle Type				Total
	CAR	Bus	Truck	MC	
2020	29085	418	12656	130618	172777
2021	29501	415	12543	130628	173087
2022	29964	411	12429	130009	172813
2023	29964	411	12426	130009	172810
2024	30541	434	12076	130179	173230
CAGR	1,23%	-1,10%		-0,08%	
AVERAGE	0,02%				

Based on table 9. Shows the values used for the projection are the CAGR of each type of vehicle with a value of passenger cars of 1.23%, buses and trucks are classified as medium vehicles with a value of -1.10% and motorbikes of -0.08%.

Table 10. U - Turn Performance Projection 10 Year Ahead

U-TURN PERFORMANCE PROJECTION 10 YEARS AHEAD												
	U-Turn 1		U-Turn 2		U-Turn 3		U-Turn 4		U-Turn 5		U-Turn 6	
	V/Hour	SMP/hour	V/Hour	SMP/Hour	V/Hour	SMP/Hour	V/Hour	SMP/Hour	V/Hour	SMP/Hour	V/Hour	SMP/Hour
Passenger Car	3860	3860	3852	3852	-	-	3845	3845	2564	2564	2238	2238
Medium Vehicles	9	16	8	15	-	-	7	13	6	11	6	12
Motorcycle	6676	1335	6099	1220	-	-	5618	1124	3982	796	3062	613
Total	10544	5211	9959	5086	-	-	9470	4981	6552	3371	5307	2863
Capacity	4824		3297		-		4406		2957		3022	
Degree of Saturation	1,08		1,54		-		1,13		1,14		0,95	
Intersection Delay (T)	23,59		-		-		28,22		29,35		16,96	
Service Level Based on Delay (T)	**C**		**F**		**(CLOSED)**		**D**		**D**		**C**	

Based on table 10. Shows the highest delay value at U-Turn 5 of 29.35 seconds with LOS D, U-Turn 4 of 28.22 seconds with LOS D, U-Turn 1 of 23.59 seconds with LOS C, and U-Turn 6 of 16.96 seconds with LOS C. With these data, it results in a decrease in road performance at U-Turn 4 from LOS C to LOS D, U-Turn 5 from LOS C to LOS D, and U-Turn 6 from LOS B to LOS C.

PTV VISSIM Modeling

Based on the analysis using PKJI 2023 in the projection year 2035 regarding the performance of U-Turn 1 to U-Turn 6, an alternative solution is needed to improve the level of traffic service. The modeling approach uses PTV VISSIM software with projected performance data in 2035 and the input is attached in the discussion of the Methodology in microscopic simulation modeling.

Table 11. Parameter Driving Behavior

		Parameter Driving Behavior	Core Values	Calibration Value
1	Following			
	a	Look ahead distance Minimum	0 m	0 m
	b	Look ahead distance Maksimum	200 m	225 m
	c	Number Of Interaction Objects	4	8
	d	Look Back Distance Minimum	0 m	15 m
	e	Look Back Distance Maksimum	150 m	100 m
2	Car Following Model			
	a	Wiedemann 74 (motorcycle)		
		Average Standstill Distance	2 m	0,2 m
		Additive part of safety Distance	3	0,3
		Multiplicative Part of Safety Distance	3	0,4
	b	Wiedemann 74 (All Vehicle)		
		Average Standstill Distance	2 m	0,6 m
		Additive part of safety Distance	3	0,6
		Multiplicative Part of Safety Distance	3	1
3	Lane Change			
	a	Waiting time before diffusion	60 s	180 s
	b	Minimum headway	0,5 m	0,3 m
4	Lateral			
	a	Consider next turning direction	No	Yes
	b	Desired position at free flow = Any	Middle	Any
	c	Overtake on same lane	No	On Left and Right
	d	Min. lateral distance at 0 & 50 kmph (m) Motorcycle	0,2 and 1	0,1 and 0,3
	e	Min. lateral distance at 0 & 50 kmph (m) Passenger Car	0,2 and 1	0,2 and 1,0
	f	Min. lateral distance at 0 & 50 kmph (m) Truk	0,2 and 1	0,5 and 1,5
	g	Collision Time gain Motorcycle and All Vehicle	2 s and 2 s	0,5 s and 1 s
	h	Minimum Longitudinal Speed Motorcycle	3,6 Km/h	0 Km/h

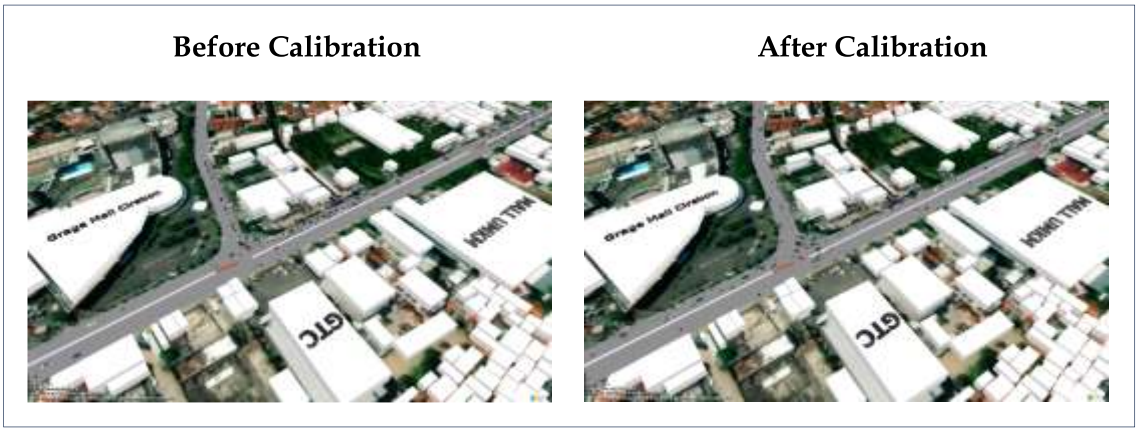

Figure 9. Before - After Calibration

VISSIM calibration was conducted to modify the characteristics of vehicle drivers according to the site conditions at the study site. Afterwards, the GEH statistical test (Geoffery E. Havers) was conducted; GEH is the standard way to compare two sets of traffic volumes from field data to modeled data. Model validation was conducted by using the GEH test to compare simulated traffic volumes with observed traffic volumes where a GEH value <5 indicates a valid model. (Pratiwi & Rusmandani, 2025).

$$\mathbf{GEH = \sqrt{2(M-C)^2/(M+C)}}$$

Table 12. GEH

No.	Road	Field Volume (vehicles/hour)	Field Volume (vehicles/hour)	GEH	Similarity Percentage (%)	Note
1	1: Tuparev	1832	1838	0,142	100	OK
2	2: Wahidin	928	862	2,216	92	OK
3	3: Kartini	958	935	0,758	98	OK
4	4: Tentara Pelajar	1218	1195	0,663	98	OK
5	5: Sutawinangun	852	797	1,907	93	OK
6	6: Arya Kemuning	424	438	0,696	97	OK
7	7: Sasana Budaya	89	75	1,563	81	OK
8	8: Terusan Cipto	397	389	0,418	98	OK
9	9: Pembangunan Raya	246	256	0,630	96	OK
10	10: Dr. Sutomo	622	637	0,604	98	OK
11	11: Pemuda Raya	1822	1758	1,506	96	OK
12	12: Dr. Sudarsono	1070	1036	1,057	97	OK
13	13: Karang Sari Indah	10	14	1,095	73	OK
14	14: Karang Jalak Mekar	39	37	0,335	94	OK
15	15: Sunyaragi	341	368	1,437	93	OK
16	16: Kesambi (from the direction Kuningan)	710	700	0,374	99	OK
17	17: Pangeran Drajat	1172	1169	0,093	100	OK
18	18: Kesambi	487	505	0,786	97	OK

Based on the data in Table 12, validation between field traffic volume and VISSIM simulation results at 18 entry and exit zones of Jl. Cipto Mangunkusumo shows a GEH value <5, thus declared "OK" and valid. The simulation results show accuracy and can represent actual conditions, so that evaluation can be carried out to improve U-turn performance.

PTV VISSIM MODELING RESULTS

Figure 10. VISSIM Simulation Results Projection for the Next 10 Years

Based on Figure 10. Showing Traffic Phenomena in the VISSIM simulation in 2035, the image shows the U-Turn 1 location, which is experiencing conflict due to a U-turn and turning onto Jl. Tentara Pelajar.

Table 13. VISSIM Simulation U - Turn Performance Projection 10 Years Ahead

U-TURN PERFORMANCE PROJECTION 10 YEARS AHEAD												
	U-Turn 1		U-Turn 2		U-Turn 3		U-Turn 4		U-Turn 5		U-Turn 6	
	North	South	North	South	North	South	North	South	North	South	North	South
Queue Length (m)	1,06	3416	0,17	8,90	-	-	122,76	0,02	17,69	0,60	0,94	3,11
Queue Length Max (m)	52,19	18	23,96	49,32	-	-	505,21	16,43	120,96	43,03	54,47	98,61
Speed Max (50m) (km/Hour)	34,85	1346	38.68	42,78	-	-	9,47	42,49	31,52	39,81	40,63	28,09
Intersection Delay (T)	20,07		32,26		-	-	29,84		28,45		15,22	
Vehicle Level of Service	**C**		**D**		**(CLOSED)**		**D**		**D**		**C**	

Based on table 13. Shows the level of traffic service at U-Turn 1 with a delay value of 20.07 seconds with LOS C, U-Turn 2 of 32.26 seconds with LOS D, U-Turn 4 of 29.84 seconds with LOS D, U-Turn 5 of 28.45 seconds with LOS D, and U-Turn 6 of 15.22 seconds with LOS C.

Alternative

Alternative 1

Urban roadway median opening requirements have separate values for each class of vehicle passing through it; 4.5 meters for small vehicles, 5.5 meters for medium vehicles, and 12 meters for heavy vehicles. That indicates that the opening sizes are at the respective standards,; however, U-Turn/median opening 6 was only stated to accommodate medium vehicles and has a size of 7 meters. (*Pedoman U-Turn.Pdf*, n.d.).

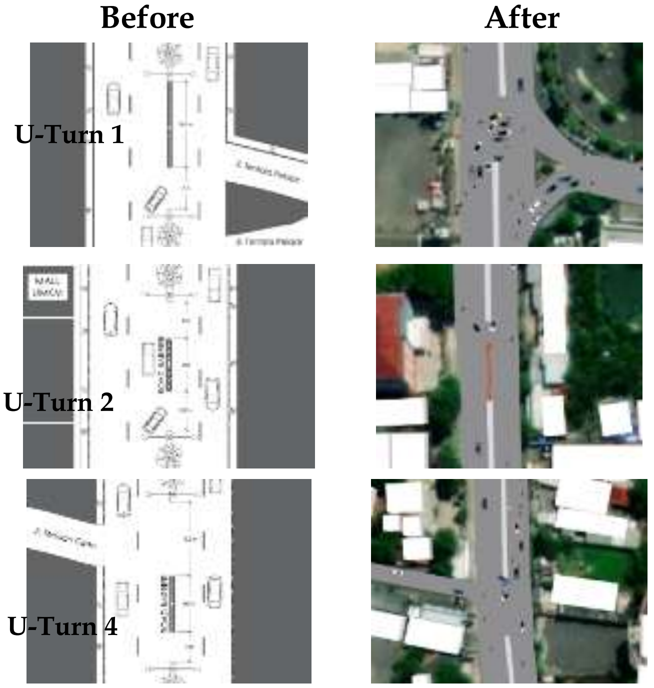

Figure 11. Alternative Simulation 1

Based on Figure 11, Simulation Alternative 1, the researchers made several U-Turn performance coordinations.

1. Opened entire U-Turn 1 from 7m to 21.5m, blocking obstructions on the roadway, and maximizing U-turn service capacity.
2. Can a partial closure on U-Turn 2, closing from the south with an 8m opening from the north (8m Open, 13.5m Closed); lessens traffic conflict and retains U-turn access from the north, as vehicles making a maneuver are encouraged to not jam-up the next U-Turn.
3. Opened entire U-Turn 4 from 17.5m to 26m, blocking obstructions on the roadway, therefore maximizing the U-turn service capacity.

Table 14. Alternative Simulation 1

U-TURN PERFORMANCE MODELING SIMULATION VISSM												
Alternative 1	U-Turn 1		U-Turn 2		U-Turn 3		U-Turn 4		U-Turn 5		U-Turn 6	
	North	South	North	South	North	South	North	South	North	South	North	South
Queue Length (m)	2,06	2,92	1,70	1,16	-	-	5,39	1,14	14,19	0,12	1,10	2,09
Queue Length Max (m)	93,21	48,81	98,77	32,63	-	-	133,94	58,09	221,77	20,42	62,31	92,49
Speed Max (50m) (km/Hour)	32,32	39,80	36,99	42,82	-	-	31,28	42,18	31,14	40,14	41,38	29,70
Intersection Delay (T)	15,97		10,68		-	-	9,43		25,13		15,14	
Vehicle Level of Service	**C**		**B**		**(CLOSED)**		**B**		**D**		**C**	

Based on table 14, it shows that the level of traffic service at U-Turn 1 has a delay value of 15.97 seconds with LOS C, U-Turn 2 has a delay value of 10.68 seconds with LOS B, U-Turn 4 has a delay value of 9.43 seconds with LOS B, U-Turn 5 has a delay value of 25.13 seconds with LOS D, and U-Turn 6 has a delay value of 15.14 seconds with LOS C. The data shows an increase in performance at U-Turn 2 from LOS D to LOS B and U-Turn 4 from LOS D to LOS B.

Alternative 2

For the second alternative, do the same thing as alternative 1, but the difference is that engineer U-Turn 5 and U-Turn 6 which have less than optimal performance.

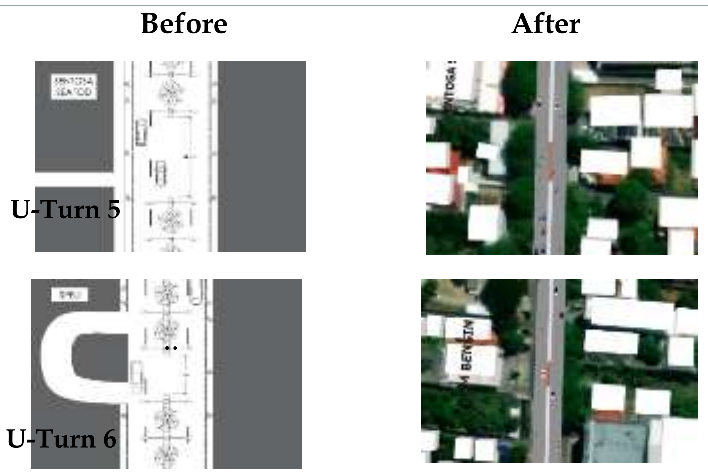

Figure 12. Alternative Simulation 2

In Alternative Simulation 2, as depicted in Figure 12, the researchers evaluated a number of U-Turn performance optimizations.

1. Close all U-Turn 5s at Sentosa to optimize traffic service performance based on high traffic flow of U-turns, and narrow road segment in that area to manoeuvre into the opposite lane thus likely creating vehicle conflicts.
2. Close all U-Turn 6s in front of gas stations to optimize traffic service performance considering the existing condition of U-Turn 6s area a signalized intersection that experiences congestion because of conflicts, and the narrow road segment in that area to manoeuvre into the opposite lane thus likely creating vehicle conflicts.

Table 15. Alternative Simulation 2

U-TURN PERFORMANCE MODELING SIMULATION VISSM												
Alternative 2	U-Turn 1		U-Turn 2		U-Turn 3		U-Turn 4		U-Turn 5		U-Turn 6	
	North	South	North	South	North	South	North	South	North	South	North	South
Queue Length (m)	1,56	1,13	1,22	1,33	-	-	4,97	0,26	-	-	-	-
Queue Length Max (m)	78,16	33,72	77,80	40,59	-	-	137,67	23,91	-	-	-	-
Speed Max (50m) (km/Hour)	32,30	41,18	37,34	43,69	-	-	31,68	41,50	-	-	-	-
Intersection Delay (T)	15,15		9,10		-	-	9,11		-		-	
Vehicle Level of Service	**C**		**B**		**(CLOSED)**		**B**		**(CLOSED)**		**(CLOSED)**	

Based on table 15. shows the level of traffic service at U-Turn 1, the delay value is 15.15 seconds with LOS C, U-Turn 2, the delay value is 9.10 seconds with LOS B, and U-Turn 4, the delay value is 9.11 seconds with LOS B. The data shows an increase in the performance of U-Turn 2 from LOS D to LOS B, U-Turn 4 from LOS D to LOS B and closes the service performance of U-Turn 5 and U-Turn 6.

Alternative 3

The third alternative essentially involves doing what Alternative 1 did, except for Loopbacks 5 and 6, which did not work optimally.

Figure 13. Alternative Simulation 3

Based on Figure 13, Simulation Alternative 3, the researchers took several steps to coordinate U-Turn performance, namely.

1. Closing all U-Turn 6s in front of gas stations to optimize traffic service performance, taking into account the existing condition of U-Turn 6,

which is located near a signalized intersection prone to conflict, and the relatively narrow road section at that location for maneuvering into the opposite lane, potentially causing vehicle movement.

Table 16. Alternative Simulation 3

U-TURN PERFORMANCE MODELING SIMULATION VISSM												
Alternative 3	U-Turn 1		U-Turn 2		U-Turn 3		U-Turn 4		U-Turn 5		U-Turn 6	
	North	South	North	South	North	South	North	South	North	South	North	South
Queue Length (m)	2,21	2,98	0,95	2,01	-	-	4,74	1,41	8,00	0,92	-	-
Queue Length Max (m)	83,67	51,78	63,18	45,78	-	-	136,11	52,69	101,22	68,81	-	-
Speed Max (50m) (km/Hour)	31,92	39,97	37,07	43,32	-	-	30,42	41,79	31,98	38,78	-	-
Intersection Delay (T)	15,61		10,45		-	-	9,88		27,73		-	
Vehicle Level of Service	**C**		**B**		**(CLOSED)**		**B**		**D**		**(CLOSED)**	

Based on table 16 shows the level of traffic service at U-Turn 1, the delay value is 15.61 seconds with LOS C, U-Turn 2, the delay value is 10.45 seconds with LOS B, U-Turn 4, the delay value is 9.88 seconds with LOS B and U-Turn 5, the delay value is 27.73 seconds with LOS D. The data shows an increase in the performance of U-Turn 2 from LOS D to LOS B, U-Turn 4 from LOS D to LOS B and the closing performance of U-Turn 6.

RECOMMENDATION

Table 17. Recommendation

U-TURN PERFORMANCE PROJECTION 10 YEARS AHEAD							
Intersection Delay (T)	20,07	32,26	-	-	29,84	28,45	15,22
Vehicle Level of Service	**C**	**D**	**(CLOSED)**		**D**	**D**	**C**

U-TURN PERFORMANCE MODELING SIMULATION VISSM Skenario 1							
Intersection Delay (T)	15,97	10,68	-	-	9,43	25,13	15,14
Vehicle Level of Service	**C**	**B**	**(CLOSED)**		**B**	**D**	**C**

U-TURN PERFORMANCE MODELING SIMULATION VISSM Skenario 2							
Intersection Delay (T)	15,15	9,10	-	-	9,11	-	-
Vehicle Level of Service	**C**	**B**	**(CLOSED)**		**B**	**(CLOSED)**	**(CLOSED)**

U-TURN PERFORMANCE MODELING SIMULATION VISSM Skenario 3							
Intersection Delay (T)	15,61	10,45	-	-	9,88	27,73	-
Vehicle Level of Service	**C**	**B**	**(CLOSED)**		**B**	**D**	**(CLOSED)**

Based on Table 17. In determining the recommendations, the Service Level Characteristics according to Permendag No. 96/2015 are taken into account, thus recommending the second scenario, where the second scenario fully opens U-Turn 1 and 4, partially closes U-Turn 2, and fully closes U-Turn 5 and 6 by minimizing the area conflicts that occur so that U-turn or turning maneuvers are more in accordance with the requirements for median openings on urban roads adjusted to the type of vehicle passing, namely 4.5 meters for small vehicles, 5.5 meters for medium vehicles, and 12 meters for heavy vehicles. (*Pedoman U-Turn.Pdf*, n.d.).

CONCLUSION

Research analysis of the Jl. Cipto Mangunkusumo section concluded that Scenario 2 is one of the best alternatives to improve traffic service conditions in the next 10-year projection. This aligns with Minister of Trade Regulation No. 96/2015. Delay (T) and LOS (Level of Service) in Scenario 2 are better than those in other scenarios.

In Scenario 2, U-Turns 1 and 4 are fully opened, U-Turn 2 is partially closed, and U-Turns 5 and 6 are closed. This strategy is effective in reducing traffic conflicts caused by right- and left-turning vehicles, which occur in areas where forward visibility is limited. Implementing Scenario 2 is expected to result in better traffic flow, increased travel time reliability, and enhanced comfort and safety for road users. However, the data used in this study was from Saturday nights. Given that Saturday nights are a busy time for recreational and commercial activities, this engineering approach is more appropriate for weekends or holidays.

ADVANCED RESEARCH

This study was conducted on a Saturday night, reflecting typical weekend traffic conditions influenced by recreational and business activities. To gain a more comprehensive understanding of traffic patterns on Jl. Cipto Mangunkusumo, further research is needed during weekdays and at various times. Future studies should also examine driver behavior, particularly gap acceptance during U-turns, and assess the effects of on-street parking as a potential obstruction. Additionally, traffic safety evaluations and cost-benefit analyses of proposed engineering solutions are essential. Exploring alternative intersection designs like MUTIs or signalized U-turns, along with AI-based predictive models and real-time sensors, is recommended to enhance simulation accuracy and support data-driven policies.

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