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Traffic Impact Analysis of Hotel & Convention Center Development on National Road in Malang City

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Abstract

The rapid growth of tourism in Malang City has increased traffic volume around commercial corridors, particularly near hotel and convention facilities. This study analyzes the traffic impact of the CDR-INN Hotel & Convention construction at Jaksa Agung Suprapto Street using Traffic Impact Analysis (TIA) framework. The analysis includes trip generation, origin-destination matrix, and road performance evaluated through PTV Vissim microsimulation for existing, construction, initial operation, and five-year operation conditions. Results indicate existing intersections experience moderate to high congestion. Construction activities significantly increase delays and saturation. Initial and five-year operations show substantial traffic load decreasing service levels without mitigation. Do Something scenarios—including signal optimization, turn restrictions, continuous-flow lanes, and selective widening—improve performance. The study concludes integrated engineering interventions are essential to maintain traffic performance and support sustainable urban mobility.

Keywords: *Convention center, Hotel development, Microsimulation, Traffic impact analysis, Urban mobility..*

1. Introduction

Tourism accommodation is an essential component of the tourism industry, providing temporary lodging for tourists and playing a significant role in shaping the quality of their travel experience [1]. As global tourism continues to grow, the variety and functions of accommodation are becoming increasingly diverse, accompanied by new challenges related to sustainability, innovation, and socio-economic impacts. The availability, quality, and distribution of accommodation are factors that greatly influence the attractiveness and success of a tourist destination. From an economic perspective, the growth of tourism accommodation can generate new sources of income, expand employment opportunities, and improve the welfare of local communities, especially in tourist areas and rural regions [2]. Meanwhile, from a social perspective, tourism accommodation can encourage infrastructure development, improve access to social services, and raise community living standards, but it also has the potential to cause traffic congestion, pollution, and pressure on public facilities [3].

Tourism in Indonesia is a strategic sector that contributes significantly to the national economy, job creation, and increased regional income. Accommodations such as hotels, homestays, and various types of lodgings play a crucial role in driving tourism growth and increasing the competitiveness of a destination. The development of tourism accommodation in Indonesia shows a wide diversity, ranging from star-rated hotels to community-based homestays, with each type of accommodation contributing to shaping the tourist experience. Service quality is a major factor that determines the value of accommodation for tourists, and research shows that service quality significantly affects tourist satisfaction and loyalty [4]. In addition, global trends show an increasing focus on sustainable hotels that implement environmentally friendly practices and energy efficiency, an approach that has been proven to strengthen the image of a destination and attract tourists who care about sustainability [5]. Malang is one of Indonesia's main tourist destinations, supported by its rich culture, historical value, and diverse natural scenery. The development of the tourism sector in this city has also encouraged the emergence of various forms of accommodation, ranging from star-rated hotels to homestays in thematic villages, as well as the use of digital innovations to facilitate tourists. In the context of Malang City, the existence of hotels and accommodations with a sustainability concept is an important element in supporting the city's identity as a destination for nature, culture, and education.

The development of a city is generally accompanied by increased mobility of residents and tourists, making the need for accommodation facilities such as hotels increasingly crucial. In cities that serve as centers of education, tourism, and business activities, accommodation has a strategic function in supporting human mobility and economic dynamics. The city of Malang is one such example, with the number of domestic tourist visits in 2024 reaching 3,089,759 people and foreign tourists numbering 67,148 people. The high intensity of these visits is in line with findings in the city of Zagreb, which indicate that increased tourist mobility drives the strengthening of accommodation supply in urban areas [6]. In addition, the growth in demand for accommodation in Malang is also reflected in the number of registered accommodation facilities in 2024, namely 43 star-rated hotels, 34 non-star-rated hotels, 66 guest houses, and 24 tourist lodges. Other studies also support this phenomenon by confirming that the increase in the number of tourists directly contributes to the increase in demand for tourism services, including accommodation [7]. These conditions make the construction of new hotels in strategic locations a rational response to the increase in tourism, academic activities, and business activities in Malang City. However, the existence of hotels not only contributes to the city's economic and service functions but also has implications for vehicle traffic, whether from guests, employees, operational services, or logistics activities. Thus, hotel development has the potential to increase traffic congestion on the surrounding road network, requiring technical studies to ensure that it does not disrupt the smooth running of the urban transportation system.

The growth of tourism activities in Malang City has led to an increase in travel to various accommodation areas, commercial centers, and community activity locations. This increase in mobility has also led to an increase in the use of private vehicles in urban areas, as seen in the number of motor vehicles in 2024, with 231,006 motorcycles, 68,426 passenger cars, 2,762 trucks, and 93 buses, as recorded by the Malang City Statistics Agency. Malang City's road network, which is 968.898 km long and serves as the main connector for various urban activities, is facing increasing pressure, especially in tourist corridors and commercial areas such as main roads. International studies indicate that the development of tourist and commercial areas in developing cities tends to increase dependence on private vehicles, which ultimately increases traffic congestion [8], [9]. Therefore, tourism activities that require high mobility are one of the significant factors affecting the increase in vehicle volume and traffic density in Malang City.

One form of traffic management that must be implemented by every hotel or tourist accommodation owner is the preparation of a Traffic Impact Analysis (TIA). This analysis is prepared in accordance with the provisions of laws and regulations. Law No. 22 of 2009 concerning Road Traffic and Transportation and Government Regulation No. 32 of 2011 concerning Management and Engineering, Impact Analysis, and Traffic Demand Management stipulate that every activity center that has the potential to cause disturbances to traffic safety, order, and smoothness must conduct a TIA before obtaining a construction permit. The Andalalin document includes an analysis of trip generation and attraction, an evaluation of road and intersection performance before and after construction, and simulations of various traffic management scenarios. Through this study, the potential for congestion, queues, and a decline in road service levels can be identified at the planning stage, enabling the government and developers to prepare effective management strategies to maintain smooth traffic flow in the area surrounding the project.

Researchers conducted a study on the planned construction of a hotel and convention center located in the center of Malang City. The facility is located at Jl. Jaksa Agung Suprapto No. 91, Klojen District, an area that is part of the national road network and serves as a strategic corridor for urban and regional traffic. This area is a meeting point for several main roads and is equipped with signalized intersections that experience high vehicle volumes during peak hours. Given the characteristics of the location, which is at the center of city activities and located on a route with significant traffic density, an Andalalin study in this area is relevant and important to conduct.

A number of previous studies have discussed the traffic impact anal on the construction of commercial facilities in Indonesia, such as a study on the construction of a freight terminal in Pati that assessed traffic generation and attraction during the construction and operational phases using MKJI and network simulation [10], as well as research on the Front One Hotel in Tulungagung that analyzed the impact of construction on road and intersection performance through traffic loading and parking space requirement calculations [11]. However, most of these studies still focus on existing conditions or the initial operational phase without compiling a gradual origin-destination matrix, and have not discussed multi-phase scenarios such as construction, initial operation, or long-term projections with a comprehensive comparison of Do Nothing and Do Something. Based on these gaps, this study provides new contributions through the calculation of generation-attraction using the ITE method and similar land uses, the preparation of MOD from existing conditions to five-year projections, and the evaluation of road and intersection performance through simulations in Do Nothing and Do Something scenarios to produce more measurable traffic engineering recommendations.

2. Literature Review

2.1. Traffic Impact Analysis

Traffic Impact Analysis (TIA) is a crucial process used to assess the traffic impact of development plans on the performance of the surrounding road network. TIA includes stages of data collection, analysis of trip generation and attraction, trip distribution, traffic flow loading on road sections or intersections, and evaluation of traffic performance based on parameters such as degree of saturation, delay, queue length, and Level of Service (LOS). The TIA process begins with data collection through existing traffic surveys to obtain information on volume characteristics, vehicle composition, and peak hour patterns on the road network around the development site [12], [13]. The next stage involves estimating trip generation and travel demand using the trip generation method, which generally refers to trip generation manuals or other relevant empirical models.[12], [13].

The construction of large-scale facilities such as shopping centers, hotels, and convention centers has the potential to cause significant traffic congestion. One journal state that hotels in tourist areas generate different travel patterns compared to residential or office areas.

Activities such as guest arrivals, conference organization, logistics operations, and accommodation services create waves of vehicle movement at certain times, especially during peak hours or when activities are taking place [14]. This finding shows that hotel development not only increases vehicle volume but also affects traffic flow distribution patterns on the surrounding road network. Other studies confirm that the tourism sector has unique travel characteristics, requiring a more specific approach to modeling generation and attraction for tourist facilities and accommodations [15] Therefore, the construction of large-scale hotels and convention centers in densely populated urban areas needs to be analyzed comprehensively so as not to cause traffic disruptions.

In addition to manual calculations, modern Traffic Impact Analysis practices require the use of microscopic simulations to obtain a more realistic representation of traffic conditions. Microsimulation models enable analysis of interactions between vehicles, queue lengths, potential conflicts between directions of movement, and the response of road networks to changes in access and facility layout [16]. Research shows that many developing countries still rely on conventional analysis methods, so TIA results often do not accurately reflect field conditions [17]. In this context, software such as PTV VISSIM has proven capable of visualizing various operational scenarios, evaluating signal phases, road segment widening, parking arrangements, and entrance-exit arrangements based on empirical data [16]. Therefore, the use of simulation is an important component in the preparation of Andalalin for the construction of large-scale commercial facilities.

2.2. Four Step Model

The Four Step Model is one of the most widely used approaches to travel demand forecasting in modern transportation planning. This model was developed in the 1950s and 1960s and remains the mainstay of urban transportation system analysis. It is used to predict travel patterns in a region based on the relationship between land use, population characteristics, and transportation network performance [16]. The Four Step Model consists of four core stages, namely trip generation, trip distribution, mode choice, and route assignment. These four stages are carried out sequentially so that the output from one stage becomes the input for the next stage. The main advantages of this model lie in its systematic structure, ease of analysis, and flexibility in evaluating the impact of development or changes in the road network on traffic movement.

Overall, the stages in the Four Step Model can be described as follows:

1. Trip Generation, This stage serves to estimate the number of trips generated and received by an area or building. The volume of trips is influenced by the type of activity, facility capacity, number of users, operating hours, and land use function. This stage is commonly applied to predict the traffic impact of large-scale facility development such as residential areas, shopping centers, and hotels [14].
2. Trip Distribution, Once the number of trips is known, this stage determines the distribution of trips from the origin zone to the destination zone, forming an origin-destination (OD) [16].
3. Mode Choice This stage analyzes the distribution of trips based on the mode of transportation used for each trip (e.g., car, bus, bicycle). Influencing factors include travel time, cost, convenience, and availability of public transportation [16].
4. Route Assignment The final stage is the total assignment of trips to the road network to determine the route or path selected in the transportation network for each trip. The results are used to assess vehicle volume on each section, degree of saturation, level of service (LOS), congestion points, and traffic engineering needs [16].

3. Methods

3.1. Research location

The research location is in a commercial building on the south side of the intersection of Jalan Raya Gempol–Malang and Jalan WR Supratman, right in the area marked on the map. This area is in a neighborhood with fairly dense business activity, close to the Samsung Service Center Malang and not far from the Savana Hotel & Convention. Its location on a busy road with heavy traffic makes it an important site for research, especially to see how the activities within it can affect the flow of traffic in the surrounding area.

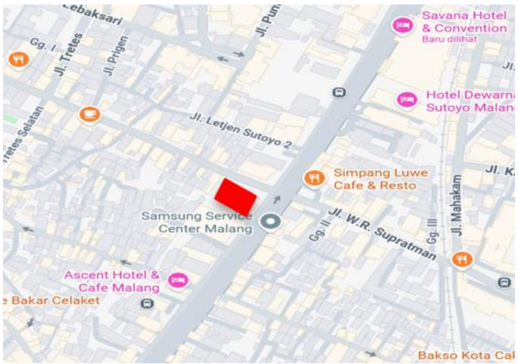

Fig 1. Research location

Cross-flow occurs along the axial coordinate $z \in [0, L]$ in the feed channel, while solvent and ion transport through the active layer are resolved in the radial coordinate $x \in [0, \delta_x]$. The electrolyte contains five ionic species, Na^+, Cl^-, Ca^{2+}, Mg^{2+}, and SO_4^{2-}, which are assumed to satisfy local electroneutrality everywhere inside the pore solution. Steady-state, isothermal conditions ($T = 298.15$ K) are imposed, with the brine treated as an incompressible Newtonian fluid of constant bulk density and viscosity over the operating range, consistent with mechanistic NF models for spiral-wound leaves in the literature [12][13].

3.2. Data collection

The data requirements for this study consist of primary and secondary data used as the basis for analyzing travel generation and attraction as well as evaluating road network performance in the study area. Secondary data was obtained from relevant agencies and used as a reference for planning and as a source of historical information, including regional spatial planning documents, city statistics, previous study results, historical traffic data, and road network development plans. Meanwhile, primary data was collected through field surveys covering traffic volume counts, road service level assessments, and trip generation and travel demand surveys, as well as the compilation of a Matrix of Origins and Destinations (MOD). All types of data required in this study are summarized in Table 1.

Table 1. List of primary and secondary data requirements

No.	Data Type	Categories	Data Source
1	Regional Spatial Plan	Secondary	Malang City Regional Development Planning Agency
2	Malang City in Figures	Secondary	Central Bureau of Statistics
3	Previous study documents	Secondary	Relevant institutions / web
4	Traffic history data of related road segments	Secondary	Malang City Transportation Agency
5	Road network development plan of the study area	Secondary	Malang City Transportation Agency
6	Intersection Traffic Volume (pcu/hour)	Primary	Traffic Count Survey
7	Level of Service (LOS)	Primary	Road performance
8	Trip Generation and Attraction & Origin–Destination Matrix (OD Matrix)	Primary	Traffic Count Survey

3.3. Traffic performance

3.3.1. Section performance

Road section performance analysis is conducted to determine the capacity of a road segment to accommodate traffic flow based on the provisions of MKJI (1997). In MKJI (1997), road section capacity can be calculated based on the following equation:

$$C = C_0 .\ FC_W .\ FC_{SP} .\ FC_{SF} . FC_{CS} \quad (1)$$

Definition 1: C = capacity (pcu per hour), C_0 = base capacity (pcu per hour), FCSP = distribution adjustment factor, FCW = road width adjustment factor, FCSF = side interference adjustment factor, FCCS = city size adjustment factor.

Once the capacity is obtained, the actual traffic flow (Q) is calculated by converting all vehicles into passenger car units (pcu) using the emp value according to MKJI in Table 2.

Table 2. Vehicle Conversion to Passenger Car Unit

Vehicle Type	emp for Approach Type	
	Shielded	Opposed
Light Vehicle (LV)	1,0	1,0
Heavy Vehicle (HV)	1,3	1,3
Motorcycle (MC)	0,2	0,4

Calculate for each vehicle ratio can be calculated by the formula:
In MKJI (1997), traffic flow can be calculated based on the following equation:

$$Q\ (RT, ST, LT) = QLV + QHV \times empHV + QMC \times empMC \quad (2)$$

Definition 2: Q = Traffic Flow, emp = Passenger Car Unit Conversion.

The traffic flow value is then used to determine the degree of saturation (DS) as the main indicator of road performance.

$$DS = \frac{Q}{C} \quad (3)$$

Definition 3: DS = Road Service Level, Q = Traffic Volume (pcu/hour), C= Road Capacity (pcu/hour).

3.3.2. Intersection performance

VISSIM itself is microscopic traffic simulation software capable of visualizing vehicle movements in detail. VISSIM can represent real conditions through modeling driver behavior, vehicle interactions, and signal settings. In this process, calibration is necessary so that the driving behavior parameters in the model can describe the actual behavior of drivers in the field. Calibration is carried out by adjusting parameters such as following behavior and lateral behavior through trial and error until the simulation approximates the observed results [18].

The data obtained from the field was then analyzed to achieve the research objectives. The analysis process was carried out in several stages, namely:

1. Conduct field surveys to collect geometric data on roads, vehicle volume, speed, and queue length.
2. Recapitulate vehicle types, speeds, volumes, and queue lengths using Microsoft Excel.
3. Input volume, speed, cycle time, and geometric data into the VISSIM software.
4. Run simulations on VISSIM to obtain the required output.
5. Perform the calibration process through trial and error by comparing the simulation model with actual conditions.
6. Evaluate and improve intersection performance by adjusting signal cycle times.

3.4. Traffic modeling

3.4.1. Existing

Fig 2 and Table 3 present the research location and the division of study zones based on the main access roads as sources of traffic movement into and out of the study area. The division of zones is used to represent existing movement patterns on each approach road and forms the basis for traffic modeling in the study area.

Fig 2. Map of Research Locations

Table 3. List of street names that are part of the study zone at the research location.

No	Roads / Details
1	Traffic movement on W.R. Supratman Street
2	Traffic movement on Letnan Sutoyo Street
3	Traffic movement on Sarangan Street
4	Traffic movement on Tawangmangu Street
5	Traffic movement on Kaliurang Street
6	Traffic movement on Brigjen Slamet Riyadi Street
7	Traffic movement on Basuki Rahmat Street
8	Location of the CDR Inn Hotel & Convention development

The determination of movement magnitude in the base year was carried out using vehicle volume data obtained through traffic surveys. The generation and attraction values for each zone were then calculated to illustrate the distribution of movement within the study area. The results of these calculations are presented in Table 4.

Table 4 Trip generation and attraction values for each zone

No	Zone	Trip Generation		Trip Attraction	
		Vehicle/hour	%	Vehicle/hour	%
1	W. R. Supratman St.	1959	14%	1605	12%
2	Letnan Sutoyo St.	2806	20%	3477	25%
3	Sarangan St.	1136	8%	1068	8%
4	Tawangmangu St.	1255	9%	1378	10%
5	Kaliurang St.	826	6%	1356	10%
6	Brigjen Slamet Riyadi St.	2800	20%	1083	8%
7	Basuki Rahmat St.	3164	23%	3979	29%

3.4.2. Construction

This stage analyzes the distribution process of generation and travel demand during the construction period. Each zone receives movement loads based on the origin of the construction materials used. Materials are obtained from Pakis, Malang Regency, and from Raya Karanglo St., Malang City, then distributed via W. R. Supratman St. and Letnan Sutoyo St. To provide a clearer picture of the location and distribution routes of materials, Figure 3 shows the position of the batching plant as the starting point for concrete delivery.

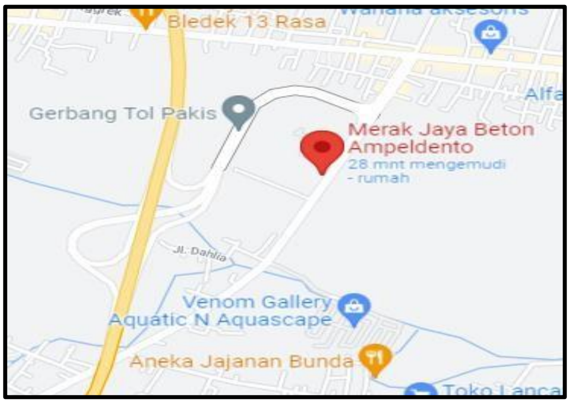

Fig 3. Batching plant locations

In addition, other material requirements such as aggregates and supporting materials are shown in Figure 5, which displays the location of material storage before being transported to the project area.

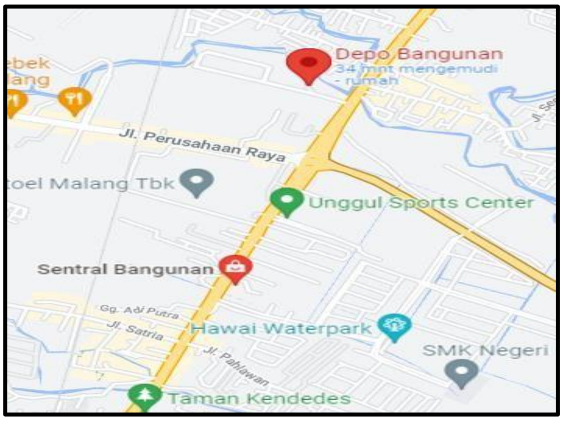

Fig 4. Material locations

3.4.3. Post construction

This study used two approaches to calculate trip generation and trip demand, namely the Similar Land Use Method and the ITE Method. From the two calculation results, the highest value was selected.

1. Similar Land Use Method
   This method predicts generation and attraction by comparing similar facilities that are already in operation. In this study, a survey was conducted at the Savanna Hotel over two days. The first day was a weekend with no events, assuming that vehicles during peak hours were hotel guests. The second day was a weekday with events, assuming that vehicles during peak hours were attracted by activities at the convention center.
2. ITE Method (Institute of Transportation Engineers)
   The ITE method calculates generation-attraction based on data and equations in the ITE Trip Generation Manual, which uses international survey data and has been standardized for various types of land use.

Both methods are essential in Traffic Impact Analysis (TIA) for the construction of the CDR INN Hotel and Convention Center. The data obtained is used to assess the performance of the existing road network, as well as to identify and predict potential traffic problems due to movement characteristics and land use patterns, both at present and in the future. Additionally, Figure 5 below shows the location of the Savanna Hotel, which is the subject of the comparative survey, as well as the location of the CDR INN Hotel and Convention Center construction, which is the focus of the generation-attraction analysis.

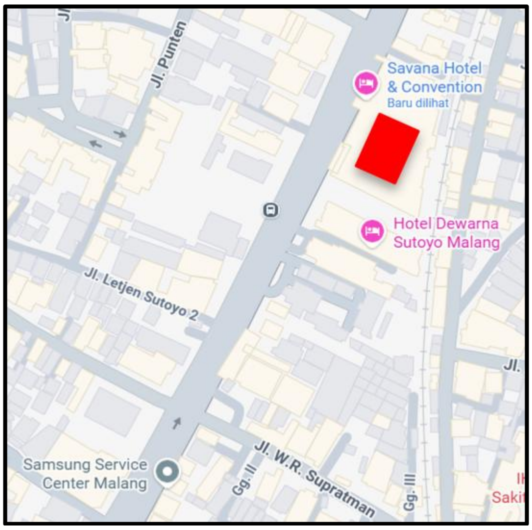

Fig 5. Map of the location of Hotel Savanna as a comparison object

4. Results & Discussion

4.1. Analysis of existing data

4.1.1. Existing matrix origin-destination

The base year travel pattern is compiled based on vehicle volume data from traffic surveys that describe existing traffic conditions on the road network. The results of data processing are presented in the form of an origin-destination matrix (OD) to determine the distribution of trips between each zone in the study area. The existing origin-destination matrix is shown in Table 5

Table 5. MOD Existing

MOD EXISTING								
Zone	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Pi**
1	0	661	139	475	455	72	157	1959
2	318	0	458	79	75	587	1289	2806
3	76	575	0	19	18	140	308	1136
4	468	15	3	0	445	102	223	1255
5	229	7	2	429	0	50	109	826
6	118	511	107	87	83	0	1893	2800
7	396	1709	359	290	278	132	0	3164

4.1.2. Existing matrix origin-destination

1. Intersection performance

Based on the existing MOD results in Table 5, it can be seen that each zone has different trip generation and attraction values, resulting in traffic flows entering and exiting the intersections in the study area. The distribution of these movements was then analyzed further to determine their effect on intersection performance under existing conditions. The intersection performance evaluation was conducted using Vissim simulation with vehicle delay and queue length parameters at each intersection arm. The existing intersection performance simulation results are shown in Tables 6.

Table 6. Performance of Intersection 1 - 4 under Existing Conditions

Intersection	Direction	VehDelay(ALL)	Qlen
1	South	37,5	55,7
	East	239,4	142,7
	North	139,8	148,3
	West	164,9	161,2
2	East	9,9	11,3
	North	2,1	0,0
	West	3,9	1,2
3	North	97,94	161,78
	West	68,98	58,41

Intersection	Direction	VehDelay(ALL)	Qlen
	South	16,92	21,04
4	North	29,78	76,72
	West	163,50	117,79
	South	83,13	112,38

2. Section performance

The results of the performance calculations for the J.A. Suprapto Street segment in the North and South directions are presented in Table 7.

Table 7. Degree of Saturation of J.A Suparapto St.

Direction	Traffic Flow veh./hour	Degree of Saturation	Speed Km/hour	Level of Service
North	2094	0,72	51	C
South	2223	0,99	49	E

4.2. Analysis of construction data

4.2.1. Construction matrix origin-destination

To illustrate changes in traffic distribution during the construction period, MOD was modified based on increases in vehicle numbers and changes in traffic flow between zones. The results of the construction MOD can be seen in Table 8.

Table 8. Modified MOD for Construction Period

MOD Construction (2025)									
Zone	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Pi**
1	0	690	145	496	476	75	164	6	2052
2	332	0	478	82	79	613	1345	4	2934
3	76	577	0	19	18	141	309	0	1139
4	488	15	3	0	465	106	233	0	1310
5	239	8	2	448	0	52	114	0	863
6	124	534	112	91	87	0	1977	0	2924
7	413	1784	375	303	291	138	0	0	3304
8	6	4	0	0	0	0	0	0	10
Ai	1679	3612	1115	1438	1415	1125	4142	10	14536

4.2.2. Construction traffic performance

Based on the MOD that has been adjusted for construction conditions in Table 4.6, it can be seen that there is an increase in the intensity of inter-zone movement as a consequence of the increase in heavy vehicles and changes in traffic flow patterns during construction activities. This phenomenon has the potential to increase the traffic load entering intersections and road sections around the project area. Therefore, a further analysis was carried out to assess the impact of these changes on traffic network performance.

1. Intersection performance

The increase in traffic flow during the construction period was analyzed through modeling using VISSIM to identify changes in delay values, queue lengths, and degrees of saturation at each intersection arm. The results of the intersection performance evaluation during the construction period are presented in Tables 9.

Table 9. Performance of Intersection 1 during Construction

Intersection	Total Delay	Average Delay	Critical Movement (Highest Delay)
1	3,041,664.32	628.176	West (Queue 908.43 m, Delay 1,175,957.20 sec/pcu), Degree of Saturation (1,77)
3	803,909.57	203.148	North (Queue 771.97 m, Delay 629,357.67 sec/pcu), Degree of Saturation (1,22)
4	4,813,005.00	1,256.43	West (Queue 2,158.59 m, Delay 4,635,577.34 sec/pcu), Degree of Saturation (0,99)

2. Section performance

In addition to intersections, vehicle increases during the construction period were also assessed on road sections. The analysis was conducted by calculating traffic flow and the degree of saturation in each direction of the section so that the level of service of the road section during the construction period could be determined. The results of the road section performance calculations are shown in Table 10.

Table 10. Performance of Section during Construction Period

Direction	Traffic Flow veh./hour	Degree of Saturation
	Q	DS
North	11292	3,89
South	12049	5,34

4.3. Analysis of the initial operational period

4.3.1. Trip generation and attraction forecast

In the initial operational stage, vehicle generation and attraction estimates were made by referring to the results of surveys of facilities with similar characteristics. In addition to similar land use methods, vehicle generation and attraction predictions are also calculated using the ITE (Institute of Transportation Engineers) method. Based on these coefficients, the recapitulation of the predicted generation-demand of Hotel CDR INN using the ITE method and similar land use methods is presented in Table 11.

Table 11. Recap of Forecasted Occupancy and Demand for CDR INN Hotels

Land Use Types	ITE Methods				Similar Land Use Methods			
	Car	Motorcycle	Total Vehicle	Total Vehicle (pcu/hout)	Car	Motorcycle	Total Vehicle	Total Vehicle (pcu/hout)
Hotel	70	110	180	114,12	68	108	176	111,38
Convention	190	310	500	314	188	306	494	310,40
Total	260	420	680	428,12	256	414	670	421,78

From the calculations of similar land use and ITE, the highest value was used, which was the result of the ITE method: 260 cars/hour and 420 motorcycles/hour. After the vehicle generation value was obtained, the next step was to determine the direction of vehicle distribution entering the road network around the study location.

Table 12. Initial Operational MOD

INITIAL OPERATIONAL MOD (2026)									
Zone	1	2	3	4	5	6	7	8	Pi
1	0	721	152	518	497	78	172	11	2148
2	348	0	501	86	83	643	1410	115	3185
3	80	603	0	20	19	147	323	25	1217
4	517	16	3	0	492	112	246	33	1420
5	246	8	2	461	0	53	117	14	901
6	125	539	113	91	88	0	1996	148	3100
7	446	1926	405	327	314	149	0	45	3611
8	22	127	26	22	10	127	59	0	391
Ai	1783	3940	1201	1524	1501	1309	4322	391	15973

Based on Table 12, the total number of trips under the initial operational condition is 15,973 trips. This matrix is subsequently used as the primary input for traffic assignment on the road network and for traffic performance simulation. The results of the traffic assignment serve as the basis for evaluating the performance of intersections and road segments under two scenarios: Do Nothing, representing the condition without any intervention, and Do Something, representing the condition with the implementation of proposed mitigation measures.

4.3.2. Do Nothing initial operation

Based on the initial operational MOD in Table 12, it can be seen that the distribution of trips between zones has increased compared to the existing conditions. This increase has a direct impact on the additional vehicle load entering intersections in the study area. To determine the condition of intersection service without any intervention, a performance analysis was conducted on the Do Nothing scenario (initial operation). The results of the intersection performance evaluation under these conditions are presented in Table 13.

1. Intersection performance

The intersection performance analysis at the start of operations was conducted using Vissim simulation with parameters of average vehicle delay and queue length at each intersection arm. The results of the intersection performance calculations under these conditions are shown in Table 13.

Table 13. Total delay and queue length for each arm of intersection 1-4

Intersection	Direction	VehDelay(ALL)	Qlen
1	South	24,5	35,9
	East	245,1	144,3
	North	129,4	160,1
	West	161,1	187,5

Intersection	Direction	VehDelay(ALL)	Qlen
2	East	13,54	24,76
	North	2,39	0
	West	10,38	6
3	North	140,2	175,85
	West	78,01	65,18
	South	13,84	17,99
4	North	38,21	94,22
	West	188,96	121,18
	South	59,87	86,43

2. Section performance

In addition to intersections, increased vehicle movement at the start of operations also affected roads in the vicinity of the study area. To observe changes in traffic load and service levels in each direction, road performance analysis was conducted for the Do Nothing scenario (start of operations). The results of road performance calculations are shown in Table 14.

Table 14. Section Performance

Direction	Traffic Flow veh./hour	Degree of Saturation
	Q	DS
North	2503	0,86
South	2594	1,15

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4.3.3. Do something initial operation

The evaluation results for the Do Nothing scenario (initial operation) show that several intersections and road sections still experience high delays and increased queue lengths. Based on these conditions, the Do Something scenario (initial operation) was implemented as an effort to improve traffic performance through technical engineering at intersections and road sections. The performance evaluation for this scenario is shown in Table 15.

At Intersection 1, namely the signalized intersection of Jaksa Agung Suprapto St. – Kaliurang St. – L. Sutoyo St. – W.R. Supratman St., the evaluation results indicate that several intersection arms still experience high delay values and long queue lengths. To address these issues, improvements such as changing the signal configuration to a two-phase system and prohibiting right-turn movements are recommended to reduce conflict points and improve overall traffic flow. Furthermore, at Intersection 3, which is the signalized intersection of Letnan Sutoyo St. and Sarangan St., the analysis shows that delays predominantly occur along the north–south movement. To enhance performance at this intersection, one recommended measure is the implementation of a continuous-flow lane for northbound traffic, allowing vehicles to proceed straight without stopping at the red signal.

Table 15. Total delay and queue length for each arm of intersection 1 & 3

Intersection	Direction	VehDelay(ALL)	Qlen
1	South	14,7	11,5
	East	108,5	108,6
	North	25,6	30,1
	West	83,8	92,3
3	North	46,39	105,33
	West	78,80	65,69
	South	14,45	17,90

4.4. 5-Year operational analysis

Based on data obtained from the initiator of Hotel & Convention CDR-INN, there are no plans to add facilities, either rooms or meeting rooms, in the next five years. Thus, the amount of travel demand in the next five years of operation is assumed to remain the same as at the start of operation. Based on this assumption, the origin-destination distribution is shown in the Origin-Destination Matrix (MOD) for the five-year operational period in Table 16 below.

Table 16. MOD 5 Year operational

MOD 5 YEAR OPERATIONAL (2028)									
Zone	1	2	3	4	5	6	7	8	Pi
1	0	896	188	643	617	97	213	11	2667
2	435	0	627	108	103	804	1763	115	3954
3	99	752	0	25	24	184	403	25	1511
4	644	20	4	0	613	140	307	33	1762
5	306	10	2	573	0	67	146	14	1118

MOD 5 YEAR OPERATIONAL (2028)									
Zone	1	2	3	4	5	6	7	8	Pi
6	156	675	142	115	110	0	2501	148	3848
7	555	2397	504	407	390	185	0	45	4483
8	22	127	26	22	10	127	59	0	391
Ai	2219	4878	1493	1892	1867	1603	5392	391	19734

4.4.1. Do nothing 5-year operational

Based on the 5-year operational MOD in Table 16, there was an increase in travel between zones as hotel and supporting facility activities in the study area increased. This increase in travel distribution added to the vehicle load at intersections around the research location.

1. Intersection performance

To determine the performance of the intersection if no action is taken, an analysis was conducted on the Do Nothing scenario for a 5-year operational period. The results of the evaluation of delays and queue lengths at each arm of the intersection are presented in Table 17.

Table 17. Total delay and queue length for each arm of intersection 1-4

Intersection	Direction	VehDelay(ALL)	Qlen
1	South	70,6	87,4
	East	212,9	147,3
	North	146,7	182,0
	West	152,6	216,2
2	East	14,5	38,4
	North	3,2	0,0
	West	33,2	23,2
3	North	147,4	183,8
	West	86,6	74,1
	South	28,9	44,6
4	North	103,15	188,40
	West	186,20	124,09
	South	77,98	133,91

2. Section performance

In addition to intersections, increased traffic flow during the 5-year operational period also affected the main roads leading to the CDR-INN area. To determine changes in road service levels without mitigation measures, traffic flow and saturation levels were calculated for the Do Nothing scenario. The results of the road performance calculations are shown in Table 18.

Table 18. Section Performance

Direction	Traffic Flow veh./hour	Degree of Saturation
	Q	DS
North	3108	1,07
South	3220	1,43

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4.4.2. Do something 5-year operational

The results of the analysis in the Do Nothing scenario show that several intersections and road sections experienced an increase in delays, queue lengths, and congestion levels during the 5-year operational period. To reduce this impact, a scenario to improve traffic performance was implemented through the Do Something concept. The evaluation of intersection and road section performance during the 5-year operational period with the Do Something scenario is shown in Table 19.

At the 3rd intersection, which is a signalized intersection at Letnan Sutoyo St. – Sarangan St., the evaluation results show that traffic from the North still causes significant delays. Therefore, one of the recommended solutions is to implement a continuous flow lane, so that vehicles from the North traveling straight ahead do not have to stop at the red light. Additionally, the capacity of the intersection can be increased by widening the road by 0.5 meters.

Table 19. Total delay and queue length for each arm of intersection 3

Direction	VehDelay(ALL)	Qlen
North	40,3	108,7
West	86,6	74,0
South	25,7	40,1

5. Conclusion

The conclusion shows that each intersection has different conditions and handling requirements. At Intersection 1, a two-phase arrangement, a ban on right turns, and the implementation of one-way streets in accordance with TATRALOK directives are recommended to reduce congestion. Intersection 2 is still functioning well and therefore does not require any intervention. At Intersection 3, priority should be given to straight movement from the north without stopping at red lights, and the road should be widened by approximately 0.5 meters to increase capacity. Meanwhile, Intersection 4 has reached saturation point and cannot be managed through signals or widening, so in accordance with TATRALOK, it is directed to become a one-way street as part of the Kayutangan Heritage Tourism Area arrangement. Overall, these recommendations are expected to improve traffic flow and support the city's road network arrangement.

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