Traffic Management Simulation to Improve Tanah Aji Intersection Road Network Performance

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Abstract. This paper is prepared to find out alternative traffic management that can reduce congestion on the Road Network at Tanah Aji Intersection. This research method is carried out by collecting primary and secondary data. Primary data includes field surveys, road geometry, traffic flow volume, and traffic light settings. The secondary data is road network data. After that, the route selection modeling was made with the help of transportation planning software and charged to the idealization of the road network. Furthermore, an analysis is carried out to find alternative traffic management that results in better road network performance than the existing condition. The results obtained show that the existing condition of each road section at the Tanah Aji intersection reaches a V/C Ratio of up to 0.61 for the Majapahit Road, and 0.50 for the Airlangga Road, 0.68 for the Sriwijaya Road, and 0.88 for Gajah Mada Road. To improve the performance of the segment and the performance of the intersection, various alternative simulations are made. The best result is alternative simulation III (three) with a performance increase of 32.79% for Majapahit Road, 0% for Airlangga Road, 33,33% for Sriwijaya Road, and 61.8% for Gajah Mada Road.

Keywords: traffic management · road network performance · traffic simulation

1 Introduction

The number of vehicles that continues to grow and is not accompanied by changes in the geometry of the intersection causes the existing condition of the Tanah Aji intersection to experience congestion at certain hours. The existing condition of the Tanah Aji intersection was initially a signalized intersection, but the intersection was closed due to high delays and long queues at each arm of the intersection. Therefore, it is recommended to close the intersection in 2018 by diverting traffic flow to u-turn east and u-turn west. in 2022 due to the increasing volume of traffic, every u-turn begins to experience delays and long queues, so it is necessary to re-analyze to improve road performance. In addition, increased traffic volume at intersections is known to lead to higher fuel consumption, which in turn results in greater emissions (Gunawan and Budi, 2017).

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This paper will analyze the existing conditions at the intersection and the approach arm of the intersection and then look for alternative traffic management to improve road and intersection performance (without considering other aspects such as costs, social and legal). The primary data needed is a road and intersection inventory survey with the target of road and intersection geometry information in the form of roads, land use, vehicle circulation arrangements around the location, applicable intersection control arrangements, and intersection inventory. Then the existing traffic data with information on the target volume, speed of vehicle composition, and the performance of sections and intersections, as well as the average loading factor of each vehicle (occupancy) for people/vehicles and the condition of public transportation around the location. Traffic performance analysis was carried out with PTV Visim software.

2 Existing Traffic Condition

In general, the transportation modeling used is a four-stage transportation planning model, namely the generation stage, the distribution stage, the mode selection stage, and the trip loading stage. These stages can be seen in Fig. 1.

Origin-Destination Matrix (O-D Matrix) is the main input that is most widely used in various kinds of transportation system planning and management. It can be said that the 'actually happening' MAT in the field can never be known with certainty by anyone,

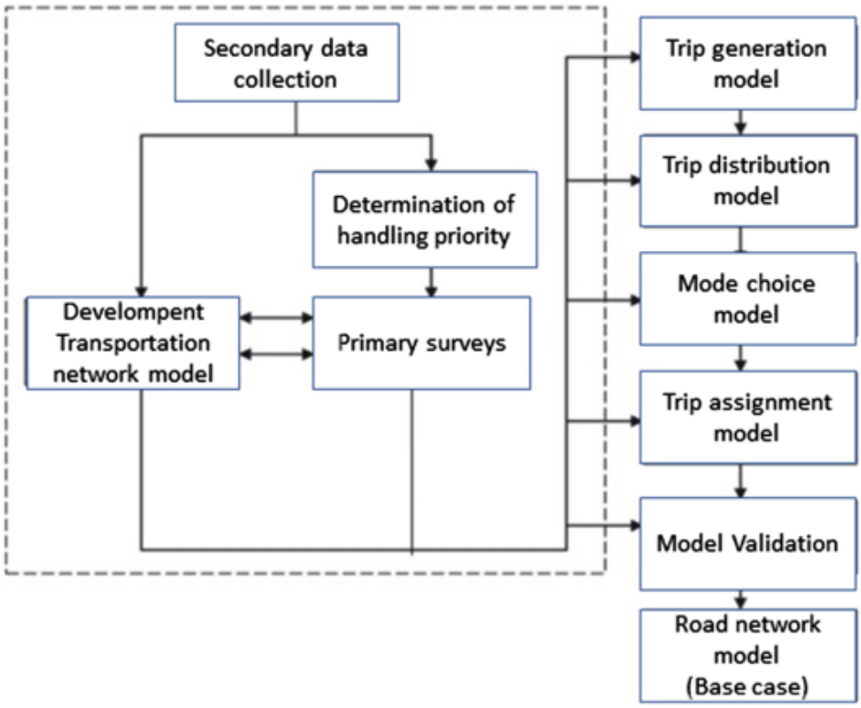

Fig. 1. Transportation Model

Fig. 2. Existing Road Network Condition

so researchers have developed various methods in recent years to be able to estimate the MAT. At the Tanah Aji intersection, a matrix of origin and destination has been created based on the results of the Car Turning Moving Counting (CTMC) survey. The results of this survey will later be used as the basis for calculating the performance of sections and intersections.

To facilitate analysis and simulation, inventory surveys and geometric intersections were also carried out. This data is used to calculate the road capacity at the Tanah Aji intersection. The level of service for sections and intersections will be seen based on the calculation results. From the calculation results, it will be seen whether or not handling is necessary to improve road performance. Based on the results of observations in the field, the following is a description of the existing condition of the Tanah Aji intersection based on the results of the inventory both in terms of geometric and road completeness (Fig. 2).

From the results of the turning movement survey and the classified segment volume, an estimated origin-destination matrix is currently available (in 2022) in units of pcu/hour as shown in the Tables 1 and 2.

Based on Table 1, it can be seen that the largest travel origin is dominated by zone 4 at 2110 pcu/hour while the largest travel destination is dominated by the direction to zone 2 at 1803 pcu/hour. Current performance needs to be studied to find out the current condition problems so that it can be used as a basis for determining potential impact management. From the results of traffic loading carried out, the performance of the road network and the performance of each road segment for the current (existing) condition can be seen in Table 4.

Based on Table 3, it can be seen that the existing roads around the Tanah Aji intersection can still accommodate existing traffic, but problems arise for Gajah Mada Road,

Table 1. Origin-Destination Matrix

OD	1	2	3	4	Quantity
1	0	911	71	310	1292
2	871	0	279	684	1834
3	24	62	0	453	539
4	398	830	882	0	2110
Quantity	1293	1803	1232	1447	5775

Table 2. Origin Destination Matrix (OD) Existing Condition (PCU/HOUR)

OD	1	2	3	4	Quantity
1	0	911	71	310	1292
2	871	0	279	684	1834
3	24	62	0	453	539
4	398	830	882	0	2110
Quantity	1293	1803	1232	1447	5775

Table 3. Zona Description

Zona	Description
1	Airlangga
2	Sriwijaya
3	Gajah Mada
4	Majapahit

Table 4. Zona Description

Name	Type	Volume (pcu/hour)	Capacity (pcu/hour)	VCR	LOS	Speed (km/h)	Density (pcu/km)
Majapahit	4/2 D	3445	5655	0.61	C	37.15	92.73
Airlangga	4/2 D	2471	4906	0.50	C	42.78	57.76
Sriwijaya	4/2 D	3590	5251	0.68	C	35.55	100.98
Gajah Mada	2/2 UD	1841	2089	0.88	E	32.54	56.58

where the V/C ratio has reached 0.88. Meanwhile, the performance of the existing intersection for the Tanah Aji intersection shows the highest delay in the morning, namely

Table 5. Zona Description

Name	Morning peak	Afternoon peak
	Existing	Existing
Tanah Aji	Junction delay	
	14,86	13,44
	LOS	
	B	B
	Queue	
	23,92	60,82 m/h

Fig. 3. Tanah Aji intersection with Do-Something I

14.86, Level of Service (LOS) B, and the longest queue length in the afternoon is 60.82 m/h (Table 5).

3 Traffic Conditions with Do-Something I Scenario

The existing condition of Tanah Aji intersection is a priority intersection, so that in the first scenario (do-something I) it is proposed to change the intersection into a signalized intersection. To be more optimal, it is planned and integrated with the Mataram City ATCS (Area Traffic Control System) which is at the Mataram City Transportation Service. The following is a picture of the condition of the Tanah Aji intersection with traffic light settings (Fig. 3).

The traffic light cycle that is made is using 3 phases with the south approach foot or the Gajah Mada Road not being given traffic light but given a sign to turn left. The following traffic light cycle time is given at the Tanah Aji intersection with different cycle times for certain hours (Fig. 4).

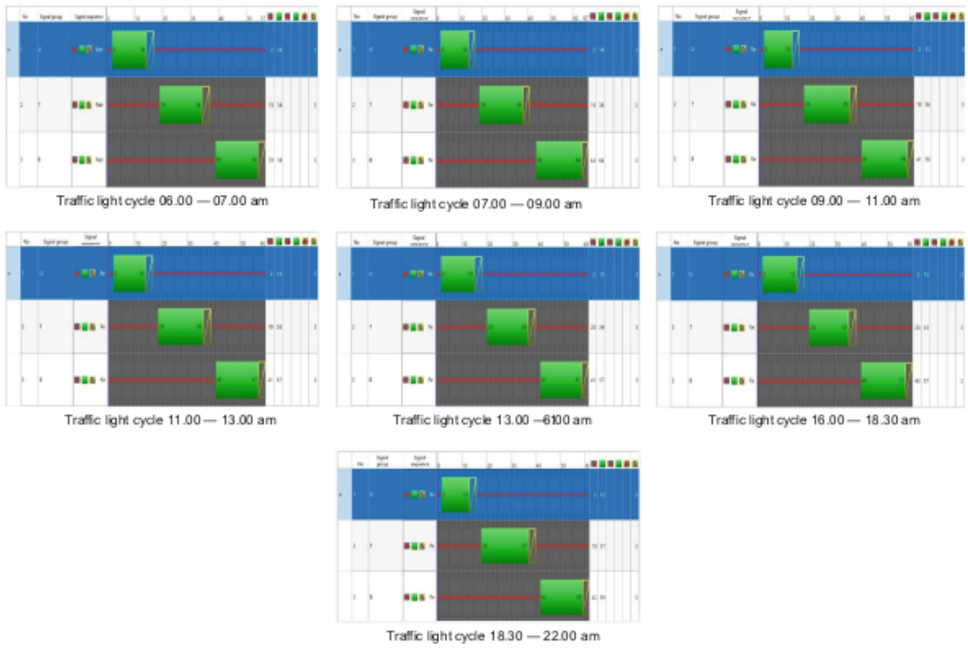

Fig. 4. Cycle Time Traffic Light

Table 6. Comparison of Existing Intersection Performance with Do-Something I Scenario

Time	Junction Delay		Los		Queue	
	Existing	Traffic Light	Existing	Traffic Light	Existing	Traffic Light
06.00–07.00	2,12	14,47	A	B	0,25	7,62
07.00–09.00	14,86	38,32	B	D	23,92	70,69
09.00–11.00	9,50	9,24	B	B	3,49	6,71
11.00–13.00	9,62	30,66	B	D	7,74	31,44
13.00–16.00	3,20	4,37	A	A	0,04	15,75
16.00–18.30	13,44	41,17	B	E	60,82	67,49
18.30–22.00	3,80	12,37	A	B	0,08	10,99

The results of the performance of the intersection with the application of traffic light and its comparison with the existing conditions at the Tanah Aji intersection are as shown in Table 6.

From the results of the intersection performance above, there is a performance with Level of Service (LOS) D and E in the morning peak, afternoon peak, and afternoon peak. The table above shows that with the setting using Traffic Light, there is a higher delay compared to without Traffic Light.

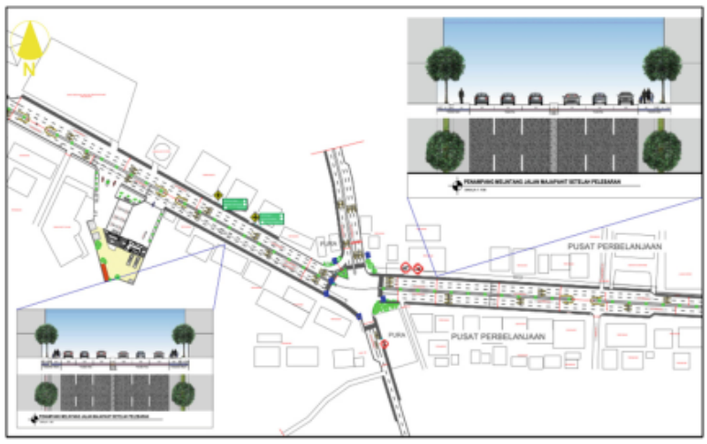

Fig. 5. Tanah Aji intersection with Do-Something II

Table 7. Intersection Performance with Do-Something II Scenario

Name	Morning peak	Afternoon peak
	DS II	DS II
Tanah Aji	Junction delay	
	9,55	10,89
	LOS	
	B	B
	Queue	
	18,24	7,67

4 Traffic Conditions with Do-Something II Scenario

In the do-something II scenario at the Tanah Aji intersection, to improve network performance, it is tried to increase the capacity of Majapahit and Sriwijaya to 6/2 D each. The following is the geometric design of the Tanah Aji intersection with the do-something II scenario model (Fig. 5).

Road widening is carried out to reduce queues and delays at intersection points and intersection approach arms, so that traffic flow becomes smoother. The performance of the intersection with scenario II can be seen in the Table 7.

Table 8. Performance of Each Road with Do-Something II Scenario

No	Name	Type	Volume (pcu/hour)	Capacity (pcu/hour)	VCR	Los	Speed (km/h)	Density (pcu/km)
1	Majapahit	6/2 D	3457	8482.32	0.41	B	45.40	62.17
2	Airlangga	4/2 D	2483	4906.44	0.51	C	42.66	58.21
3	Sriwijaya	6/2 D	3602	7876.44	0.46	C	43.45	67.68
4	Gajah Mada	2/2 UD	1851	2089,04	0,89	E	32,43	57,07

From the performance of the intersection above, it can be seen that all nodes/intersections on the road network around the Tanah Aji Intersection experienced a significant increase in performance, namely at nodes/intersections that had LOS D and E performance changed to LOS A and B performance. In addition to having an impact on intersections, Road widening also makes roads have increased capacity which can improve road performance. The following is the impact of implementing scenario 2 on roads (Table 8).

It can be seen on the Majapahit road segment which originally had a section speed of 37.15 km/h increased to 45.40 km/hour and the Sriwijaya road segment from a segment speed of 35.48 km/hour increased to 43.45 km/h.

5 Traffic Conditions with Do-Something III Scenario

At the Tanah Aji intersection, we tried to apply the do-something scenario III by increasing the capacity of the Majapahit and Sriwijaya roads to 6/2D and Gajah Mada roads to 4/2D. Here's a geometric image of Tanah Aji Intersection with Do-Something III (Fig. 6).

The widening of the intersection approach arm can also be done to reduce queues and delays at the opening/u-turn points around the intersection, so that traffic flow becomes smoother both at the intersection and at the intersection approach arm. The performance of the intersection with the Do-Something III scenario can be seen in the Table 9.

From the performance of the intersection above, it can be seen that all nodes/intersections on the road network around the Tanah Aji Intersection experienced a significant increase in performance, namely at nodes/intersections that had LOS D and E performance changed to LOS A and B performance.

In addition to having an impact on intersections, road widening also makes roads have increased capacity which can improve road performance. The following is the impact of implementing scenario III on roads (Table 10).

It can be seen on the Majapahit road segment which originally had a segment speed of 37.15 km/h increased to 45.40 km/h and the Sriwijaya road segment from 35.48 km/h increased to 43.45 km/h, and Gajah Mada road.

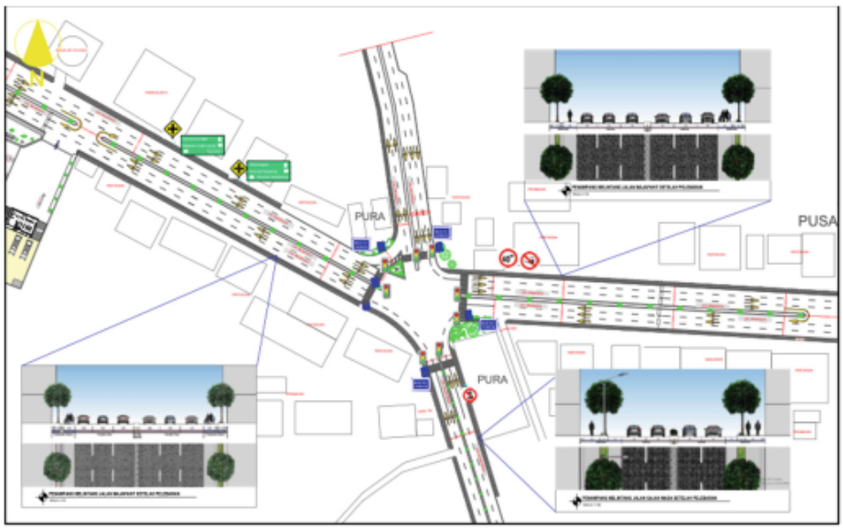

Fig. 6. Tanah Aji intersection with Do-Something III

Table 9. Intersection Performance with Do-Something III Scenario

Name	Morning peak	Afternoon peak
	DS III	DS III
Tanah Aji	Junction delay	
	8,42	9,78
	LOS	
	A	B
	Queue	
	18,24	6,82

Table 10. Performance of Each Road with Do-Something III Scenario

No	Name	Type	Volume (pcu/hour)	Capacity (pcu/hour)	VCR	Los	Speed (km/h)	Density (pcu/km)
1	Majapahit	6/2 D	3457	8482.32	0.41	B	45.40	62.17
2	Airlangga	4/2 D	2483	4906.44	0.51	C	42.66	58.21
3	Sriwijaya	6/2 D	3602	7876.44	0.46	C	43.45	67.68
4	Gajah Mada	4/2 D	1851	5464,80	0,34	B	52,46	35,28

6 Comparison of Simulation Results

Based on the results of research and simulations, it was found that the performance of the Tanah Aji intersection significantly increased network performance if the approach arm was widened. The existing condition of the Tanah Aji intersection based on the results of the analysis has a delay of 14.86 in the morning and 3.44 in the afternoon. If traffic light (do-something I) is paired with various cycle time settings, there is a decrease in intersection performance due to high delays, namely 38.32 in the morning and 41.17 in the afternoon. The implementation of do-something II has an impact on a significant increase in performance, namely at nodes/intersections that have LOS D and E performance changed to LOS A and B performance. The Majapahit road section which originally had a segment speed of 37.15 km/h increased to 45.40 km/h and the Sriwijaya road segment from the speed of the section of 35.48 km/h increased to 43.45 km/h. Simulation results with the do-something scenario III on the Majapahit road segment which originally had a segment speed of 37.15 km/h increased to 45.40 km/h and the Sriwijaya road segment from a segment speed of 35.48 km/h increased to 43.45 km/h, and Gajah Mada road segment from 32.43 km/h increased to 52.46 km/h. Based on the overall results of the simulation, the short-term handling of the Tanah Aji intersection is the installation of traffic light while in the long term it can be applied to do-something III because it can improve road performance.

7 Conclusion

Based on the results of research and simulations, it was found that the performance of the existing arm at the Tanah Aji intersection should be improved, especially on the Gajah Mada road. Based on the overall simulation results, the short term handling of the Tanah Aji intersection is to reinstall the traffic light with three phases, while in the long term it can be applied to do something III or increase the capacity of Majapahit and Sriwijaya roads to 6/2D and Gajah Mada roads to 4/ 2D because it can significantly improve road performance.

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