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Management of Signaled T-Junction on the MayjendSutoyo S.– ZafriZam-ZamStreets in the City of Banjarmasin

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ABSTRACT: *Mayjend Sutoyo S. and Zafri Zam-Zam Streets are situated in the central part of the city of Banjarmasin, with traffic having a high rate of growth. This occurs because the area constitutes one of the primary routes to the centers of the economy, education, and health; offices; and banks, and provide access to and from Trisakti Port. On the Mayjend Sutoyo S. streets, there is a signaledt-junction where jams commonly form, which is the signaled t-junction on the Mayjend Sutoyo S. Streets–Jalan Zafri Zam-Zam Streets. This results from heavy traffic and heavy vehicles (trucks, trailers, and so on) that slow down the traffic on the Mayjend Sutoyo S. Streets.This research carried out an analysis based on the Indonesian Highway Capacity Manual,1997, under the condition that the t-junction was managed using several alternatives.Research findings suggest that performance of the signaled t-junction under the existing condition is the lowest as it has a delay value (30.46 s/pcu) or, which means that, the LOS of the t-junction obtains a grade D. The improvement to make in order to get the best LOS is Alternative 4, which is to improve the cycle time, forbid heavy vehicles, and add lanes where those who intend to turn left can turn left directly with a delay value of 18.05 s/pcu and the LOS getting a grade C.*

KEYWORDS*: Traffic Performance, Signaled T-Junction, Level of Service.*

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I. INTRODUCTION

Mayjend Sutoyo S.and Zafri Zam-Zam streets are situated in the central part of the city of Banjarmasin, with traffic having a high rate of growth. This occurs because the area constitutes one of the primary routes to the centers of the economy, education, and health; offices; and banks, and provide access to and from Trisakti Port. On Mayjend Sutoyo S. street, there is a signaled t-junction where jams commonly form, which is the signaled t-junction on Mayjend Sutoyo S.– Zafri Zam-Zam streets. This results from heavy traffic and heavy vehicles that slow down the traffic on Mayjend Sutoyo S street.

This research aims to:

1. Analyze the existing traffic condition of the t-junction onMayjend Sutoyo S.–Zafri Zam-Zam streets in Banjarmasin; and
2. Analyze several alternatives to improve the traffic performance along MayjendSutoyo S.–ZafriZam-Zam streets in Banjarmasin.

II. LITERATURE REVIEW

A T-Junction is an inseparable part of any road system. It can be defined as a public area where two roads or more join or intersect, including roads and facilities on the roadside to facilitate movement of the traffic therein [1]). Generally there are three types of T-Junction, they are 1). T-junction at grade, i.e. a type of T-Junction where two highways or more join, with each highway heading outside a T-Junction and forming part of it; 2) division of the lane without a ramp; and 3) interchange [2]. The capacity of the urban road network system is influenced not only by its road capacity but also by the capacity of each T-Junction (whether or not regulated by Traffic Lights). No matter how excellent the performance of a road of a road network system, if the performance of its T-Junction is very poor, the performance of the entire road network system will also be poor [3]. Each T-Junction includes traffic movements that intersect one or more arms of the T-Junction, and includes rotational movements as well. Such traffic movements are controlled using various ways depending on the type of T-Junction [4]. Signaled T-Junctions that are part of a fixed-time control system that are arranged together or isolated 'vehicle actuation signals', usually require specific methods and software in their analysis [5]. Nevertheless, the input for the signal time of a stand-alone T-Junction can be obtained using this manual. The analysis of signaled T-Junctions is based on the main principles as follows: geometry, flow and traffic, entry

capacity, signal timing, capacity and degree of saturation, traffic behavior, road segment assessment, and T-Junction performance evaluation. For the extent of the level of service and road characteristics as well as the level of service (LOS) of secondary collector and arterial roads [6], the Traffic Level of service by Degrees of Saturation [7], and calculations of the manual software KAJI for Signalized T-Junctions [8]. As for previous studies, the following are the previous studies used as referencesand taken into consideration in the execution of this thesis research[9]; [10]; [11];[12]; [13]; [14] and [15].

III. RESEARCH METHOD

3.1 Research Stages

This research was conducted using the following stages:

- Identification
- Collection of Primary Data and Secondary Data
- Analysis of the Data
- Formulation of Performance for Each Alternative
- Determination of the Best Performance value among the alternatives

The research flowchart is illustrated in Figure 1.

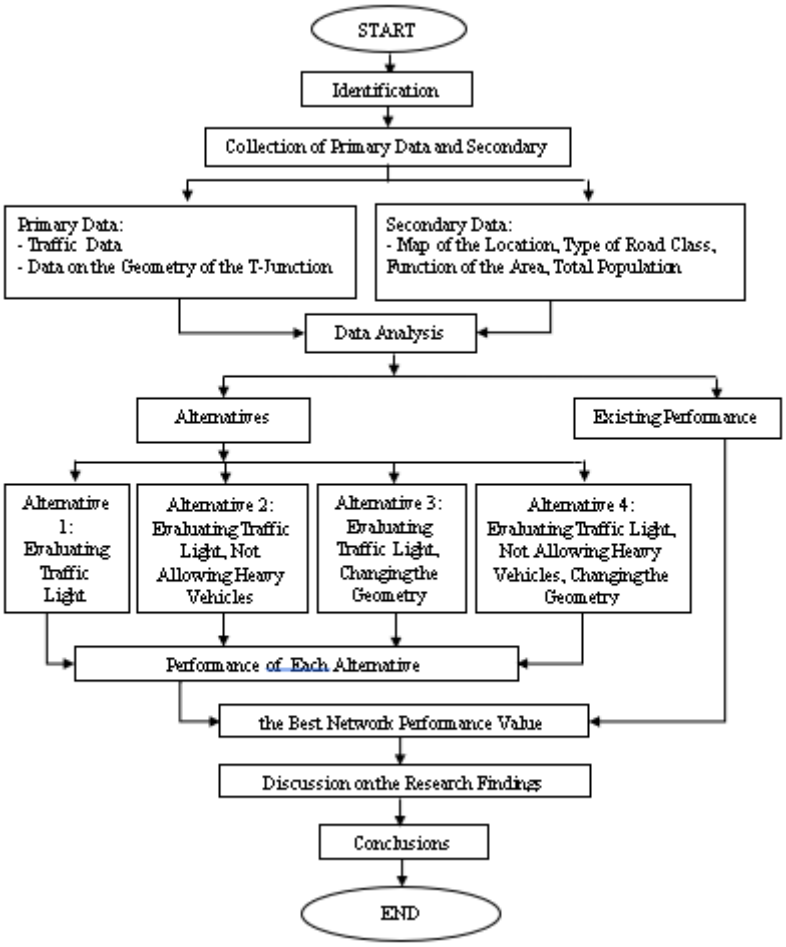

Figure 1.Research Flowchat

3.2 Analytical Method

Overall, the methodology of data analysis began with the process of compiling data, followed by the analysis of the t-junction under the existing condition. At this stage, the t-junction's capacity, degree of saturation, and traffic behaviour were calculated. After performing the analysis under the existing condition, another analysis was also conducted under the optimum condition before selecting the best alternative for t-junction management. Under the optimum condition, several modifications in the ways the calculation is done were made, including modifying the signal phase, traffic management, and the geometry of the t-junction.

IV. DATA ANALYSIS

In this research, the survey to carry out a traffic census was performed in the signaled t-junction on MayjendSutoyo S. streetsfor 16 hours, starting from 06.00 to 22.00 Central Indonesia Time Zoneat 10-minute intervals, on Tuesday, January 16th 2018. The data were then used to describe fluctuations in the traffic in the area under study. There were three streets studied, they wereJafri Zam-Zam streets, MayjendSutoyo S. streets (Trisakti), and MayjendSutoyo S. streets (from downtown), for Banjarmasin with a population of 675,440 [16]with results of the road capacity analysis as listed in Table 1.

Table 1. Road Capacity

No.	Road Name	Co	FCw	FCsp	FCsf	FCcs	C (pcu/hr)
1	MayjendSutoyo S. (from downtown)	6000	0.91	1	1	0.94	5132
2	MayjendSutoyo S. (Trisakti)	6000	0.91	1	1	0.94	5132
3	ZafriZam-Zam	6000	1.05	1	1	0.94	5922

4.1 Signaled T-Junction Analysis

In this signaled t-junction analysis, the roads under study were classified into two, which were the major road and the minor road, and the calculation was carried out using the software KAJI 1.10F under two types of conditions, they were:

A. Performance of the signaled t-junction under the existing condition, in this case all the conditions, including the geometry and the traffic, were adjusted to the existing condition. This aims to determine the performance of the t-junction under the existing condition. If the performance value does not meet the requirement for the t-junction on the primary collector road, i.e. "B" [17], an improvement should be made by formulating several alternatives in order to improve the performance of the t-junction.

B. Performance of the signaled t-junction after several alternative changes, including to traffic light (traffic signaling devices), the geometry, and the traffic. The following are the alternatives analyzed:

1. Alternative 1, i.e. performance of the signaled t-junction under condition of an improvement to traffic light, especially by calculating the cycle time;
2. Alternative 2, i.e. performance of the signaled t-junction under condition of an improvement to traffic light, especially by calculating the cycle time and not allowing heavy vehicles (HV=0) to cross the MayjendSutoyo S. and ZafriZam-Zam streets;
3. Alternative 3, i.e. performance of the signaled t-junction under condition of an improvement to traffic light, especially by calculating the cycle time and changing the geometry of the t-junction between the MayjendSutoyo S. and ZafriZam-Zam streets through the addition of the eastward lane (MayjendSutoyoS.streetsfrom downtown) as the lane to directly turn left and the addition of the special lane for turning left directly on the westward lane (MayjendSutoyo S. streets to Trisakti) and the northern lane (ZafriZam-Zam streets).
4. Alternative 4, i.e. performance of the signaled t-junction under condition of an improvement to traffic light, especially by calculating the cycle time and changing the geometry of the t-junction between the MayjendSutoyo S. and ZafriZam-Zam streets through the addition of the eastward lane (MayjendSutoyo S. streets from downtown) as the lane to directly turn left and the addition of the special lane for turning left directly on the westward lane (MayjendSutoyo S. streets to Trisakti) and the northern lane (ZafriZam-Zam streets). Afterwards, heavy vehicles are not allowed to cross the roads MayjendSutoyo S. streets and ZafriZam-Zamsstreets (HV=0).

4.2 Performance of the Signaled T-Junction under the Existing Condition

The geometry of the t-junction under the existing condition can be seen in Figure 2.

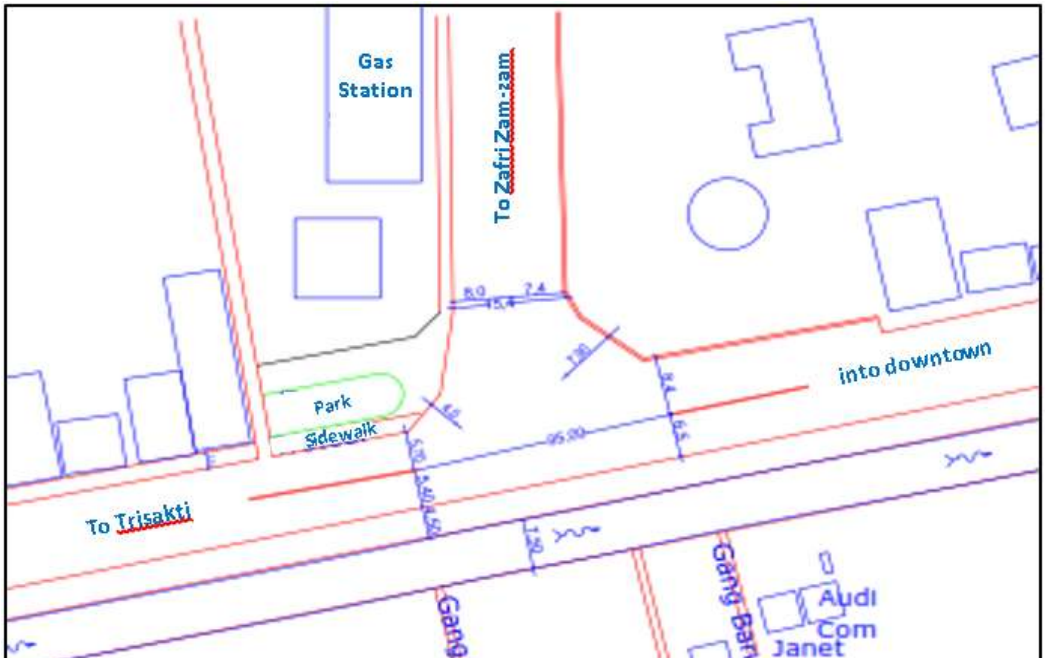

Figure 2. The Geometry of the T-Junction under the Existing Condition

Values of the Degree of Saturation (DS) of each road heading to the t-junction using the method of IHCM 1997 are as follows:

1. MayjendSutoyo S. streets (from downtown) DS = V/C = 3887/5132 = 0.75
2. MayjendSutoyo S. streets (from Trisakti) DS = V/C = 4157/5132 = 0.80
3. ZafriZam-Zam streets DS = V/C = 1890/5922 = 0.31

The following is the performance of the t-junction under the existing condition:

1. The highest performance by Degree of Saturation of the signaled t-junction is equal to 0.86, which is generated by MayjendSutoyo S. streets (from Trisakti).
2. The average traffic delay of the t-junction amounts to 30.46 s/pcu.
3. The Level of service of the t-junction is D.
4. The existing cycle time is 100 seconds with LT1 = 26 seconds and yellow time as long as 3 seconds per phase (Figure 3).

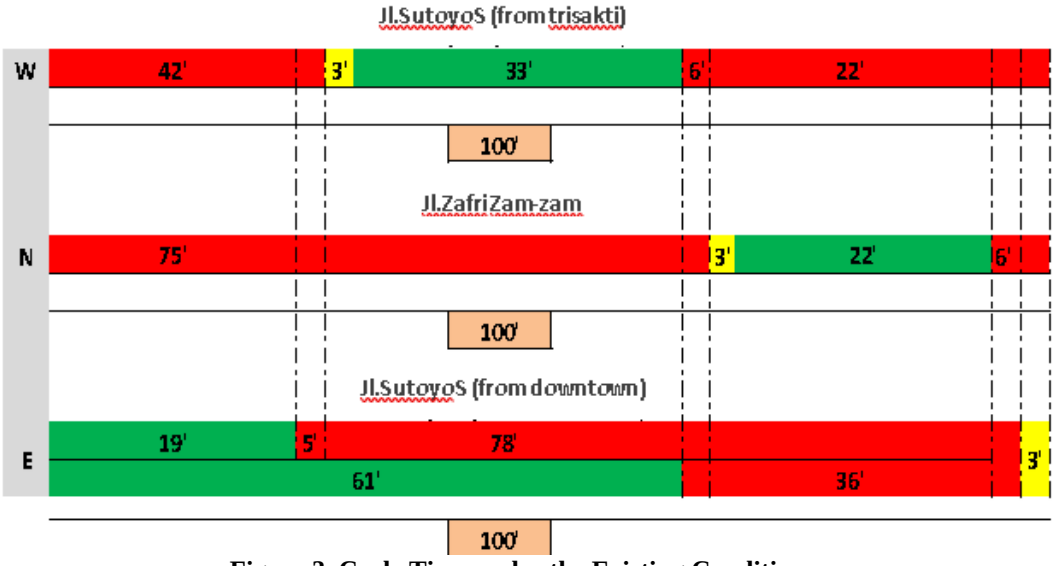

Figure 3. Cycle Time under the Existing Condition

4.3 Alternative 1: Performance of the Signaled T-Junction with Improvement in Traffic Light (traffic signaling devices)

In the analysis of the signaled t-junction performance under this condition, an improvement was made to traffic light (traffic signaling devices), especially by calculating the cycle time. This aims to determine performance of the t-junction under the traffic light condition consistent with results of the analysis based on the existing traffic condition, performance of the signaled t-junction viewed from the values of the degree of saturation, average delay, and possibility of a queue. The following are results of the t-junction performance analysis under condition of Alternative 1:

1. The highest performance by Degree of Saturation of the signaled t-junction is equal to 0.89, which is generated by Jl. ZafriZam-Zamstreets.
2. The average traffic delay of the t-junction amounts to 27.12 s/pcu.
3. The Level of service of the t-junction is D.
4. The cycle time generated by the analysis is 107 seconds with LT1 = 16 seconds and yellow time as long as 3 seconds per phase (Figure 4).

Figure 4. Cycle Time under Condition of Alternative 1

4.4 Alternative 2: Performance of the T-Junction based on the cycle time analysis and a prohibition on heavy vehicles (HV=0)

In the analysis of performance of the signaled t-junction under this condition, an improvement was made to the traffic light by calculating the cycle time and not allowing heavy vehicles to cross the roads MayjendSutoyo S. and ZafriZam-Zamstreets (HV=0). This aims to determine performance of the t-junction under the traffic light condition consistent with results of the analysis based on the existing traffic condition minus the volume of heavy vehicles crossing the t-junction on the roads MayjendSutoyo S.– ZafriZam-Zam streets by 0.37% and thus, performance of the signaled t-junction can be seen from the values of the degree of saturation and the average delay.

The following are results of the t-junction performance analysis under condition of Alternative 2:

1. The highest performance by Degree of Saturation of the signaled t-junction is equal to 0.89, which is generated by Jl. ZafriZam-Zam streets.
2. The average traffic delay of the t-junction amounts to 22.81 s/pcu.
3. The Level of service of the t-junction is C.
4. The cycle time generated by the analysis is 90 seconds with LT1 = 14 seconds and yellow time as long as 3 seconds per phase (Figure 5).

Figure 5. Cycle Time under Condition of Alternative 2

4.5 Alternative 3: Performance of the T-Junction with improvement in Traffic Light (traffic signaling devices) and modifications to the geometry of the T-Junction

In the analysis of performance of the signaled t-junction under this condition, an improvement was made to the traffic light by calculating the cycle time and making changes to the geometry of the t-junction on MayjendSutoyo S. and ZafriZam-Zam streets through the addition of the eastward lane (MayjendSutoyo S. streets from downtown) as the lane to directly turn left and the addition of the special lane for turning left directly on the westward lane (MayjendSutoyo S. streets to Trisakti) and the northern lane (ZafriZam-Zam streets). This aims to determine performance of the t-junction under the traffic light condition consistent with results of the analysis based on the condition of the existing traffic crossing MayjendSutoyo S. and ZafriZam-Zam streets the geometry of the t-junction that underwent changes, and performance of the signaled t-junction viewed from the values of the degree of saturation and the average delay.The geometry of the t-junction used as input for this analysis can be seen in Figure 6.

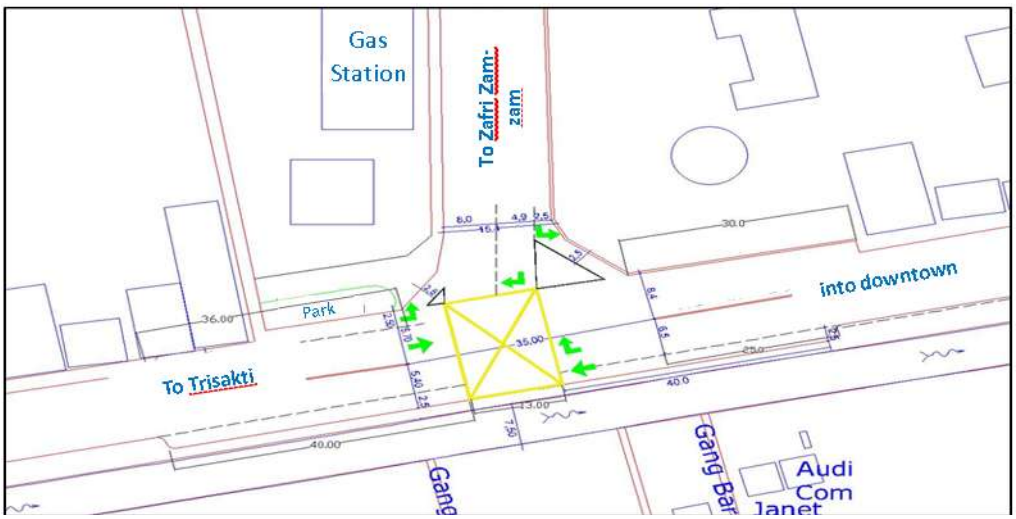

Figure 6. The Geometry of the T-Junction with Modifications (Alternative 3)

The following are results of the t-junction performance analysis under condition of Alternative 3:

1. The highest performance by Degree of Saturation of the signaled t-junction is equal to 0.74, which is generated by MayjendSutoyo S. streets (from Trisakti).
2. The average traffic delay of the t-junction amounts to 18.52 s/pcu.
3. The Level of service of the t-junction is C.
4. The cycle time generated by the analysis is 53 seconds with LT1 = 13 seconds and yellow time as long as 3 seconds per phase (Figure 7).

Figure 7. Cycle Time under Condition of Alternative 3

4.6 Alternative 4: Performance of the T-Junction with improvement in Traffic Light (traffic signaling devices) and modifications to the geometry of the T-Junction and a prohibition on heavy vehicles (HV=0)

In the analysis of performance of the signaled t-junction under this condition, an improvement was made to the traffic light by calculating the cycle time and making changes to the geometry of the t-junction on MayjendSutoyo S and ZafriZam-Zamstreets through the addition of the eastward lane (MayjendSutoyo S. streets from downtown) as the lane to directly turn left and the addition of the special lane for turning left directly on the westward lane (MayjendSutoyo S. streets to Trisakti) and the northern lane (ZafriZam-Zam streets) as well as by not allowing heavy vehicles to cross the road MayjendSutoyo S. streets (HV=0). This aims to determine performance of the t-junction under the traffic light condition consistent with results of the analysis based on the condition of the existing traffic minus the volume of heavy vehicles (HV=0) crossing MayjendSutoyo S. and ZafriZam-Zam streets, the geometry of the t-junction that underwent changes, and performance of the signaled t-junction viewed from the values of the degree of saturation and the average delay.The geometry of the t-junction used as input for this analysis can be seen in Figure 8.

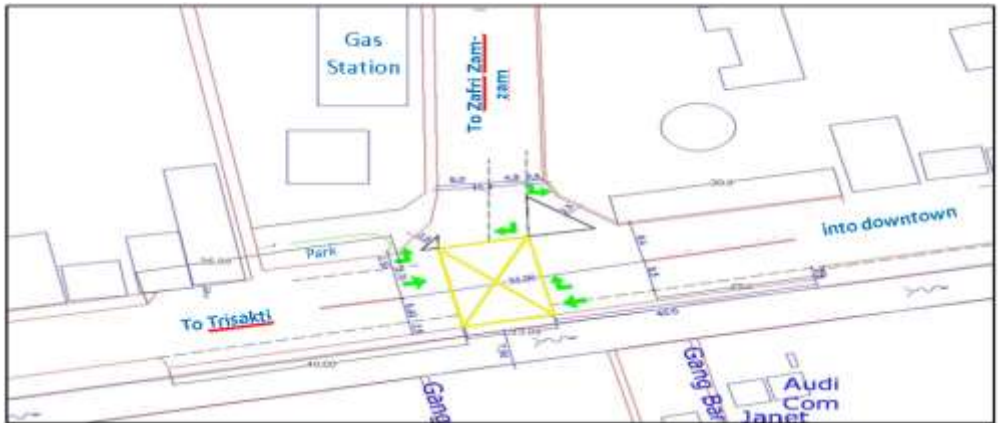

Figure 8. The Geometry of the T-Junction with Modifications (Alternative 4)

The following are results of the t-junction performance analysis under condition of Alternative 4:

1. The highest performance by Degree of Saturation of the signaled t-junction is equal to 0.72, which is generated by MayjendSutoyo S. streets (from Trisakti).
2. The average traffic delay of the t-junction amounts to 18.05 s/pcu.
3. The Level of service of the t-junction is C.
4. The cycle time generated by the analysis is 52 seconds with LT1 = 13 seconds and yellow time as long as 3 seconds per phase.

4.7 Discussion Of The Research Findings

The performance of the roads and the signaled t-junction of MayjendSutoyo S.– Zafri Zam-Zam streets can be concluded as follows:

1. Viewed from the t-junction's DS value, it is revealed that several conditions examined geberate a value higher than 0.80, which are Existing Conditions, Alternative 1, and Alternative 2. As for the best DS value, it is generated by Conditions under Alternatives 3 and 4.
2. Viewed from the DS value of each road, there is an improvement in the DS value for the street Jalan Mayjend Sutoyo S. (to Trisakti) and Jalan Mayjend Sutoyo S. (from downtown) under a condition where there is a geometric change as a result of the addition of lanes to turn left directly, resulting in an improvement in the existing DS value from 0.75–0.80 to 0.50–0.56.
3. The average delay of the t-junction under the existing condition generates the highest delay value of 30.46 s/pcu. Under the t-junction condition in Alternative 4, the delay value generated is the lowest one, which is equal to 18.05 s/pcu.
4. In the event that in the t-junction, traffic light(traffic signaling devices) are mounted, based on the value of the average t-junction delay, the LOS of the signaled t-junction generates a grade **D** under the existing condition and it improves to **C** under the condition of Alternatives 2, 3, and 4**.**

Based on all the conditions analyzed, it is indicated that the condition of the signaled t-junction under Alternative 4 is the best condition of all conditions analyzed in terms of performance of the t-junction viewed from the values of DS and Average Delay. It is recommended that in order to maintain performance of the t-junction viewed from results of the analysis of each alternative, management efforts may start from Alternative 2, followed by Alternative 3 and, lastly, Alternative 4.

V. CONCLUSIONS

Based on the results of the analysis conducted by the researcher, the following conclusions can be drawn:

1. Performance of the signaled t-junction under the existing condition is the lowest with a delay value of 30.46 s/pcu and LOS with a grade **D.**
2. This research generates four (4) alternatives to improve performance of the t-junction, they are: 1) improving the cycle time; 2) improving the cycle time and forbidding heavy vehicles; 3) improving the cycle time and adding the number of lanes to directly turn left; and 4) improving the cycle time, forbidding heavy vehicles, and adding the number of lanes to directly turn left with the LOS for each alternative showing grades D, C, C, and C, respectively. Of the four alternatives, the best one is Alternative 4.

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