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PERFORMANCE ANALYSIS OF SIGNALIZED INTERSECTION DUE TO OPENING OF JATIKARYA EXIT ACCESS TO CIMANGGIS – CIBITUNG TOLL SEGMENT USING PTV VISSIM SOFTWARE

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Abstract. The advancement of infrastructure, especially road construction, also has an affect on changes in various urban systems in an area. Developments in the transportation system, including the opening of toll road access, will certainly affect increasing traffic flow. With the opening of toll road access, it creates new intersections so that the Cibubur Alternative Road experiences a high increase, especially during peak hours. This study points to deciding the impact of access to the Cimanggis-Cibitung toll road on the performance of the Cibubur Alternative Road. The study method begins with collecting data concurring to the parameters needed as the premise for analyzing road performance, namely the degree of saturation and the level of service based on the 2014 PKJI by comparing the conditions and assumptions of normal conditions (by dividing 75% of the existing conditions) followed by microsimulation of traffic using PTV Vissim to get a comparison of the results of vehicle speed, vehicle composition, and optimization of signal time at intersection under certain conditions. The results of the analysis show that the highest degree of saturation is on Alternative Cibubur Road 0.74 and if it is assumed under normal conditions it is 0.99 (the lowest service level is E with the lowest speed reaching 30.0 km/hour), queue length 194.47 meters and delays time. Reaching 109.87 seconds indicates a conflict at the signalized intersection because the queue length affects the performance of the Cibubur alternative road. After doing the simulation and getting an effective intersection optimization, namely resetting the green time with VISSIM software modeling, it gives better results during peak hours and reduces the highest queue length by 56,58% and delays by 80,16%.

Keywords : delay; level of service; queue length; signalized intersection; vissim.

1. INTRODUCTION

The trend of regional development to the outskirts of the city has occurred in the last decade which of course has a broad goal of building equitable growth to areas that have not been a priority through the development of regional infrastructures such as roads, buildings, transportations, and others [1]. Growth and development in the Greater Jakarta area proceed to increase rapidly so that support for the growth of road traffic volume is also increasing. This makes traffic flow disrupted, especially during peak hours within the morning and evening. The rapid growth of traffic is also felt on the adjacent intersections and also many median openings for vehicles that want to make a U-turn, causing conflicts and decreasing road performance, especially during rush hour. At the Jatikarya intersection, there was a change in the intersection from an unsignalized intersection to a signalized intersection. this creates waiting times due to signal time as well as queue length of each approach. Especially on the highway exit to the intersection, the long queue of vehicles is very clearly visible because there are only 4 or more wheeled vehicles crossing the road. Therefore, research related to the analysis of the performance of signalized intersections is very necessary. Vissim software is a traffic microsimulation application whose results can be synchronized in this research method.

This study points to analyze the performance of the Cibubur Alternative Road section and the current performance of the Jatikarya intersection and provide appropriate solutions for problems on the road and intersection. The problem at the intersection is a high delay. The current traffic light regulation has not been able to overcome the frequent traffic jams, especially during peak hours. The existing conditions at the intersection are still quite dense, plus there are intersections and roundabouts that are close together so that there are still queues at the green light, and vehicles crossing the intersection often stop or are stuck due to conflict.

When vehicles are moving people in a road space, this is what we called Traffic [2]. The performance of a road segment is a marker of the capacity of a particular road to provide services to vehicles that pass through it. In calculating the performance of roads in this study, the 2014 Indonesian Road Capacity Guidelines (Pedoman Kapasitas Jalan Indonesia/PKJI 2014) were determined by looking at the value of the degree of saturation and speed of travel under certain conditions related to geometry, traffic flow, and road environment. One of the road segment performance criteria is side obstacles, side obstacles are the impact on traffic performance due to activities on the side of the road [3].

Free Flow Speed (V_B) is vehicle speed that is not influenced by the existence of other vehicles namely the speed at where a driver can travel comfortably in a portion of the road where there are no other vehicles in the geometric bottom, environment, and transportation traffic control conditions (km/h) [4].

$$V_B = (V_{BD} + V_{BL}) \times FV_{BHS} \times FV_{BUK} \quad (1)$$

Where :
V_B = free flow speed for light vehicles (KR) under field conditions (km/h)
V_{BD} = basic free flow speed for KR (km/h)
V_{BL} = speed adjustment value due to road width (km/h)
FV_{BHS} = free speed factor due to side obstacles on roads that have shoulders or roads equipped with curbs/sidewalks with the distance of the curb to the nearest obstacle
FV_{BUK} = free speed adjustment factor for city size

Capacity is defined as the maximum traffic flow in units of skr/hour that can be maintained by a road section under certain conditions, namely roads include geometry, environment, and traffic flow [5].

$$C = C_0 \times FC_{LJ} \times FC_{PA} \times FC_{HS} \times FC_{UK} \quad (2)$$

Where :
C = capacity (skr/hour)
C_0 = base capacity (skr/hour)
FC_{LJ} = capacity adjustment factor related to lane width or traffic lane
FC_{PA} = capacity adjustment factor regarding directional splitters, only on undivided roads
FC_{HS} = capacity adjustment factor related to side obstacles on the shoulder or curb roads
FC_{UK} = capacity adjustment factor related to city size

The degree of saturation is the main parameter used to determine the level of performance of roads. Score saturation represents traffic flow performance quality level, start from zero to one. A value close to zero indicates current no fed up, that is, the current condition relaxed and stable, and the vehicle will not affect it at all. On the other hand, number 1 indicates an unstable capacity condition, with the degree of saturation limit not exceeding 0.85 in the road design. Here are the degree of saturations equations:

$$PA = N_Q \times \frac{20}{LM} \quad (5)$$

RKH, which is the ratio of vehicles on an approach that must stop because of a red signal before passing through an intersection to the magnitude of the in-phase current on that approach [9]. It can be calculated utilizing the following equations and diagrams. The average amount of NH stops is the normal number of stops per vehicle before crossing the intersection (including the number of repeated stops in the queue), which is calculated by the taking after formula.

Delays are calculated at intersections that are equipped with traffic signaling device/priority intersections (APILL) [10]. Traffic delays at the APILL intersections include a. traffic delay is the waiting time caused by traffic interactions and traffic movement conflicts; b. geometric delay is the waiting time caused by abnormally slowing and accelerating vehicles and/or stopping at a red light. In this study, the performance of signalized intersections is examined through the parameters of queue length and delay. The delay is caused by light traffic at the marked intersection [11]. If the green time is below 10 seconds it will cause too many opposite drivers after the red light and make it difficult for pedestrians to cross the road [12].

The level of service (LOS) is a quality level that describes the traffic conditions received by vehicle drivers and is generally used as a measure to measure the effect of restrictions due to an increase in volume from A to F at a certain level [13]. Qualitative measures that explain operational conditions in traffic flow and drivers' perceptions of vehicle quality are represented by the level of service on the road [14]-[15]. The determination of the level of service at the intersection can be determined based on the delay [10].

Table 1. Intersection Service Level Based on Average Delay.

Level of Service	Average Delays (s/skr)
A	< 5
B	5 – 15
C	15 – 25
D	25 – 40
E	40 – 60
F	> 60

Source: Minister of Transportation Regulation Number 96 of 2015

PTV Vissim is a software simulation used by professionals to make a simulation scene dynamic traffic before planning actually. Vissim simulates the various types and characteristics of the vehicles we used daily, among others vehicles (cars, buses, trucks), public transportation (tram, buses), bicycles (bicycles, motorbikes), and pedestrians. Through pictures in 3D, Vissim displays simulation animation like the original made. Of course, use Vissim will reduce costs to change design becomes a reality. The user software can model various user behavior that occurs on the transportation system [16]-[17].

2. METHOD

The flowchart of this research is as follows.

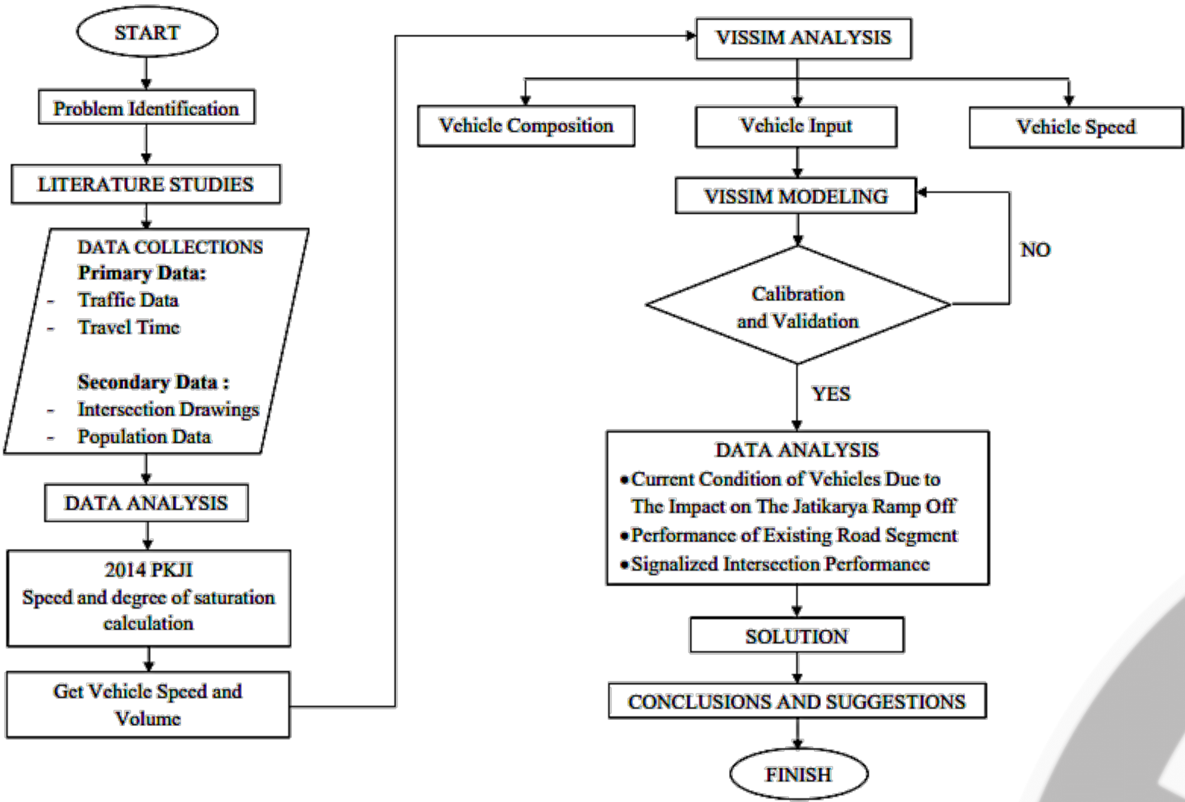

Figure 1. Flow Chart

Based on Figure 1, this research begins with problem identification, data collection carried out by literature studies, field observations, and data from agencies related to research, research, and optimization using PTV Vissim software based on 2014 PKJI. The final results of the study are the performance of the Alternative

Cibubur Road section, the performance of the Jatikarya intersection is based on queue length and delay, and the solution is in the form of intersection optimization.

3. RESULTS AND DISCUSSION

3.1 Performance Analysis of Existing Road Segment

a. Capacity

One of the parameters for calculating the degree of saturation is capacity. The calculation of the capacity is carried out by way of looking at the adjustment factors for actual road conditions that affect road capacity.

b. Degree of Saturation

Based on the capacity analysis, the value of the degree of saturation with a comparison of several conditions, namely in 2019 (before the intersection), in 2021 existing (after the intersection and in a pandemic condition), and 2021 assumptions (after the intersection and normal conditions with a ratio of 1 : 0.75) on the Alternative Cibubur Road.

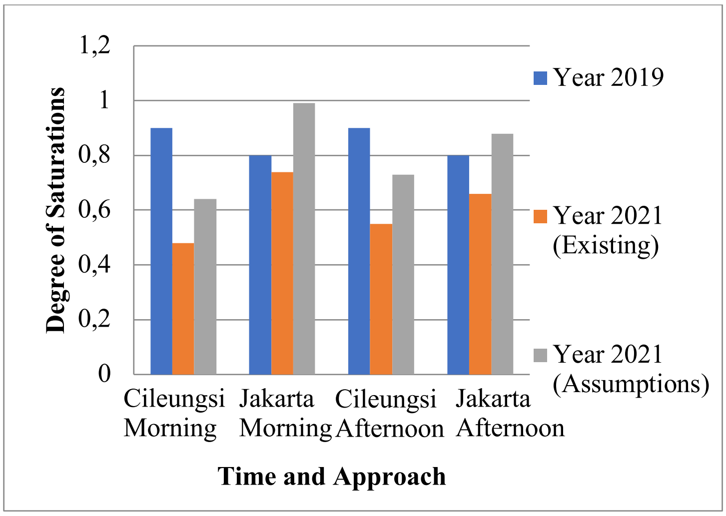

Figure 2. Comparison of Degrees of Saturation

If the existing conditions are adjusted to normal conditions (not affected by the pandemic) by assuming, the results of the road performance towards Cileungsi during the morning rush hour are 0.64 and the afternoon rush hour is 0.73 then the direction to Jakarta during the morning rush hour is 0.99 and the afternoon rush hour is 0.88.

c. Speed

The analysis carried out is to compare 2 conditions, namely, speed under normal conditions (before the pandemic) and existing conditions (pandemic conditions) with a comparison between both conditions are 1 : 0.75. speed recapitulation can be seen in Figure 3.

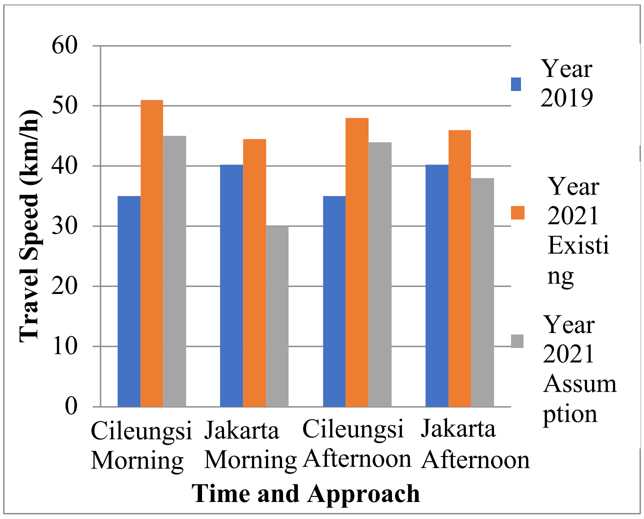

Figure 3. Comparison of Theoretical Travel Speed

From the results of the comparative analysis in the graph above, in 2019, the vehicle travel speed towards Cileungsi was known to be 35 km/hour and the direction to Jakarta was 40.3 km/hour. In 2021, the travel speed towards Cileungsi is 51 km/hour (morning rush hour) and 48 km/hour (afternoon rush hour); the direction of Jakarta is 44.5 km/hour (morning rush hour) and is 46 km/hour (afternoon rush hour). However, if the existing conditions are adjusted to normal conditions (not affected by the pandemic) by making assumptions, the result obtained that the travel speed towards Cileungsi during the morning rush hour is 45 km/hour and the afternoon rush hour is 44 km/hour. Then the direction to Jakarta during the morning rush hour is 30 km/hour and the afternoon rush hour is 38 km/hour.

d. Density

Based on the speed quotient, the value of the density of the Alternative Cibubur road towards Cileungsi during the morning rush hour is 45.20 skr/km and at the afternoon rush hour is 55.23 skr/km. While the road density in the Alternative Cibubur Road towards Jakarta during the morning rush hour is 81.00 skr/km and in the afternoon it is 69.28 skr/km.

e. Road Level of Service

The results of the service level analysis based on the Regulation of the Minister of Transportation Number 96 of 2015 concerning Guidelines for the Implementation of Traffic Management and Engineering Activities in 2019 the service level is E (unstable flows speed sometimes stops, demand is approaching capacity) for both directions, in 2021 the existing condition of service level is C (stable flow, but vehicle speed and motion are controlled) for both directions and if an assumption is made in 2021, the comparison is C for the Cileungsi direction and E for the direction of Jakarta.

3.2 Performance Analysis of Signalized Intersection

In this section, the performance of signalized intersections in terms of queue length and delay is carried out using PTV Vissim. According to the Minister of Transportation Regulation Number 96 of 2015, delays are calculated to determine the level of service at intersections. The data requirements that are inputted to Vissim to get the performance of the intersection are described in the following discussion.

a. Vehicle Composition

From the results of the analysis of vehicle traffic flow, the composition for each type of vehicle in each direction is calculated. The composition of the vehicle will be used as input of Vissim. The composition of vehicles for each intersection approach is shown in Figure 4.

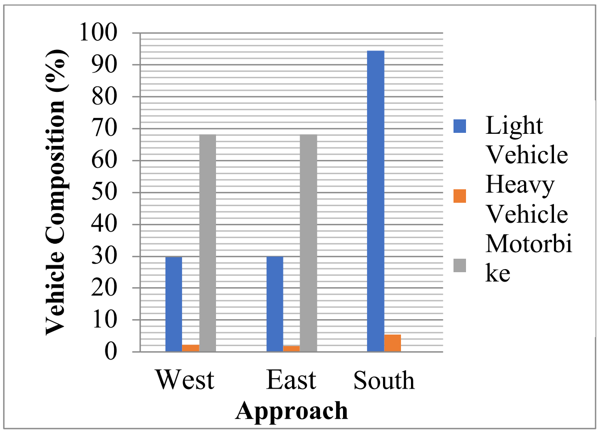

Figure 4. Vehicle Composition

b. Existing Vehicle Speed

Analysis of vehicle speed distribution is used as input to the VISSIM program on the Desired Speed Distribution menu. The results of the analysis of the vehicle speed distribution and its graph can be seen in Figure 5.

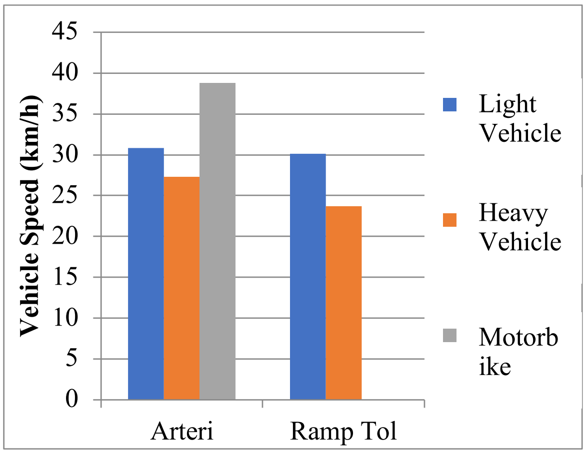

Figure 5. Existing Travel Speed

c. Signal Time

Traffic signal light settings based on survey results are carried out on the Signal Controller menu. In this menu, inputs are entered in the form of cycle time, signal phase, all red time, green time, inter-green time, and amber. In this study, green time changes are calculated for intersection optimization. Table 2 explains the comparison between the existing condition and optimization as follows.

Table 2. Intersection Signal Time

Movement	Existing Condition	Junction Optimization
	Green Time (seconds)	Green Time (seconds)
Jakarta – Cileungsi	63	73
Jakarta – Enter Toll	14	18
Cileungsi – Jakarta Cileungsi – Enter Toll	53	53
Toll Ramp – Cileungsi Toll Ramp - Jakarta	38	42

d. Calibration and Validation

Calibration and validation are carried out so that the simulation model that is run can represent the actual field conditions in the field. In this study, calibration was carried out using the VISSIM application trial and error driving behaviors. Driving Behavior is entered in the input in the Link window and can be made closer to the real thing. For arterial roads, the Car Following Model uses the *Wiedemann* 74, and for toll ramps, carried it uses the *Wiedemann* 99.

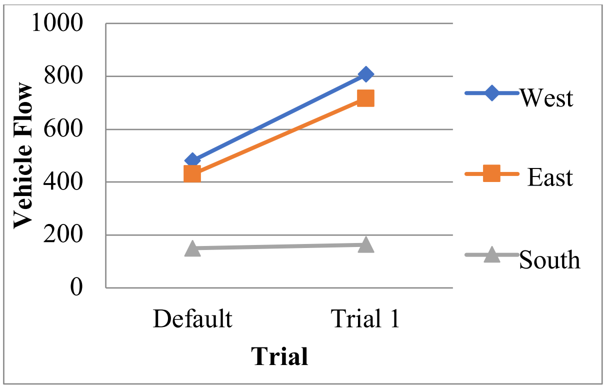

Figure 6. Vissim Calibration Results

e. Vissim Analysis and Solutions

After calibration and validation were completed and the model is declared valid, in addition evaluation is completed at the VISSIM modeling. VISSIM evaluation on this observe is an evaluation of the outcomes by comparing queue length and vehicle delays at intersections.

In this observe, traffic management was carried out as one of the answers to research problems. Traffic control is completed in optimizing the intersection cycle time with the aid of using converting the green time and cycle time. The intersection optimization is executed the use of the Optimize All Fixed Time Signal Controllers menu withinside the VISSIM program. For the scholar version, it's far executed with the aid of using trial and error by changing converting optimization by proportional sizing the length of the queue at every arm of the intersection in keeping with the traffic flow that passes through every arm of the intersection in order that the intersection can lessen vehicle delay time and enhance intersection performance. The following is a recapitulation of outcomes of the contrast of vissim evaluation of current situations and optimization amswers.

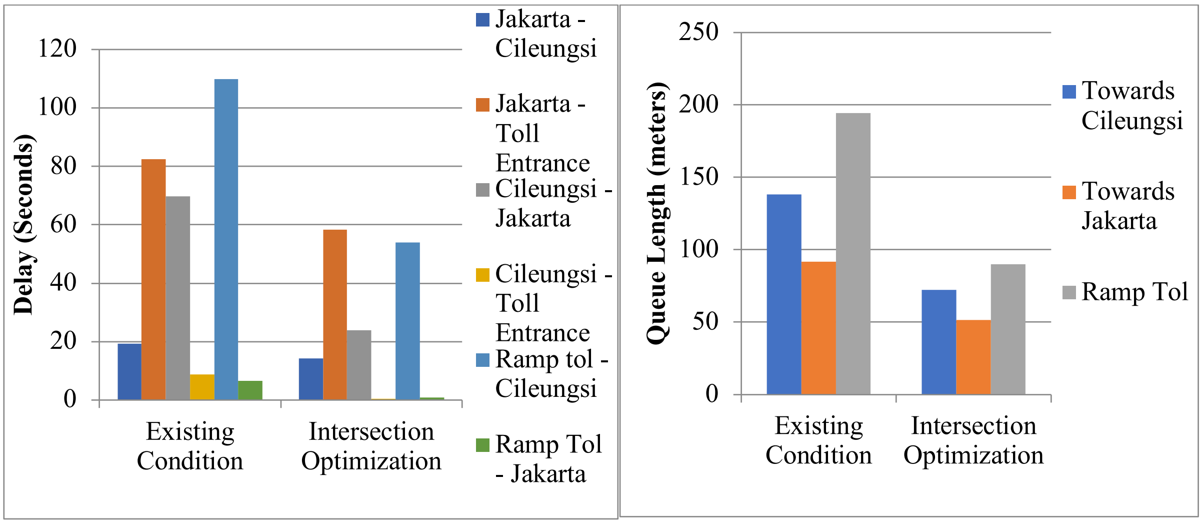

Figure 7. Delay and Queue Length Comparison

From Figure seven above, it will be seen that changing the dynamic time and green time at the intersection leads to modifications in queues and vehicle delays at every intersection approach. The largest change occurred at the East approach intersection (Alternative Cibubur Road) by 56.58% for queues and 80.16% for delays (change in service level from C to B and F to E). Within the Western approach, there has been a decrease in queue length by 52.29% and a decrease in delays by 27.41% (change in service level from F to C and B to A). It can be over that the Alternative Solution by changing the cycle time and green time at the intersection contains a vital result on reducing queues and delays that occur on the Alternative Cibubur Road and Jatikarya Toll Access.

From the results above, to resolve the performance downside of the Jatikarya intersection, it is necessary to adjust the length of green time and cycle time. This is often a recommendation for companies, governments and different stakeholders concerned in political opinions to boost intersection performance.

4. CONCLUSION

From the result of the analysis, it can be concluded that the performance of the Alternative Cibubur Road segment in the existing condition is obtained the largest degree of saturation is 0.74 (morning rush hour) in the direction of Jakarta with service level C. The level of service at the Jatikarya intersection is obtained by the largest queue length and delay, namely the South approach (Toll Exit Access) with a queue length of 194.87 seconds with service level F which affects the West and East approaches (Alternative Cibubur Road). The solution is optimizing the intersection, changing the green time and cycle time, resulting in a significant effect with the largest decrease in queue length and delay, namely 56.58% and 80.16% with changes in service level up to A.

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