Simulation Modelling of Traffic Flows in the Central Business District Using PTV Vissim in Pekanbaru, Indonesia

Ari Sandhyavitri\textsuperscript{1a), Agru Maulana\textsuperscript{1b), Mu\textsuperscript{n}ammad Ikhsan\textsuperscript{1c), Agus Ika Putra\textsuperscript{1d), Rizki Ramadhan Husaini\textsuperscript{2e), Fajar Restuhadi\textsuperscript{3f}\textsuperscript{)\textsuperscript{)}}

\textsuperscript{1}Civil Engineering Department, Universitas Riau, Pekanbaru, Indonesia 28293
\textsuperscript{2}Civil Engineering Department, Universitas Abdurrahman Ar-Rouf, Pekanbaru, Indonesia 28294
\textsuperscript{3}Agribusiness Department, Universitas Riau, Pekanbaru, Indonesia 28293

ari.sandhyavitri@eng.unri.ac.id

Abstract. The state of art simulation modelling in managing traffic flow within a busy central business district (CBD) is demonstrated in this article. The objectives of this article were to identify the existing condition of the street V/C ratios within the CBD area, and to develop various simulations modelling. The development of microscopic traffic simulations encompassing 5 streets within the CBD area in Pekanbaru, Indonesia using the PTV Vissim application was performed as a case study. The existing conditions of these 5 streets were very busy (Level of Service C and D) with on-street parking and on-street traders (vendors) along the streets. Several simulations model based on 4 traffic management approaches were applied; (i) controlling on street traders (vendors) activity, (ii) controlling parking lots, and (iii) changing the on-street parking angle and (iv) combination of these approaches. The simulation results have indicated that the optimum simulation modelling in managing CBD traffic flow within these 5 streets was conducted by managing the on-street parking angle at the position of 30\textdegree \textsuperscript{) as well as controlling on street traders activity. Hence, by conducting simulations using this application improved the streets Level of services (LOS) within this CBD area from D (0.75 < VC < 0.84) to C ( 0.45 < VC < 0.74).

1. Introduction
Traffic management is a series of businesses and activities that include planning, procurement, installation, regulation, and maintenance of the street equipment facilities supporting and maintaining street security, safety, and traffic flow [1-3].

Traffic management addressed several issues for maintaining its performance. According to Tamin [4], states that urban traffic performance can be assessed using traffic parameters, namely for roads, which can be in the form of V/C ratio, speed and traffic density. As for the intersection, it can be in the form of delay time and queue length. If available, traffic accident data can also be considered in evaluating the effectiveness of the urban traffic system.

Pekanbaru City CBD area, Indonesia encompasses Sukaramai Trade Center (STC), Ramayana Shopping Center, Central Market shops were appointed as a case study in managing the traffic flow in a systematic approach using 4 Simulation modellings. This CBD may attract at the average of 13,354 trips generation per person/day so that it can impose a significant traffic load [5].
Based on the Department of Transportation Pekanbaru, 2018, it was reported that the V/C traffic flows of the main streets within this CBD area were 0.74, which means that the volume of vehicles is approaching road capacity (Figure 1). It was also reported that too many on-street traders (vendors) and on-street parking vehicles caused the capacity of the street to decrease, hence the traffic performance within this streets’ CBD becomes ineffective.

The objectives of this article are as follows: (i) to identify the existing street network performances within the CBD area of Pekanbaru City encompassing 5 main streets; Jenderal Sudirman, Ahmad Yani, Ir. H. Juanda, M. Yamin, and Sam Ratulangi; (ii) Developing simulation micro-simulation model in managing traffic flows using PTV Vissim; and (iii) making a suggestion for the government what the optimum solution in managing traffic flow within this CBD area. This study demonstrated the systematic development of microscopic traffic simulations within the CBD area for making appropriate strategic decisions in managing urban transportation [6-8].

This article may be as a reference for Pekanbaru local Government, the Department of Transportation and Engineering students in simulating traffic flow in the CBD area systematically using PTV Vissim.
2. Methodology

- This research methodology is divided into 3 main stages:
  - Identification of the existing problems and data collection,
  - Analyses the traffic flow and developing Simulation modelling,
  - Selecting the best simulations modelling options for the short-term traffic management strategy.

The traffic counting data were obtained from the Department of Transportation Kota Pekanbaru, 2018 data (and projected to the 2020 traffic condition with the traffic increasing rate at the average of 5% per year).

Assessment of the street performance was referred to the ratio of volume per capacity (V/C Ratio), speed and traffic density. These three characteristics are then used to find the level of service [9].

The basic equation for determining capacity is as follows:

\[ C = C_0 \times F_{CW} \times F_{CSp} \times F_{CSf} \times F_{Cs} \]  

Source: Indonesian Highway Capacity Manual (MKJI), 1997

Where:
- \( C \) = Highway capacity (passenger car unit or pcu/hour)
- \( C_0 \) = Basic capacity (pcu/hour)
- \( F_{CW} \) = Traffic lane width adjustment factor
- \( F_{CSp} \) = Directional separator adjustment factor
- \( F_{CSf} \) = Side highway resistance adjustment factor
- \( F_{Cs} \) = City size adjustment factor

The following equation is used to determine an average of vehicle speed:

\[ V = \frac{L}{TT} \]  

Where:
- \( V \) = Average vehicle speed (km/hour)
- \( L \) = Segment Length (km)
- \( TT \) = Average travel time of light vehicles along the road segment (hours).

The equation for determining Traffic density is as the following equation:

\[ K = \frac{Q}{Us} \]  

Where:
- \( K \) = Traffic density (vehicle/km or junior high school/km)
- \( Q \) = Traffic flow (vehicles/hour or junior high school/hour)
- \( Us \) = Space mean speed (km/hour).

2.1. Level of Service (LOS)

The Level of Service (LOS) is a qualitative measurement that describes the operational conditions of a certain traffic flow and the perception of drivers or passengers of a vehicle on these conditions [10]. The following Table 1 describes the characteristics of LOS.
Table 1. Level of Service Characteristic.

| Level of Service (LOS) | Characteristics                                      | V/C ratio |
|------------------------|------------------------------------------------------|-----------|
| A                      | Free Flow with low traffic volume                    |           |
|                        | Average Travel Speed 80 km/h                         | 0.00 - 0.20|
|                        | Low traffic density                                  |           |
| B                      | Stable Flow with moderate traffic volume             |           |
|                        | Average Travel Speed Decreased to 70 km/h            | 0.20 - 0.44|
|                        | Low traffic density                                  |           |
| C                      | Stable Flow with higher traffic volume               |           |
|                        | Average Travel Speed Decreased to 60 km/h            | 0.45 - 0.74|
|                        | Medium traffic density                               |           |
| D                      | Approaching Unstable Flow with high traffic volume   |           |
|                        | Average Travel Speed Decreased to 50 km/h            | 0.75 - 0.84|
|                        | Medium traffic density                               |           |
| E                      | Unstable Flow with traffic volume approaching capacity|           |
|                        | Average Travel Speed Approx. 30 km/h for inter-city roads and 10 km/h for urban roads | 0.85 - 1.00|
|                        | High traffic density due to internal barriers        |           |
|                        | Stalled Flow and queues occur                        |           |
| F                      | Very high traffic density and low volume             |           |
|                        | Average Travel Speed < 30 km/h                      | >1.00     |

Source: Minister of Transportation Regulation No. 96 of 2015 [11]

A simulation modelling in traffic engineering is defined as the process of creating or analyzing a physical model of traffic flows to predict their behaviour based on some parameters such as V/C ratio, delay, and LOS in the future by performing simulation software packages [12].

The pragmatical reason for using PTV Vissim in simulating traffic flow in this study is because of the ability of the PTV Vissim to simulate the traffic flow and impacts, with the possibilities to define multiple what-if scenarios as well as to develop traffic and transport planning systematically [13,14].

2.2. Simulating traffic flow using PTV Vissim

This article highlights at least 9 stages in using PTV Vissim:

- The first step was conducted by calibrating data using the trial and error method. This is performed to achieve results that are close to the observation data. For example, the value of the driving behaviour parameter is altered according to the estimated conditions in the field.
- Determine the type of vehicle in 2D/3D Models, add and adjust vehicle types, adjust the speed of each vehicle, then adjust vehicle processes so that this application will display the type of vehicle appropriate to the field condition.
- Create a link in PTV Vissim for the construction of the studied streets encompassing; the width of the roads, the width of the road shoulders, pavement thicknesses, the heights (of bridge or fly over).
- Set the conflict areas or street intersections in the Conflict Areas menu. In this menu, priority is given to each intersection approach.
- Input the traffic volume data on the vehicle input first so that the vehicle can appear when it is simulated. This menu contains the volume of vehicles that will pass through the streets in the simulation model.
- Determine travel routes in static vehicle routing decisions. This menu serves as the determination of the fastest route to pass each zone.
- Obtain the results of the simulation analysis, enter the analysis icon into PTV Vissim to read the results of the analysis that have been made. This menu contains nodes, data collection
points, vehicle travel time, queue counters and selection to obtain the data from the modelling

- Enter analytical data into the measurement definition so that the analysis data is read by the Vissim application. The analysis icon points for measurement the results of the simulation modelling can be conducted.
- Then run the Simulation modelling and the results will be obtained.

The final results from those 3 simulations modelling will be compared and the best results will be put into consideration as the recommendation.

3. Results and Discussions

The results finding concerning the existing street conditions and the simulations model of the CBD’s street traffic flow V/C ratios and LOS would be discussed in this section. Currently, there are 5 streets access existed from and to the CBD area (Table 2):

| No | Streets          | Functions | Status    | Types     | Length (m) | Width (m) |
|----|------------------|-----------|-----------|-----------|------------|-----------|
| 1  | Jendral Sudirman | Artery    | National  | 6/2 D     | 823        | 12        |
| 2  | Ahmad Yani      | Artery    | Provincial | 2/2 UD    | 850        | 12        |
| 3  | Ir. Juanda      | Collector | City      | 2/2 UD    | 466        | 10        |
| 4  | Sam Ratulangi   | Collector | City      | 2/2 UD    | 482        | 9         |
| 5  | M. yamin        | Local     | City      | 2/2 UD    | 492        | 6         |

This article illustrates 1 example for calculating street capacity (i.e. the Jendral Sudirman street). Based on the table of correction factors existed in the 1997 MKJI, it was calculated that the Jendral Sudirman street capacity was:

\[
C = C_0 \times FC_w \times FC_{sp} \times FC_{cs} \times FC_{sf}
\]

\[
= 4.950 \times 1.00 \times 1.00 \times 1.00 \times 0.98
\]

\[
= 4.851
\]

The traffic volume of this street was fluctuating with the V/C ratio = 0.84 and LOS = D (Figure 2).

![Figure 2. The Fluctuation of traffic volume in Jendral Sudirman Street.](image)

Based on the calculation it is summarized that the V/C ratio and LOS of these existing 5 streets are as follow;
Table 3. V/C ratio and Level of Service (LOS)

| No | Street           | Capacity | Volume | V/C Ratio | Speed (km/hour) | Level of Service (LOS) |
|----|------------------|----------|--------|-----------|-----------------|------------------------|
| 1  | Jend. Sudirman   | 4851.00  | 3954   | 0.82      | 46              | D                      |
| 2  | Jend. A. Yani    | 3264.24  | 2634   | 0.80      | 20              | D                      |
| 3  | Ir. Juanda       | 3217.26  | 2390   | 0.74      | 44              | C                      |
| 4  | Sam Ratulangi    | 3671.25  | 2594   | 0.71      | 47              | C                      |
| 5  | M. Yamin         | 2396.85  | 1782   | 0.74      | 46              | C                      |

The average vehicle speed passing these 5 streets is 40.6 km/hour. The V/C ratio is in the range of 0.71 to 0.82 (Table 3). The levels of service (LOS) of these 2 first streets are D and the rest are C. There is some room for improving those streets LOS in a systematic procedure.

3.1. First Simulation modelling: Managing on-street parking and on-street traders.

The simulation modelling was conducted by the implementation of 2 approaches, such as (i) managing on-street parking, as well as (ii) on-street traders located within the study areas. The PTV Vissim simulation results are presented in the following table.

Table 4. An Average of Vehicle Speed, street V/C ratio and LOS after 1st Simulation

| No | Street           | Volume | Speed (Km/Hour) | V/C Ratio |
|----|------------------|--------|-----------------|-----------|
|    |                  |        | Existing | 1st Simulation | Existing | 1st Simulation | LOS |
| 1  | Jend. Sudirman   | 3954   | 3954      | 46         | 49.73    | 0.82           | 0.78 | D |
| 2  | Jend. A. Yani    | 2634   | 2634      | 20         | 30.46    | 0.80           | 0.74 | C |
| 3  | Ir. Juanda       | 2390   | 2390      | 44         | 49.69    | 0.74           | 0.69 | C |
| 4  | Sam Ratulangi    | 2594   | 2594      | 47         | 48.79    | 0.71           | 0.66 | C |
| 5  | M. Yamin         | 1782   | 1782      | 46         | 47.86    | 0.74           | 0.74 | C |

Table 4 shows that after conducting 1st Simulation modelling, it was identified that there are some improvements in the vehicle speed parameter passing these 5 streets within CBD area at the average of 11% from 40.6 km/hour to become 45.30 km/hour, and a reduction of V/C street ratio at the average of 5.2% (which means that it is better than before). The LOS of the streets are also even better from 2 streets’ LOS = D (Table 3) to become 1 street remains D (Table 4).

3.2. Second Simulation modelling: One Way Street.

The second traffic management simulation modelling was implemented in 2 approaches. The approaches were to shift traffic flow circulation from a-two way to one-way street within the CBD collector streets (i.e. Sam Ratulangi street to Jendral Sudirman street) and recalculated the cycle time of the existing traffic light signals (APILL) located at 2 intersections (i.e. Ahmad Yani – M. Yamin intersection and A. Yani – Samratulangi one). After implementation of this second simulation, the performance of the streets can be seen as follow;
Table 5. An Average of Vehicle Speed, street V/C ratio and LOS after 2nd Simulation

| No | Street         | Volume | Speed (Km/Hour) | V/C Ratio | LOS |
|----|----------------|--------|-----------------|-----------|-----|
|    |                | Existing | 2nd Simulation | existing | existing | 2nd Simulation |
| 1  | Jend. Sudirman | 3954    | 3615            | 46        | 50.21    | 0.82          | 0.70          | C   |
| 2  | Jend. A. Yani  | 2634    | 2602            | 20        | 30.06    | 0.80          | 0.73          | C   |
| 3  | Ir. Juanda     | 2390    | 2687            | 44        | 41.12    | 0.74          | 0.74          | C   |
| 4  | Sam Ratulangi  | 2594    | 2806            | 47        | 45.57    | 0.71          | 0.71          | C   |
| 5  | M. Yamin       | 1782    | 1644            | 46        | 51.56    | 0.74          | 0.68          | C   |

Based on Table 5 it was identified that there are some improvements in the vehicle speed parameter passing these 5 streets within CBD area at the average of 7.6% from 40.6 to 43.70 km/hour, and a reduction of the V/C ratio at the average of 6.5%. The LOS of the street was also even better from 2 streets LOS = D (Table 3) to become C (Table 5).

3.3. Third Simulation modelling: One Way Street

The third traffic management scheme was conducted by combining 3 approaches; (i) re-arrange parking direction from 60°-90° to 30°, (ii) control on-street traders vendors located at Jendral Sudirman and Ir. Juanda streets, and (iii) change traffic flow circulation from two way to a one-way street of M.Yamin.

Table 6. An Average of Vehicle Speed, street V/C ratio and LOS after 3rd Simulation

| No | Street         | Volume | Speed (Km/Hour) | V/C Ratio | LOS |
|----|----------------|--------|-----------------|-----------|-----|
|    |                | Existing | 2nd Simulation | existing | existing | 2nd Simulation |
| 1  | Jend. Sudirman | 3954    | 3568            | 46        | 51.22    | 0.82          | 0.69          | C   |
| 2  | Jend. A. Yani  | 2634    | 2595            | 20        | 33.89    | 0.8          | 0.72          | C   |
| 3  | Ir. Juanda     | 2390    | 2656            | 44        | 49.73    | 0.74          | 0.73          | C   |
| 4  | Sam Ratulangi  | 2594    | 2844            | 47        | 51.91    | 0.71          | 0.71          | C   |
| 5  | M. Yamin       | 1782    | 1691            | 46        | 52.16    | 0.74          | 0.69          | C   |

Based on Table 6 above, it can be seen that the technical performances of the streets in the CBD area are improved after performing 3rd Simulation modelling. This can be seen from the average vehicle speed on these streets increased at an average of 7.5% from 40.6 to 47.8. Improvement of the V/C ratio of Jendral Sudirman street from 0.82 to become 0.69 and A. Yani from 0.74 to 0.69, Ir. Juanda from 0.74 to 0.73. The overall streets LOS become better to the category of C.

3.4. Resume of the Simulations Modelling

After implementing various approaches and conducting 3 simulations modelling, the results are presented in the following table.
Table 7. Head to head of 3 simulations modelling.

| No | Existing and Simulation Modelling                                                                 | Speed (km/hour) | Rage of V/C ratio | LOS                      |
|----|--------------------------------------------------------------------------------------------------|-----------------|-------------------|--------------------------|
| 0  | Existing condition                                                                               | 40.6            | 0.71 to 0.82      | 2 streets D, 3 streets C |
| 1  | Managing on-street parking and on-street traders                                                  | 45.30           | 0.66 to 0.78      | 1 street D, 4 streets C  |
| 2  | Shifting traffic flow circulation from a two-way to one-way street and recalculated the cycle time of the existing traffic light signals | 43.70           | 0.68 to 0.74      | 5 streets C              |
| 3  | Re-arrange parking direction, control on street traders, and change traffic flow circulation from two way to one-way street. | 47.8            | 0.69 to 0.73      | 5 streets C              |

Based on Table 7 it is summarized that the best simulation modelling result from these 3 options above is 3rd simulation modelling.

Figure 3. Third Simulation modelling.
This simulation modelling suggests stakeholders conducting the following actions: re-arrange parking direction to 30°, control on-street traders, and change traffic flow circulation from two way to a one-way street (Figure 3). The results would improve the initial travel speed from 40.6 km/hour to 47.8 km/hour, reduce the V/C ratio range from 0.71 -0.82 to 0.69 to 0.73, and improve the LOS of 2 streets from D to C. Figure 3 also suggests that to regulate 7 locations of on-street parking along the main road of Jendral Sudirman street. The regulation of parking lots systematically may also reduce the V/C ratio and improve the LOS of the streets within the CBD area [15].

4. Conclusions
The systematic development of microscopic traffic simulations within the CBD area in Pekanbaru, Indonesia using the PTV Vissim application has been proven to assist stakeholders in making an appropriate strategic decision for managing urban transport. This study demonstrated that by developing 3 simulation modelling in the Pekanbaru CBD streets would yield a comprehensive result and a logical suggestion. This article suggested that the best simulation model for this case study was simulation modelling 3rd as this simulation yield the following results; the initial travel speed increased from 40.6 km/hour to 47.8 km/hour, the V/C ratio decreased from max 0.82 to 0.73, and the LOS of 2 streets become better from D to C.

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