Identification scenario of dedicated lane for Suroboyo Bus Purabaya - Rajawali route by Rapid Demand Assessment Method

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Abstract. Surabaya City has recently launched the new Suroboyo Bus service which serves the North-South corridor of the city. Based on the BRT service spectrum chart, this service system is currently in between the category of ordinary buses and busways systems. To convert into a full busway system, a dedicated bus lane for Suroboyo Bus is necessary. This paper aims to understand the suitable types of dedicated lanes in the route, confirmed with the size of the demand, the city's policy, and the geometric characteristics and the nature of the built environment along the corridor. This research conducts demand analysis and calculates the operational services by using the Rapid Demand Assessment method. It can be seen that the scenario of the type of dedicated lane development in the form of traffic lane conversion and segregated busways have matched the demand which can serve 75 buses per lane per hour and improved the travel time by 35-65% during congestion.

1. Introduction
The Surabaya City Government through the Surabaya City Transportation Department launched the Suroboyo Bus which serves the North-South corridor of Surabaya City on the Purabaya - Rajawali route in April 2018. The bus fleet carrying capacity of 67 passengers expected to reduce traffic congestion in the North-South corridor of the Surabaya City road network.

The large variety in the operation of the BRT system makes it difficult to define the system. At least, one could provide a minimum quality limit that must be met to able to define the service system. From the spectrum (see figure 1), Suroboyo Bus services currently could be categorized as in between the regular bus and busways system services. Although Suroboyo Bus has good services, there is no specific bus lane for the vehicle that made it beyond the BRT system category. Suroboyo Bus busways system needs a Dedicated Lane.

Dedicated Lane (special lane) is not intended to limit the choice of the driver's lane, on the contrary, it is designed to reduce congestion and to maintain traffic flow (Impact Recovery System). Dedicated Lane commonly known as exclusive right-of-way lane in the Bus Rapid Transit (BRT) system is a special lane that can only be passed by a predetermined transportation mode, in this case, the bus in the BRT system (ITDP:2013). Especially Dedicated Lane for buses that are effective in maintaining smooth traffic. Dedicated Lane is very crucial to be applied in areas with high traffic congestion which will be difficult to change the function of the lane of mixed traffic lanes to become a special lane for buses.
Figure 1. Busways Spectrum
Source: BRT Trans Surabaya

Dedicated Lane or also commonly known as a right-of-way lane for BRT systems can be divided into 2 types of bus lanes and Busways based on the physical form. Busways are Dedicated Lane that is physically separated from other lines in the road network that are specifically designated for public transportation. Busways can be built on the road surface, on the road surface, or underground (Wright, 2015).

The bus lane is a road surface that is devoted to the mode of public transportation permanently at certain times and is not physically separated from other lines.

The criteri
unregistered operator
the fare is paid when passenger already board
Simple bus stop infrastructure
Poor service

unregistered operator
the fare is paid when passenger already board
Simple bus stop infrastructure
Poor service

individual operator
the fare is paid when passenger already board
Simple bus stop infrastructure
Poor service

separated bus lane
The fare is paid inside the bus
Simple bus stop infrastructure
Standart service

separated bus lane
The fare is paid outside the bus
Better bus stop infrastructure
Clean technology
Have its own market identity

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Table 1. Type of Dedicated Lane

| Type of Dedicated Lane     | Warrants                                                                 |
|---------------------------|--------------------------------------------------------------------------|
| Segregated Busway.        | When warrants are met a busway should be investigated for the corridor   |
|                           | [AECOM:2012]. All of the following conditions met:                       |
|                           | • > 75 buses per one hour peak direction at the time of commissioning.   |
|                           | • Without bus lanes, congestion increases bus travel times > 80%.         |
|                           | • Without bus lanes, < 85% of buses arrive on time.                      |
| Conversion of the traffic lane. | Conversion of an existing general traffic lane to an exclusive bus lane is preferred. Depending upon the location (such as physical, environmental, financial considerations) conversion to transit / HOV lane may be accept, if similar outcomes with exclusive bus lane [AECOM:2012]. | Bus lane if, without bus lanes, three or more of the following are met: |
|                           | • Buses carry 65% - 80% of passengers in adjacent traffic lanes.         |
|                           | • > 12 buses per hour.                                                   |
|                           | • Without bus lanes, bus travel times increase 35% - 65% under congested condition. |
|                           | • Without bus lanes, < 75% of buses arrive on time.                      |
|                           | HOV lane if the following exist:                                         |
|                           | • Buses carry 40% - 65% of passenger volumes carried in adjacent general traffic lanes. |
From table 1, it can be seen that to find out what type of dedicated lane that is suitable to be developed in a route, it is necessary to know the condition of the bus service that passes that route. Thus, this study aims to identify the criteria for determining the type of scenarios suitable for the development of the Suroboyo Bus dedicated lane Purabaya - Rajawali route, according to bus service conditions, through Rapid Demand Assessment analysis.

2. Methods

2.1. Research Approach

This research is a quantitative explorative study using a rationalistic approach. The variables to be examined in this journal are the number of passengers, the number of fleets per hour, and changes in travel time.

2.2. Data Collection

The variables to be examined in this journal are the number of passengers, the number of fleets per hour, and changes in travel time. Primary data collection in this study uses the observation method of the existing road network along the Suroboyo Bus Purabaya-Rajawali route. Meanwhile, secondary data collection uses literature study.

The purpose of observation is to understand patterns, norms and meanings of observed behaviour, and researchers learn from informants and people observed. Furthermore, Spradley argued that what was observed was a social situation consisting of places, actors and activities (Spradley, 1980).

The observation data collection technique was used to collect data to identify the criteria for the development of the Dedicated Lane for the Suroboyo Bus on the Purabaya - Rajawali route which must be following the existing conditions in Surabaya, as follows:

1) The collection of land use data was conducted by way of observation along the road by collecting data on the main buildings and many are recognized as landmarks of certain road networks. This will later become one of the characteristics of the road which is expected to make it easier for experts to recognize each road segment. By doing so, it is hoped that the experts will more easily obtain an overview of the existing conditions. The data collection was carried out at 22:00 until the morning at 04.30 on February 28, 2019.

2) The calculation of the number of passengers was conducted as part of a Rapid Demand Assessment analysis, by counting the number of passengers whose boarded, aligned, and were in buses vehicles in each segment of the road. The peak hour time taken was at 06.00 - 07.00 am so that the calculation of passengers was done at that time. The calculation of the passengers was carried out by 6 surveyors, consisted of 3 people for each of the Purabaya-Rajawali and the Rajawali-Purabaya routes. The calculation of the number of passengers was done to calculate the city bus passengers by primary survey since there was no available data.
on the city bus occupancy found in the Trans Surabaya BRT literatures, neither in the SAUM (Sistem Angkutan Umum Massal or the mass transit system) documents. The route taken was the P1/PAC1 (Purabaya – Pasar Turi) city bus route majoring in Purabaya-Perak which is managed by DAMRI (State-owned public transit bus company). This route was chosen because it has the same route as Suroboyo Bus. Passenger data collection was carried out on every bus that departs from the Purabaya Terminal and the Rajawali Bus Stop at 06.00 - 07.00 am. For small transit feeder vehicles or angkot occupancy, there has been a study of occupancy in the SAUM report, while for motorbikes and cars, the occupancy level has been mentioned in the Trans Surabaya BRT document. Followed these data, the Rapid Demand Assessment calculation was also done by processing traffic counting data from the Surabaya City Transportation Department Transportation Department, and from the manual traffic counting from the CCTV footage of the Surabaya City Transportation Department.

3) The collection of travel time data was carried out by surveying on board in the Suroboyo buses to estimate the stop time at each stop in the process of loading passengers. These data then were used later for the estimated travel time.

4) Data collection on the width of the road network was done by observation. This observation was done by measuring the width of the road directly at one point in each road segment. This measurement used a special roller meter to measure the length of the road. The observation was carried out at 22:00 pm until the morning at 04.30 am. The results of these measurements were then visualized using the streetmix application for the cross-section of the front view and the powerpoint for the cross-section of the top view.

5) Collecting road capacity data in the form of road geometric is done in the same way as collecting road width data. This observation is carried out by measuring road components. This measurement uses a special roller meter to measure the length of the road. This observation is carried out at 22:00 until the morning at 04.30. The timing is because at this hour all the roads in the city of Surabaya are quiet enough so that researchers can freely cross the road and take measurements directly. The results of this measurement divide the analysis unit based on segments.

6) Segment distribution was done by dividing each road network (road name) according to the similarity of its physical characteristics. For example, for roads that have the same physical characteristics along the road, it can be made into one segment. However, if along the road network per street name has different physical characteristics, then one road name has more than one segment according to the group of different characteristics found. The results of these measurements were then visualized using the streetmix application for the cross-section of the front view and for the cross-section of the top view.

The secondary data collection were carried out using literature studies. The following are the types of data obtained through literature studies:

1) Data collection on the number of passengers in this section was related to basic data for demand calculation. This basic data was obtained from the Transportation Department of the City of Surabaya Transportation in the form of the results of traffic counting on Jalan Kota (street city). While for the road network that includes National Roads, this basic data was obtained by traffic counting through CCTV cameras belonging to the SITS (Surabaya Intelligent Transportation System) of the Traffic Division of Surabaya City Transportation Department.

2) The collection of route length data was done through the route input in the Google Earth software and then inputted these data into the ArcMap software to see the route length.

3) The collection of road network classification data was done through the literature study of the Surabaya City Detailed Spatial Plan Document.
2.3. Data Analysis

The variables to be examined in this paper are the number of passengers, the number of fleets per hour, and changes in travel time. The identification of this development scenario is intended to find out the types of the dedicated lane that are suitable to be developed for the Suroboyo Bus on the Purabaya-Rajawali route. The choice of the type of dedicated lane is to adapt AECOM and is used as a guide for the development of Dedicated Lane for buses. This guide determines the type of dedicated lane that is suitable to be developed according to the conditions of the bus service. To find out this condition, it is necessary to calculate the passenger demand using the rapid demand assessment method. After the demand is obtained, the fleet, headway and travel time will be calculated so that later it can be seen which type of dedicated lane is suitable to be developed under the condition of the Suroboyo Bus.

This rapid demand assessment analysis technique is a simple demand analysis technique. This analysis was carried out by collecting data on the number of passengers who boarded, alighted, and were in the vehicle at each public transport stop that coincided with the BRT route that was planned to be (ITDP, 2018). This analysis is done by calculating the number of vehicles and occupancy, then the projected passenger demand for the Suroboyo Bus with Dedicated Lane. The following are the stages of rapid demand assessment analysis:

1) Below are the simple formulas using in the calculation table of the rapid demand assessment method:

\[
\text{Passenger demand projection} = \text{Average vehicle/hour} \times \text{Mode shift} \times \text{Vehicle Occupancy}
\]

2) Compilation of the number of vehicles per road segment per hour was obtained from vehicle counting (traffic counting) by the Surabaya City Transportation Department before the Suroboyo Bus, which was in February 2018. The traffic counting data used was the average number of vehicles per hour of the entire data collected for 16 hours. The road segment used as an observation point can be seen in Figure 3.

3) Calculation of the modal shift target which was divided into four according to the type of vehicle, namely public transportation, city bus, motorbike, and four-wheeled private vehicle. In this calculation, it was assumed that all passengers from public transportation and city buses will move to the BRT. As for motorbikes and private vehicles, as many as 20% of road users will make a capital shift (World Bank, 1987). This movement will be calculated by occupancy instead of the number of vehicles so that the number of vehicles will first be multiplied by occupancy per type of vehicle. Occupancy of a 4-wheeled private vehicles was set 1.5 passengers/vehicle and motorcyclists was set 1 passenger/vehicle. For angkot occupancy was set 4 passengers/vehicle, and city bus occupancy will be obtained from the observation of the number of passengers. Furthermore, the Trans Surabaya BRT stated that about 8% of motorbike users have travel destinations along the Suroboyo Bus route and 12% of car users have travel destinations along the Suroboyo Bus route according to the survey.

4) The estimation of demand per road segment per hour will be carried out based on projections with baseline data in 2018. According to the Trans Surabaya BRT, the reductions in the development of BRT demand assuming demand growth for the initial period of BRT operation was 2.5% per year. In the operating year, demand growth was estimated and assumed to be equal to the economic growth.

From the results of the demand calculation, it is necessary to calculate the number of the fleet, headway and travel time. The following is the process of calculating the number of fleets, headway, and travel time:

1) Calculation of the number of fleets was done by a simple calculation method that was to dividing passenger demand projection by fleet capacity.

2) The calculation method of headway was to divide the circulation time of one hour with a fleet number.
3) Calculation method of travel time was conducted by adding the time taken by the bus to take the Purabaya - Rajawali and Rajawali - Purabaya routes, the time stops at each stop for loading passengers. The travel time was divided into two types, namely, travel time by lower limit speed and travel time with the upper limit speed.

4) The calculation of total travel time was done by calculating the difference between the total travel time Suroboyo without Dedicated Bus Lane and the total travel time with the travel lane. Travel time of Suroboyo bus without a dedicated bus lane on observation results obtained from the travel bus travel time. Travel time with dedicated Suroboyo Bus Lane is the travel time discussed in numbers 3 and 4.

The flow of rapid demand assessment analysis can be seen in Figure 2.

![Figure 2. Rapid Demand Assessment Flow Chart](image)

![Figure 3. Observation Point Map](image)
3. Result and Discussions

The demand calculation for the Dedicated Lane development plan was carried out using rapid demand assessment techniques. The basic data used was the latest data on the number of vehicles, namely traffic counting data in February 2018, exactly two months before the Suroboyo Bus was launched. In the following discussion, the Suroboyo Bus demand calculation process will be explained in one hour peak hour for 2019 on the Purabaya - Rajawali route. Data basic traffic counting for each of the road network along the route can be seen in 1 and 2, in which the number 1 represents data on the number of vehicles along the route Purabaya - Rajawali and the number 2 are data on the number of vehicles along the route Rajawali - Purabaya.

### Table 2. Hourly Average of Vehicles in the Purabaya-Rajawali Road Network

| No | Street             | City Bus | Angkot | Car  | Motor  |
|----|--------------------|----------|--------|------|--------|
| 1  | Frontage Barat Ahmad Yani | 22       | 82     | 780  | 11880  |
| 2  | Wonokromo         | 2        | 48     | 1458 | 6936   |
| 3  | Darmo             | 3        | 24     | 1952 | 3679   |
| 4  | Urip Sumoharjo    | 7        | 31     | 2213 | 3860   |
| 5  | Basuki Rahmat     | 15       | 66     | 3818 | 5235   |
| 6  | Embong Malang     | 9        | 33     | 2606 | 5374   |
| 7  | Blauran           | 4        | 15     | 1922 | 6520   |
| 8  | Bubutan           | 5        | 21     | 1713 | 3485   |
| 9  | Indrapura         | 15       | 77     | 1340 | 5751   |
| 10 | Rajawali          | 24       | 67     | 983  | 3744   |
|    | **Total**         | **106**  | **464**| **18785** | **56462** |

### Table 3. Hourly Average of Vehicles in the Rajawali- Purabaya Road Network

| No | Street             | City Bus | Angkot | Car  | Motor  |
|----|--------------------|----------|--------|------|--------|
| 1  | Veteran            | 7        | 94     | 1210 | 2457   |
| 2  | Pahlawan           | 10       | 55     | 1792 | 4648   |
| 3  | Gemblongan         | 10       | 76     | 1385 | 4136   |
| 4  | Tunjungan          | 8        | 16     | 1471 | 5117   |
| 5  | Gubernur Suryo     | 16       | 27     | 1979 | 4295   |
| 6  | Panglima Sudirman  | 6        | 44     | 2845 | 5887   |
| 7  | Urip Sumoharjo     | 8        | 32     | 2187 | 4267   |
| 8  | Darmo              | 7        | 25     | 1665 | 3270   |
| 9  | Wonokromo          | 7        | 33     | 1124 | 5238   |
| 10 | Frontage Timur Ahmad Yani | 0       | 0      | 396  | 4412   |
| 11 | Ahmad Yani         | 7        | 26     | 1376 | 3564   |
|    | **Total**          | **86**   | **428**| **17430** | **47292** |

The two tables above are data of existing traffic conditions in 2018. The next discussion covers the target of moving passengers from the original type of vehicle to the Suroboyo Bus. The following is an explanation of the calculation of displacement targets for each mode:

1) The scenario for city bus mode shifted to Surabaya bus so that automatically all city bus passengers will be switched to Suroboyo Bus. Meanwhile, to find out the number of City Bus passengers, the number of vehicles will be multiplied by the occupancy of city buses per road network. The following table is the occupancy of city buses per road network according to the
observation results.

2) The scenario for angkot passenger shifted to Surabaya bus was by the removal of the angkot route that coincides with the Suroboyo Bus, while the branch route will be facilitated with a feeder so that all angkot passengers will move using the Suroboyo Bus. Meanwhile, to find out the number of angkot passengers, the number of vehicles will be multiplied by the number of angkot occupancies. Public transportation in the city of Surabaya has an average of up to 4 passenger/transportation vehicle (Surabaya Transportation Department, 2012).

3) Scenarios for car users was by assuming that 20% of all car users targeted to transfer or shifted to Suroboyo Bus. The number of car passengers that shifted was the number of all 20% vehicles multiplied by car occupancy rate. Car occupancy was 1.5 passenger/vehicle (BRT Trans Surabaya).

4) Scenarios for motorcycle users was by assuming that 20% of all motorcycles users to shifted to Suroboyo Bus. The number of motorcycles will be multiplied by its occupancy. Motor occupancy is 1 passenger/vehicle (BRT Trans Surabaya).

5) With all the above scenario, the following table 4 and 5 displays the result of calculated the shifted mode and passenger numbers Suroboyo Bus on each road network along the route.

### Table 4. Mode Shift Projection of Suroboyo Bus in Rajawali- Purabaya Route

| No | Street                        | City Bus | Angkot | Car | Motorcycle |
|----|-------------------------------|----------|--------|-----|------------|
| 1  | Frontage Barat Ahmad Yani     | 616      | 328    | 28  | 190        |
| 2  | Wonokromo                     | 56       | 192    | 52  | 111        |
| 3  | Darmo                         | 79       | 96     | 70  | 59         |
| 4  | Urip Sumoharjo                | 184      | 124    | 80  | 62         |
| 5  | Basuki Rahmat                 | 335      | 264    | 137 | 84         |
| 6  | Embong Malang                 | 189      | 132    | 94  | 86         |
| 7  | Blauran                       | 84       | 60     | 69  | 104        |
| 8  | Bubutan                       | 93       | 84     | 62  | 56         |
| 9  | Indrapura                     | 265      | 308    | 48  | 92         |
| 10 | Rajawali                      | 616      | 268    | 35  | 60         |
|    | **Total**                     | **2518** | **1856** | **676** | **903** |

### Table 5. Mode Shift Projection of Suroboyo Bus in Purabaya-Rajawali Route

| No | Street                        | City Bus | Angkot | Car | Motorcycle |
|----|-------------------------------|----------|--------|-----|------------|
| 1  | Veteran                       | 376      | 44     | 39  | 177        |
| 2  | Pahlawan                      | 220      | 65     | 74  | 260        |
| 3  | Gembongg                      | 304      | 50     | 66  | 260        |
| 4  | Tunjungan                     | 64       | 53     | 82  | 211        |
| 5  | Gubernur Suryo                | 108      | 71     | 69  | 453        |
| 6  | Panglima Sudirman             | 176      | 102    | 94  | 176        |
| 7  | Urip Sumoharjo                | 128      | 79     | 68  | 245        |
| 8  | Darmo                         | 100      | 60     | 52  | 217        |
| 9  | Wonokromo                     | 132      | 40     | 84  | 212        |
| 10 | Frontage Timur Ahmad Yani     | 0        | 14     | 71  | 0          |
| 11 | Ahmad Yani                   | 104      | 50     | 57  | 163        |
|    | **Total**                     | **2375** | **1712** | **627** | **757** |
6) From the targeted mode shift as table 4 and 5 mentioned, a demand projection calculation is performed. Passenger growth is set to 2.5% for the first 2 years of operation (BRT Trans Surabaya) so that the number of passengers per vehicle type will be multiplied by 2.5%. Besides, it turns out that 12% of car users have a destination along the route and 8% of motorcycle users have a destination along the route (BRT Trans Surabaya). Thus, the projection results will also be calculated based on the percentage of the purpose of the trip. The resulted passenger demand is presented in table 6 and 7.

Table 6. Suroboyo Bus Passenger Demand Projection for Rajawali-Purabaya Route

| No | Street                  | City Bus | Angkot | Car  | Motorcycle | Total |
|----|-------------------------|----------|--------|------|------------|-------|
| 1  | Frontage Barat Ahmad Yani | 631      | 336    | 29   | 195        | 1191  |
| 2  | Wonokromo               | 57       | 197    | 54   | 114        | 422   |
| 3  | Darmo                   | 81       | 98     | 72   | 60         | 312   |
| 4  | Urip Sumoharjo          | 189      | 127    | 82   | 63         | 461   |
| 5  | Basuki Rahmat           | 343      | 271    | 141  | 86         | 841   |
| 6  | Embong Malang           | 194      | 135    | 96   | 88         | 513   |
| 7  | Blauran                 | 86       | 62     | 71   | 10         | 325   |
| 8  | Bubutan                 | 96       | 86     | 63   | 57         | 302   |
| 9  | Indrapura               | 272      | 316    | 49   | 94         | 731   |
| 10 | Rajawali                | 631      | 275    | 36   | 61         | 1004  |
|    | Total                   | 2435     | 1755   | 643  | 776        | 5608  |

Table 7. Suroboyo Bus Passenger Demand Projection for Rajawali- Purabaya Route

| No | Street                  | City Bus | Angkot | Car  | Motorcycle | Total |
|----|-------------------------|----------|--------|------|------------|-------|
| 1  | Veteran                 | 182      | 385    | 45   | 40         | 1300  |
| 2  | Pahlawan                | 267      | 226    | 66   | 76         | 270   |
| 3  | Gembongan               | 267      | 312    | 51   | 68         | 823   |
| 4  | Tunjungan               | 216      | 66     | 54   | 84         | 482   |
| 5  | Gubernur Suryo          | 465      | 111    | 73   | 70         | 745   |
| 6  | Panglima Sudirman       | 180      | 180    | 105  | 97         | 651   |
| 7  | Urip Sumoharjo          | 251      | 131    | 81   | 70         | 788   |
| 8  | Darmo                   | 222      | 103    | 61   | 54         | 795   |
| 9  | Wonokromo               | 218      | 135    | 41   | 86         | 509   |
| 10 | Frontage Timur Ahmad Yani | 0       | 0      | 15   | 72         | 118   |
| 11 | Ahmad Yani              | 167      | 107    | 51   | 58         | 396   |
|    | Total                   | 2435     | 1755   | 643  | 776        | 5608  |

Thus, the projected total passenger demand for the Purabaya - Rajawali route is 6102 and the total passenger demand for the Rajawali - Surabaya route is 5608. With the largest number of passengers of 6102 passengers for an hour on average and the carrying capacity of vehicles of 67 passengers, the number of fleets needed by Suroboyo Bus is 91 fleets. With 91 fleets, the headway for each fleet is 0.66 minutes or 40 seconds. The time needed to take the Purabaya-Rajawali route with a distance of 15.1 km with a lower bound speed of 26 km/hour for the Purabaya-Rajawali route is 35 minutes and for the upper
limit of 30 km/hour is 30 minutes. Meanwhile, to take the Rajawali Purabaya route with a distance of 16.55km with a lower limit speed of 26 km/h is 38 minutes and for the upper limit of 30 km/h is 33 minutes. With an estimated stop time at each stop for 30 seconds, there will be an additional 9.5 minutes for the Purabaya-Rajawali route and 11.5 minutes for the Rajawali-Purabaya route.

According to the results of the bus frequency in one hour, the bus frequency condition in one hour is eligible to develop the segregated busways. The requirements for developing segregated busways are 75 buses per hour in the peak direction at the time of commissioning. Furthermore, another condition that must be met is that without a bus lane, congestion increases bus travel time of more than 80%, while based on the calculation results an increase in travel time is between 59% and 64%. Therefore, the development of segregated busways can only meet one condition, namely bus frequency in one hour. The condition of increasing travel time without a dedicated lane or decreasing travel time with a dedicated lane would be more suitable for scenarios other than segregated busways.

By not fulfilling all conditions to develop segregated busways, it is necessary to analyze other types of scenarios that will be under the current condition of Suroboyo Bus. When compared to existing conditions without Dedicated Lane, there are travel time savings. Whereas at present, the time needed to take the Purabaya-Rajawali route is 62 minutes and the time needed to take the Rajawali-Purabaya route is 84 minutes. Thus, the total time to travel back and forth from Purabaya to Rajawali is 142 minutes. With Dedicated Lane, the travel time back and forth from Purabaya to Rajawali will take 84 minutes - 94 minutes. Without Dedicated Lane, travel time will increase by 59% - 64%. According to the results of travel time changes, then the lane conversion scenario will be suitable for this condition. While the suggested hourly bus frequency is more than 12, so the hourly bus frequency conditions can also meet the conditions for lane conversion development.

The following are the results of Suroboyo Bus fleet operational calculations following demand calculations. Details of the operational calculation of the Suroboyo Bus service to determine the dedicated lane scenario can be seen in table 8 and 9.

Table 8. Suroboyo Bus Operational

| Variable        | Total | Unit | Information          | Total | Unit | Information          |
|-----------------|-------|------|----------------------|-------|------|----------------------|
| Passenger       | 5608  | pass | -                    | 6102  | pass | -                    |
| Capacity        | 67    | pass | -                    | 67    | pass | -                    |
| Fleet           | 84    | bus  | -                    | 91    | bus  | -                    |
| Headway         | 0.72  | km   | -                    | 0.66  | km   | -                    |
|                 | 43    | seconds | -                   | 40    | seconds | -                  |
| Distance        | 16.55 | km   | -                    | 15.10 | km   | -                    |
| Speed           | 26    | km/h | Lower limit          | 26    | km/h | Lower limit          |
|                 | 30    | km/h | Upper limit          | 30    | km/h | Upper limit          |
| Travel time     | 0.64  | hour | Lower limit          | 0.58  | hour | Lower limit          |
|                 | 38    | minutes | -                   | 35    | minutes | -                 |
|                 | 0.55  | hour | Upper limit          | 0.50  | hour | Upper limit          |
|                 | 33    | minutes | -                   | 30    | minutes | -                 |
| Bus stop        | 23    | Bus stop | -                   | 19    | Bus stop | -                 |
| Loading time    | 0.50  | minutes | Per bus stop         | 0.50  | minutes | Per bus stop         |
| Additional time | 11.50 | minutes | Total loading        | 9.50  | minutes | Total loading        |
| Total time travel | 50    | minutes | Lower limit          | 44    | minutes | Lower limit          |
|                 | 45    | minutes | Upper limit          | 40    | minutes | Upper limit          |

To conclude, there are 2 types of scenarios suitable following the existing conditions of the Suroboyo Bus. Even though not all conditions are following the proposed type of scenario, but several conditions...
remain declared to be fulfilling. Thus, the two scenarios, namely the segregated busways and traffic lane conversion scenarios, are stated as appropriate. A summary of the suitability of Suroboyo Bus existing conditions and the required conditions in AECOM (American multinational engineering firm) can be seen in Table 9.

**Table 9. Type of Dedicated Lane considering its Suitability with the Projected Service of Suroboyo Bus**

| Type of Dedicated Lane         | Condition                                                                 | Projection of Suroboyo Bus Service                        |
|-------------------------------|---------------------------------------------------------------------------|----------------------------------------------------------|
| Segregated Busways            | > 75 buses per one hour peak direction at the time of commissioning       | 91 Bus/Hour                                              |
| Conversion of a traffic lane  | Without bus lanes, bus travel times increase 35% - 65% under congested condition. | 84 Bus/Hour, Increased time: 61% - 64%                   |
|                               |                                                                          | 87 – 94 minutes two ways                                 |
|                               |                                                                          | Existing Condition: 142 minutes two ways                 |

Segregated busways and the conversion of traffic lane are the suitable scenarios for dedicated lane development of Suroboyo Bus in Surabaya. Busways are Dedicated Lane that is physically separated from other lines in the road network that are specifically intended for public transportation. The entrance to the Busways can only be taken at certain points. These busways are physically separated in a way that is limited by the construction of walls, curb, cones, or other visible physical structures. Other vehicles are not allowed to use this line at all except emergency vehicles such as ambulances and fire trucks. Busways can be built on the road surface, above the road surface, or underground (Wright, 2005). Bus lane is a road surface that is devoted to the mode of public transportation permanently at certain times. Bus lanes are not separated from other lines physically. This particular lane can be painted or given a road sign, but users can still change lanes. In some cases, bus lanes must still be used with heavy vehicles, other public transportation, or non-motorized vehicles. Usually, this special lane can be used freely at certain points, especially near curves (Wright, 2005).

Bus lanes should be provided as much as possible without reducing the available lanes. This may be realized by means of parking removal or reduction in lane width to provide additional lane, elimination of left turn lane, and/or use of reversible lane operations (NCHRP, 1975).

4. Conclusions

Based on the results of the rapid demand assessment of Suroboyo Bus operational services, the type of dedicated lane development scenario that is suitable to be applied in the road network along the Suroboyo Bus Purabaya - Rajawali route is a type of segregated busways and a type of traffic lane conversion. These suitable scenarios are basically converting one of the existing lane into busways or traffic lane conversion to bus lane. Some traffic lane width adjustment might be necessary to maintain the number of existing lane and adding the dedicated lane for Suroboyo Bus. This adjustment will make the traffic lane narrower but will maintain the number of the traffic lane.

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