

# THE IMPACT OF ROUTING OPTION ON TANGERANG BUS LANE CORRIDOR

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## Abstract

The objective of this study is to analyze the impact of re-routing bus lane corridor on some performance indicators. The Tangerang Bus Lane is taken as a case study. The discussion is focused on comparison of service planning performance indicators such ridership, passenger-km, and bus-km. A primary survey on bus operational characteristics and user attitude is conducted. Prior to the analysis, some basic formula is derived and modified and, then, performance indicators for both route option are estimated. The analysis is conducted by comparing the estimated indicators. The result shows that the alternative route gives better performance and yields to a need of re-evaluating the originally proposed route.

**Keywords:** Bus lane, performance indicator, ridership, service productivity

## Abstrak

Tujuan penelitian ini adalah untuk menganalisis dampak *re-routing* koridor jalur bis pada beberapa indikator kinerja. Tangerang *Bus Lane* diambil sebagai studi kasus. Diskusi difokuskan pada perbandingan layanan perencanaan indikator kinerja penumpang tersebut, penumpang-km dan bus-km. Sebuah survei utama pada karakteristik bis operasional dan sikap pengguna dilakukan. Sebelum analisis, beberapa rumus dasar yang dikembangkan berasal dan dimodifikasi, dan kemudian indikator kinerja untuk kedua rute pilihan diperkirakan. Analisis dilakukan dengan membandingkan indikator diperkirakan. Hasil penelitian menunjukkan bahwa rute alternatif memberikan kinerja yang lebih baik. Ini menghasilkan sebuah kebutuhan mengevaluasi kembali rute awalnya diusulkan.

**Kata-kata Kunci:** Bus jalur, indikator kinerja, pembonceng, produktivitas layanan

## INTRODUCTION

The implementation of bus priority systems in Jakarta since 2004, has brought a new horizon to the public transportation service in Indonesia and could be considered a breakthrough. Having inspired by the success of TransJakarta Busway, the Government of Tangerang City plans to operate a bus lane corridor connecting Poris Plawad Bus Terminal with Kalideres Bus Terminal in Jakarta. However, the selection of Poris Plawad Bus Terminal as the service origin can potentially reduce its attractiveness to the user because it had been under utilized since the beginning of its operation in 2001.

Meanwhile, there is an alternative location, e.g. Cikokol Terminal, which is more attractive to the potential user for the service origin. Historically, the location was a bus terminal and traditional market and now is being transformed into a very modern

commercial complex and will be one of Central Business Districts (CBDs) in Tangerang City. Therefore, there is still a chance for the Government to review its decision on Poris Plawad Bus Terminal as the origin of its bus lane service.

This study tries to analyze the impact of changing the bus route due to different terminal locations on some operational characteristics and performance indicators, such as bus frequency, number of fleet, ridership, service productivity, and demand patronage. In the following section, the basic theory, research framework, and current situation will be described. The last section will discuss the impact of bus routing option on some performance indicators and the final section will be the conclusion of the study.

The bus represents the most common means of urban transit today. It can be used to cover sprawling areas or can be operated in a linear network, which can be quickly adapted at low cost to meet changing demands. The bus performance evaluation plays an important role in bus operation. The evaluation is usually based on some service planning indicators such as vehicle-kms, passenger-kms, passenger/vehicle-kms, and passenger-kms/vehicle-kms (Giannopoulos, 1989). These performance indicators usually have to be derived from demand and operational characteristics, namely ridership, route length, service frequency, vehicle occupancy, operating speed, and line capacity.

Demand estimates, represented in term of passenger volume or flow along the route, are critical to designing the system, planning operations, and predicting the financial viability of the system. It often directly dictates bus operational characteristics such as, headway or frequency, number of fleet, and productivity. When developing volume estimates, there is a trade-off between cost, accuracy, and timing and this yields to a choice between full demand modelling exercise and rapid assessment techniques. In this study, volume estimates will be based on such rapid assessment approach. Conventionally, the existing demand (i.e. pasenger volume) can be derived from boarding-alighting survey. Yet, alternatively it can be derived from sectional bus occupancy and frequency survey along the route as expressed in the following equation:

$$\sum_{t=1}^n \sum_{i=1}^m (V_i)_t = \sum_{t=1}^n \sum_{i=1}^m (\overline{Oc}_i \times f_i \times Cb_i)_t \dots \dots \dots (1)$$

with:

- $V_i$  = sectional observed passenger volume for bus  $i$
- $\overline{Oc}_i$  = sectional average observed occupancy rate for for bus  $i$
- $f_i$  = sectional observed frequency for for bus  $i$
- $Cb_i$  = capacity for bus  $i$
- $i$  = bus type
- $t$  = time interval

In order to determine bus operational design parameters, such as headway and number of bus, this estimated volume needs to be converted to a maximum load/flow section. The flow can be obtained by the following expression ( McShane and Roess, 1990):

$$F_{max} = 4 \times V_{15-max} \dots \dots \dots (2)$$

with:

- $F_{max}$  = directional maximum volume per hour or flow (passengers per hour per direction)
- $V_{15-max}$  = the highest observed volume on 15 minutes interval (passengers)

In the other hand, the potential revenue is determined by the daily riderships. This ridership could also be derived from the sectional maximum flow. The formula is represented in the following equation (TRB, 2007):

$$F_{max} = \frac{R_d}{to} \times C_{ph} \times C_{pd} \dots \dots \dots (3)$$

with:

- $F_{max}$  = sectional maximum flow (passengers per hour per direction)
- $R_d$  = daily ridership (passengers)
- $to$  = turnover rate
- $C_{ph}$  = peak hour percentage
- $C_{pd}$  = peak direction percentage

Utilizing the existing directional flow both for peak and off peak hour, the equation (3) can be re-formulated as follows:

$$R_d = to \times [ \{ (\bar{F}_a^p + \bar{F}_b^p) \times \bar{T}_p \} + \{ (\bar{F}_a^{op} + \bar{F}_b^{op}) \times T_{op} \} ] \dots \dots \dots (4)$$

with:

- $\bar{F}$  = average maximum flow (pax/hr)
- $a, b$  = flow direction
- $p$  = peak
- $op$  = off peak
- $T$  = operational service time (hours)

Referring to TRB (2007), turn over ranges from about 1.2 to 2.0 passengers per bus depending on the route structure and areas served. Based on the sectional maximum flow and bus capacity, the service frequency and bus headway can be calculated by equation (4) and (5), respectively (Khisty, 1990):

$$f = \frac{F_{max}}{C_b} \dots \dots \dots (5)$$

with:

- $f$  = frequency (bus per hour)
- $F_{max}$  = sectional maximum flow (pax/hr)
- $C_b$  = bus capacity (passengers per bus)

Therefore, peak headway,  $h$ , can be expressed as:

$$h = \frac{60}{f} \dots \dots \dots (6)$$

The total bus required for operation during peak hour depends on round trip travel time, lay over or recovery time, and peak headway:

$$n_{op} = \frac{T_{rt} + R_t}{h} \dots \dots \dots (7)$$

with:

- $n_{op}$  = total number of operating bus
- $T_{rt}$  = round trip travel time (minutes)
- $R_t$  = lay over or recovery time (minutes)

While the round trip travel time can be obtained from the route length and the average speed as follows:

$$T_{rt} = \frac{(2L \times 60)}{V} \dots \dots \dots (8)$$

with:

- $T_{rt}$  = round trip travel time (minutes)
- $L$  = one way route length (km)
- $V$  = average design speed (km/hr)

Therefore, by substituting equation (7) and equation (6), the total bus required for service is:

$$n_{op} = \frac{(2L/V + 60) + R_t}{h} = \frac{2L \times 60}{V \times h} + \frac{R_t}{h} \dots \dots \dots (9)$$

and the total bus required for the service is the sum of required bus in operation and some bus spares:

$$n_{tot} = n_{op} + Sp \dots \dots \dots (10)$$

with:

- $n_{tot}$  = number of total bus
- $Sp$  = number of spares

Number of spares is usually (2-3) buses or (10-20) % of number of bus in operation, which ever is greater (TRB, 2007).

Bus productivity is an important parameter for vehicle operational cost calculation. It can be derived from the total number of round trip achieved by each bus during the designated operation hours. Therefore, the total productivity can be expressed as follows:

$$N_{rit} = \frac{T_{op} - T_{spbu}}{T_{rt} + R_t} \dots\dots\dots (11)$$

with:

- $N_{rit}$  = total number of round trip
- $T_{op}$  = total time of operation
- $T_{spbu}$  = time for fuelling

## RESEARCH FRAMEWORK

In general, the study is conducted in four basic steps, namely data acquisition, data processing, literature search, methodological setup, and finally research analysis, as shown in Figure 1.

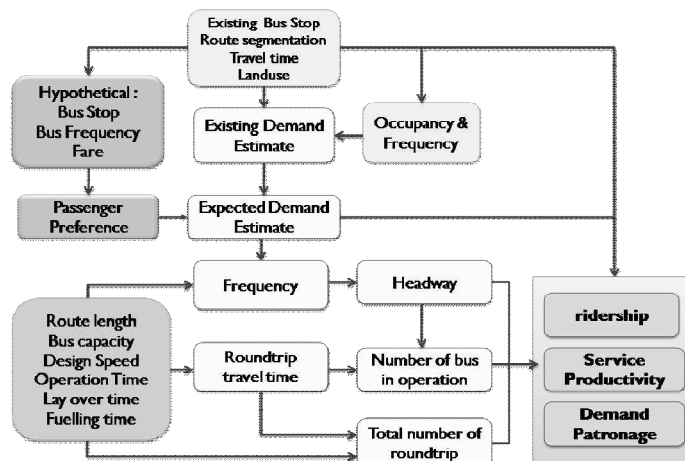
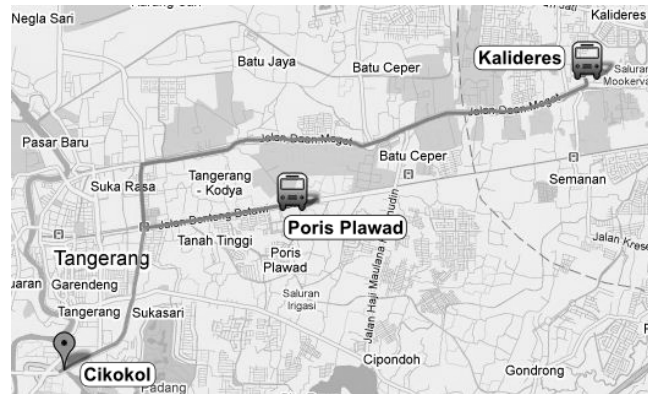


Figure 1 Flow of Research

Initially, a problem formulation is discussed with some related stakeholders which yields to some data requirements. Referring to the discussion, primary surveys consisting of bus operational characteristics, existing bus stops location, and user attitude/opinion are conducted. Based on the occupancy and frequency data, the existing demand is determined and, then, by utilizing the result of user preference survey, the expected demand on proposed bus lane is estimated. Referring to the estimated demand on the proposed bus lane and some operational parameters (i.e. bus capacity, design speed, operation time route length, recovery time, and bus fuelling time), the frequency, headway, number of bus required for operation, total number of round trip, and the potential ridership are then calculated. Based on the calculated demand and operational parameters, an analysis on some performance indicators is carried out and the comparison on both bus lane routing option is discussed.

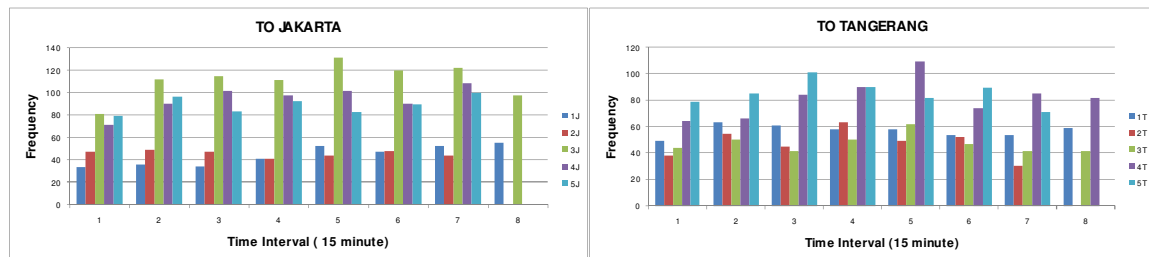
## CURRENT SITUATION

The Tangerang bus lane corridor is illustrated in Figure 2. Basically, both routes share the corridor more than half of its total length and there is only slight difference in term of route length. The one way route length of the proposed route (i.e. Poris Plawad) is about 10.8 km and the alternative route (i.e. Cikokol) is about 11.6 km.



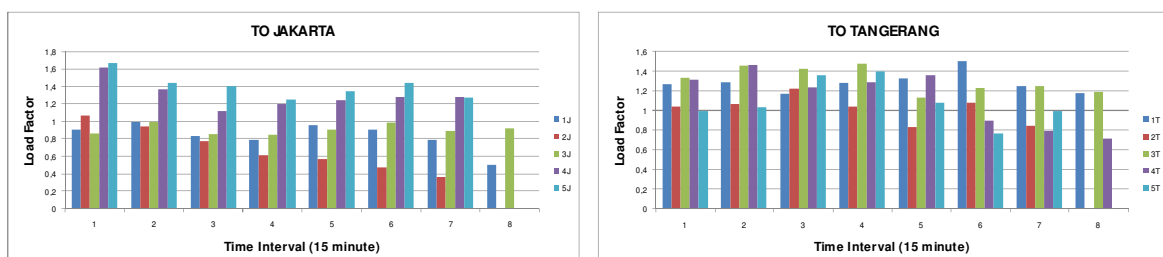
**Figure 2** Tangerang Bus Lane

Along the corridor, the existing service predominantly occupied by small or mini buses (around 23 routes) and their frequency and occupancy are relatively high, especially during peak hours as indicated by Figure 3 and Figure 4.



**Figure 3** Peak Morning Bus Frequency

The observed average speed along the corridor are 21.2 km/hr (morning peak) and 26.1 km/hr 14 (evening peak). There are 18 bus stops (including the informal bus stop) along the corridor and their spacings range from 200 m to 1000 m between subsequent stop.



**Figure 4** Peak Morning Average Load Factor

## ANALYSIS AND DISCUSSION

For the purpose of this study, the corridor is divided into 5 segments based on the existing routing system as illustrated in Figure 5. As in Table 1, route A (Poris Plawad-Kali Deres) consists of segment 2, 3, 4, and 5 while route B (Cikokol-Kali Deres) consists of segment 1, 3, 4, and 5. It is found that both routes share most of the corridor length. Derived from the average load factor and frequency of each segment, the existing maximum flow is found to be 2,388 pax/hr, and it is common for both route options. This value will be the main factor in determining the operational parameters. Table 1 represents maximum sectional and average flow for peak and off peak hour in both direction.

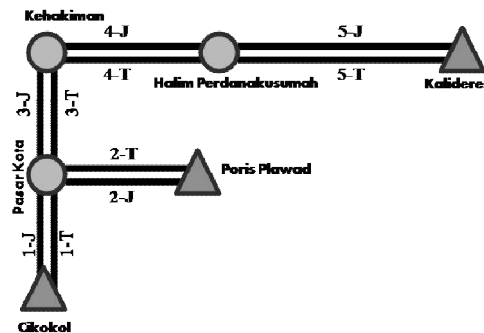


Figure 5 Corridor segmentation

In order to get an estimated demand for the proposed bus service (bus lane system), an attitude or opinion survey is conducted along the designated corridor in parallel with occupancy and frequency survey. After analyzing the collected data, it is found that 88% of the total 118 respondents interviewed agree to choose the proposed service. Hence, the estimated maximum flow in Peak and off peak hour will be 2,105 pax/hr and 1,385 pax/hr respectively. These demand figures will be used as a basis in determining some operational parameters of the proposed service.

Prior to determining the operational parameters of the proposed service, assumption is made on the average design speed, bus capacity, operation time window, recovery (lay over) time, and fuelling time, as indicated in Table 2. Based on the estimated maximum flow, the predefined parameters and related equations developed in previous section, the operational parameters of the proposed service can be determined as shown in Table 3. Taking the operational parameters from Table 2 and Table 3 as a basis, some service production and demand patronage performance indicators can be calculated. The indicators, as shown in Table 4, are vehicle-km, passenger-km, passenger/vehicle-km, passenger-km/vehicle-km, ratio of number of vehicles in peak and off peak service and the potential ridership. Since the maximum flow occurs on same segment of both routes, therefore, as the consequence, the headway and frequency of both route options are exactly the same as indicated in Table 3.

**Table 1** Existing Sectional Maximum Flow

	Segment*	Peak Hour		Off-Peak Hour	
		max. Flow (pax/hr)	Average flow (pax/hr)	max. flow (pax/hr)	Average flow (pax/hr)
<b>ROUTE A</b> (Poris Plawad – Kalideres)	2J	780		288	
	3J	2028	1857	1572	1086
	4J	2292		1152	
	5J	2328		1332	
	2T	1104		576	
	3T	1236	1731	888	831
	4T	2388		864	
	5T	2196		996	
<b>ROUTE B</b> (Cikokol – Kalideres)	1J	792		420	
	3J	2028	1860	1572	1119
	4J	2292		1152	
	5J	2328		1332	
	1T	1440		828	
	3T	1236	1815	888	894
	4T	2388		864	
	5T	2196		996	

Note: \*) J=Jakarta; T=Tangerang

**Table 2** Assumed Parameter

Parameters	Peak Hour	Off-Peak Hour
Average Design Speed	17 km/hr	20 km/hr
Bus Capacity	85 (seats & standing)	85 (seats & standing)
Time Window	6 hrs	11 hrs
Fuelling Time	15 minutes	15 minutes
Lay over time	10 minutes	10 minutes
Turn over rate	1.3	1.3

**Table 3** Estimated Operational Parameters

Parameters	Route A		Route B	
	Peak	Off-Peak	Peak	Off-Peak
Initial Headway (minutes)	2.4	3.7	2.4	3.7
Adjusted Headway (minutes)	2.5	4.0	2.5	4.0
Adjusted Bus Frequency	24	15	24	15
Rndtrip travel time (minutes)	76	65	82	69
Number of Bus in operation (bus)	34	19	37	20

While the roundtrip travel time and the number of bus required for the operation are higher for route B, this is quite logical because route B is longer 800 m than route A. Consequently, this yields to a higher bus productivity (i.e. bus-kms and bus-kms/bus) as shown in Table 4. This result gives early indication that the operational cost of route B will be potentially higher than that of route A.



**Tabel 4** Bus Performance Indicator

Indicator	Route A	Route B
Ridership	48.827	50.635
Passenger-kms	475.135,30	510.536,30
Bus-kms	7.566,41	7.811,67
Bus-kms/bus	204,50	211,13
Passenger/bus-kms	6,45	6,48
Passenger-kms/ Bus-kms	62,80	65,36
Peak-Bus/ off-peak Bus Ratio	1,79	1,85

In the other hand, as in Table 4, route B produces higher ridership about 3.7 % compared with that of route A. This situation is also reflected in the passenger-km values. In contrast with that of bus productivity indicators, this higher ridership and passenger-kms give a clue that route B will potentially produce greater revenue for the service provided. At this situation, it is difficult to see if the impact of re-routing the proposed service from route A to route B will lead to a positive direction. Therefore, this conflicting situation requires further verification with some other performance indicators.

Referring to the performance indicators in Table 4, two other indicators, reflecting the ratio of demand and supply side, show that the performance of route B is relatively better than that of route A, which is indicated by higher ratio of passenger/bus-kms and passenger-km/bus-kms in the magnitude of 0.45 % and 4.8 %, respectively. Taking analogy from the benefit-cost ratio analysis in engineering economics, this situation shows that the margin resulted by the operation route B is higher than that of route A, although the expected operational expenses of route B are potentially greater than that of route A.

With this very preliminary result, it is important for the Tangerang City Government to re-evaluate the option of route A as the proposed bus lane and conduct a more in-depth study on route B as an alternative. This is very critical because the success of this first bus priority system in the area will determine the success of the following plan. Since a public transport system is naturally part of a business domain, the following works and economics parameters must be taken into account in the analysis in order to have a more comprehensive and convincing results.

## CONCLUSION

The impact of re-routing Bus Priority corridor on some performance indicators has been analyzed with the Tangerang bus lane as a case study. The analysis gives the indication that the service will potentially give better performance if the alternative route (i.e. route B) is chosen. There is a need for the Government of Tangerang City to re-evaluate the proposed route. A Further research with some economics parameters taken into account in the analysis is needed.

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