



# INDONESIAN URBAN TRANSPORT INSTITUTE

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RAILBASE TRANSIT DUE TO THE  
OPERATION OF EXTENSIVE BUS  
SEMIRAPID TRANSIT NETWORK

(CASE: JABODETABEK PUBLIC  
TRANSPORT NETWORK)\*

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## IMPACT ON RIDERSHIP OF NEW RAILBASE TRANSIT DUE TO THE OPERATION OF EXTENSIVE BUS SEMIRAPID TRANSIT NETWORK (CASE STUDY: JABODETABEK PUBLIC TRANSPORT NETWORK)

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### INTRODUCTION

In the near future Jabodetabek (Greater Jakarta) area will have a new railbase mass transit system which consists of Central Government Light Rail Train (CG-LRT) and Jakarta Local Government Light Rail Train (DKI-LRT). Currently, two CG-LRT corridors connecting Cibubur (Southeast of Jakarta) area and Bekasi (Eastern of Jakarta) area with City of Jakarta and DKI-LRT phase-1 of the first corridor connecting Kelapa Gading area with Velodrome at Pulo Mas area are under construction. Besides, the construction of Jakarta North-South MRT stage 1 connecting Southern part of Jakarta with Central part of Jakarta is also on progress. These new railbase mass transit shown in Figure 1, are expected to be in operation in the year of 2020. Meanwhile, in early 2016, the Central Government established a new agency under Ministry of Transportation called Badan Pengelola Transportasi Jabodetabek (BPTJ) which is responsible for all transportation issues in Jabodetabek (Greater Jakarta) Area.

Unfortunately, due to current prevailing regulation almost all public transport service are ruled and managed under different authority, and consequently this new established agency cannot function optimally as it supposed to be. In the worst case, these all public transport include the new railbase mass transit could be potentially managed and operated independently. Hence, the sustainability of operation of such technology could be in hazard, if public money should be minimized in supporting this kind of public service. On the other hand, the most potential program of BPTJ that could be implemented in a very short period is the extensive high capacity bus network service as shown in Figure 2.

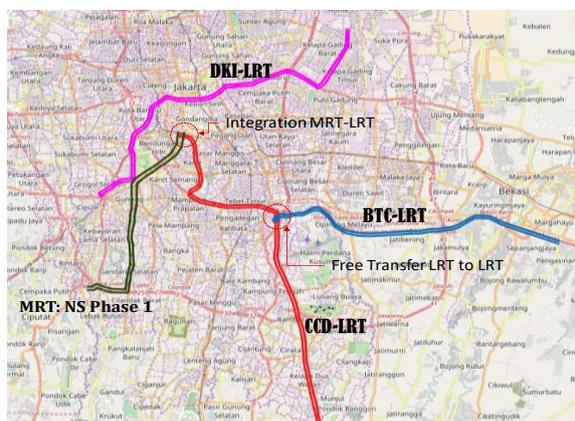


Figure 1. LRT & MRT Network in 2020



Figure 2. BST Network in 2020

Having reviewed to the Master Plan and the existing TransJakarta Busway system, and referring to Vuchic (2002), this kind of high capacity bus system can be categorized as Bus Semirapid Transit (BST). Referring to the Public Transport Master Plan (IUTRI, 2016), there are many BST services that share the route with the new railbase mass transit. Therefore, when all those mass transit are already in operation, number of ridership of each system could be a very potential issue if they are operated independently. Considering the flexibility and accessibility of BST service and its improved operational characteristics such as travel time, method of transaction, and directness of service (ITDP, 2007; Vuchic, 2002), the ridership of new railbase mass transit could possibly be affected in a very significant way.

Based on previous paragraphs, this research tries to analyze the implication of the proposed BST service to the new LRT ridership especially along the overlapping routes. The following sections describe the research framework, and model simulation, the result analysis and discussion and finally the research conclusion.

### RESEARCH FRAMEWORK

The first step in this research is to prepare a transport model for the analysis. Generally, the preparation of public transport passenger demand forecasting model is based on network development on supply side and the projected socio-economic framework on demand side which involves network scenario development for mass transit system. The passenger traffic demand is forecasted by applying the four-step method. Diagrammatically, the research framework is summarized in Figure 3. A base year model both the network and demand model is adopted from previous work (Alvinsyah and Hadian, 2016; BSTP, 2009; BSTP, 2010; ; IUTRI, 2016; JICA, 2004; CTS, 2004) which has been calibrated and modified several times (Alvinsyah and Hadian, 2016; IUTRI, 2016; JICA, 2012; KOICA, 2011).

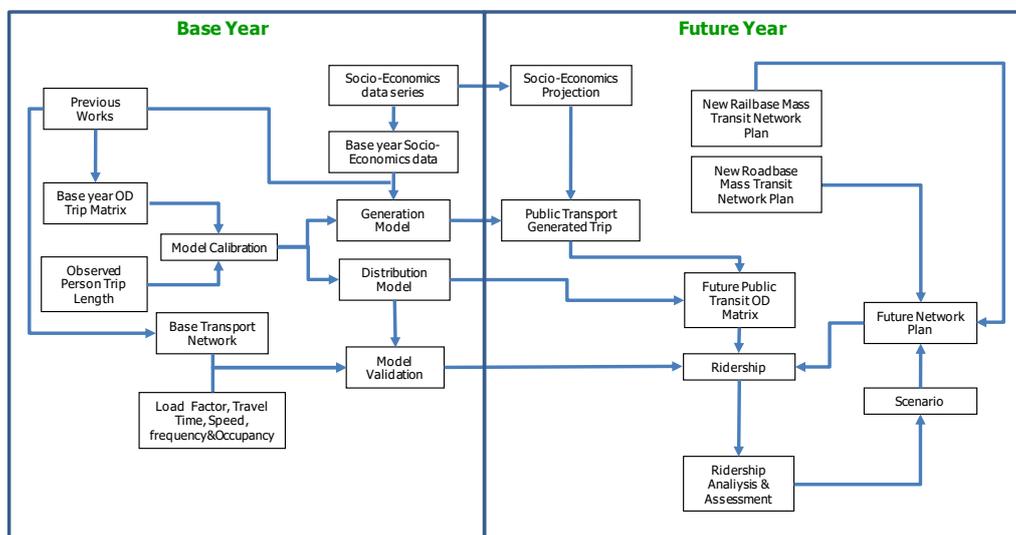


Figure 3. Research Framework

The modeling stage begins with defining a zone and network system based on the city base map and zoning system as well as the surrounding area. The traffic analysis zone (TAZ) system will be defined based on the administrative jurisdiction, namely kelurahan (district). Hence, it will ease in utilizing socio economic data based on the census data. Then, the distribution model is calibrated using trip length data from the field (Kemenhub, 2013; Kemenhub, 2014; Alvinsyah&Hadian, 2016). The distribution model used in this research adopts the gravity method as follows (Papacostas and Prevendeoros,2001);

$$T_{ij} = P_i \left[ \frac{A_j \cdot F_{ij} \cdot K_{ij}}{\sum_x A_x \cdot F_{ix} \cdot K_{ix}} \right] \tag{1}$$

where:

- $T_{ij}$  = Nuber of trip between zone  $i$  and zone  $j$
- $P_i$  = Total trip Production in zone  $i$
- $A_j$  = Total trip attraction Total in zona  $j$
- $F_{ij}$  = Friction factor or trip impedance between zone  $i$  and zone  $j$
- $K_{ij}$  = Socio-economics constant

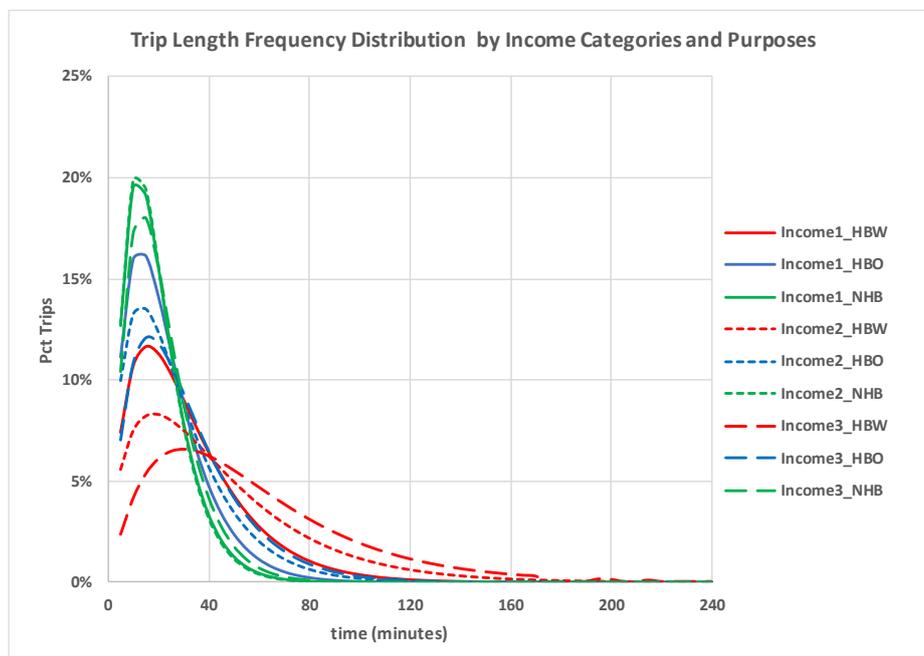
While the *impedance* function in the gravity model is developed through the following basic formula (FHWA, 2010);

$$F_{ij} = A(d_{ij}^n)e^{(-\beta d_{ij})} \tag{2}$$

where,

- $d_{ij}$  = friction factor (impedance/time) between zone  $i$  and zone  $j$
- $e$  = base natural of logarithms
- $A, n, \beta$  = calibration constants

Utilizing the travel time and person trip data (Alvinyah and Hadian, 2016; Kemenhub, 2014; Kemenhub, 2013) a calibration procedure, an iterative process in curve fitting between trip length data and that of model is conducted to obtain an impedance function. Once the gap between data and model reaches convergency as shown in Figure 4, the impedance function parameters,  $A$ ,  $n$ , and  $\beta$  are determined.



**Figure 4. Transit User Trip Length Frequency Distribution**

Having determined the impedance function for each transit user category, the base year synthesized O-D Matrix (i.e. Distribution Model) is developed by applying Furness Method (Ortuzar and Willumsen, 2011) for balancing trip between zone. The next step, based on the updated network, the synthesized O-D Matrix, passenger flow, and travel time data from the survey, is validate the model by applying transit assignment. The transit assignment includes links and section of the services running between two stops or stations. The concept of link capacity is associated to the capacity of each unit and its corresponding frequency. The travel time has an-in vehicle component and components for waiting at stops and access and egress time. The other component, the monetary cost (i.e. fare variable) for particular transit lines is converted to ‘time’, and is weight-combined with total travel time to represent “generalized costs” as shown in the following (INRO, 2015);

$$C_{ij} = a_1 t_{ij}^v + a_2 t_{ij}^w + a_3 t_{ij}^t + a_4 t_{ij}^n + a_1 \delta^n + a_5 F_{ij} \quad (3)$$

where,

- $t_{ij}^v$  = In vehicle time from  $i$  to  $j$
- $t_{ij}^w$  = Walking time from station or to station
- $t_{ij}^t$  = Waiting time at the station
- $t_{ij}^n$  = Transfer Time at station
- $\delta^n$  = Penalty for transfer
- $F_{ij}$  = Fare from  $i$  to  $j$
- $a_1$  to  $a_5$  = Coefficients.

In the validation process, the person trip from the O-D matrix is assigned to the transit network and adjustment to all parameter values in the generalised cost are made until the passenger flow from the assignment process is conformed with that of from field data. The macro planning software called EMME is used to execute the assignment process where the standard transit assignment model implemented in this software is based on the concept of optimal strategies which minimize transfer, waiting and in-vehicle time (INRO, 2015). The most general formulation of this model is described in Spiess (1989), where the cost of a strategy is the sum of link travel times,  $c_a$ , weighted by the probability of traveling on link  $a$ , and the waiting time at nodes  $i$  is weighted by the probability of traveling through node  $i$ . The assigning of the trips from all origins to destination  $r$ , according to the optimal strategy, corresponds to solving the following linear optimization problem:

$$\text{Min} \sum_{a \in A} c_a v_a + \sum_{i \in I} \omega_i \quad (4)$$

Subject to

$$\sum_{a \in A_i^+} v_a - \sum_{a \in A_i^-} v_a = g_i \quad i \in I,$$

$$\begin{aligned} v_a &\leq f_a \omega_i & a \in A_i^+, \quad i \in I, \\ v_a &> 0 & a \in A \end{aligned}$$

Variables  $\omega_i$  as in formula (4) represent the total waiting time (in person minutes) at node  $i$ . Further and detail explanation on the mathematical derivation of the above objective function can be found in Spiess (1989). Using this generalized formulation any transit network  $T$  can be represented, and the mechanics that are involved in constructing the links and the nodes of the generalized network depend very much on the particularities of the transit network and the degree of aggregation considered. The fundamental concept of this strategy is based on the assumption that a passenger arrived at a station select an optimum route from a group of route randomly to reach his or her destination and board the the first vehicle arrived. This mechanism is done repetitively until reaching the final destination. Prior to conducting a simulation, future O-D Matrix is developed by applying the gravity model and the forecasted trip generation. Finally, based on several assumptions and scenarios set in this research, a simulation to ridership is conducted through the validated transit assignment procedure.

**ASSUMPTIONS AND SCENARIOS**

To obtain the ridership through model simulation, some basic assumptions and scenarios related with trip generation, public transport share, and operational parameter of the system need to be established first. Referring to previous work (IUTRI, 2016), the growth rate for Jabodetabek area from 1971 to 2005 is about of 4,7% per annum and that for DKI Jakarta is around 2,0% per annum. In 2020, the growth rate prediction is about 1,32% and 0,49% per annum for Bodetabek and Jakarta respectively. While in 2030, the predictionis about 1,03% and 0,19% per annum for Bodetabek and Jakarta respectively. Based on these growth rate prediction, the trip growth for each district (kelurahan) in Jabodetabek area is derived as shown in Table 1.

**Table 1. Trip Growth for Jabodetabek Area (person/day)**

<b>Administrative Jurisdiction</b>	<b>2020</b>	<b>2025</b>	<b>2030</b>
Kota Depok	1.58%	1.30%	1.12%
Jakarta Barat	0.82%	0.53%	0.40%
Jakarta Pusat	0.81%	0.52%	0.40%
Jakarta Selat	0.78%	0.50%	0.38%
Jakarta Timur	0.77%	0.50%	0.38%
Jakarta Utara	0.81%	0.52%	0.40%
Kab Bekasi	1.64%	1.39%	1.20%
Kab Bogor	1.67%	1.39%	1.21%
Kab Tangerang	1.99%	1.60%	1.43%
Kota Bekasi	1.45%	1.24%	1.08%
Kota Bogor	1.63%	1.35%	1.17%
Kota Tangerang	1.99%	1.58%	1.40%
<b>Average</b>	<b>1.38%</b>	<b>1.10%</b>	<b>0.95%</b>

The public transport share adopted for this research is taken from the survey conducted in the previous work (JICA, 2011), which is 24% from the total motorised person trip in Jabodetabek area. While, all each public transport mode parameter and and the tariff rate are adapted from the previous work (IUTRI, 2016). Basically there will be two basic scenarios that will be simulated in obtaining new LRT ridership, namely base case scenario and alternative case scenario, and these two basic scenario will be tested with three BST speed design, namely

optimistic, moderate and pesimistic BST. The design speed are 40 km/hr, 25 km/hr and 17 km/hr respectively. The time horizon used for the ridership forecasting is only for year 2020 and, the predetermined scenarios are shown in Table 2.

**Table 2. Scenario for Simulation**

Scenario	Description	Remarks
<b>Base Case (BC)</b>	Consider no BST service, Fare integration applies for the <b>same technology only</b> , except for the existing bus system <sup>a</sup> , while for physical integration <sup>b</sup> applies for all type of public transport mode, excepts for the existing bus system.	
<b>Alternative Case-1 (AC-1)</b>	Similar with the <b>BC</b> , but considers BST service	
<b>Alternative Case-2 (AC-2)</b>	Similar with <b>AC-1</b> , but fare integration applies between new railbase mass transit, but not with BST/ BRT and with KCJ.	Discount fare Rp 1,000,- between MRT and LRT
<b>Alternative Case-3 (AC-3)</b>	Similar with <b>AC-2</b> , but fare integration applies for all new proposed mass transit, but not with KCJ	Discount fare Rp 1,000,- between BST/BRT, MRT and LRT
<b>Alternative Case-4 (AC-4)</b>	Similar with <b>AC-3</b> , but fare integration applies for all new proposed mass transit and KCJ	Discount fare Rp 1,000,- between BST/BRT, MRT, LRT and LRT

<sup>a)</sup> Fare integration is referred to IUTRI (2016)

<sup>b)</sup> Physical integration means that passenger is able to transfer to all alternatives modes depend on his/her journey characteristics.

## SIMULATION AND ANALYSIS

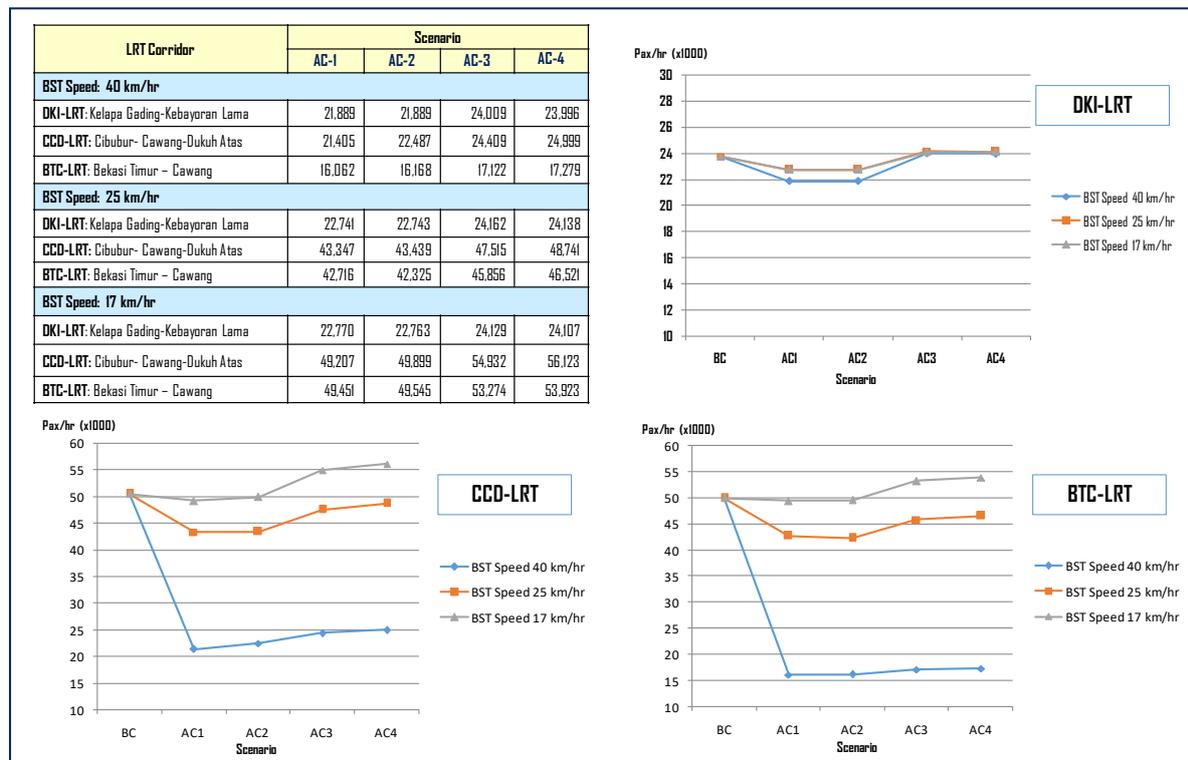
Based on the simulation result to the base case scenario, the potential demand (i.e. ridership) for new LRT system represented in total boarding passenger (in the peak hour) is shown in Table 3. While, simulation result to all alternative case is presented in Figure 5.

**Table 3. Potential Demand of LRT System in 2020 (pax/hour in thousands)**

<b>DKI-LRT</b> (Kelapa Gading-Kebayoran Lama)	<b>CCD-LRT</b> (Cibubur- Cawang-Dukuh Atas)	<b>BTC-LRT</b> (Bekasi Timur – Cawang)
<b>23,761</b>	<b>50,556</b>	<b>50,017</b>

Looking at Table 5, seems that the CG (i.e. CCD & BTC) LRT ridership in peak hour is very promising where this potential demand is considerably significantly high for such system. Taking into account the actual condition represented in the BC scenario, this simulation result is quite logic, because there are no reliable and good transit service that close to that of LRT in the origin area and mostly trip in the peak hour is dominated by commuting trip. In addition, the traffic performance reflected in travel speed along the existing toll and the arterial road where the LRT corridor lies are severely congested (IUTRI, 2016), while, on the other hand the LRT commercial speed is relatively high (40 km/hr). A bit different with the first corridor of DKI-LRT, the ridership is not as high as that of CG-LRT where it accounts only 47% of CG-LRT ridership. This is quite logic due to various public transport services in term of type

of service and mode, includes TransJakarta Busway, are available along and around this LRT corridor. Yet this figure is still within acceptable range for this kind of system (Deen and Pratt, 1992; Vuchic, 1992; Wright and Feljstorm, 2003).



**Figure 5. Simulation to all Alternative Scenarios**

In contrary, when BST services with the same commercial speed as that of LRT are in operation reflected in AC-1 scenario, the CG-LRT ridership is significantly reduced, where the potential passenger is dropped around 57.66% for CCD-LRT and 67.89% for BTC-LRT compared with that of BC scenario. This significant change indicates that most of CG-LRT potential demand is shifted to the BST. There are several reasons that can be explained about this phenomenon, among others are; the BST routes have more accessibility to the passenger origin and destination compared with CG-LRT routes; its commercial speed is comparable with that of LRT due to the HOV lane provision along the tollroad; their services apply multiroute and direct service, so most passengers do not need to transfer several times to reach his or her destination. Furthermore, in Jakarta area, they are fully integrated with TransJakarta Busway in term of sharing the exclusive lane and stations, and also the transaction, so passengers get a high accessibility to fulfill his/her travel need without additional payment if they have to transfer to TransJakarta Busway and vice versa.

In contrary, this situation does not occur on DKI-LRT ridership, where the change is relatively small, around 7.89%. As explained previously, since DKI-LRT serves the area that becomes destination for the commuter from Bodetabek area, the existence of BST service does not have any significant influence to the DKI-LRT. If this situation is kept going on without any intervention from the government to improve the CG-LRT ridership, as explained in previous section, in the long run it will endanger the sustainability of the CG-LRT operation due to revenue shortfalls.

One potential policy that can be implemented is to apply a full integration between all mass transit system in Jabodetabek by reinforcing the role and level of authority of BPTJ. Consequently, this kind of policy will reduced other related institution authority both at central government and local government level. To observe the impact of the above policy to the CCG-LRT ridership, three scenarios that mimic the policy as shown in Table 2 are introduced. But, since the fare system for BST is different with that of LRT, a discount method is applied to represent the fare integration between different system. Simulation result shows that there is an increase in ridership for LRT system. Although the increase is not significant, but at least this shows that such policy can help. In the other hand, if the HOV lane provision along the toll road is assumed cannot be realized, reflected by BST speed reduction to 17 km/hr, the simulation results show that the BST operation with low design speed does not significantly affect the LRT ridership where it decrease only 1.33% for CCD-LRT and 2.67% for BTC-LRT compared with BC scenario. While, if the fare is fully integrated as reflected by AC-4, the LRT gain additional ridership around 7.81% for BTC-LRT and 11.01% for CCD-LRT as shown in Figure 5. Now, assumming if BPTJ cannot provide HOV lane along the tollroad but still want to have an ideal BRT speed performance (ITDP, 2007), another scenario with the BST design speed set at 25 km/hr is tested. The simulation result indicates that with this design speed BST are able to attract the LRT ridership around 14.26% from CCD-LRT and 14.59% from BTC-LRT, and if fully integrated fare system is applied to all mass transit (AC-4) LRT ridership decrease only 3.59% for CCD-LRT and 6,69% for BTC-LRT. It is seen that if the proposed BST service is designed and operated in a very good way, and no fare or system integration policy is applied to manage these all mass transit, there will be a contra-productive situation will occur as indicates by significant reduction on LRT ridership.

## CONCLUSION

An analysis has been conducted on the impact on the proposed LRT ridership due to the introduction of BST route network in Greater (Jabodetabek) area. The analysis is focused on the forecasted demand in term of total boarding passenger at peak hour for each LRT corridor by utilizing a transit model. Asumptions and scenarios which account for transit operational characteristics, fare setting, and trip growth rate are set for the analysis. Simulation results to the predetermined scenarios yield that the BST service will potentially attract a very significant number of passenger from the CG-LRT if this proposed BST is designed, operated and managed in a very porper and good method. In contrary, such situation does not occur for DKI-LRT in all alternative cases tested. When, a full system integration is applied to all mass transit, the simulation result shows that an increase in LRT ridership can be expected. This indicates that the government needs to enforce a strong and good policy to integrate all these proposed mass transit in all aspects when they are in operation in order to have a sustainable, reliable and satisfactory service for the Jabodetabek people.

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