

Mode technology assessment of mass transport master plan in Greater Jakarta (Jabodetabek)

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Abstract. The aim of this paper is to evaluate the appropriateness of the proposed mass transit mode technology in the Greater Jakarta (Jabodetabek) Public Transport Master Plan. The analysis is focused on the estimated demand on the proposed bus rapid transit (BRT) network. A transport demand model based on the four step modeling approaches is prepared to estimate the demand on each proposed BRT route. Prior conducting a simulation, the model developed from previous works is calibrated and validated with various primary data namely, trip length frequency distribution and bus passenger data obtained from the field. In parallel, some assumptions and operational scenarios were established by taking into account the total number of ridership, maximum passenger flow, operational headway and proposed mode capacity. The appropriateness of the proposed mode was assessed and analyzed. The results show that the ridership and operational headway exceed the standard commonly used for the operational aspects of BRT on some proposed BRT routes. In addition, the evaluation shows that the proposed routes should be shifted to a rail base mass transit technology in order to maintain best level of services.

1. Introduction

Referring to the draft of the *Badan Pengelola Transportasi Jabodetabek* (BPTJ) Transport Master Plan [1] seems that the most ambitious and potential program that should be implemented in a very short period is Bus Rapid Transit (BRT) network plan. Assuming that the definition of BRT [2, 3] is held, and taking into account the existing physical condition for its proposed network, it seems that BPTJ needs a special treatment and very extra effort to accomplished this Plan. Yet, regardless the difficulties found to implement the plan, some of the previous works [4-6] indicate that the potential public transport demand on some proposed BRT corridors is quite significant high. Although, choosing a proper type of mass transit technology can be a difficult and complex process [7], and the real intense controversies seem to be generated in making choice between rail and bus system [7, 8], this effort is clearly a worthwhile goal, since the choice will affect travel times, personal transport expenditures, and commuter comfort and safety.

Since implementing and operating an urban mass transport system will involve a very huge capital, a decision on adopting a specific mass transport technology must be done with a very careful, thorough and prudent process, hence the investment either from public or private fund for the infrastructure, system operation and maintenance will not be wasted for the whole life of the system. Therefore, prior continuing to a more detail work for implementation, it is necessary to conduct an assessment to the Plan, especially the appropriateness of the proposed mode technology.



Vuchic [9] indicates that the first step of mode evaluation should consider right of way (ROW) category, mode technology and type of service/operation on the basis of system requirements, where they are mutually independent. Yet, the basic one is ROW category, which influences the choice of technology and operations. The next phase is to evaluate each candidate mode in one of three basic ways that are monetary units, other quantitative units and qualitative (descriptive) terms.

Since passenger demand or ridership plays a dominant role in urban mass transit system, it is often used as a basis reference to determine the capacity of mass transit [7-9] either for the future plan or the implementation. Therefore, this research aims to assess the suitability of BRT system proposed in the aforementioned Plan based on quantitative units, and focused on the projected demand and the operational headway for each proposed corridors. The subsequent sections discuss research methods, model assumptions and operational scenarios, simulation and result analysis and finally the reached conclusion.

2. Research methods

This research is initiated with collecting and reviewing previous works [1, 6, 10-13] to prepare a transport model for the analysis which is based on the four-step method. The model adopted from previous works [1, 4, 5, 10, 12, 14] is then updated by a calibration and validation process where the updating procedure is explained in a more detail in [15]. Once the updated model, commonly called as base year model, is set, then it is utilized to estimate future motorized person trips.

Taking the actual mode share composition [13], this total motorized person trip is split into trips with private vehicle (i.e. car and motorcycle) and trips with public transport. Having obtained the total public transport trip, then, this trip is assigned to the existing and the planned public transport network through a transit assignment procedure. In this step, a macro planning software called EMME is utilized and a standard transit assignment based on the concept of optimal strategies which minimize transfer, waiting and in-vehicle time is adopted [16]. Further detail explanation on functions of this optimal strategy can be found in [17].

In transit assignment model, the monetary cost, which is fare applied to each particular line services are converted to 'time' and is weight-combined with total travel time which consists of in-vehicle, waiting at stops, access and egress time components in the specific form called 'generalized cost' function. The detail mathematical function can be found in [15].

Once the potential demand is obtained from the simulation, the estimated total boarding passenger for each BRT Corridor is then analyzed. Based on the magnitude of total boarding passenger, corridors having demand more than 8,000 pax/hr [7, 18, 19, 20], are identified as the potential mass transit corridors need to be served by a higher capacity technology (i.e. rail base system) and further analysis can proceed. To assure that the above potential corridors need a higher capacity mode, an operational parameter like service headway could be used as criteria [9, 21]. Therefore, to verify and assess the appropriateness of the proposed mode technology (i.e. BRT system), an initial headway need to be calculated [11, 19].

In order to know whether a transit mode can be operated safely and feasibly and also within the acceptance level of passenger waiting time, a standard headway need to be determined as a benchmark. For operation purpose, this standard headway is usually determined by the government as regulator (i.e. called policy headway). While, for planning or design purpose, a minimum and maximum headway can be defined based on technical aspects, safety operation, and passenger preference. An acceptable maximum headway for a mass rapid transit system should be less than 5-6 minutes [2, 9, 22], while the minimum headway varies from 12 seconds to 2 minutes [9, 19, 20, 23, 24] depends on ROW category, operational characteristics and the adopted policy or LOS standard for a particular transit mode. Yet, minimum headway commonly used in transit operation is 2 - 3 minutes [21]. In a more generic form, minimum headway for various urban mass rapid transit is described in detail in [9, 20] and [19].

It is important to note that the minimum (line) headway is usually adopted either from way headway or station headway [9]. Yet, in public transport, line or corridor capacity is mostly dictated

by station capacity [3], so consequently in vast majority cases the line minimum headway is determined by station headway [9]. Since the range of minimum headway is significantly wide, the designated value need to be verified by the station capacity with the formula as suggested in ITDP [3]. By comparing total passenger boarding per hour and initial headway, with that of commonly used in mass transit system operation [3, 21, 23], the appropriate mode technology could be determined as a preliminary assessment. Further, it is then verified with the standard of station or platform saturation level.

3. Model assumptions and operational scenarios

Referring to previous work [1] the trip growth for each district in Jabodetabek area is ranged from 0.77% to 1.99% for each local city in Jabodetabek with average of 1.38% in 2020. While, the public transport share adopted in this research is 24% [13], and the operational parameters and fare setting assumptions for each public transport is adopted from [1]. The simulation scenario which considers network plan, fare system and setting, and operational plan, is set for the year of 2020, a more detail the simulation scenario can be seen in [15].

4. Simulation and analysis

Simulation results show the estimated ridership for BPTJ-BRT corridors with high potential demand represented in total boarding passenger and the maximum station boarding-alighting passenger (in peak morning) are shown in table 1. Besides the boarding passenger, the maximum flow or commonly called as peak hour per direction (PHPD) volume occurs at each service route is also estimated. This PHPD figure is important for designing the operational plan of public transport such as number of fleet, service frequency, load factor, and the operation and maintenance cost.

Table 1. Potential demand on BPTJ-BRT.

BPTJ-BRT Service Route	Total Boarding (pass./peak-hr)	Maximum flow (pass./peak-hr)	Max. Total Boarding at Station (pass./peak-hr)	Max. Total Alighting at Station (pass./peak-hr)
Bekasi–Senen	32,114	12,344	6,463	5,372
Depok–BlokM	13,692	6,402	3,504	2,253
Bogor–Senen	14,512	3,624	2,945	2,409
Poris Plawad –BlokM	16,941	7,560	3,503	5,184
Cikarang–BlokM	47,811	19,276	7,373	6,325
Tn. Abang – Bekasi	25,700	9,093	3,406	2,092

From 20 (twenty) proposed BRT service routes simulated, there are 6 (six) routes have demand number that can be served either by rail system or high capacity BRT system. Also from table 1, two of the proposed BRT route have a very high demand (i.e. approximately around 30,000 passengers per hour) which close to the level that commonly served by heavy rail transit. Taking the projected demand as the initial criteria to select appropriate technology or system is quite common in practice [7, 8, 9]. Yet, using it as a dominant parameter for making decision can be misleading [7, 9]. This is due to some mass transit systems may blur the boundaries with the definition of other transit system when they, for instance, utilize same ROW category as a standard, hence it consequently affects the capacity boundaries as well [7, 9]. Therefore, specifically, for this research purpose, a service headway is used to verify whether the chosen technology or system based on the projected demand could be safely and feasibly operated under given ROW or other transit operational characteristics. By inputting all required parameters into the formula suggested in [11, 19], the initial headway for various transit mode technology for each proposed BRT routes are obtained as shown in table 2.

Table 2. Initial headway for various mode technology.

BPTJ-BRT Service Route	Max. Flow (x1,000 pax/hr)	MRT (C=1000 pax)	LRT (C=600 pax)	BRT Bi- Articulated (C=250 pax)	BRT Articulated (C=140 pax)	BRT Single Bus (C= 90 pax)
Bekasi–Senen	18,507	5.21	3.10	1.30	0.73	0.47
Depok–BlokM	9,102	8.84	5.30	2.21	1.24	0.80
Bogor–Senen	8,692	11.68	7.01	2.92	1.64	1.05
Poris Plawad –BlokM	11,443	6.42	3.85	1.61	0.90	0.58
Cikarang–BlokM	21,813	4.40	2.64	1.10	0.62	0.40
Tn. Abang – Bekasi	12,303	6.49	3.89	1.62	0.91	0.58

Looking at the calculated headway in table 2 and if 3 minutes is referred as the minimum standard headway [21], only two proposed routes in table 3 are still feasible served by BRT system with bi-articulated bus, while the others need to be served by a higher capacity system. In the other hand, if the minimum headway as described in [9, 21] and [19] is referred as the standard value, all proposed BPTJ-BRT routes are still could be served by BRT system [23, 24]. But minimum headway figures indicated in [9, 21] and [19], should be treated with caution, since it is in a generic form, especially for bus system operation. As explained previously for BRT system, the minimum headway depends on ROW category, operational characteristics such as safety standard operation, way and station capacity and also traffic signal cycle time. Therefore, it is necessary to conduct further assessment to make sure that a high demand corridor/route is still be able to be served by BRT system safely and feasibly. Referring to [3], in this case, the dwelling time for single bus, articulated bus, and bi-articulated are assumed 14 seconds, 13 seconds and 12 seconds respectively. While the average boarding and alighting time per passenger are assumed 0.3 seconds for articulated and bi-articulated bus and 3 seconds for single bus. The above values are adopted with assumptions that station and bus platform are level, and the transaction is done off board. Taking the headway values as shown in table 2, and utilizing formula for platform saturation level is in [3], the station saturation level is presented in table 3.

Table 3. Bus platform station saturation level.

BPTJ-BRT Service Route	Bi-Articulated (C=250 pax)	Articulated (C=140 pax)	Single Bus (C= 90 pax)
Bekasi–Senen	1.16	1.28	10.29
Depok–BlokM	0.58	0.65	5.05
Bogor–Senen	0.53	0.57	4.65
Poris Plawad –BlokM	0.87	0.96	7.58
Cikarang-BlokM	1.35	1.49	11.92
Tn. Abang–Bekasi	0.60	0.69	4.93

Referring to the calculated saturation level in table 3, and taking the maximum saturation level allowed is not more than 0.4 [3], it is shown that all proposed BPTJ-BRT routes in table 2 need a higher capacity mode such rail technology with ROW-A category. Based on the calculated headway in table 2, the alternative mode includes the operational headway that could be considered to serve the proposed service routes are described in table 4. From table 4, there are still two routes that can be served by bi-articulated bus with 2 minutes' headway. Yet, assuming that BRT is chosen to serve these two corridors, a precaution on platform design, Traffic Signal Priority (TSP) setting at intersection, and probability of providing passing lane need to be kept in mind.

It is important to notice, knowing that station saturation level presented in table 4 exceed that of the allowed level, that these proposed routes with high demand are still possible to be served by BRT system [3, 7, 23, 24].

Table 4. Alternative mode technology for BPTJ-BRT.

BPTJ-BRT Service Route	Mode Technology	Operational Headway^a (minutes)
Bekasi–Senen	MRT or LRT	3.0 – 5.0
Depok–BlokM	Bi-Articulated Bus or LRT	2.0 – 5.0
Bogor–Senen	Bi-Articulated Bus or LRT	2.5 – 7.0 ^b
Poris Plawad –BlokM	LRT or MRT	3.5 – 6.0
Cikarang-BlokM	LRT or MRT	2.5 – 4.0
Tn. Abang–Bekasi	LRT or MRT	3.5 – 6.0

^a The values are rounded down^b Complies with prevailing standard value

But, special treatment or care need to be carried out, like passing lane provision at station, applying multiplatform or long station, dual lane provision, multirouting, good traffic engineering measure like TSP, along the corridor [9, 19, 22, 23, 24]. But if, these kind special treatment are almost impossible or very difficult to implement due to physical, political, legal or budget constraint, the minimum headway 2 or 3 minutes is applied, provided that the cycle time at each intersection along the corridor is not significantly higher than the above values.

5. Conclusion

An assessment to the proposed BPTJ-BRT network route by conducting a simulation through a transit model indicates that six routes have a relatively high demand reflected by total boarding passenger and a PHPD volume. These high demand corridors, at some extend might potentially be served by a higher capacity mode technology such as rail system. Yet, since the line capacity boundary between different transit modes is somewhat overlapped, further analysis on the minimum acceptable headway and station saturation level are necessary to be carried out. This further analysis yields that four proposed BRT corridors are need to be served by LRT with ROW-A or by MRT system. While the other two corridors still possible to be served by bi-articulated bus, with a very special care and attention to several aspects like proper platform design, Traffic Signal Priority (TSP) setting, and passing lane provision.

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