

OPTIMAL SCHEDULE IN URBAN TRANSPORTATION TO REDUCE THE PASSENGER CROWDED AREA

Johannes Hamonangan SIREGAR¹, Mohamad Johan BUDIMAN¹, RESDIANSYAH¹

DOI: 10.21163/GT_2020.151.31

ABSTRACT:

The crowded area in the bus stop are happen at the peak time where a lot of passengers wait for the bus. That kind of situations is one of the reasons for some people to decide not to use public transportation. This reseach is aimed to optimize the schedule time model of the urban transportation problems in high-density city, in order to reduce crowding in the area of bus stop. The condition that makes the bus stop becoming crowded is considered. An effective schedule is proposed in order to minimize the crowded area of the bus stop. The proposed schedule are evaluated and compared with the existing schedule which can predict the optimal schedule of the problem. The bus route and bus stop locations are constructed based on TransJakarta, operator of bus rapid transit system in Jakarta city, Indonesia.

Key-words: Bus Rapid Transit, schedule, crowded area, TransJakarta.

1. INTRODUCTION

Public transportation in urban area offers the potential solution for the problem of traffic which are normally becoming arise in high-density city. The traffic congestion problems contribute air pollution because of a lot of people use private vechiles. It will increases travel times, unsure to estimate time arrive, fuel consumption and feeling distressed. The congestion at the road make it difficult for people which using private vechiles, but this situation cannot make those people change to use public transportation, they still using private vechiles that give them more convenient, safe and secure. There are problems and challenges in public transportation, delay time of schedule or bus vechile did not arrive on time, this problem cause inconvenience for people due to crowded area and waited for long. The convenient transportation condition with good facilities and service support are nece, will attract people who use private vechile to . Large vechiles of public transportation such as buses can get easy access than train for the people looking convenient.

Bus rapid transit (BRT) in modern public transportation are equipped with using information technologies applications in large-scale networks that can be useful to know the situation of the bus enviroment inside and outside the bus. With development the application of passenger information systems software, nowadays passengers can know where the position of the bus then predict which bus will arive soon or suitable with their need. Giving passengers the right information is critical to high quality of BRT systems. The need of real-time passenger information that can be handled by device from any place such smartphone or computer devices are still in challenges. Type information should be part of the passenger

¹*Universitas Pembangunan Jaya, Department of Information Systems, Pembangunan Jaya Center for Urban Studies; Bintaro Jaya, Sawah Baru, Ciputat, Tangerang Selatan 15413, Banten, Indonesia; johannes.siregar@upj.ac.id; johan.budiman@upj.ac.id; rediansyah.mansyur@upj.ac.id*

information according to BRT standard must include with route maps, time arriva/schedule and service alert (ITDP, 2016).

Many BRT system research are proposed the solution of the transportation problem in the city. There is gaps between different levels of policy development and implementation of BRT projects (Wijaya & Imran, 2019). The government policy support is important to implement BRT system in the city. The standard of BRT is decided by Institute for Transportation & Development Policy (ITDP, 2016). The performance of BRT of the city is evaluated and mark is given according the operational condition of BRT. An ordered choice approach is developed for performance contributors of BRT systems within that standard (Li & Hensher, 2019). With this BRT Standard, the BRT operator and policy maker can have a reference to do the better services.

Research about schedule problems are developed for timetable optimization for single bus line (Nguyen, 2015; Tran et al., 2018) there is a another cost for a bus of different size. The advantage of different type of bus can have low cost of operation (Sun et al., 2015). The crowded area problem in BRT system is considered arise when the peak time comes for bus rapid transit in assigned route. During the peak time period, the number of passenger are becoming overloaded that cannot pickup some additional passenger at the bus stop. Understanding the platform at the bus stop based on the performance are considered. There are two model of crowded happen, in the BRT capacity and in the bus stop area (Duduta & Subedi, 2015; Al- Mudhaffar et al., 2016; Batarce et al., 2016; Sitorus & Permasari, 2019).

In this research, the time schedule that related for crwded area is considered. The objective is to find the condition which makes the area of the bus stop becoming crowded is decreased. The crowded problem is arise from the human space calculations that exceeds the limits of the room such as geography, environmental studies, spatial planning, topography or economics.

2. STUDY AREA AND DATA

Jakarta is part of Java island which have high-density for the people who lived in area comprises 661,521 km²and population reached 10,374,235 inhabitants in 2016 (BPS, 2017).

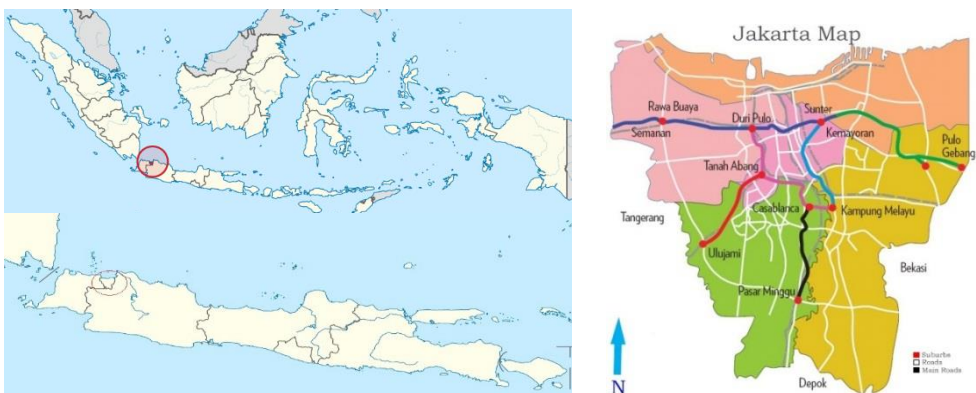


Fig. 1. Indonesia, Java Island and Jakarta City.

As the national capital and largest city in Indonesia, Jakarta is the only city in Indonesia that has provincial level status. This city also the place where government head offices, private companies and foreign companies are located, and become center for business, politics, and culture. A lot activities need good flow mobility for moving from other city and inside the city. There is a network of highways and toll roads that serve the entire city, but the development of the number of cars with the number of roads is very unbalance. According to data from the Jakarta Transportation Department, there are 46 areas with 100 intersection points prone to traffic jams in Jakarta. The definition of congestion is unstable current, low speed and long queues. Congestion often occurs in the morning and evening, which is when the hours go to and from work.

Since 2004, the Jakarta Government has provided a public transportation service known as TransJakarta. This service uses air condition buses and bus stops that are on special lanes. TransJakarta is the Bus Rapid Transit (BRT) system in Jakarta, Indonesia. Transjakarta began operations that have one route with name Transjakarta Corridor 1. The definition of Corridor in BRT is a section of roads served by one bus route or multiple bus route that has dedicated bus lanes (ITDP, 2016). As shown in Fig. 2, illustrate for dedicated bus lane, the bus is running in the middle of the road. The term “bus-way” is popular word to simplify meaning for the road only use for BRT. Passengers go to bus stop by using pedestrian bridge and can choose which bus they would like to use.

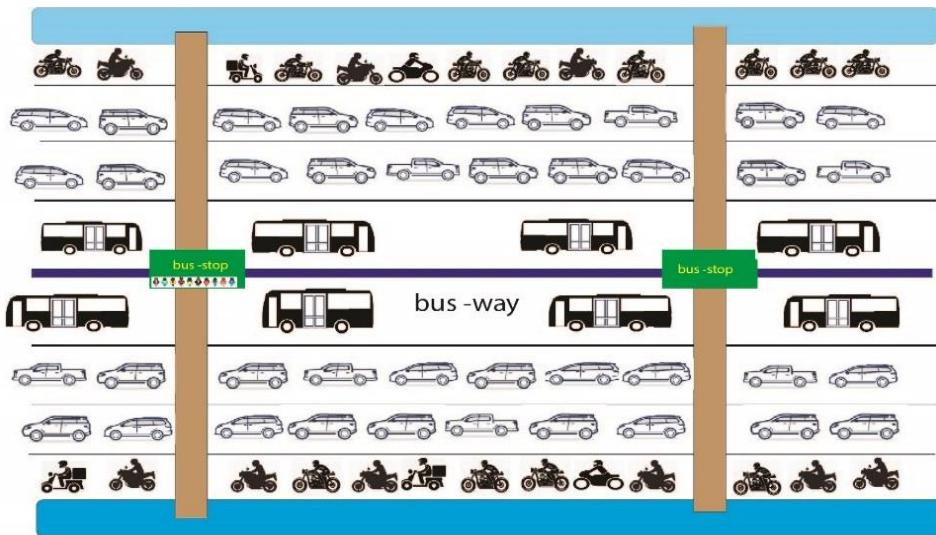


Fig. 2. Illustration of corridor for dedicated BRT bus lane.

Until 2019, TransJakarta has 13 corridors with a total length of 204 kilometers. Now, the transportation company owned by the Jakarta Provincial Government has served Jakarta residents for 15 years. TransJakarta has become a symbol of renewal of road-based public transportation in Jakarta and even Indonesia. Because of the dedicated lane, the speed of the BRT in the road is normal not affected by the congested surrounding road. The BRT is expected to be able to change private vehicle user using BRT.

For the purpose of numerical experiments in this research, BRT TransJakarta Corridor 1 is used because in this route extremely busy than other corridors. **Fig. 3** shown Corridor 1 which through protocol road in Jakarta.

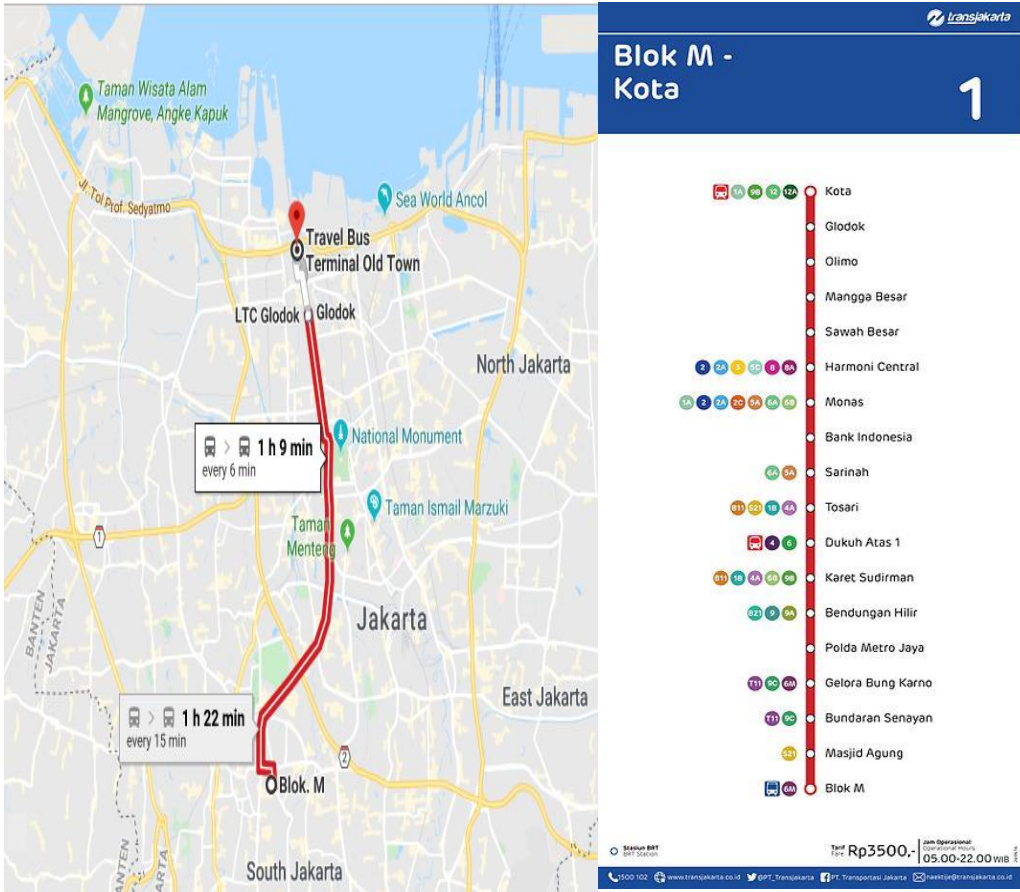


Fig. 3. TransJakarta Corridor 1 map in Jakarta City (red line) and bus stop routes.

In **Table 1** shows the existing schedule that provided to serve 24 hours operation time of TransJakarta Corridor 1. As the bus schedule operates for 24 hours, it has 10 periods of time with 3 types that is normal period, peak period and midnight period. The time schedule of schedule the normal period start from 5.00 in the morning on period 1 (5.00 - 6.00) where the number of active buses (#Active bus, shown in the Table 1) 30 buses operate which start with headway 3 minute. Headway is the length of time between a single bus route. If the headways of the buses is 3 minutes, that mean the buses on that route arrive every 3 minutes. The number of buses from starting point Blok M terminal is 15 buses and other 15 buses start from starting point Kota terminal. The peak time in the morning is in the period 2 of the schedule, the number of active bus is increased to maximum by using 60 buses. In the peak period headway of the bus becoming 1 minute. After peak time period then normal period

will start again. Some buses will be off from the activity to take rest, bus maintenance or refueling. This procedure runs repeatedly and flexible. This procedure runs repeatedly and is flexible depending on the condition of the bus and the the services to be provided from the operator to decide whether a bus will be active or not on the route. The number of buses which operates in this time schedule depart from the terminal orderly, the first bus will be follow for the second bus and so on. The rule of the order must be obey for driver to follow, there should not be a bus precedes the order, the reason is to maintain the range of the headway of buses.

Table 1.

Transjakarta daily time bus schedule for a day.

Corridor 1 route from Blok M terminal to Kota terminal					
Period	Time Range	Start from Blok M		Start from Kota	
		#Active Bus	Headway	#Active Bus	Headway
1	05.00 – 06.00	15 buses	3 min	15 buses	3 min
2	06.00 – 08.00	30 buses	1 min	30 buses	1 min
3	08.00 – 11.00	15 buses	3 min	15 buses	3 min
4	11.00 – 13.00	30 buses	1 min	30 buses	1 min
5	13.00 – 16.00	15 buses	3 min	15 buses	3 min
6	16.00 – 18.00	30 buses	1 min	30 buses	1 min
7	18.00 – 19.00	20 buses	2 min	20 buses	2min
8	19.00 – 21.00	15 buses	3 min	15 buses	3 min
9	21.00 – 23.00	10 buses	3 min	10 buses	3 min
10	23.00 – 05.00	5 buses	5 min	5 buses	5 min

3. METHODOLOGY

3.1. Evaluation of bus schedule time

In the peak time or rush hour the number of passenger has jumped and it is difficult to predict how many passengers will arrive at the bus stop and which destination they will go for the next stop. For bus stops that have locations close to business activities, offices and bus stops which intersect from the bus corridor, at the end of office hours the number of passengers will increase drastically at these stops. From the large number of active buses, because the bus has to wait until the previous bus moves even though it has a short headway, the slowdown occurs when the bus moves to the next bus stop.

3.2. Analysis of the relationship between crowded and schedule

From the given schedule, this research consider the relation of crowded area bus stop and the schedule of BRT will arrive at the bus stop. The capacity of bus is assumed same for the sake of simplify the calculation. If the number of passenger in bus is same or almost near to the capacity, this condition is becoming crowded inside the bus and cannot take in the number of passenger at bus stop.

To illustrate that situation, let define the number of the bus stop, the number of bus, headway long time, bus capacity and assume the number passenger are coming to the bus stop by random number. The example of numerical calculation can be describe as follow:

- The number of bus = 3
- The number of bus stop = 5
- Headway time = 5
- Bus capacity = 25
- Assume the number of passenger
 - Passenger from start terminal = 20
 - Passenger at bus stop 1 = 6
 - Passenger at bus stop 2 = 10
 - Passenger at bus stop 3 = 10
 - Passenger at bus stop 4 = 7

Constraint: The number of passenger must not exceed the capacity is 25

Table 2.

Bus 1 schedule for a route.

Stop Area	#Passenger	# Out	#diff	#In	#Capacity	#wait
Terminal	20	0	20	20	20	0
Bus Stop 1	6	3	3	6	23	0
Bus Stop 2	10	2	8	4	25	6
Bus Stop 3	10	3	7	3	25	7
Bus Stop 4	7	3	4	3	25	4

Table 2 shown the number of passenger at the bus stop which denoted by #Passenger in the column table. When the bus arrive at the bus stop, there is a number of passenger out from the bus (#Out), the difference from the number of passenger at bus stop and out from the bus (#diff), then the number of passenger to go in the bus (#In) can be calculate not to exceed the capacity. The number capacity (#Capacity) is decided to take the passengers or not. Then the number of people waiting in the bus will be happen that can make crowded area in the bus stop.

4. RESULTS

By using crowded area concept as shown in **Fig. 4**, numerical calculation is performed. Calculation based onthen method of this study, the results were found as follows.

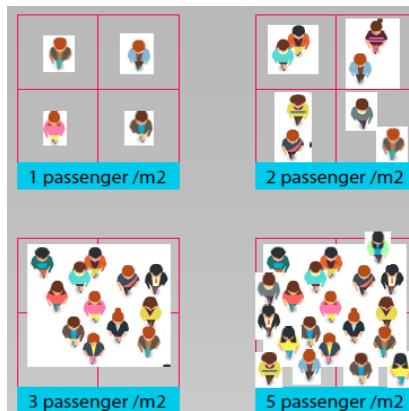


Fig. 4. Crowded area concept

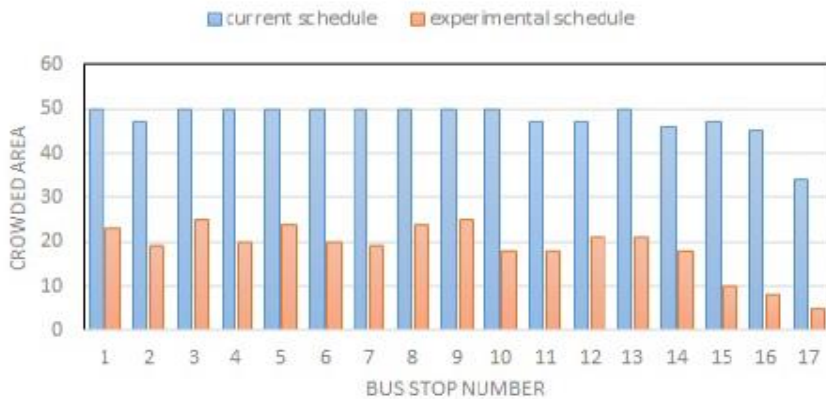


Fig 5. Comparative result of schedule.

By comparative experimental results measurement as shows in **Fig. 5**, the experimental schedule can decrease the number of crowded areas rather than the current schedules.

5. CONCLUSIONS

Optimal time schedule data obtained by numerical calculation proved to be useful in using bus schedule. Numerical experimental is comparing the existing schedule by ordering the bus to depart, with proposed schedule for bus to depart by priority to the heaviest crowded area bus stop first.

REFERENCES

- Al-Mudhaffar, A. , Nissan A. & Bang K. (2016) Bus stop and bus terminal capacity, *Transportation Research Procedia*, 14, 1762 – 1771.
- Batarce, M., Muñoz, J. C., & de Dios Ortúzar, J. (2016). Valuing crowding in public transport: Implications for cost-benefit analysis. *Transportation Research Part A: Policy and Practice*, 91, 358-378.
- BPS (2017). *DKI Jakarta Province Regional Statistics 2017*, BPS-Statistics of DKI Jakarta Province
- Duduta, N., & Subedi, A. (2015). Understanding platform overcrowding at bus rapid transit stations. *Transportation research record*, 2533(1), 118-123.
- ITDP (2016). *The BRT Standard* - Institute for Transportation & Development Policy. Available from: <https://www.itdp.org/2016/06/21/the-brt-standard/> [Accessed December 2019].
- Li, Z. & Hensher, D.A (2013) Crowding in Public Transport: A Review of Objective and Subjective Measures, *Journal of Public Transportation*, 16 (2)
- Li, Z., & Hensher, D. A. (2019). Performance Contributors of Bus Rapid Transit Systems within the ITDP BRT Standard: An Ordered Choice Approach.

- Nguyen, Q. T. & Phan, N. B. T. (2015) Scheduling Problem for Bus Rapid Transit Routes. *Advances in Intelligent Systems and Computing*, 358, 69–79.
- Reilly, J., and H. Levinson. 2012. Public Transport Capacity Analysis Procedures for Developing Cities. World Bank, Washington, DC.
- Sun, D. J., Xu, Y., & Peng, Z. R. (2015). Timetable optimization for single bus line based on hybrid vehicle size model. *Journal of Traffic and Transportation Engineering (English Edition)*, 2(3), 179–186.
- Sitorus, F.J.P, Permanasari, E., 2019, Analysis On Shuttle Bus Stop Service Performance Based On The User'S Perception The Case Study of Trans Bintaro, South Tangerang (Indonesia), *Geographia Technica*, 14, 185-193.
- Tran, T. H., Nagy, G., Nguyen, T. B. T., & Wassan, N. A. (2018). An efficient heuristic algorithm for the alternative-fuel station location problem. *European Journal of Operational Research*, 269(1), 159–170.
- Wijaya, S. E. & Imran, M. (2019) *Moving the Masses: Bus-Rapid Transit (BRT) Policies in Low Income Asian Cities*, Springer, Singapore
- Zhou, C., & Gao, Z. (2010). A Real-Time Information System for BRT Based on GPS/Signpost Compound Navigation Technology. *2010 International Conference on Logistics Engineering and Intelligent Transportation Systems*.