OPTIMIZATION OF LRT JAKARTA HEADWAY PHASE1

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Abstract: This research was conducted at the Jakarta LRT with a 10-minute flat headway every day, including peak hours. LRT Jakarta is one of the urban passengertransportation services in DKI Jakarta that has a special nature, namely that there arealways peak hours in the morning and evening. With a traffic length of only 5,8 km,the waiting time for passengers is still long during peak hours in the morning and evening. This study aims to determine and analyze the existing operating pattern of the Jakarta LRT and then make an operating schedule after optimizing the headway during peak hours. The research method used is the descriptive quantitative researchmethod because it presents how the existing operating pattern of the Jakarta LRT and how the making of the operating schedule after optimiziation headways by analyzing the data systematically. With increasing the speed of the Jakarta LRT trainby 85% and calculating the minimum headway on the farthest block (St. Pegangsaan Dua – North Boulevard), which produces a speed of 51,61 km/hour with a travellingtime of 8.67 minutes and the circulation time of the facility becomes 3 minutes from7 minutes. The proposed headway during the morning and evening peak hours is for6 minutes with 4 trainsets operating, for a total of 60 trips for 180 minutes during themorning and evening peak hours of the Jakarta LRT. The number of trips in the existing operating pattern is 204 trips to 258 trips after the headway is optimized.

Keywords: *Operation, Cross Capacity, and Operating Schedule*

Introduction

The development of technology in the current era is getting faster and more sophisticated, including in the field of transportation. The development of the railway sector in Indonesia in a more progressive direction has a vital role in supporting transportation activities as a system for the progress of the country because transportation is the backbone of the country's economic growth. The railway is a unified system consisting of infrastructure, facilities, and human resources, as well as norms, criteria, requirements, and procedures for the operation of rail transportation (UU NO 23 Tentang Perkeretaapian, 2007). Jakarta is a developing area in its railway sector which is the Special Capital Region of Indonesia with a densely populated area and continues to grow in population. Light Rail Transit, hereinafter abbreviated as LRT, is railway transportation using light rail, an electric operating system, operating on its path that is inaccessible to pedestrians and any vehicle. Jakarta LRT is also an urban or commuter passenger transportation service that has special characteristics compared to medium-distance or long-distance transportation

services, especially with goods transportation services, namely there are always peak hours in the morning and evening. The special nature of the morning and evening peak hours is applied to assist passengers traveling during the morning and evening peak hours, especially going to and from work. Some characteristics of urban passengers are not concerned with schedules, headway less than or equal to 10 minutes, and heavy traffic (Conner, Harris, & Schmid, 2015). The Jakarta LRT has a total length of 5,8 kilometers, starting from the Pegangsaan Dua Station to the Velodrome Station. LRT Jakarta operates from 05.30 – 23.00 WIB on weekdays and weekends but still with a flat 10-minute headway between transports even during peak hours. Weekday is the operational time that applies on working days, namely Monday to Friday, while Weekend is the operational time that applies on Saturdays and Sundays or Weekends. Based on these observations, the obstacle that exists in the Jakarta LRT with a short distance is the waiting time for passengers in the morning and evening peak hours which is still the same as the headway outside of peak hours, so it is necessary to study the optimization of the headway during the morning and evening peak hours of the Jakarta LRT. (Handayani et al. 2021)

Methodology

The research method used is the descriptive quantitative research method because it presents how the existing operating pattern of the Jakarta LRT and how the making of the operating schedule after peak hour headways is optimized by analyzing the data systematically.

Discussion and Result

Based on the Jakarta LRT Gapeka, the Jakarta LRT has a main line of 5,746 kilometers (km) that passes from Pegangsaan Dua station to Velodrome station, of which there are 4 stations, namely St. North Boulevard, South Boulevard, Pulomas, and Equistrian, with a flat headway of 10 minutes, a travel time of 13 minutes, and a total of 204 train trips per day. The average speed was 31.34 km/h, with the lowest speed on the swath of the road between St. Pegangsaan Dua and St. North Boulevard at 25,6 km/hour, with a 9 minute headway, and a traffic capacity of 224 trains per day on that route. The

terminal waiting time is 7 minutes, so that the circulation time of the facility becomes 40 minutes by using four stamformations. To optimize the headway during the morning and evening peak hours, the authors conducted an analysis, namely :

1. An Analysis of Circulation Time

   a. Travel Time
   The author's suggestion is to shorten the travel time of the Jakarta LRT, namely by using graphic speed, which is the speed applied to create a train travel timeline by calculating the percentage (80-95%) of the lowest maximum speed of the maximum speed of facilities and infrastructure (Supriadi 2008). The LRT Jakarta has a top speed of 80 km/h and acceleration and deceleration rates of 1.0 m/s2 (OCC LRT Jakarta). The following is the calculation of the 85% graphics speed, acceleration time, and deceleration time:

   Graphics speed = 85%80 = 68km/h

   Acceleration time, $t = \frac{Vt - V0}{a}$

   $$= \frac{(\frac{68 \times 1000}{3600}) - 0 \text{ m/s}}{1 \text{m/s}^2}$$

   $$= 19 \text{ seconds}$$

   Deceleration time, $t = \frac{Vt - V0}{a|}$

   $$= \frac{0 - (\frac{68 \times 1000}{3600}) \text{m/s}}{1 \text{m/s}^2}$$

   $$= 19 \text{ seconds}$$

Furthermore, the calculation of the braking distance is carried out with the following
calculations:

Braking distance :

$$v_t = v_0^2 + 2as$$

$$s = \frac{v_t^2 - v_0^2}{2a}$$

(Source: Straight Motion Formula changes regularly)

$$s = \frac{0^2 - (68km/jam)^2}{2 \times 1{,}0m/s^2}$$

$$s = \frac{0^2 - (18{,}88\ m/s)^2}{2 \times 1{,}0m/s^2}$$

$$s = \frac{0^2 - 356{,}4\ m/s}{2 \times 1{,}0m/s^2}$$

$$s = 178\ meter$$

The results of the above calculations produce the time and distance of acceleration and deceleration. Furthermore, the calculation of the distance traveled to calculate the travel time is as follows:

Travel distance

$$t_{travel} = \frac{s_{travel}}{v}$$

Travel Time st. Pegangsaan Dua – North Boulevard =

Braking distance, $s = 1706 - 178\ m - 178\ m$

$s = 1350\ m$

Braking time, $t = \frac{1350\ m}{68 \times \frac{1000}{3600}\ m/s}$

$t = 72$ detik

After that, with the same calculation formula, the travel time will be found:

Table 1. Time Travel Suggestion

Station	Distance (m)	Acceleration (s)	Deceleration (s)	Passenger Boarding Time (s)	Time Trip (s)	Traveling Time	
						Second	Minute
Pengangsaan Dua	1706	19	19	0	72	110	1,83
Boulevard Utara							
Boulevard Utara	1200	19	19	30	45	113	1,88
Boulevard Selatan							
Boulevard Selatan	1150	19	19	30	42	110	1,83
Pulomas							
Pulomas	750	19	19	30	21	89	1,48
Equistrian							
Equistrian	940	19	19	30	31	99	1,65
Valedrome							
Total	5746	95	95	120	211	521	8,67

The travel time required is the sum of the acceleration, deceleration and travel times with a result of 401 seconds (95 + 95 + 211) or 6,68 minutes after analysis to cover the traffic from

the Pegangsaan Dua station to Velodrome station. Furthermore, it is necessary to propose the operational speed of the Jakarta LRT with the follow

$$V = \frac{S}{T_{travel}}$$

$$V = \frac{5{,}746\ \text{km}}{6{,}68\ \text{minutes}} \times 60$$

$$\mathbf{V = 51{,}61\ km/h}$$

b. Turnback Time

By trimming the cleaning of the St. start and end of work time to 3 minutes.

c. Circulation Time

$$\text{Circulation Time} = (2 \times \text{time travel}) + (2 \times \text{turnback time})$$
$$\text{Circulation Time} = (2 \times 8{,}67\ \text{m}) + (2 \times 3\ \text{m})$$
$$\text{Circulation Time} = 23{,}34 \approx \mathbf{24\ minutes}$$

2. Headway Optimization Analysis in peak hours

For optimizing the Jakarta LRT headway, using the farthest block plot, which is 1,706 meters long on the Pegangsaan Dua–North Boulevard station crossing by:

$$V = \frac{S_{a-b}}{T_{travel\,a-b}}$$

St. Pegangsaan Dua – Boulevard Utara (1.706 m)

$$V = \frac{1706\ m}{110\ s}$$

$$V = 15{,}5\ m/s \times \frac{3600}{1000}$$

$$V = 55{,}8\ km/h$$

With these calculations, the speed at the farthest block plot is 55,8 km/hour. The average speed of the Jakarta LRT train has increased by 85% to 51,61 km/hour. Because in the farthest block the speed is higher than the average speed, for the headway calculation in the farthest block, the minimum headway calculation is carried out at a speed of 45 km/hour so as not to exceed the average speed and the lowest speed between Jakarta LRT stations, as follows:

$$H = \frac{60 \times B + 90}{V} + 1{,}5$$

St. Pegangsaan Dua – Boulevard Utara (1.706 m)

$$H = \frac{60 \times (1{,}706 + 1{,}5)}{45} + 1{,}5$$

$$H = 5{,}8\ minutes$$

3. Operation Schedule After Optimizing Headway

The author proposes optimizing the headway for 6 minutes during peak hours in the morning and evening to make it safer and outside peak hours, continue to use the existing headway of LRT Jakarta for 10 minutes, as follows:

Table 2. Period Time

Time Group	Time Period	Headway (minute)	Total Trip	Total Trains in Operations
Off-Peak Hours	05.30-06.30 WIB	10	12	4

Peak Hours	06.30-09.30 WIB	6	60	4
Off-Peak Hours	09.30-16.30 WIB	10	84	4
Peak Hours	16.30-19.30 WIB	6	60	4
Off-Peak Hours	19.30-23.00 WIB	10	42	4
TOTAL			**258**	**4**

The following is the proposed operation schedule after all the analysis is carried out:

Table 3. New Operation Schedule

Time	Total Trip	Headway (minute)	Total Trains in Operations
05:30 - 06:30	12	10	4
06:30 - 07:30	**20**	**6**	4
07:30 - 08:30	**20**	**6**	4
08:30 - 09:30	**20**	**6**	4
09:30 - 10:30	12	10	4
10:30 - 11:30	12	10	4
11:30 - 12:30	12	10	4
12:30 - 13:30	12	10	4
13:30 - 14:30	12	10	4
14:30 - 15:30	12	10	4
15:30 - 16:30	12	10	4
16:30 - 17:30	**20**	**6**	4
17:30 - 18:30	**20**	**6**	4
18:30 - 19:30	**20**	**6**	4
19:30 - 20:30	12	10	4
20:30 - 21:30	12	10	4
21:30 - 22:30	12	10	4
22:30 - 23:00	18	10	4

Conclusion

From the previous discussion, Based on the analysis, the headway optimization is done by increasing the graphics speed by 85%, which covers a distance of 5,746 meters with a travel time of 8,67 minutes and an average speed of 51,61 km/hour. By cutting the terminal waiting time to 3 minutes,

the circulation time is increased to 24 minutes. From the calculations that have been carried out, the recommended headway optimization is 6 minutes in the morning and evening peak hours with 4 trainsets operating and 60 tripsin each morning and evening peak hour for 180 minutes. Outside peak hours,the headway is still used, and the turnback time is 10 to 7 minutes. The proposed operating pattern of the Jakarta LRT after the headway is optimizedis that the headway is 6 minutes during peak hours in the morning (06:30 – 09:30) and in the afternoon (16:30 – 19:30), outside of peak hours, still usingthe existing headway of 10 minutes. with a total of 258 trips per day and 4 trainsets operating.

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