Simulation of Train Scheduling and Evaluation of Passenger Level of service A Case Study of Mass Rapid Transit Blue Line

Kanticha Machoo[1*], Jirapat pakchamsai[2], Chayut Ngamkhanong[1] and Boonchai Sangpetngam[1]

[1] Department of Civil Engineering, Faculty of Engineering, Chulalongkorn University, Bangkok, THAILAND

[2] Railway Systems Engineering Department, Railway Systems Division, Toshiba Infrastructure Systems & Solutions Corporation, Kawasaki 212-8585, Japan

**Corresponding author address: kanticha.machoo@gmail.com*

Abstract

This research studies the train scheduling of the Mass Rapid Transit (MRT) blue line, which is one the major lines in Bangkok with a total distance of about 48 kilometers and 38 stations. The blue line is the first of the MRT system and connects major business, residential and cultural areas of Bangkok. Presently, the blue line is connected to other lines including purple line, red line, green line and airport rail link line with a plan to extend to orange line, yellow line and purple line in the future. This has led the blue line to become one of the Bangkok's busiest line with an average of 400,000 passengers per day passing through. The aim of this study is to improve efficiency of train scheduling and thus provide a better level of service for passengers. This research considers significant factors influencing train operation such as train specifications, train speed, train capacity, route of train line, distance between the station, headway and dwell time. This paper adopts cloud-based transit scheduling software called "TRUELINE" to create varieties of run curve and timetable considering different factors in order to improve efficiency and passenger level of service. The outcome of this study will provide information for train operators that can be applied to optimize operations in real life.

Keywords: Train Operation, Passenger's level of service, Mass Rapid Transit

1. Introduction

Due to the growing population and urbanization[1], people using more about the transportation so public transportation system have to increase and has developed. Encouraging and enhancing systems can prompt a shift from private car usage to the use of public transportation, rail transportation, which is an effective method of transporting many people quickly, safely, and comfortably. The availability of train scheduling is planner for passenger who want to use public transport and comfortable about planning.

Currently, passengers using rai transportation dramatically increasing trend of Mass Rapid Transit(MRT) and Bangkok Mass Transit System (BTS) users from 2011 to 2022 about 200,000 passengers per day to 400,000 passenger per day [2] show as figure1. The reason that its growth is expected to continue due to the increasing number of residents and commuters living along the rail lines and those using the connections to the suburbs of Bangkok.

The purpose of this research paper is to improve efficiency of train scheduling and to provide a better level of service for passengers by simulation of train scheduling at "TRUELINE" programming. Factors is using on simulation are number of passengers, headway of train, dwell time of train and operation of train with all 2 types are Short turning and Stop skipping.

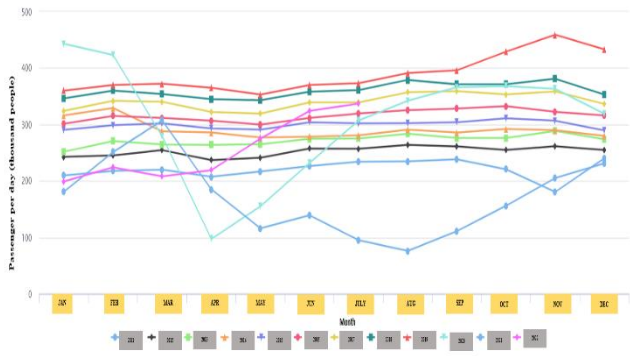

Fig. 1 Average Passenger per day[3]

2. Study Area and Simulation

The study area of study is Mass Rapid Transit (MRT) of blue line from Tha Phra station (BL01) to Laksong station (BL38) at 07.00-09.00 am on July 2022 and layout of using simulation show as figure 2.

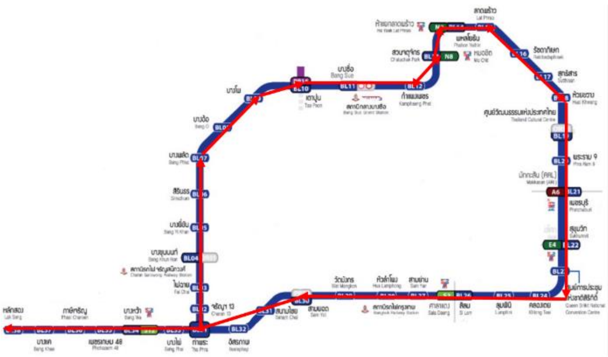

Fig. 2 Study area, From Tha Phra station (BL01) to Laksong station (BL38)[4]

2.1 Train Scheduling

The types of main train scheduling have two types is considering of study are public scheduling is scheduling that shows information about the schedule for each route, including information about the route of travel time for each round and working scheduling is shows information about the plan for displaying the train's movement, which is managed by traffic controllers responsible for the stations related to the train operation[5].

2.2 Train Operation

The types of train operation have 5 types are firstly, deadheading operation is from the origin station to the designated destination station without any intermediate stops to pick up passengers. Secondly, Holding operation involves adding a waiting time for trains at designated stations or locations. Thirdly, Zone scheduling operation involves determining the stations or locations on the route to stop for picking up and dropping off passengers. Fourthly, Stop-skipping operation is specifying the stations where passengers are picked up and dropped off and last of operation, Short turning operation is operated together with long-distance train services or trains that stop at every station[6].

2.3 Simulation

The simulation of train scheduling will use “TRUELINE” program, which program creating “train scheduling” develop by Toshiba Infrastructure Systems & Solutions Corporation, Kawasaki Japan, with the following details; headway and dwell time.

2.4 Headway

Headway is the distance between two operating train lines affects the frequency of train service. If the distance between the train lines is short, the frequency of train service will be higher. This is because train schedules require more round trips, which necessitates a higher number of train cars rotating in the system to accommodate the high frequency of train service. This factor is therefore an important consideration when calculating the number of train cars required for each project. The time it takes to complete a round trip also affects the number of train cars in the system. If the time it takes to complete a round trip is long, there will be more train cars in the system at any given time, resulting in a higher number of train cars. This is because the longer the time it takes to complete a round trip, the slower the average speed of the train, which is affected by the distance between stations and the speed of the train. These factors result in different numbers of train cars in the system for each train project show as figure 3 [7].

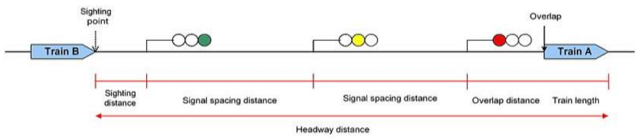

Fig. 3 Headway distance[8]

2.5 Dwell time

Dwell time is period of time when a vehicle stops at a designated station or parking spot, such as the designated stations of each subway line or public transportation stops. In the case of mass rapid transit systems, there are specifications regarding the structure of the platform because the duration of time that the vehicle's doors and the platform structure are coordinated needs to be determined[9].

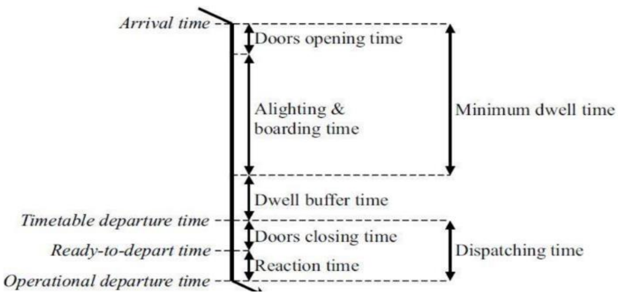

Fig. 4 Dwell Time[10]

2.6 Level of service

Designing the interior convenience of a transportation station system typically follows the guidelines for capacity and service quality provided in the mass transit system's capacity and service quality manual follows the Transit Capacity and Quality of Service Manual (TCQSM)[11], which measures the Level of Service (LOS) of each area in providing service to passengers, such as the waiting area and walkway. Evaluating the quality of service requires considering data such as the ratio of passenger volume to capacity during travel time, the estimated volume of passengers that the walkway service level can accommodate at a subway station, and the delay time in leaving the waiting line. The level of service for pedestrian movement is divided into 6 levels, A to F, with A being the best service level, characterized by the lowest level of pedestrian congestion for each service level.

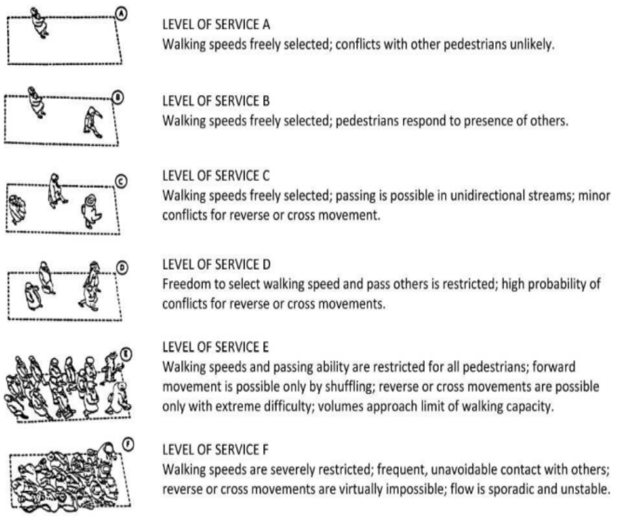

Fig. 5 Level of service

3. Methodology

3.1 Data Preparation

Data preparation to use "TRUELINE" program are actual number of passengersfrom Tha phra station to Laksong station during peak time in July 2022 at 07.00-09.00 am, Layout of the platform and the rolling stock, Branching of Mass Rapid Transit(MRT) Blueline.

Layout of the platform of blueline is consider about depot of train, Blue line have 2 depot are Depot IBL locate between Thailand Cultural Centre (BL19) and Phraram 9 (BL20) and Depot BLE locate between Bang Wa (BL34) and BL36 - Phasi Charoen Station as show figure 6.

Branching of Mass Rapid Transit(MRT) blueline separate 4 part is using on "TRUELINE" program are branching at depot IBL, branching at depot BLE, branching at turnback Thaphra and branching at turnback Laksong station as show figure7.

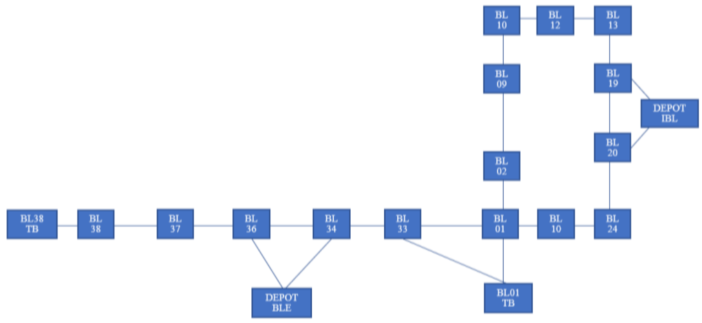

Fig. 6 Layout of the platform

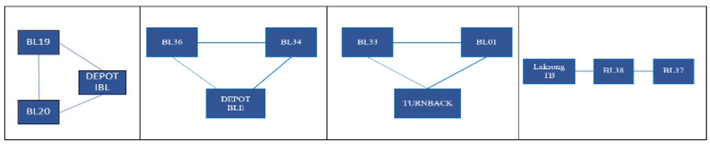

Fig. 7 Branching of Mass Rapid Transit(MRT) Blueline

3.2 Calculation of Passengers per Hour per Direction, PPHPD

Calculation of Passenger Per Hour Per Direction (PPHPD) is calculate headway following details;

Input data ;

- Passenger Demand (ppl/hr/dir)
- Total Train Capacity (ppl/train)
- Round Trip Time (sec/round)

Output data ;

- Number of required train for one round at the time by one direction (train/round), assume same headway in the same range of time
- Headway (sec/train)

No.	category	time / item	07:00-08:00	08:00-09:00
1	input	Passenger Demand (ppl/hr/dir)		
2	input	Total Train Capacity (ppl/train)		
3	input	Round Trip Time (sec/round)		
4	output	Number of required train for one round at the time by one direction (train/round), assume same headway in the same range of time		
5	output	Round-up Number of required train in the system (train/round)		
6	output	Headway (sec/train)		
7	output	Round-up headway (min/train)		

Fig. 8 Calculate Passenger Per Hour Per Direction (PPHPD)

3.3 Scenario

Scenario design consider about 4 factors are Headway, Dwell time, number of passenger and train operations.

Table. 1 Scenario Design

Station	Train Operation	Factor
Thaphra Station to Laksong Station	Stop-Skipping	Passenger
		Headway
		Dwell time
	Short turning	Passenger
		Headway
		Dwell time

3.4 Simulation

Simulation from stop skipping and short turning as show figure 9.

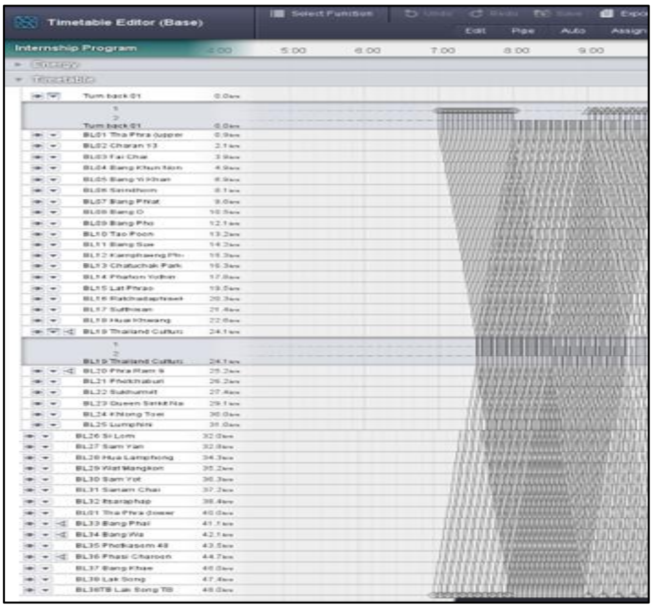

Fig. 9 Simulation display from 07.00-09.00 am

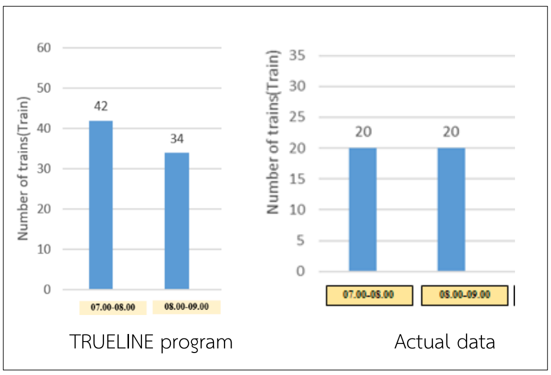

Fig. 10 Comparison Number of trains in TRUELINE program and Actual data from Mass Rapid Transit(MRT) Blueline

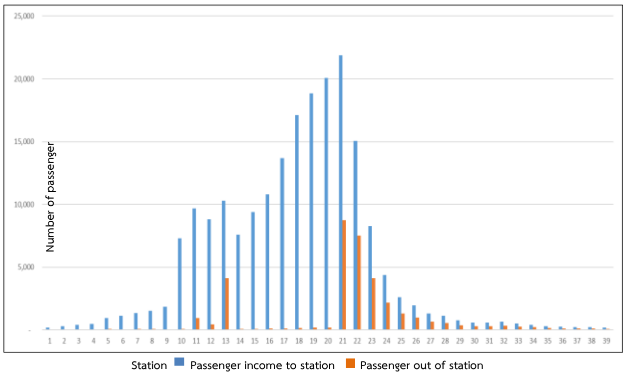

Fig.11 Passenger from Thaphra to Laksong sation at 07.00-09.00am

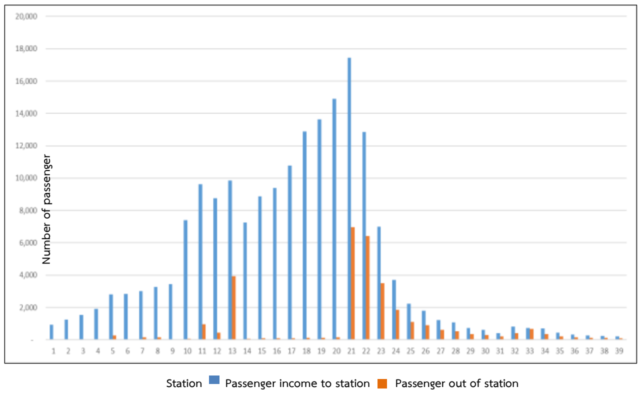

Fig. 12 Passenger from Thaphra station to Laksong station at 08.00-09.00 am

NO	Detail	
1	BL01	Tha Phra
2	BL02	Charan13
3	BL03	Fai Chai
4	BL04	Bang Khun Non
5	BL05	Bang Yi Khan
6	BL06	Sirindhorn
7	BL07	Bang Phlat
8	BL08	Bang O
9	BL09	Bang Pho
10	BL10	Tao Poon
11	BL11	Bang Sue
12	BL12	Kamphaeng Phet
13	BL13	Chatuchak Park
14	BL14	Phahon Yothin
15	BL15	Lat Phrao
16	BL16	Ratchadaphisek
17	BL17	Sutthisan
18	BL18	Huai Khwang
19	BL19	Thailand Cultural Ce
20	BL20	Phra Ram9
21	BL21	Phetchaburi
22	BL22	Sukhumvit
23	BL23	Queen Sirikit Nation
24	BL24	Khlong Toei
25	BL25	Lumpini
26	BL26	Si Lom
27	BL27	Sam Yan
28	BL28	Hua Lamphong
29	BL29	Wat Mangkon
30	BL30	Sam Yot
31	BL31	Sanam Chai
32	BL32	Itsaraphap
33	BL01	Tha Phra
34	BL33	Bang Phai
35	BL34	Bang Wa
36	BL35	Phetkasem 48
37	BL36	Phasi Charoen
38	BL37	Bang Khae
39	BL38	Laksong

Fig. 13 Number of stations showing on graph

4. Results and Discussion

4.1 Analysis simulation

From result simulation, we create train scheduling considering 4 factors, there are Headway, Dwell time, number of passenger and train operations on simulation found at peak time.

From the number of passenger walking in and out of the walkway at the train station, it was found that the number of people walking in and out each station is shown in Figure 11,12. It was found that there were more people walking out of the station in this area because it was rush hour in the morning from Silom station to Huai Khwang station and many passengers used the service to travel outside the city. The highest number of people walking in was 17,435 people during the time period of 07:00-08:00, and most passenger on train at Thaphra station

5. Conclusions

This study shows that the distance between trains during peak hour affects the quality of service provided to passengers, as well as the average flow rate of passenger who waiting train on the platform. The analysis should consider the congestion during peak hours, as well as the headway between trains, which should be between 2-5 minutes between train. The study should also consider the actual level of service (LOS) during the analyzed period. Comparison between short turning and stop skipping found the passenger on stop skipping is better than short turning

If there are limitations in space that prevent adequate provision of amenities, the management and preparation of waiting areas to accommodate the waiting queue must be considered. However, this study only collects data on the number of passengers in one hour, which may not represent all characteristics. Nevertheless, the trends in the effects of different average time intervals can be observed. For other amenities in the station, such as stairs, platform areas, and waiting areas, they should be considered in the same way. The study collects data from Bang Pho, Tao Poon, and Phet Kasem 48 stations, each of station,which may have different issues. For interchange stations with high of passenger volume in the future, such as Phahon yothin station and the Cultural Center stations, data collection in other stations should also be considered for comparative analysis.

Acknowledgement

This research is supported by Toshiba Infrastructure Systems & Solutions Corporation, Japan, Jirapat Pakchamsai (Technical Specialist, Toshiba Infrastructure Systems & Solutions Corporation, Japan), Mass Rapid Transit Authority of Thailand and Sikkapat Suksomjit (Engineer Operational Level, Mass Rapid Transit Authority of Thailand

References

[1] Schittenhelm, B. H. (2013). Quantitative methods for assessment of railway timetables (Doctoral dissertation, Technical University of Denmark, pp.7-22.

[2] Wang, Y., B. Ning, T. van den Boom, and B. De Schutter, Background(2016) Train Operations and Scheduling, in Optimal Trajectory Planning and Train Scheduling for Urban Rail Transit Systems. Springer International Publishing: Cham. pp. 7-21.

[3] Wang, G., Liu, H., & Zeng, X. (2017). Study on train headway in different turning-back mode of urban mass transit station. Transportation research procedia, 25, pp.451-460.

[4] Hansen, I.A. and J. Pachl, Railway Timetabling&Operation. (2008)

[5] Wisuthisomboon, S., & Siwakosit, W. (2020). A Study on Transferring Passengers in Morning Peak Time at Tao Poon Station (Doctoral dissertation, Kasetsart University).

[6] Hänseler, F. S., Bierlaire, M., and Scarinci, R. (2016). Assessing the usage and level-of-service of pedestrian facilities in train stations: A Swiss case study. Transportation Research Part A: Policy and Practice, 89, pp.106-123.

[7] Cepolina, E. M., Menichini, F., and Rojas, P. G. (2017). Pedestrian level of service: the impact of social groups on pedestrian flow characteristics. International Journal of Sustainable Development and Planning, 12 (4), pp.839-848.

[8] Su, S., Li, X., Tang, T., Gao, Z. (2013) "A Subway Train Timetable Optimization Approach Based on Energy-Efficient Operation Strategy", IEEE Transactions on Intelligent Transportation Systems, 14(2), pp. 883–893.

[9] Zimmermann, U. T., Lindner, T. (2000) "Train Schedule Optimization in Public Rail Transport", In: Jäger, W., Krebs, H. J. (eds.) Mathematics - Key Technology for the Future, 2nd ed., Springer, Berlin, Heidelberg, Germany, pp. 703–716.

[10] Schachtebeck, M. (2010) "Delay Management in Public Transportation: Capacities, Robustness, and Integration", Ph.D. Thesis, GeorgAugust-Universität Göttingen, Göttingen, Germany.

[11] Transportation Research Board (2013). TCRP Report 165: Transit Capacity and Quality of Service Manual, Third Edition. National Academy of Sciences, USA, Chapter 10.