Simulation and Analysis of Passengers Riding LRT 2: Recto Station

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***Abstract* — Passengers across Metro Manila use Light Rail Transit (LRT) as it is operational everyday to lighten passenger's travel time. However, during peak hours, passengers tend to increase more than usual affecting the overall accommodation of passengers, the occupancy of the train, and the time before passengers can enter the train. In this paper, simulation and analysis of passengers riding LRT 2: Recto Station is covered. The objective of this project is to determine the effectiveness of the passenger flow distribution model and whether the groups of randomized population of passengers have significant differences using unpaired t-test. The results of the t-test are interpreted and simulation of the randomized population of passengers using uniform distribution, in AnyLogic simulation software, is also included for the simulation and experimentation within this project.**

Keywords: LRT 2, Recto Station, Simulation and Analysis, AnyLogic

I. Introduction

A Light Rail Transit (LRT) is a system of railways usually powered by overhead electrical wires and used in metropolitan areas for medium-capacity local transportation for it is more segregated from street traffic. [1] LRT vehicles usually consist of two to three cars operating at an average speed of 55-60 km/h on the lines with more dense stops or stations and 65-70 km/h along the lines with less dense stations. Its service frequency differs due to demand, peak, and off-peak hours of the day. [2]

In the Philippines, there are 2 known LRT lines. First is the LRT Line 1 which is called the Green line while the LRT Line 2 is called the Purple line. The LRT 1 or the Green line system services the Taft Avenue to Rizal Avenue route while the LRT 2 or the Purple Line system services the Ramon Magsaysay Blvd to Aurora Blvd route. The LRT Line 2 was built much later than LRT Line 1 so the trains are more spacious and offer other features like barrier-free access. [3] The LRT Line 1 system has 20 stations starting with Baclaran station and ends with Roosevelt station. It has 20 stations that complete its route which are Baclaran, EDSA, Libertad, Gil Puyat, Vito Cruz, Quirino Avenue, Pedro Gil, United Nations, Central Terminal, Carriedo, Doroteo Jose, Bambang, Tayuman, Blumentritt, Abad Santos, R.Papa, 5th Avenue, Monumento, Balintawak, and Roosevelt. On the other hand, the LRT Line 2 system has 13 stations starting with Recto Station and ends with Antipolo Station. Its complete route is Recto, Legarda, Pureza, V.Mapa, J.Ruiz, Gilmore, Betty Go-Belmonte, Araneta Center Cubao, Anonas, Katipunan, Santolan, Marikina, and Antipolo, respectively. [4]

LRT provides quick and cost-effective service to passengers for interurban transportation in a metropolitan area. Due to this reason, the volume of LRT passengers increases daily, leading the researchers to focus on the topic of the simulation and analysis of passengers riding LRT. The LRT line that will be covered in the paper is LRT 2 and Recto station will be the station in focus.

II. Data

The data used for the simulation is from the official website of Light Rail Transit line 2. Figure 1 shows the data of passengers riding the LRT2 Recto Station for the month of January 2022. The Light Rail Transit (LRT) opens at Five o'clock in the morning and closes at 10 o'clock in the evening. The average number of passengers that enter the station per day is 9797. While the number that exits the station per day is 10195.

Station		Recto	
Date	Dayname	Entry	Exit
1-Jan	Sat	7,923	7,934
2-Jan	Sun	12,361	13,815
3-Jan	Mon	12,655	13,438
4-Jan	Tue	10,345	11,402
5-Jan	Wed	10,039	10,248
6-Jan	Thu	9,395	9,673
7-Jan	Fri	9,787	9,855
8-Jan	Sat	7,257	7,319
9-Jan	Sun	5,524	5,728
10-Jan	Mon	10,205	11,001
11-Jan	Tue	9,317	9,621
12-Jan	Wed	9,336	9,238
13-Jan	Thu	9,079	9,304
14-Jan	Fri	9,837	10,081
15-Jan	Sat	9,083	8,982
16-Jan	Sun	3,904	4,856
17-Jan	Mon	10,629	11,042
18-Jan	Tue	9,397	9,764
19-Jan	Wed	9,926	10,288
20-Jan	Thu	10,004	10,357
21-Jan	Fri	10,806	11,072
22-Jan	Sat	9,647	9,434
23-Jan	Sun	6,175	7,241
24-Jan	Mon	11,854	12,600
25-Jan	Tue	11,264	11,683
26-Jan	Wed	11,577	11,843
27-Jan	Thu	11,442	11,669
28-Jan	Fri	12,820	12,989
29-Jan	Sat	11,016	10,669
30-Jan	Sun	7,471	8,724
31-Jan	Mon	13,635	14,165
Monthly Total Entry & Exit	**31 Days**	**303,710**	**316,035**

Figure 1. *January 2022 data of Exit and Entry Recto Station*

The transit is open for 17 hours or 1020 minutes in a day. On weekdays, the average number of passengers that enter the station per day is 10,636, per hour is 626, per minute is 10; while the number of passengers that exits the station per day is 11,016, per hour is 648, per minute is 11. On Saturdays, the average number of passengers that enter the station per day is 9,251, per hour is 544, per minute is 9; while the number of passengers that exits the station per day is 9,101, per hour is 535, per minute is 9. On Sundays and Holidays, the average number of passengers that enter the station per day is 7,226, per hour is 425, per minute is 7; while the number of passengers that exits the station per day is 8,050, per hour is 474, per minute is 8.

	Per day		Per hour		Per minute	
	Entry	Exit	Entry	Exit	Entry	Exit
Average weekdays	10636	11016	626	648	10	11
Average Saturdays	9251	9101	544	535	9	9
Average Sundays and holidays	7226	8050	425	474	7	8
Daily Average	9797	10195	576	600	10	10

Table 1. *Average Number of Passengers per day, per hour, and per minute.*

III. Implementation

The simulation is implemented using Anylogic Software. The model of a small light rail transit station is built with the AnyLogic Pedestrian Library and Process Modeling Library. Passengers arrive at the station to get on a train and Trains arrive at the station according to the logic defined by the Rail Library flowchart.

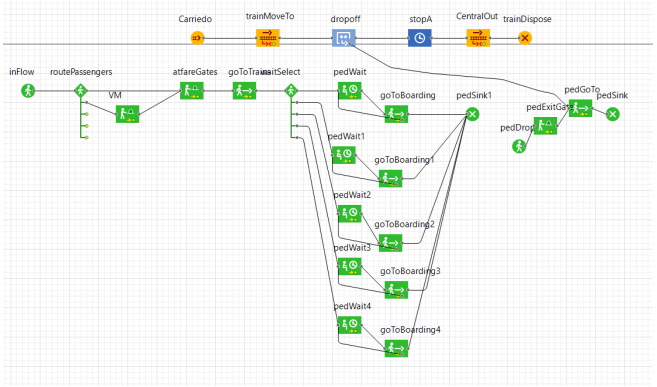

Figure 3. *Queuing system configurations of LRT2 Recto Station*

The passenger enters the station and buys train tickets and goes to the turnstile to tap their train cards. The passengers choose any train door to go to and wait in line. The passengers board the train car, while the other passengers get off the train car, exits the turnstile and then exits the station.

The list below is the description and the name of every element in the model.

Block name	Function
inFlow	Adding passenger agents to the model
RoutePassengers	Passenger agents moving.
VM	Passenger agents moving to the ticketing zone.
atFareGates	Passenger agents entering the turnstile of the station.
goToTrain	Passenger agents entering the station.
waitSelect	Passenger agents choose a traindoor to go to.
PedWait	Passenger agents waiting for the train to arrive.
goToBoarding	Passenger agents boarding the train.
pedSink	Removing passenger agents from the model.
pedDrop	Passenger agents unboarding the train.
pedExitGate	Passenger agents exiting the turnstile of the station.
pedGoTo	Passenger agents going to the exit gate.
Carriedo	Train Source from Carriedo
trainMoveTo	Train moving to the Central
dropOff	Drop off the passengers that are inside the train car.
stopA	Time of the train staying in the station
CentralOut	Train leaving the station.
trainDispose	Removes the train from the model.

Table 2. Description of the block elements of the simulation model.

Figure 4 shows the layout and the interface of the model which is similar to how the Recto Station functions. The figure 5 shows a screenshot of a 3-dimensional simulation of the model using Anylogic Simulation Software.

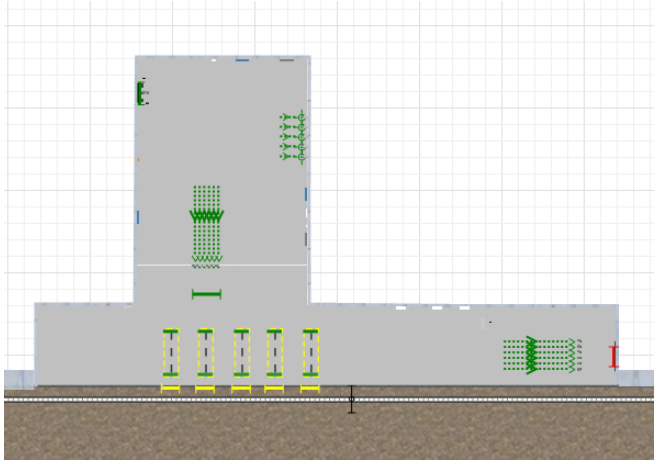

Figure 4. *Layout and Interface of the Simulation Model*

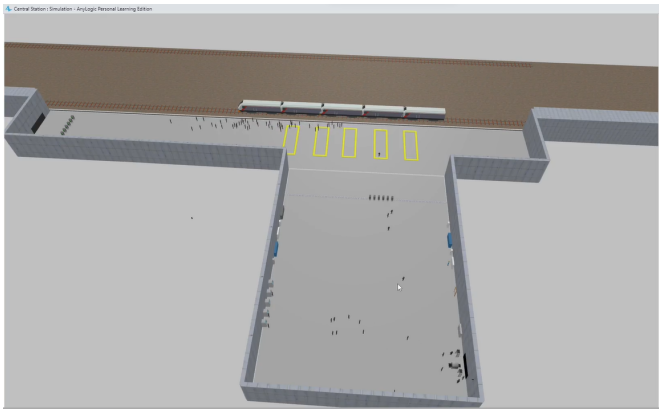

Figure 5. *A Screenshot of Simulation of LRT2 Recto Station implemented using Anylogic Simulation Software.*

IV. Experiments

The simulation ran 10 randomized populations of the passengers using uniform distribution with the maximum of 5524 and minimum of 12665 (Group B) and that is based on the data of Light Rail Transit(LRT) on Line 2 from the year 2022, January 1 to January 10 (Group A) that is shown below.

Group A	Group B
7923	12482
12361	11099
12665	11583
10345	10642
10039	8420
9395	7367
9787	7523
7257	6492
5524	8601
10205	5885

Table 3. Data used tested in T-test.

The experiment used unpaired t-test to see if there are any significant differences between the two groups. The mean of Group A is 9550.10 and the mean of Group B is 9009.40. The standard deviation of Group A is 2188.33, while the standard of Group B is 2290.91. The Standard Error of Measurements of Group A is 692.01 while group B has a standard error measure of 724.45. The

V. Results

Based on the data gathered from the experiment, it shows that the result from the unpaired t-test between the two groups is 0.5960 which is not statistically significant.

VI. Conclusion

We used the AnyLogic simulation software to study and analyze the passenger flow at LRT 2: Recto Station. In the simulation model, passengers entering and exiting the station have been observed. Modification of variables such as number of passengers per day, train interarrival time per minute, and train waiting time is tested in the simulation process and model.

Based on the results, there is no difference between the data used for the model and the data output gathered from the simulation. This means that the developed simulation and model are effective and accordant with the reality scenario, and the simulation precision is comparatively ideal.

In this study, due to basic definition and assumption, it has its limitations and may not be free of mistakes. Future research could be conducted on this study to improve the performance of the passenger flow distribution model and focus on the reality application.

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