Train Simulation in LRT-2 Legarda Station

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Abstract *- Making sure that passengers are secure and comfortable is crucial while promoting the usage of trains that are imported. Transit authorities must monitor crowding on the rail system. Crowding data has effects on customer information, service planning, performance evaluation, and operations control. The purpose of this study is to build a model and simulate the number of passengers in the LRT-2 Legarda Station. Inputs to the model include the number of passenger arrivals in the station within a specific time frame. The researchers have gathered data through the approval of request by eFOI (Electronic Freedom of Information). The process modeling library of AnyLogic was used in simulating the LRT 2 Legarda Station. The model consists of three different services. Each service has a probability. One service has 60% and the other two has a probability of 20%. After gathering all the tools needed, the researchers declared a sequence of processes for the simulation to function properly. The model can be viewed in 3D Mode.*

Keywords: modeling, simulation, train simulation, anylogic, lrt-2, legarda, philippines train

I. INTRODUCTION

Accurate train simulations are necessary for development purposes, but also as a tool to improve train scheduling and optimize fuel consumption. However a train is a very complex mechanical system. Especially if wheel/rail contact, suspension, mechanical stresses, track layout (curves, slope, tunnels) and other factors would be accurately represented. Furthermore several parameters such as load, weather and wear and tear change over time and are difficult to predict. Modeling the entire system would have significant computational requirements and would still be burdened by errors in input parameters. Results would not achieve the accuracy proportional to complexity of the approach. Also, the need for train modeling was recognized many decades ago, when powerful digital computers were not available Danzer (2008); Drabek (2010).

Metro Manila, with its high population density and economic activity, is known for its bad traffic situation. The heavy traffic congestion not only contributes to bigger carbon dioxide emissions leading to health risks, but also costs the Philippines billions of pesos every day, from a report by the Japan International Cooperation Agency (JICA). According to the same report by JICA, public transport in Metro Manila accounts for 69% of the total number of trips taken daily, and 71% of which are by buses and jeepneys. These figures clearly show the large proportion of trips by motorized vehicles that contribute to road congestion.

A highly suggested solution is to improve and promote the railway system. Rail transportation is one of the quickest ways of land transportation. It is one of the commonly used modes of transportation in different countries like the Philippines. Currently, Metro Manila has three mass rapid transport train systems: the Light Rail Transit Line 1 (LRT-1), Light Rail Transit Line 2 (LRT-2), and Metro Rail Transit Line 3. These train systems, being alternatives to motorized vehicles, recorded a daily average of about 985,000 passengers in total.

LRT 2 is the newest and the shortest line among the existing light rails in the Metro. It is branded as the Blue Line that aims to ease the travel from east to west of Metro Manila. The LRT 2 Stations Map starts at Recto Station and ends in Santolan (which is close to SM Marikina), with stopovers in Gilmore in San Juan and in between stations of Quezon City like Cubao, Anonas and Katipunan.

The Legarda Transit Station is large enough to accommodate the existing population of its patrons, and it is seen to still have extra capacity to accommodate more since growth in student population may grow after urban renewal has been implemented in the area The large area below the station calls for more vibrant development as well. There are more people using the services and amenities of the Transit Station during weekdays, day or night. The trains and loading platforms are very much uncrowded and shops leading to the train station are closed on a Sunday.

In this paper, the researchers successfully obtained the data they requested through eFOI (Electronic Freedom of Information). The data contains the daily number of passengers in the LRT 2 Stations from October to November 2021. Among the stations, the researchers chose Legarda Station since they observed that based on the data, it's the least busy station. The researchers built a model and simulated the number of passenger arrivals in the Legarda Station within a specific time frame (October 4 2021). AnyLogic was used in building and simulating the model. During the creation of the model, the researchers included a specific amount of probability in each process. The researchers also conducted a T-Test to examine the validity of the model. The next section describes the literature review, experiments, results, conclusion and references.

II. REVIEW OF RELATED LITERATURE

According to Lindfeldt, A. (2015), Sweden's transportation demand is growing. Railways play a vital role in meeting this growing demand. The capability of the Swedish rail network is currently not being expanded at the rate required to keep up with the rise in traffic demand. As capacity usage grows, so does the railway system's sensitivity. Maximum capacity is attained when the marginal advantage of running one more train is less than the costs of longer travel times and higher susceptibility to delays.

There were different methodologies that were used in this thesis. The first analyzes how different factors impact available capacity and train delays using real data from the Swedish rail network, train operation, and delays. In the second method, comprehensive simulation tests are conducted using the railway simulation program RailSys. This approach is used to investigate the features of double-track operation. Hundreds of scenarios are simulated to examine the impact of traffic density, traffic heterogeneity, primary delays, and inter-station frequency on subsidiary delays, utilized schedule allowance, and capacity.

TigerSim, a simulation model for strategic capacity evaluation, is created and may be used to accelerate and enhance capacity planning and evaluation of future infrastructure and schedule designs on double-track railway lines. From a quality of service standpoint, the model's output may be utilized to either calculate capacity directly or as an input for cost-benefit analysis (CBA).

According to Stephen M. Howard, Linda C. Gill, and Peter J. Wong a computer algorithm that simulates the operation of a single train over a predetermined railway route is known as a train performance simulation (TPS) or train performance calculation (TPC) model. It does not simulate how different trains in a railway network interact with one another. Information on performance characteristics including journey time, train velocity, and energy or fuel use as the train travels along the route is provided through the model's numerical and graphical output. Further information on brake applications, tractive effort, train resistances, and track profiles may be provided by a TPS model. Although different wavs can implement the 'l'PS model notion, the fundamental structure of all 'T'PS models are crucial

Train Data

Train data requirements depend on the intended application of the model. Some models represent the propulsion system in great detail and consequently require extensive and detailed data. In general, the locomotive specifications include tractive effort curves, aerodynamic and mechanical resistance characteristics, fuel or energy consumption, and brake-system parameters. Specification of the train makeup can range from the individual description of each car and locomotive in the consist to the number of cars of a single type.

Route Detail.

Any track segment can be specified hy data that describe curves, grades or elevations, speed limits, and station stops (usually by milepost). Enhancements to these data can include specifications of equations of track, direction of travel or reverse segments, and complex curve descriptions of the point-tangent-spiral form. Track data can be formatted in either point or interval form. Point data describe characteristics that hold at a single point on the track, such as elevation or station stops, whereas interval data describe a track characteristic that holds between two points, such as grade or speed limit.

Operating-Scenario Detail

In addition to descriptions of the route and train makeup, certain operating parameters and strategies must be specified for the running of the train. These may include train starting time, train starting speed, place and time of stops along a route, temporary speed orders, consistent changes end route, velocity and direction of prevailing winds, explicit throttle settings and brake application specifications, and maximum allowable acceleration and deceleration.

III. EXPERIMENTS

A. *AnyLogic*

A simulation tool called AnyLogic enables companies in the transportation, manufacturing, rail logistics, mining, supply chain, healthcare, and other sectors to test and investigate what-if scenarios using 2D and 3D models. It has built-in animation libraries for a variety of sectors, including material handling, rail, and pedestrian and vehicular traffic.

B. *Data Sets*

Light Rail Transit Authority
Fare Revenue Operations Group - AFC System Administration Divisio
Line 2 - Ridership Report Entry Traffic LEGARDA
November to December 2021

Station Date	OCTOBER	NOVEMBER	DECEMBER
1	1,243	513	1,811
2	935	1,274	1,681
3	635	1,209	1,907
4	1,147	1,354	1,556
5	1,109	1,491	1,114
6	1,147	687	1,871
7	1,206	696	1,885
8	1,315	1,519	1,284
9	885	1,441	1,811
10	650	1,523	1,930
11	1,220	1,528	1,699
12	1,187	1,416	1,392
13	1,233	1,309	2,005
14	1,183	72	2,007
15	1,339	1,558	2,016
16	1,077	1,541	2,267
17	715	1,603	2,165
18	1,341	1,605	1,838
19	1,283	1,665	1,159
20	1,378	1,313	2,112
21	1,356	1,079	2,021
22	1,433	1,741	2,041
23	1,076	1,533	1,864
24	675	1,746	1,268
25	1,436	1,723	963
26	1,371	1,819	1,039
27	1,541	1,471	1,656
28	1,497	873	1,643
29	*1,689*	*1,951*	*1,617*
30	*1,328*	*1,178*	*1,035*
31	*588*	*0*	*707*
Monthly Total Entry Ridership	**36,218**	**40,431**	**51,364**

Note:
Nov 1- All Saint's Day (Special Non-Woking
Nov 1-14 - National Capital Region (NCR) under Alert Level 2
**Nov 14 - Stop Operation from 7:56 to 21:00 (end of revenue operation)*
Nov 15-30 - National Capital Region (NCR) under Alert Level 2
Nov 29 - National Vaccination Day (Special Working Holiday)
Nov 30 - Bonifacio Day (Regular Holiday)

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Figure 1. Data Sets of LRT 2 Legarda Station

Figure 1 shows the Daily Ridership in LRT 2 Legarda Station from October to December 2021. In order to make the simulation, the researchers requested data sets from the Electronic Freedom of Information (eFOI) on March 28, 2022. The gathered information is now being utilized to estimate the daily ridership of LRT-2 Legarda Station in October 2021.

Total Passengers in the month of October:	36, 218
Total no. of Passengers in October 4 & 6:	1, 147
Average Passengers in the month of October:	1, 168
Average Passengers per hour:	78
Estimated Process Time of each Passengers to do services:	5 minutes

Table 1. Data Analysis of Passengers in LRT 2 Legarda Station

There were a total of 36,218 passengers in the month of October 2021. The researchers divided the total passengers by the number of days in the month of october. The average passengers in the month of october was 1,168, which is the closest to October 4 and 6, which is 1,147. The average passengers was then divided into the number of operating hours of the LRT 2, from 5:00 am to 9:00 pm every day, which is 78 people per hour. The estimated process time of each passenger to do different services is 5 minutes.

IV. IMPLEMENTATION

Building the model requires a sequence of events or processes for the simulation to function effectively. The model includes three services; a set of passengers who have beep cards but don't have enough load, a set of passengers who will buy a single journey ticket and lastly, a set of passengers who have enough load in their beep card and will go directly to the entrance gate. This section will show the processes of the model as well as the probability of each service.

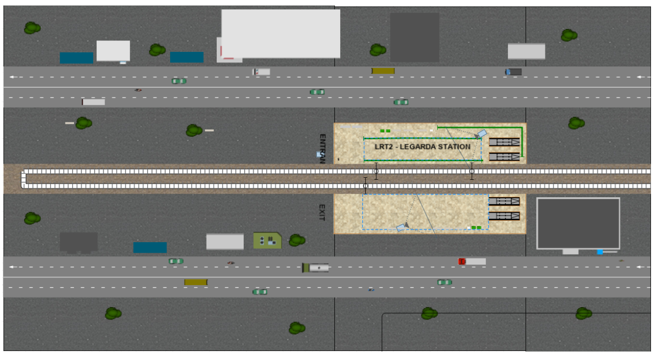

Figure 2. Aerial View of the Model

Figure 2 shows the aerial view of the model.

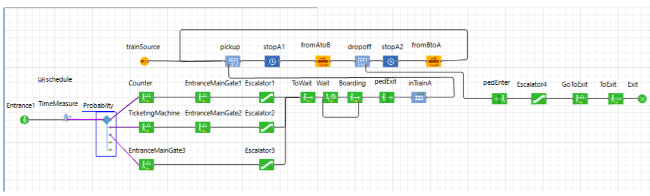

Figure 3. Processes of the Model

Figure 3 shows the sequence of events needed for the model to work properly. These are the logic behind the simulation. The researchers made use of the process modeling library of AnyLogic in simulating the LRT 2 Legarda Station. Objects such as entrance gate machine, ticketing machine, counter and escalator are placed in the creation of the model. There is only one source of passengers that will go to the three different services in the model. The passengers will randomly go to different services in order to accomplish their task and some waiting time will be shown in the simulation. From the services, the passengers will now proceed to the 2nd floor using the escalator. Passengers will wait for the train to arrive, pick them up and drop them off to the next station.

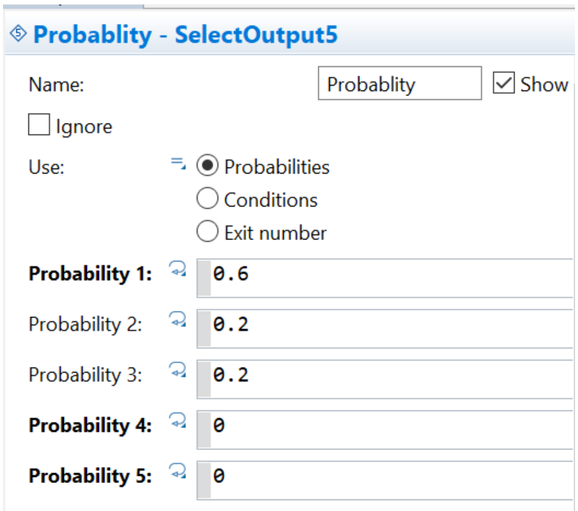

Figure 4. Probability of each Service

Figure 4 shows the probability of the passengers using the different services. The researchers concluded that there is a 60% probability that people will buy a single journey ticket. The 20% is for people who already have a stored value ticket.

V. RESULTS

	Average		Run	
	1147		1107	
	1147		1168	
	1147		1132	
	1147		1162	T-TEST
	1147		1097	0.069560234
	1147		1084	
	1147		1146	
	1147		1144	
	1147		1139	
	1147		1148	
TOTAL			11242	
MEAN		1147	1124	

Figure 5. T-test

Figure 5 shows the average of passengers that is inputted in the probability of the simulation. The researchers run the simulation ten times to determine the mean of the 10 runs and calculate the t-test of the probability of passengers from three services.

t-Test: Paired Two Sample for Means		
	Variable 1	*Variable 2*
Mean	1147	1132.7
Variance	0	776.6777778
Observations	10	10
Pearson Correlation	#DIV/0!	
Hypothesized Mean Differenc	0	
df	9	
t Stat	1.622615416	
P(T<=t) one-tail	0.069560234	
t Critical one-tail	1.833112933	
P(T<=t) two-tail	0.139120468	
t Critical two-tail	2.262157163	

Figure 6. P-value

Figure 6 shows the p-value of the t-test that was conducted through excel in the previous figure.

3D View of the Full Process of Train Simulation

Figure 7. View at the Main Entrance

Figure 7 shows the entrance where passengers will go through the metal detector.

Figure 8. View at the Counter

Figure 8 shows one of the services. The passengers who don't have a ticket will fall in line here.

Figure 9. View at the Ticketing Machine

Figure 9 shows the ticketing machine where the passengers can buy a load for their beep cards.

Figure 10. View at the Entrance Gate Machine

Figure 10 shows the entrance gate machine where the passengers will tap their cards in order to enter.

Figure 11. View at the Second Floor of the Model

Figure 11 shows the second floor where the train will arrive and pick up all the passengers.

VI. CONCLUSION

Legarda Station is the least busy station in LRT 2, according to our analysis and there is a certain month, like December, when it gets packed. The simulation depicts the daily routine at LRT 2 Legarda Station as well as the struggles of each passenger. They can use this kind of simulation to have better management in handling their services and accommodating passengers that they can apply to other stations as well.

VII. RECOMMENDATIONS

The following recommendations may be necessary in the future:

- Future researchers may use different stations of LRT 1 or LRT 2.
- Future researchers can enhance the design of the simulation.
- Future studies may consider a different time frame to simulate.

REFERENCES

[1] Electronic Freedom of Information "The Daily Riders of LRT2 Legarda Station in The Philippines" Light Rail Transit Authority. April 6, 2022.

[2] Howard, S., Gill, L. and Wong, P., n.d. Review and Assessment of Train Performance Simulation Models. [online] Onlinepubs.trb.org. Available at: <https://onlinepubs.trb.org/Onlinepubs/trr/1983/917/917-001.pdf > [Accessed 10 July 2022].

[3] Lindfeltd Anders "Methods for simulation and evaluation of timetables, delays and infrastructure" Railway capacity analysis. 2015.