Simulation and Analysis of Alabang – Zapote Road Traffic Flow

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***Abstract*—** Because of rising traffic demand, the difficulties with city traffic are becoming more severe. The traffic conditions and management systems are also becoming increasingly complicated. Increased construction of traffic simulation models has been aided by considerable advances in information technology. Traffic simulation is a useful technique for modeling the functioning of complex traffic systems and for analyzing the causes and possible solutions to issues like overcrowding and traffic safety. The creation of a broad urban traffic simulator is the focus of this research. A simulator allows for a controlled examination of the traffic system without disrupting real-world traffic. The ultimate goal was to create a flexible research and planning tool that could be used to investigate the traffic system and its relationships in greater depth. The traffic count data will be gathered hourly on foi.gov.ph from the Metropolitan Manila Development Authority.

I. INTRODUCTION

In nature, road traffic is always shifting. Traffic circumstances are changing as a result of new cars and infrastructural technologies. Traffic is a serious and pressing issue. Failures in the interplay between the driver, the automobile, and the traffic systems create many accidents. The number of contacts involving driving is rising.

The primary motive for adjustments and regular advancements in the road system has typically been to expand capacity and improve service quality in order to boost speed and minimize queue time. Other concerns, such as traffic safety and traffic's influence on the environment, are receiving greater attention these days. It is critical that the actions performed give significant advantages in order to alleviate traffic congestion, safety, and pollution. Proposed traffic system changes must thus undergo impact evaluations. For these kinds of evaluations, traffic simulation models that explain traffic system activities have been shown to be useful.

People consider the Philippines' traffic to be one of the worst in the world. According to a Waze survey performed in 2015, Metro Manila has the "worst traffic in Southeast Asia" [1]. Despite the closure, Manila has the 4th worst traffic congestion in the world, according to Business World. Due to the coronavirus shutdown, annual traffic congestion in Metro Manila decreased dramatically in 2019, yet the Philippine capital remained the fourth-most crowded city in the world, according to data from a location technology firm [2]. Las Pinas has some of the worst traffic congestion in the Philippines. Major highways, potholes, diggings, and inept traffic enforcers all contribute to Las Pinas traffic congestion.

The goal of the research is to use historical raw data to simulate and evaluate traffic flow on the Alabang-Zapote route. Hourly traffic counts are among the datasets that will be used. A request to the Metropolitan Manila Development Authority will be used to acquire the hourly traffic count on the Freedom of Information Philippines website. The data will help determine traffic flow in Alabang and along Zapote Road.

This paper is divided into six main sections. The second section addresses the background of Las Pinas area and its traffic congestion and approaches in traffic simulation. The third section introduces the experiments performed to do the simulation, and the fourth section provides the results of the said experimentations. The fifth section focuses on the investigations of the related literature of the study. Finally, in the sixth section, the relevant conclusions are drawn based on this study.

II. BACKGROUND

The city of Las Pinas, specifically in Zapote Street in Alabang, is known to have heavy traffic due to numerous intersections as well as the lack of functioning traffic lights. In place of traffic lights, traffic enforcers have been in charge of controlling the flow of traffic, which is deemed to be ineffective due to the daily traffic jam.

Various projects have been conducted in Alabang to aid the decongestion of traffic and lessening the burden of travelling. Examples taken from the Department of Public Works and Highways (DPWH) are the 18-km Zapote River Drive by Cynthia Villar which also aims to ease flooding, and the Sucat-Alabang Skyway which aims to reduce travel time by around 50%. However, the traffic in Zapote Street can still be congested in Zapote Street at most times.

Lack of functioning traffic lights is one of the causes of traffic that greatly burdens riders (Liew, S., 2018). This gives the hypothetical question: would traffic lights be able to control the traffic flow of Zapote Street better than the current traffic enforcers? The researchers aim to simulate the traffic flow of Zapote Street and to get the peak hours of traffic jam, and to see the impact of adding traffic lights. The category of this traffic simulation is macroscopic, in which traffic flow is the basic entity, and the simulation modelling software to be used is AnyLogic.

III. REVIEW OF RELATED WORKS

Traffic has been a very big problem in the Philippines considering the number of vehicles on the roads, the narrow roads, the road repairs and poor traffic flow in some areas. These factors greatly contribute to the traffic congestion here in the Philippines, mostly in rural areas like Las Pinas-Zapote Road. Traffic flow can be very vital in one country's economy and to the lives of many people. Highway networks that are designed and managed well minimize the cost of delivering products, reduce energy usage, and save countless person-hours of driving time. Many nations have invested considerably in road construction and traffic control systems in order to decrease congestion. Because of human interactions and man–machine interactions, traffic systems have become complex systems. Because of the complexity of this sort of system, simulation is essential before implementation to test, evaluate, and show a recommended course of action.

Significant advances in information technology have aided in the creation of traffic simulation models. Traffic simulation is an important technique for modeling the operations of dynamic traffic systems and aids in the analysis of the causes and potential solutions to traffic issues such as congestion and traffic safety [6]. Traffic simulation can be used in various different ways to help the road-planning and traffic flow management. These models of traffic simulation are intended to simulate the time-varying traffic operations of a road network. Today's traffic simulation models use a scanning simulation method that is time-based [7]. The manipulation of a model in such a manner that it acts on time or space to compress it, allowing one to notice interactions that would otherwise be invisible due to their separation in time or space [8]. To understand more, a simulation model is a mathematical representation of a dynamic system that may be used to derive inferences about the attributes of the real system. A simulation model's primary independent variable is time. The simulation model can use a time-based scanning method, in which the model is updated at regular intervals, or an event-based strategy, in which the model is updated only when the state of the system changes [7].

Traffic simulation programs are classified into three types [8] (microscopic, mesoscopic, and macroscopic). Microscopic models forecast the status of individual cars in a continuous or discrete manner, with a primary focus on individual vehicle speeds and positions. Microscopic simulation models give a thorough picture of the traffic process, making them ideal for assessing complex traffic infrastructure and Intelligent Transportation Systems, which frequently include complex traffic management, safety, and information systems [6].

Microscopic models represent traffic dynamics in more detail, yet are faster and easier to deploy and calibrate than macroscopic models [6]. Macroscopic models combine the description of traffic flow with the effectiveness metrics of speed, flow, and density. Mesoscopic models incorporate elements from both macro and microscopic models. Mesoscopic models bridge the gap between the aggregate level approach of macroscopic models and the individual interactions of microscopic models by defining traffic elements in great detail while designing their behavior and interactions in less depth [8]. Therefore, both Macroscopic and Mesoscopic are most suitable for modelling large networks, while microscopic models are usually applied to smaller areas.

Road segments, junctions, cars, traffic lights, signs, and sensors are the primary entities in the traffic network, and they are represented as agents. Upon careful consideration to these factors, it is called an agent-based simulator. The traffic network may be divided into areas based on geographical borders. Agents belonging to entities in the same region are housed in the same agent community, allowing for high-bandwidth, low-latency communication [9].

IV. SIMULATION MODELING METHODS

The researchers developed Alabang Zapote Road traffic model to evaluate and assess the frequency of incoming vehicles to its specified routes per hour.

Dataset

The dataset used for modeling the Alabang Zapote Road traffic was gathered from Metropolitan Manila Development Authority (MMDA) Freedom of Information Team, the researchers requested the hourly traffic count data from incoming vehicles Alabang Zapote Road. MMDA was able to provide the, however only three road intersections were provided, namely: Alabang-Zapote Rd- CAA Rd - BF Resort Drive, Alabang-Zapote Rd - Admiral St., and Alabang-Zapote Rd - Marcos Alvarez.

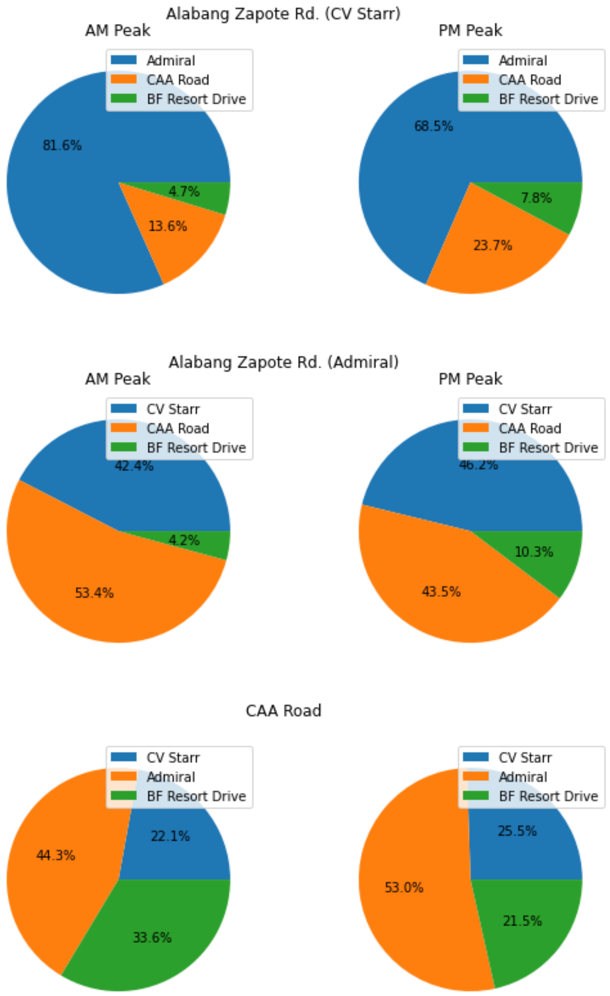
The dataset only provided the total count of vehicles from incoming roads but was not recorded or distributed by time interval, but was able to provide the counts of vehicles during peak hours. Simulating the count of vehicles from hourly time intervals is not possible, but the researchers will opt to simulate the count of vehicles per cycle during the peak hours instead.

Tables and figures below show the summary of the dataset provided: Volume of vehicles going to a specific route during its peak hour.

Source	Destination	Volume (AM)	Volume (PM)	AM / PM Peak
CAA Rd	Alabang Zapote Rd (CV Starr Ave)	44.3%	53%	7:00 AM-8:00 AM 1:00 PM - 2:00 PM
	Alabang Zapote Rd (Admiral)	33.6%	21%	
	BF Resort Drive	22.1%	26%	
Alabang Zapote Rd (CV Starr Ave)	CAA Rd	13.6%	23.7%	
	Alabang Zapote Rd (Admiral)	81.6%	68.5%	
	BF Resort Drive	4.7%	7.8%	
Alabang Zapote Rd (Admiral)	CAA Rd	42.4%	46.2%	
	Alabang Zapote Rd (CV Starr Ave)	53.4%	43.5%	
	BF Resort Drive	4.2%	10.3%	
BF Resort Drive	CAA Rd	20%	38%	
	Alabang Zapote Rd (CV Starr Ave)	70%	47%	

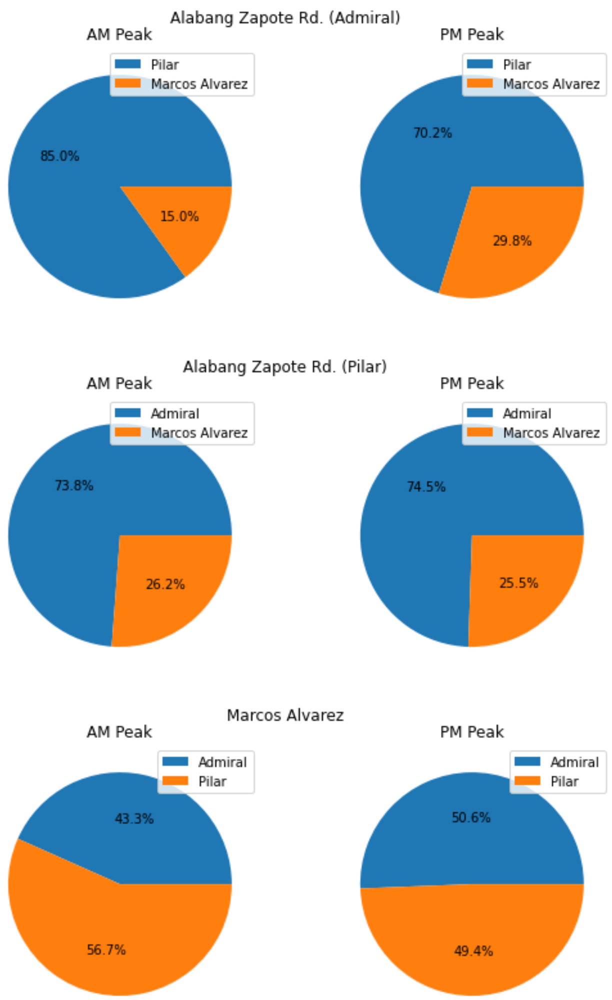
	Alabang Zapote Rd (Admiral)	10%	15%	

Table 1: Alabang-Zapote Rd - CAA Rd Junction



Source	Destination	Volume (AM)	Volume (PM)	AM / PM Peak
Alabang Zapote Rd (Admiral)	Alabang Zapote Rd (Pilar Rd)	85%	70.2%	7:00 AM - 8:00 AM 5:00 PM - 6:00 PM
	Marcos Alvarez Ave	15%	29.8%	
Alabang Zapote Rd (Pilar Rd)	Alabang Zapote Rd (Admiral)	73.8%	74.5%	
	Marcos Alvarez Ave	26.2%	25.5%	
Marcos Alvarez Ave	Alabang Zapote Rd (Admiral)	50.6%	43.3%	
	Alabang Zapote Rd (Pilar Rd)	49.4%	56.7%	

Table 2: Alabang-Zapote Rd - Marcos Alvarez Ave Junction

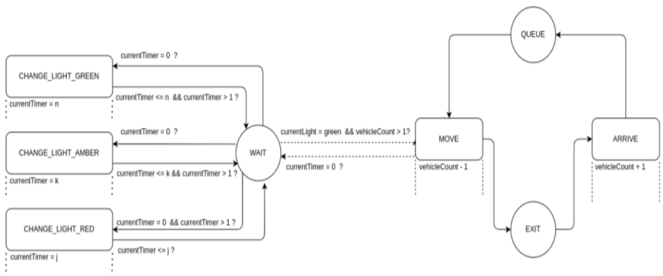


DES-Agent Based Model Conceptualization

This study used the Discrete Modeling Simulation (DES) and Agent-Based approach to describe the flow of the traffic in the model using the simulation software, Anylogic [10]. The conceptualization of model is discussed as follows:

1. Vehicles will arrive at the road
2. When the vehicle is arriving at the intersection, it will check the current state of traffic lights.

3. The traffic lights will have a timer, based on seconds.
4. Each color or state of traffic lights will have its corresponding timer, after the timer reaches its time limit, the traffic lights will change their color/state.
5. The color of traffic lights will affect the action of the vehicles.
6. If it’s green, the vehicle will proceed to its route, based on its probability.
7. If it’s amber, the vehicle will proceed to slow down towards the end of the road.
8. If it’s red, the vehicle will stop and wait in the queue.



Alabang-Zapote Rd Simulation Flowchart

Validation

The simulated results will be compared against the dataset provided by the MMDA. Researchers will use Two tailed T-Test to check if there is no significant statistical difference between the observed and simulated total count of vehicles in a specific road. (This will also serve as the null hypothesis of our test).

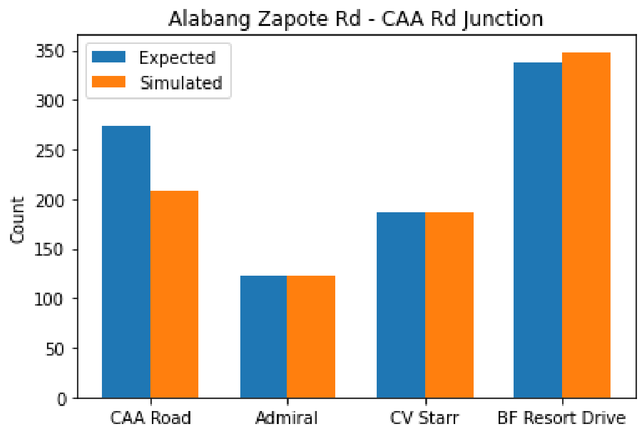
V. EXPERIMENTS AND RESULTS

Validation Results

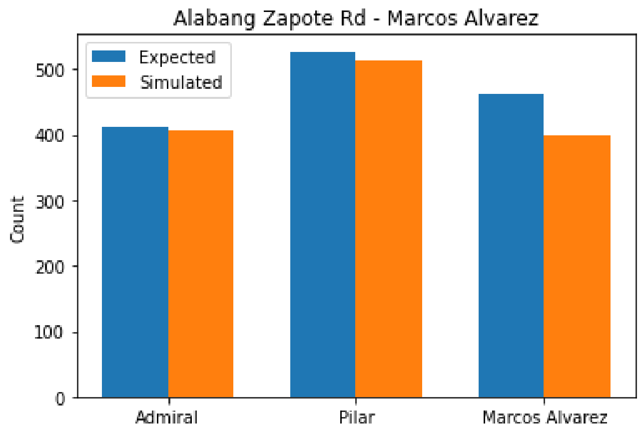
The model ran for 1000 iterations to guarantee the narrowness of the average count per hour in a 120-second traffic cycle. Data from the dataset shows that the expected value of vehicles coming from the intersection in Alabang Zapote Rd - CAA Rd Junction: CV Starr, Admiral, CAA Road and BF Resort Drive during the AM Peak are 273.5, 123, 187 and 337 respectively, and from PM Peak are 192, 338.5, 235 and 85 respectively. While vehicles coming from the Alabang Zapote Rd - Marcos Alvarez junction: Admiral, Pilar, and Marcos Alvarez during the AM Peak are 412, 527, 462.25, and in the PM Peak are 458, 540, and 242 respectively.

Results from the simulated model shows that during AM Peak, the count of vehicles in Alabang-Zapote Rd - CAA Rd Junction are 207, 122, 186, and 348, and 196, 84, 192, 333 during the PM Peak. The results from Alabang-Zapote Rd - Marcos Alvarez Ave are 405, 514, and 399 during the AM Peak, while in PM Peak are 434, 525, and 239.

Using Two tailed T-Test with a confidence level of 95%, the simulated model got 0.84 in AM Peak and PM Peak scored 0.89 in Alabang-Zapote - CAA Rd Junction. Alabang-Zapote Rd - Marcos Alvarez junction scored 0.61 during the AM Peak and 0.91 in PM peak. The scores in the T-Test showed that p>0.05, which suggests that our simulated model should accept the null hypothesis. Thus, the simulated model is close enough to the dataset.



Expected vs Simulated count in Alabang Zapote Rd - CAA Rd Junction



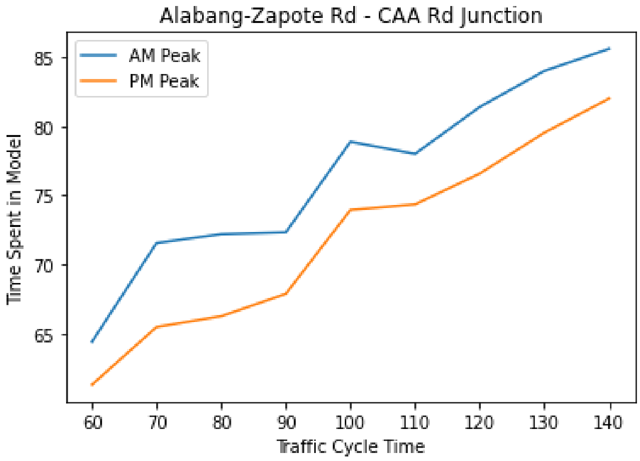
Expected vs Simulated count in Alabang Zapote Rd - Marcos Alvarez Junction

Analysis

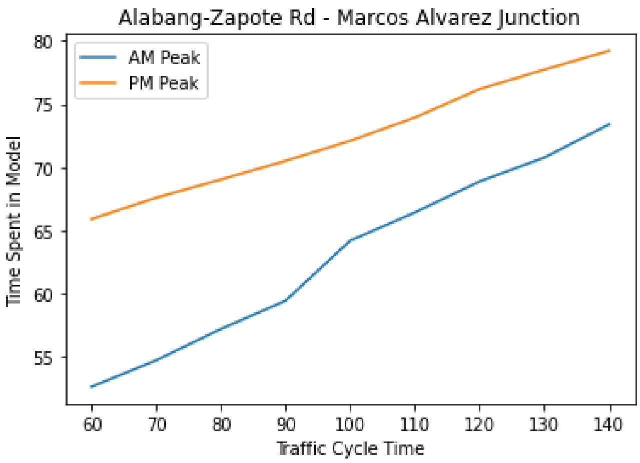
Traffic cycle vs Number of Arrivals

Researchers have simulated the model with different traffic cycles to see the relationship between the number of traffic cycles and how it affects the number of arrivals in the traffic. The Figures below show the graph of the number of arrivals in the y-axis, and the number of arrivals in the x-axis.

As the traffic cycle increases, the number of arrivals decreases, showing an inverse relationship between the two variables.



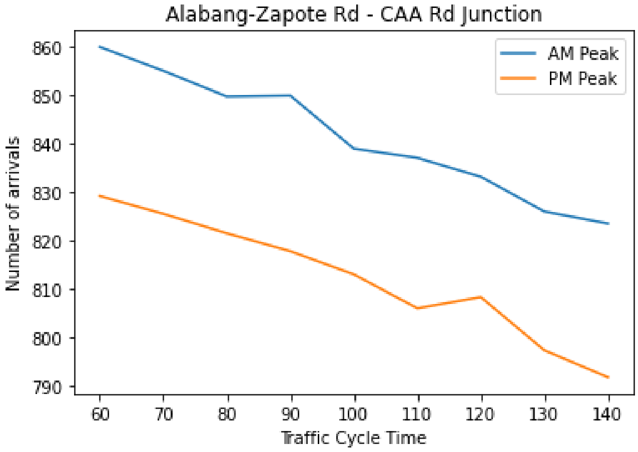
Time Spent in Model in different traffic cycle times in Alabang-Zapote Rd - CAA Junction

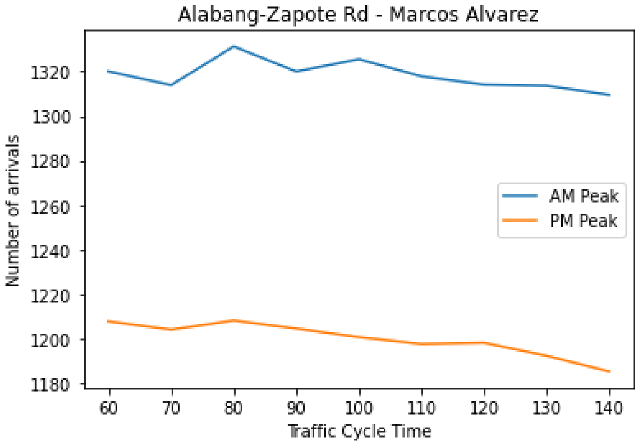


Time Spent in Model in different traffic cycle times in Alabang-Zapote Rd - Marcos Alvarez Junction

Traffic Cycle vs Time spent in model

Researchers have also simulated the time that vehicle spent in the model with different traffic cycles. The figures below show the relationship between the two variables, and it shows that as the number of traffic cycles increases, the time spent of a vehicle in the model also increases - a direct proportion relationship between the two variables.





VI. CONCLUSIONS

The researchers were able to develop and simulate a traffic model in Alabang-Zapote Road that is close approximation to real world data using discrete event modeling approach. Analysis from the simulation shows the relationship how the traffic cycle affects the number of arrivals (inverse relationship) and as well as the time the vehicle spent on the road (direct relationship).

Due to the dataset limitations, the model was only able to simulate the peak hours of the two intersections: Alabang-Zapote Rd - CAA Rd Junction and Alabang-Zapote Rd - Marcos Alvarez Junction.

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