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Simulation-Based Analysis of Flyover and Traffic Light in Jose Abad Santos Avenue- Sta. Rita- Guagua Road Intersection Using PTVVISSIM as a Basis for Traffic Condition Improvement

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Abstract:

This study focuses on the simulation of the JASA Sta. Rita Guagua Road Intersection to compare and evaluate the traffic lights and flyover effectiveness in terms of travel time, delay time, and level of service using PTV VISSIM. A traffic survey was performed by manual counting and recording of traffic during peak hours in the morning and afternoon to obtain the needed traffic volume data to execute the simulation. Using the collected data, the volume-capacity ratio was calculated, and results show that the current level of service at the intersection attained a rating of "F" which signifies that traffic congestion occurs at the intersection. Subsequently, the simulation was done to determine and compare the performance of traffic lights and flyovers using PTV VISSIM. Moreover, to establish the advantages of the study, projections of the traffic volume for 5 and 10 years were considered and performed. The results revealed that a flyover can be used to improve traffic conditions along the JASA Sta. Rita Guagua Road Intersection.

Keywords **—Traffic flow, Traffic Congestion, Traffic Simulation, Traffic Software, PTV VISSIM.**

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I. INTRODUCTION

The transportation system plays a vital role in the economic growth of a country. It takes part in a nation's advancement, modernization, and development. As time advances, public concern surrounding the impacts of the increasing number of vehicles in urban areas has risen. The efficiency and effectiveness of transportation systems can be seen from several aspects involving traffic flow, environmental quality, security, and traffic congestion control.

Traffic flow and congestion are among the most important social and economic problems related to transportation in developed countries. In this regard, managing traffic in a congested network requires a clear understanding of traffic flow behavior. Traffic congestion arises due to rapid population growth, a dramatic rise in urbanization, poor transport systems, inadequate transport facilities, and the rising number of private vehicles.

Prior research studies reviewed traffic congestion in terms of measuring metrics. In order to measure the extent of congestion, several metrics have been created that take into account various performance factors. These metrics can be classified into five distinct categories, namely speed, travel time, delay, level of service (LOS), and congestion indices (Afrin & Yodo, 2020).

Traffic management control improvement, improved public transport services, an increase in funding for transport facilities, the application of modern technology, and the overall coordination of transport and land-use policies and regulations are essential to reduce congestion (Kumar et al., 2021).

In addition, traffic signals are a key aspect influencing the operation of cars at intersections, and determining the ideal scenario for traffic lights at crossings is critical and urgent. There are numerous signal timing optimization models for crossings based 2 on various algorithms and models. Then, intersections improved significantly in terms of capacity, delays, and pollution (Pan et al.,2021).

Moreover, the traffic simulation approach is a widely utilized method in studies on traffic modeling, planning, and development of traffic networks and systems (Azlan, N., and Rohani, M., 2018). The use of traffic simulators allows for the forecast of traffic behavior and produces useful projections of future status considering various traffic conditions.

Through continuous studies and research, a different approach to reducing traffic congestion is being presented that may be utilized by engineers and other agencies that focus on managing transportation problems.

II. REVIEW OF RELATED LITERATURE

A. Traffic Flow

Traffic management on roads can be improved through field studies and field experiments with real traffic flows. In addition to the scientific question of the reproducibility of such experiments, cost and safety also play a dominant role. Due to the complexity of traffic flow systems, analytical approaches may not yield the desired results. Therefore, traffic flow (simulation) models, which characterize the behaviour of complex traffic flow systems, have become indispensable tools in traffic flow analysis and experiments.

In controlling road traffic flow, several traffic control measures are carried out according to predetermined traffic management policies and plans. As mentioned in the study by Tayyab (2019), access control regulation improves services, gives traffic priority, and lowers traffic accidents. To reduce collisions, access to the major freeways should be controlled. The best approach to preventing accidents at intersections is to install stoplights, which give drivers more time to consider their options before crossing onto the highway. At intersections, traffic safety is provided by traffic control devices like traffic signals. The absence of a control device at a junction is a major contributor to collisions involving vehicles, bikes, and pedestrians.

Lighthill and Whitham (2014) presented traffic modeling research as a model based on the similarity of particles in vehicles and fluids in traffic flow. Since then, the mathematical description of traffic flows has become a topic of active research and 5 discussions for traffic engineers. The traffic flow has two primary types:

uninterrupted flow and interrupted flow. An uninterrupted flow exists when no external elements, such as traffic control signals, are present that might interrupt traffic flow. While interrupted flows have fixed elements that can interrupt traffic flow, these elements are traffic control signals, stop signs, yield signs, and other types of control that stop traffic. (Sharma & Swami, 2016).

B. Traffic Congestion

The presence of traffic congestion occurs when the number of vehicles exceeds the capacity limit of the road. Congestion is an inevitable result of limited transportation resources such as road space, parking lots, traffic lights, and inadequate traffic management. Ghazal et al. (2016) stated that traffic light control systems are widely utilized to monitor and manage the flow of vehicles at various road intersections. Moreover, it is an essential tool to reduce congestion at intersections for effective traffic flow management. It also ensures that traffic moves at a constant speed along a predetermined course. Furthermore, a study about intelligent traffic light control algorithms maintains the effective scheduling of road traffic (Younes &Boukerche, 2016).

According to Salatoom and Taneerananon (2015), to reduce traffic congestion at an at-grade intersection near a big city, one method is the construction of a special bridge at the old junction in two directions on one of the main highways. It facilitates the traffic volume in the directions of the bridge, but the infrastructure cannot fully solve all of the problems, especially on the secondary road. The bridge, although it relieves the traffic congestion at the crossroad, still uses controls similar to those in place "before" such as the fixed timing of traffic signalization. Following this method of control, it was discovered that approximately 30 to 35% of all traffic volumes were diverted to the bridges, and time delays were reduced by 30% over the same period.

Moreover, the intersection was evaluated and compared in terms of road safety and efficiency in 3 time periods: before (at-grade intersection), during, and after the construction (flyover intersection). The study used traffic simulation software for 6 processing data as an aid for designing and evaluating. The software can be used to evaluate alternative intersection designs in terms of capacity, level of service, and wide range of performance, and it can also determine appropriate periods for phasing traffic signals. As a result, the construction of the flyover provided a benefit in terms of reduced travel time and vehicular operating costs.

Furthermore, by easing traffic congestion, flyovers contribute to the improvement of the traffic control system. Road collisions are at lower risk when there is less horizontal curvature. In the Philippines, the Department of Public Works and Highways (DPWH) released Department Order No. 53 Series of 2016, which states that the minimum vertical clearance required for a flyover is 5.33 m. It is the total height needed considering 4.88 m for vehicle clearance, 0.15 m allowance for future additional road surfacing, and 0.30 m allowance to reduce truck impact risk.

In the study of Vanshkar and Bhatia (2019), less horizontal bending lowers the chance of off-road collisions. The effectiveness of the flyover construction in reducing traffic congestion has been evaluated in terms of time savings, fuel savings, and traffic congestion. Flyovers have three primary components. The substructure, or foundation, is what distributes the bridge's loaded weight to the earth first. It is made up of elements like columns (also known as piers) and abutments. The connection between the end of the bridge and the road supported by the soil is known as an abutment, and it offers support for the flyover's end sections. The horizontal platform that extends between columns is the second component of the flyover's superstructure, followed by the deck (UrRahman et al., 2020).

C. Traffic Simulation

The term "traffic simulation" refers to the use of virtual reality technologies to recreate traffic on the road. It has many applications, including urban traffic strategic planning, road congestion assessment, and urban traffic simulation. The aim of the simulation is to achieve realistic effects, autonomous vehicles, and high computing efficiency in motion simulation. When used as part of a simulation experiment, traffic simulation can mimic actual traffic conditions and represent the driving styles of 7 moving cars. It can simulate complex and heterogeneous traffic and display the spatial-temporal changes in traffic flow (Liu et al., 2020)

The study by Utomo et al. (2020) investigated the roadway network in Bandung, West Java, Indonesia, by evaluating the performance of the current condition of the traffic in the area using PTV VISSIM. To reduce the traffic jam, a network improvement is proposed in the said area. The traffic simulation software was utilized to assess the performance of the proposed roadway network when implemented. Based on the travel time, travel speed, and queue length, the existing and proposed traffic conditions were evaluated and analyzed. The result of the computational experiment shows that the proposed condition positively improves and reduces traffic congestion in the area.

Moreover, related studies show that through traffic simulation a proposed flyover will effectively alleviate poor traffic flow along the Del Rosario intersection in the City of San Fernando, Pampanga (Young et. al, 2021).

D. PTV VISSIM

PTV (Planung Transport Verkehr) or Planning Transport Traffic, is a German firm that specializes in traffic and transportation software and consultancy services, as well as mobility and logistics. It is a program for simulating traffic using models that are used to resolve the real-time profiles of two forms of traffic depending on urban or public transportation and to investigate their time intervals and driving behaviors (Lu & Yan, 2019). Various scenarios have been compared using PTV VISSIM. Additionally, the simulation has been validated based on the average speed and delay of cars seen on several approaches to the intersection and calibrated for the current traffic circumstances (Abera, L., 2018). VISSIM is easy-to-use software with a high degree of flexibility. It is regarded as a versatile and accurate traffic simulation tool that can be applied to both simple and complex traffic situations.

Additionally, VISSIM appears to have advances in accuracy, flexibility, and education categories in comparison with the Autodesk InfraWorks 360 simulation software (Avramovic, S., & Johnsson, E., 2017). VISSIM also obtained a slightly 8 higher score in the simulation outputs category. While InfraWorks obtained a higher efficiency score, issues with regard to more complex models were observed, which made it time-consuming. InfraWorks offers many automatic settings that make life easier for the user. Although this appears to be efficient, it frequently limits the user's flexibility and the model's accuracy.

On the other hand, according to Saidallah et al., (2016), AIMSUN and TransModeler are capable of simulating three models at once while other traffic simulators produce a microscopic model. In addition, a continuous simulation of traffic is done through SUMO, VISSIM, MATSim, and AIMSUN, whereas ARCHISIM, CORSIM, Paramics, and TRANSIMS use a discrete system. While AIMSUN, ARCHISIM, and SUMO require complex coding, VISSIM and SimTraffic use simple coding for the road network.

Among the other simulators, AIMSUN, Paramics, and VISSIM were shown to be more flexible in terms of coding flexibility in the various infrastructure elements. The vehicles' type and size, along with pedestrians, emergency vehicles, and public vehicles, are mostly supported by commercial simulators in contrast to open-source simulators. Additionally, AIMSUN, Paramics, and VISSIM efficiently utilize wireless sensors, which are less expensive. AIMSUN, MATSim, TransModeler, and VISSIM use Geographic information systems (GIS), while other simulators support it only partially or not at all. VISSIM's component object model (COM) programming interface is a key feature that distinguishes it from other simulation models. C++, Visual Basic, or Python are computer programming languages that users can develop and implement on the VISSIM network through the COM interface. The COM interface provides access to the network topology, signal control, path flows, and vehicle behavior to user-developed applications, allowing VISSIM to model complex control logic and sophisticated transportation systems and components.

Enhancing road traffic management can be achieved through the implementation of field studies and experiments that involve observing and analyzing real traffic flows. It is of utmost importance to ascertain the specific characteristics of traffic in a given area, enabling the identification of unfavorable traffic conditions that 9 contribute to congestion. Congestion arises when the number of vehicles surpasses the road's capacity. Leveraging traffic simulation techniques facilitates the assessment of the current traffic condition in the area by striving for accurate and realistic simulation outcomes. To this end, the utilization of traffic simulation software, such as PTV VISSIM, proves instrumental in simulating both traffic lights and flyovers at the JASA– Sta. Rita Guagua Road intersection.

Although simulation studies on flyovers and traffic lights using PTV VISSIM have been conducted individually, there exists a research gap in terms of a comprehensive comparison of these two components within a unified simulation framework. Existing research often focuses on analyzing flyovers or traffic lights separately, without considering their combined effects and potential synergies. Consequently, there is a need for research that directly compares the simulation of flyovers and traffic lights using PTV VISSIM to better understand their interdependencies and optimize their integration for improved traffic flow efficiency, safety, and environmental sustainability.

Flyovers and traffic lights are critical elements of transportation infrastructure designed to enhance traffic operations and alleviate congestion. However, the conventional approach of treating flyovers and traffic lights as independent entities may overlook the intricate interactions and optimization opportunities that arise when they are integrated. By utilizing the advanced simulation capabilities of PTV VISSIM, which allows for detailed modeling of traffic dynamics, it becomes possible to simulate and compare the integrated performance of flyovers and traffic lights. Understanding the comparative effects and trade-offs between these components can inform transportation planners and engineers in making informed decisions regarding their design and operation.

By addressing this research gap, the study aims to contribute to the optimization of transportation systems by providing evidence-based insights on the comparative effects and potential synergies between flyovers and traffic lights. The findings will facilitate informed decision-making in the design, operation, and management of 10 Figure 1. JASA- Sta. Rita- Guagua Road Intersection (Google Earth) integrated transportation infrastructure, ultimately improving traffic flow efficiency and enhancing overall urban mobility.

III. METHODOLOGY

This chapter presents the research method needed to achieve the objectives of this study. This includes the research design, data collection procedures and data analysis.

A. *Research Design*

The research study employed a quantitative descriptive method and comparative research approach.

According to Mcleod (2023), quantitative research involves the gathering of numerical data and its analysis using statistical techniques. The primary objective is to generate objective, empirical data that can be quantified and expressed numerically. This type of research is frequently employed to test hypotheses, uncover patterns, and make predictions.

Mertler (2014) discussed that researchers cannot directly influence independent variables in descriptive research because their manifestations have already occurred or because they are inherently not easily manipulated. The use of PTV VISSIM will identify the effectiveness of the flyover and traffic lights at the intersection.

B. *Data Collection*

The study is conducted from March 13, 2023 to March 19, 2023 at the JASA–Santa Rita–Guagua Road Intersection. The study was carried out personally by collecting the data and records of traffic volume.

1) ***Local Authorities:***The researchers submitted a letter to DPWH Region III at Sindalan, City of San Fernando Pampanga and Municipality of Guagua requesting the Level of Service (LOS), Peak Hours, Geometric Plans, Traffic Conditions and Signalization Conditions.

TABLE I
TRAFFIC VOLUME COUNT SURVEY (PEAK HOUR)

.Traffic Volume Count Survey (Peak Hour Summary)											
Location		Direction			Date	Movement No.	Lane Movement		Survey Period		15 Minute Traffic Volume
Vehicle Type											
Interval	Motor	Passenger Car	Jeep	Goods Utility	Small Bus	Large Bus	2 Axle Truck	3 Axle Truck	4 Axle Truck	5 Axle Truck	
TOTAL											

2) ***Manual Counting Method:***This method was used by the researchers to gather the relative data needed in this study.The researchers manually counted the traffic flow at JASA- Sta. Rita- Guagua Road Intersection during peak hours using the recorded video footage. The counting took place over a 15-minute interval, with the aim of gathering information about the vehicle flow rate at the intersection. This was done by manually counting the vehicles that passed through the intersection during the 6:00 A.M to 7:00 A.M and 5:00 P.M to 6:00 P.M. time period. Table I was utilized for tallying the traffic volume.

The data being counted includes traffic volume during peak traffic hours, which are:

1. Vehicles from San Fernando
   a. Shoulder of the road to Sta. Rita
   b. Turning left to Guagua
   c. Going straight to Olongapo

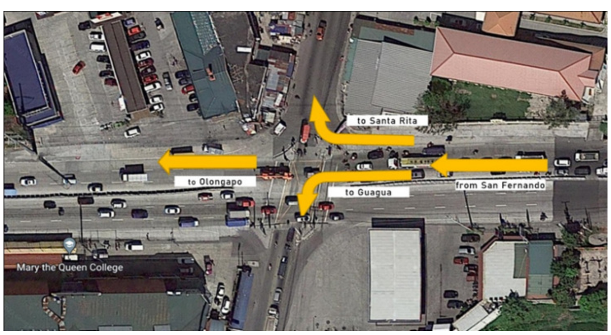


Fig. 1Vehicle flow from San Fernando

2. Vehicles from Guagua
   a. Shoulder of the road to San Fernando
   b. Turning left to Olongapo
   c.GoingStraight to Sta. Rita

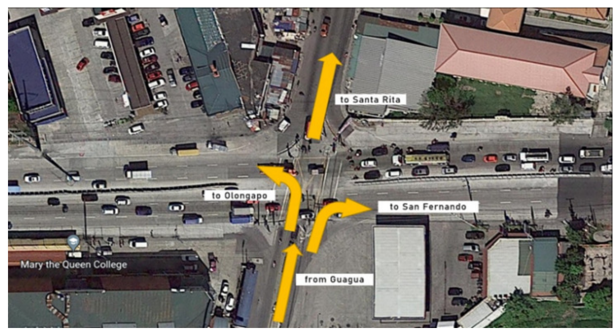


Fig. 2Vehicle flow from Guagua

3. Vehicles from Sta. Rita
   a. Shoulder of the road to Olongapo
   b. Turning left to San Fernando
   c. Going straight to Guagua

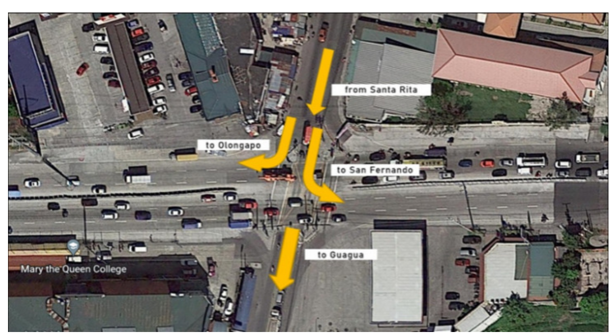


Fig. 3Vehicle flow from Sta. Rita

4. Vehicles from Olongapo
    a. Shoulder of the road to Guagua
    b. Turning right to Sta. Rita
    c. Going straight to San Fernando

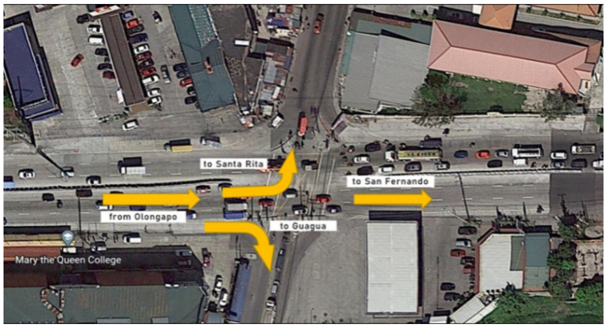


Fig. 4Vehicle Flow from Olongapo

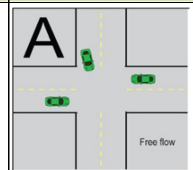
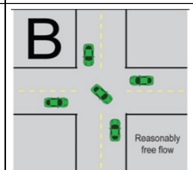
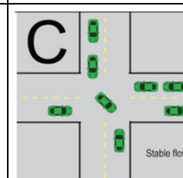
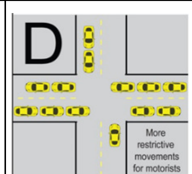
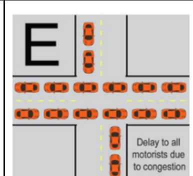
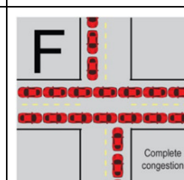
C. Data Analysis

This process involves interpreting the calculatedvolume capacity ratio to identify the current condition at the study area and summarizing the data gathered from the manual counting method that will be inputted in the simulation process to obtain the results regarding the delay time, travel time, and level of service in PTV VISSIM.

1) Level of Service:The term "level of service" was introduced in the Highway Capacity Manual (HCM) to describe the quality of a road or facility as experienced by users. The level of service can be used to assess the effectiveness of a road or facility, and to identify potential improvements or upgrades that may be needed.

To determine the level of service for road sections experiencing traffic congestion, a calculation system known as the Volume Capacity Ratio (VCR) is used to measure the hourly design traffic volume over the carrying capacity of the roadway. The Highway Capacity Manual and DPWH Planning Manual designates six levels of service ranging from A to F, with A as the most ideal condition and F representing the worst. Below is the table for level of service in accordance to the manual:

TABLE II
CLASSIFICATION OF LEVEL OF SERVICE FOR ROADWAYS

Level of Service	Characteristics	VCR	Illustration
A	**Free flowing traffic** Condition of free-flow with high speeds and low traffic volume. Drivers can choose desired speeds without delays.	0.00-0.19	
B	**Relatively free flowing** In the zone of stable flow. Drivers have reasonable freedom to select their speed.	0.20-0.44	
C	**Moderate traffic** In the zone of stable flow. Drivers are restricted in selecting their speed.	0.45-0.69	
D	**Moderate/heavy traffic** Approaches unstable flow with nearly drivers restricted. Service volume corresponds to tolerable capacity.	0.70-0.84	
E	**Heavy traffic** Traffic volumes near or at capacity. Flow is unstable with momentary stoppages.	0.85-1.00	
F	**Saturation traffic volumes**, stop and go situations Forced or congested flow at low speeds. Long queues and delays.	>1.00	

Source: Highway Capacity Manual and DPWH Planning Manual

The determination of Level of Service along the intersection requires the peak hour volume over the capacity depending on the width of the road.

$$Volume\ Capacity\ Ratio\ (VCR) = \frac{V}{C}$$

Where:
V- volume in terms of passenger car unit per hour
C- capacity of the roadway

The intersections of the maximum traffic operations have been identified for the conduction of traffic surveys. To calculate the volume needed to satisfy the equation, the peak hour traffic data have been collected through manual counting method. The traffic volume count survey of peak hour has been converted into Passenger Car Unit (PCU) for uniformity in the units using Table III.

TABLE III
PASSENGER CAR EQUIVALENT FACTORS

VEHICLE TYPE		
NO.	**DESCRIPTION**	**PCEF**
1	Motor- Tricycle	*2.5*
2	Passenger Car	*1.0*
3-5	Passenger and Goods utility and Small Bus	*1.5*
6	Large Bus	*2.0*
7	Rigid truck, 2 axles	*2.0*
8	Rigid truck, 3+ axles	*2.5*
9	Truck semi- trailer, 3 and 4 axles	*2.5*
10	Truck semi- trailer, 5+ axles	*2.5*
11	Truck trailers, 4 axles	*2.5*
12	Truck trailer, 5+ axles	*2.5*

PCU was obtained by multiplying the total traffic volume count survey of peak hour by the respective passenger car equivalent factors (PCEF) of different types of vehicles that influence the traffic survey. For the capacity, basic hourly capacity in the car units table was utilized as shown in Table IV. The carriage width consideration is per lane only.

TABLE IV
CALCULATION OF BASIC HOURLY CAR CAPACITY (BHCC)

CARRIAGE WIDTH	RURAL	URBAN
Single less than 4 meters	600	600
4.0 -5.0 meters	1200	1200
5.1 – 6.0 meters	1900	1600
6.1 – 6.7 meters	2000	1700
6.8 – 7.3 meters	2400	1800
2 x 6.7 or 2 x 7.3 meters	7200	6700

2) Peak Hours: Peak hour is a time when there is a lot of activity and demand for a particular service or resource.

Peak hour data was provided by the local government of Guagua and DPWH. 6:00 A.M to 7:00 A.M and 5:00 P.M to 6:00 P.M are considered peak hours in JASA- Sta. Rita- Guagua Road Intersection.

The researchers set up a video recording camera at the four locations in the study area, which are Sta. Rita Road, Guagua Road, San Fernando Road, and Olongapo Road, where the peak hours in the morning and afternoon were recorded. One week of video recording was done from March 13, 2023 to March 19, 2023. From the recorded videos, the volume of the vehicles during peak hours was tallied and averaged.

*3) Traffic Growth Rate:*The traffic growth rate is an important factor in predicting future traffic demand.Primarily, compound interest shows the process of exponential growth.

Compounding the values causes a snowball effect, as the initial value will grow upon itself and gain more momentum over time. It is widely accepted that traffic volume increases every year, and this is believed to be linked to population growth and development. To estimate the annual growth rate of traffic, compound growth is often used, which is based on the economic concept of compound interest (Bruwer M., 2021).

To solve the growth rate, a compound interest formula is utilized.

Compound interest formula:

$$F = P\ (1 + R)^t$$

To compute the growth rate, R was derived from the general compound interest formula.

$$R = \left(\frac{F}{P}\right)^{1/t} - 1$$

Where:
F- value of AADT at a specified date in the future
P- Initial Value of AADT
R- Growth Rate
t- Number of years

4) Simulation: Traffic simulation is the process of using computer software to model and analyze traffic flow.The researchers simulated the data provided by the DPWH and Local Government Unit of Guagua and the data from the manual counting method by using a traffic simulation software, PTV VISSIM.

5) PTV VISSIM: PTV VISSIM is one of the most utilized simulation software used for evaluating, validating, and simulating new transport policies and control systems. It is a simulation tool suitable for transportation congestion problems as it provides different calibration parameters to allow the simulated network to reproduce the real situation.To obtain the simulation results in PTV VISSIM, the following steps and input parameters will be used:

Network object type

This section focuses on the network object sidebar, which lists the different types of network objects that will be used in the study. Links and Connectors, Vehicle Inputs, Vehicle Routes, Signal Heads and Nodes are to be considered for the simulation study.

Links and Connectors- This represents a segment of a roadway that has a specified direction of flow, and can consist of a single lane or multiple lanes. Connectors are used for connecting links to build a network.
Vehicle Inputs- This data will be obtained from the number of vehicles recorded in the manual counting method.

Vehicle Routes- static routing decisions will be used to direct the traffic within the network.

Signal Heads-with lane-level positioning, this may be placed in the network at the stop line precision. Signal heads are by default seen in VISSIM as red lines.

Nodes- the places where pathways come together or split off in separate directions.

Signal Control

This section involved adding of traffic control devices in PTV VISSIM. Signal controllers were created and specific timing for signal group phases were entered. Furthermore, placing of signal heads at intersections was done and applicable signal control number and signal group phase were assigned to that specific head.

6) Simulation of Flyover and Traffic Lights: The simulation was generated once the data network had been set up. However, the simulation only gives a visual representation of the system unless outputs are specified. For this simulation study, output files for travel time and delay time were expected.

IV. RESULTS AND DISCUSSIONS

This study aimed to conduct a simulation-based analysis of the traffic conditions at the JASA - Sta. Rita- Guagua Road Intersection, comparing both flyover and traffic lights using PTV VISSIM. It presents the traffic survey data gathered through manual counting method and the results of the simulation conducted through a traffic simulation software. The results and outcomes obtained from the simulation are further discussed and analyzed.

A. Determining the Movement Groups, Traffic Volumeand Lane Width

To determine the traffic volumes, the researchers used manual counting method for the traffic survey within a one-hour time frame specifically peak hours. The one-hour time frame was divided into four (4) with fifteen (15) minutes intervals. In addition, the traffic survey was subdivided into four (4) main categories depending on the road segment or approach in the study area: San Fernando Road, Guagua Road, Sta. Rita Road and Olongapo Road. These main categories were divided into three (3) different lane groups: Left Turn (LF), Through (T) and Right Turn (RT).

TABLE V
MOVEMENT GROUPS FOR TRAFFIC LIGHT AND FLYOVER

MOVEMENTS	
TRAFFIC LIGHT	**FLYOVER**
1: Olongapo to San Fernando	1: Olongapo to San Fernando (flyover)
2: Olongapo to Guagua	2: Olongapo to Guagua
3: Olongapo to Sta. Rita	3: Olongapo to San Fernando (under)
4: San Fernando to Olongapo	4: San Fernando to Olongapo (flyover)
5: San Fernando to Sta. Rita	5: San Fernando to Sta. Rita
6: San Fernando to Guagua	6: San Fernando to Olongapo (under)
7: Sta. Rita to Guagua	7: Sta. Rita to Guagua
8: Sta. Rita to Olongapo	8: Sta. Rita to Olongapo
9: Sta. Rita to San Fernando	9: Sta. Rita to San Fernando
10: Guagua to Sta. Rita	10: Guagua to Sta. Rita
11: Guagua to San Fernando	11: Guagua to San Fernando
12: Guagua to Olongapo	12: Guagua to Olongapo

1) Lane Width (m): The data for the lane width were obtained from the DPWH Region III Office.

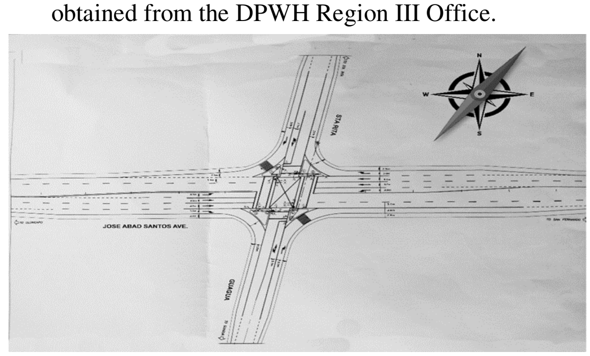


Fig.5 Layout of the Intersection

TABLE VI
AVERAGE TRAFFIC VOLUME PER LANE GROUP

Approach	**San Fernando Road**			**Guagua Road**			**Sta. Rita Road**			**Olongapo Road**		
Lane Group	LT	T	RT	LT	T	RT	LT	T	RT	LT	T	RT
Total (AM)	99	1387	240	104	172	127	185	201	120	85	1407	164
Total (PM)	175	1434	262	202	262	186	139	258	418	165	1201	197

B. Calculation of Volume in terms of Passenger Car Unit/Hr.

The total volume of various vehicles in the study, obtained by manually counting vehicles during peak hours, was converted into their equivalent traffic volume using the conversion factors obtained from the manuals of DPWH. The highest total traffic volume during the consecutive seven days of manual counting from March 13, 2023 to March 19, 2023 was considered. The table below shows the calculation of the passenger car unit per hour. The total traffic volume of different types of vehicles was multiplied by their corresponding passenger car equivalent factors (PCEF) to obtain the volume in terms of passenger car units per hour.

TABLE VII
PASSENGER CAR UNIT PER HOUR OF SAN FERNANDO ROAD

Vehicle Type	PCEF	San Fernando			
		AM	PCU/hr	PM	PCU/hr
Motor	2.5	689	1723	1077	2693
Passenger Car	1	797	797	814	814
Jeep	1.5	14	21	37	56
Goods Utility	1.5	19	29	86	129
Small Bus	1.5	10	15	3	5
Large Bus	2	12	24	15	30
2 Axle Truck	2	141	282	43	86
3 Axle truck	2.5	80	200	32	80
4 Axle truck	2.5	16	40	0	0
5 Axle Truck	2.5	38	95	47	118
TOTAL PCU/Hr			3226		4011

In San Fernando Road, the calculated total passenger car unit per hour (pcu/hr) for the morning was 3226, while 4011 was obtained for the afternoon.

TABLE VIII
PASSENGER CAR UNIT PER HOUR OF STA. RITA ROAD

Vehicle Type	PCEF	Sta. Rita			
		AM	PCU/hr	PM	PCU/hr
Motor	2.5	325	813	671	1678
Passenger Car	1	154	154	220	220
Jeep	1.5	56	84	39	59
Goods Utility	1.5	16	24	22	33
Small Bus	1.5	0	0	0	0
Large Bus	2	0	0	0	0
2 Axle Truck	2	1	2	8	16
3 Axle truck	2.5	5	13	5	13
4 Axle truck	2.5	1	3	0	0
5 Axle Truck	2.5	0	0	1	3
TOTAL PCU/Hr			1093		2022

Values of 1093 and 2022 were attained during the morning and afternoon, respectively, in Sta. Rita Road.

TABLE IX
PASSENGER CAR UNIT PER HOUR OF GUAGUA ROAD

Vehicle Type	PCEF	Guagua			
		AM	PCU/hr	PM	PCU/hr
Motor	2.5	320	800	444	1110
Passenger Car	1	104	104	230	230
Jeep	1.5	29	44	40	60
Goods Utility	1.5	14	21	12	18
Small Bus	1.5	0	0	0	0
Large Bus	2	0	0	1	2
2 Axle Truck	2	4	8	10	20
3 Axle truck	2.5	6	15	4	10
4 Axle truck	2.5	0	0	0	0
5 Axle Truck	2.5	0	0	0	0
TOTAL PCU/Hr			992		1450

On the other hand, the PCU/hr calculated for morning and afternoon are 992 and 1450, respectively, on Guagua Road.

TABLE X
PASSENGER CAR UNIT PER HOUR OF OLONGAPO

Vehicle Type	PCEF	Olongapo			
		AM	PCU/hr	PM	PCU/hr
Motor	2.5	934	2335	1015	2538
Passenger Car	1	685	685	507	507
Jeep	1.5	49	74	17	26
Goods Utility	1.5	80	120	35	53
Small Bus	1.5	5	8	2	3
Large Bus	2	27	54	16	32
2 Axle Truck	2	84	168	43	86
3 Axle truck	2.5	34	85	33	83
4 Axle truck	2.5	18	45	7	18
5 Axle Truck	2.5	21	53	12	30
TOTAL PCU/Hr			3627		3376

Meanwhile, Olongapo Road obtained PCU/hr values of 3627 and 3376 for the morning and afternoon, respectively.

C. Calculation of Volume Capacity Ratio in Determining the Level of Service

The level of service was determined by first finding the Volume/Capacity ratio using the PCU per hour values over the capacity. The capacity was based on the manual obtained from the DPWH shown in Table IV. A value of 600 was used as the design service volume under a single or less than four (4) meters per lane. Since values of PCU/hr were obtained, the volume capacity ratio for all sections of the road was attained as shown in Table XI.

$$Volume\ Capacity\ Ratio\ (VCR) = \frac{V}{C}$$

TABLE XI
LEVEL OF SERVICE FOR ALL SECTIONS OF THE ROAD

Location	Time	Total PCU/hr	No. of Lanes	V/C ratio	LOS
San Fernando	AM	3226	3	5.38	F
	PM	4011	3	6.69	F
Sta. Rita	AM	1093	2	1.82	F
	PM	2022	2	3.37	F
Guagua	AM	992	2	1.65	F
	PM	1450	2	2.42	F
Olongapo	AM	3627	3	6.05	F
	PM	3376	3	5.63	F

Since all the values obtained from the volume capacity ratio were greater than 1, the level of service for all sections of the road falls under level F, which designates the worst flow of traffic and refers to conditions in which stop-and-go situations, long queues, and delays exist. With the gathered information, it was established that the intersection experiences poor traffic conditions that need improvement and a solution.

D. Traffic Growth Rate based on AADT

The researchers gathered Annual Average Daily Traffic (AADT) Data from the official website of DPWH of Road Traffic Information System from 2016-2019 to calculate the traffic volume in the study area.

Fig.6 AADT Data from DPWH Official Website

TABLE XII
ANNUAL AVERAGE DAILY TRAFFIC (AADT) FROM 2016-2019

Year	AADT
2033	
2028	
2023	
2019	29115
2018	18921
2017	17917
2016	15612

To predict future traffic volumes in 5 years (2028) and 10 years (2033) from 2023, the compound interest formula was used to determine the traffic growth rate. Solving for growth rate considering AADT Values from 2016-2019. Using the derived formula:

$$R = \left(\frac{F}{P}\right)^{1/t} - 1$$

The researchers used 15612 from 2016 AADT to be the initial value, 29115 from 2019 AADT to be the future value and the number of years between 2016 to 2019 will be 3.

$$R = \left(\frac{29115}{15612}\right)^{\frac{1}{3}} - 1$$
$$R = 0.2309\ or\ 23.09\%$$

The compound interest formula was used to get the future value of AADT for 2023, 2028 and 2033:

$$F = P\ (1 + R)^t$$

To calculate the AADT Value for Year 2023. The researchers used the growth rate of 23.09%, 15612 from 2016 AADT as the value of P, and the number of years between 2016 to 2023 will be 7.

$$F = 15612\ (1 + 0.2309)^7$$
$$F = 66\ 838$$

To calculate the AADT Value for Year 2028. The researchers used the growth rate of 23.09%, 15612 from 2016 AADT as the value of P, and the number of years between 2016 to 2028 will be 12.

$$F = 15612\ (1 + 0.2309)^{12}$$
$$F = 188\ 857$$

To calculate the AADT Value for Year 2033. The researchers used the growth rate of 23.09%, 15612 from 2016 AADT as the value of P, and the number of years between 2016 to 2028 will be 17.

$$F = 15612\ (1 + 0.2309)^{17}$$
$$F = 533\ 637$$

TABLE XIII
ANNUAL AVERAGE DAILY TRAFFIC (AADT) AND CALCULATED GROWTH RATE

Year	AADT	Growth Rate	Growth Rate (%)
2033	533637	0.2309	23.09
2028	188857	0.2309	23.09
2023	66838	0.2309	23.09
2019	29115	0.5388	53.88
2018	18921	0.0560	5.60
2017	17917	0.1476	14.76
2016	15612	-	-

The table above shows the summarized AADT values with their respective calculated growth rate. The growth rate of 23.09% was applied alongside manually collected traffic volume data to predict the traffic volume of the study area per lane movement in the years 2028 and 2033. The resulting predictions were compiled and presented in a table as shown below.

TABLE XIV
PROJECTED VOLUME FOR THE YEAR 2028 AND 2033

Location	Time	Average Volume	Projected Volume (5 yrs)	Projected Volume (10 yrs)
San Fernando	AM	1394	1716	2113
	PM	1924	2369	2916
Sta. Rita	AM	499	615	758
	PM	819	1009	1242
Guagua	AM	412	508	626
	PM	647	797	982
Olongapo	AM	2012	2477	3049
	PM	1521	1873	2306

The average volume in the morning and afternoon for all sections of the road was multiplied by the growth rate of 0.2309, from which the projected volume for the year 2028 was obtained. Additionally, to get the projected volume for 2033, the growth rate of 0.2309 was multiplied by the five-year projected volume.

E. Setting up of the intersection model

In setting up the intersection model, the scaling of the satellite image of the selected location area, as shown in Figure 7, was used as the basis for forming the links. Through the Network Objects option, the arrangement of lanes and their approaches are established from the study area of the road'sstarting point up to its end.

Fig. 7Modeling of existing JASA- Sta. Rita-Guagua Road Intersection in VISSIM

As for the width lanes, DPWH provided the dimensions, which were utilized in mapping the model as presented in Figure 8. Additionally, setting the traffic regulations to "left hand traffic" and setting the metric units was done before the correction of conflicting areas in the traffic system.

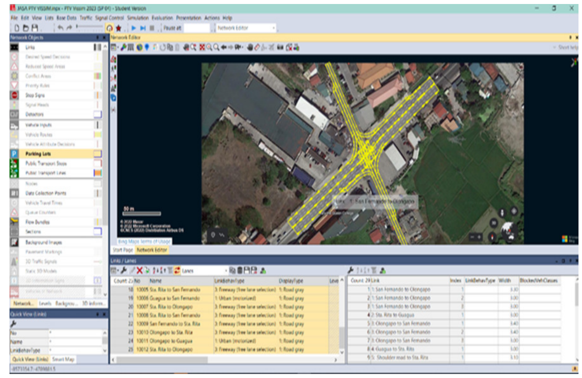


Fig. 8 Links and Connectors of the Intersection Drawn in VISSIM

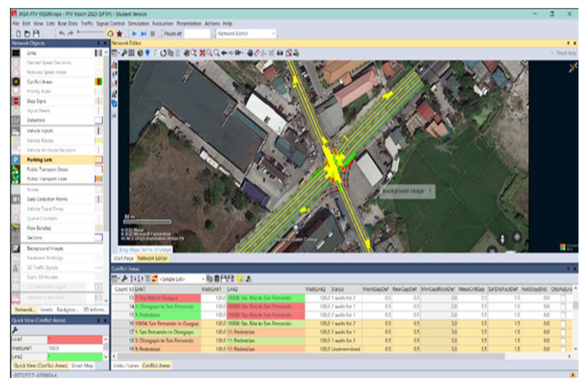


Fig.9 Correcting the Conflict Areas

Furthermore, signal heads and signal controllers were added to display the behavior of drivers at the signalized intersection. In accordance with the data gathered from DPWH, fixing signal controllers and signal groups was performed, and a sequence for the signal program was created as presented on Figure 10. The types and classes of vehicles were edited after the inputs of different vehicle compositions for the 3D model of vehicles were observed. In addition, a static vehicle routing decision was made, including their relative flow for each lane to represent the flow of traffic in a linear manner.

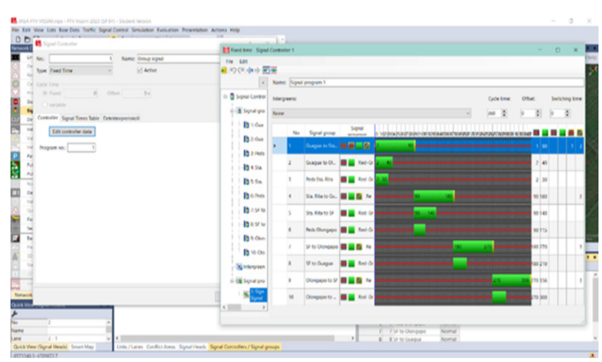


Fig.10Fixed Time for Signal Controller

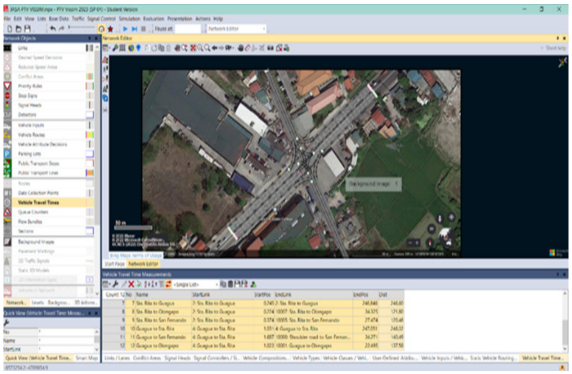


Fig.11 Distribution of 3D Model of Vehicles

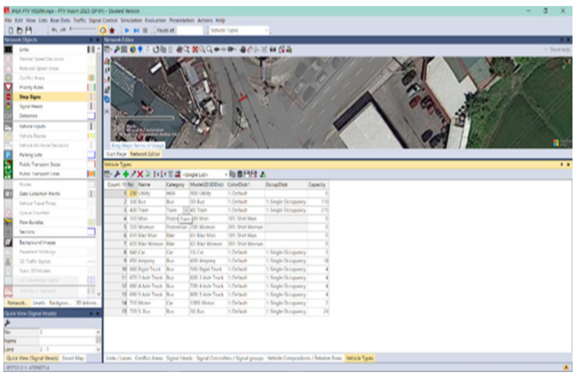


Fig.12 Inputting Vehicle Types

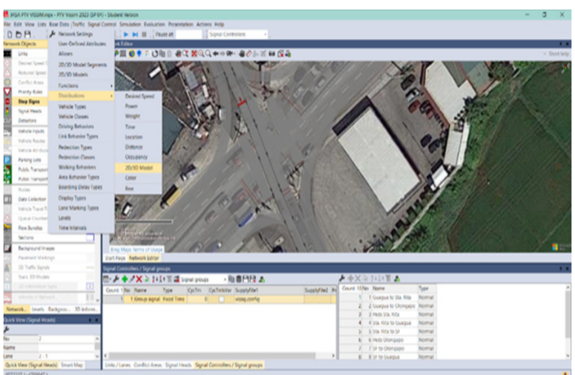


Fig.13Vehicle Travel Time

Travel time for vehicles was inputted from end to end of the lanes before the nodes were set up within the intersection being studied.

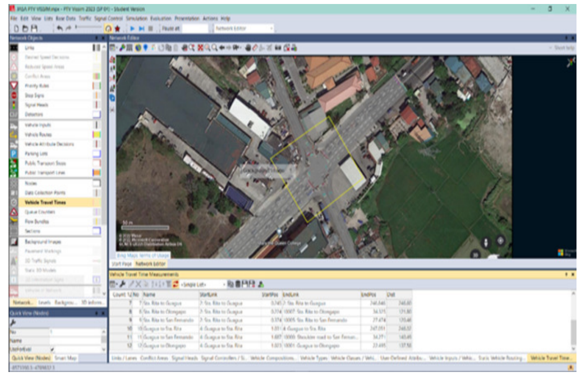


Fig.14 Setting up of Nodes within the Intersection

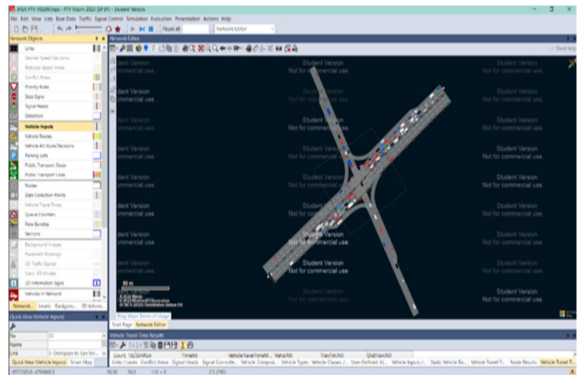


Fig. 15 Inputting Data from the Manual Counting

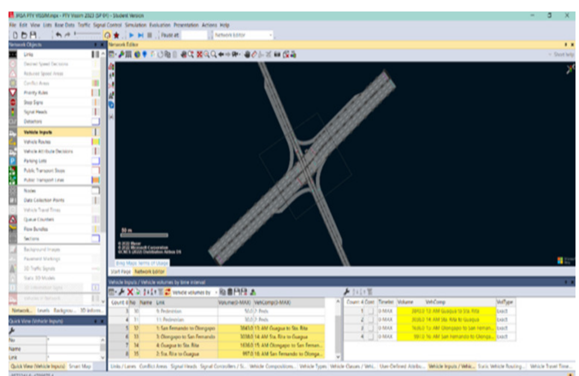


Fig.16Configuration of the Intersection

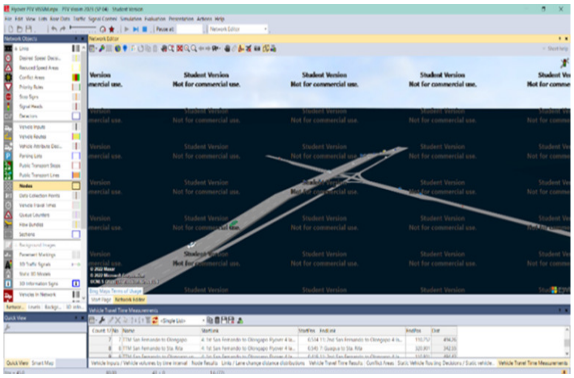


Fig. 17Simulation of the Flyover

TABLE XV
PRESENT VALUES FOR TRAFFIC LIGHT – TRAVEL TIME

TRAFFIC LIGHT - TRAVEL TIME		
DIRECTIONS	AM	PM
1: Olongapo to San Fernando	174.71s	167.14s
2: Olongapo to Guagua	96.94s	107.75s
3: Olongapo to Sta. Rita	257.06s	252.33s
4: San Fernando to Olongapo	144.09s	170.21s
5: San Fernando to Sta. Rita	39.55s	49.03s
6: San Fernando to Guagua	229.60s	264.44s
7: Sta. Rita to Guagua	105.97s	123.35s
8: Sta. Rita to Olongapo	21.66s	25.72s
9: Sta. Rita to San Fernando	117.84s	134.99s
10: Guagua to Sta. Rita	239.02s	228.09s
11: Guagua to San Fernando	38.66s	67.91s
12: Guagua to Olongapo	176.72s	194.54s

TABLE XVI
PRESENT VALUES FOR FLYOVER- TRAVEL TIME

FLYOVER - TRAVEL TIME		
DIRECTIONS	AM	PM
1. Olongapo to San Fernando Flyover	29.99s	30.44s
2. Olongapo to Guagua	41.42s	42.80s
3. Olongapo to San Fernando Under	36.23s	38.93s
4. San Fernando to Olongapo Flyover	28.57s	30.42s
5. San Fernando to Sta. Rita	33.90s	36.59s
6. San Fernando to Olongapo Under	39.59s	44.91s
7. Sta. Rita to Guagua	45.16s	45.87s
8. Sta. Rita to Olongapo	33.41s	35.99s
9. Sta. Rita to San Fernando	45.18s	45.88s
10. Guagua to Sta. Rita	45.13s	45.25s
11. Guagua to San Fernando	45.14s	45.26s
12. Guagua to Olongapo	37.50s	38.82s

TABLE XVII
PRESENT VALUES FOR TRAFFIC LIGHT – VEHICLE DELAY

TRAFFIC LIGHT - VEHICLE DELAY		
DIRECTIONS	AM	PM
1: Olongapo to San Fernando	133.13s	134.51s
2: Olongapo to Guagua	68.11s	70.53s
3: Olongapo to Sta. Rita	230.78s	230.43s
4: San Fernando to Olongapo	127.55s	131.16s
5: San Fernando to Sta. Rita	23.69s	24.34s
6: San Fernando to Guagua	216.39s	221.58s
7: Sta. Rita to Guagua	105.55s	105.81s
8: Sta. Rita to Olongapo	7.1s	7.18s
9: Sta. Rita to San Fernando	103.16s	105.26s
10: Guagua to Sta. Rita	172.67s	176.08s
11: Guagua to San Fernando	35.8s	38.9s
12: Guagua to Olongapo	161.48s	163.75s

TABLE XVIII
PRESENT VALUES FOR FLYOVER – VEHICLE DELAY

FLYOVER - VEHICLE DELAY		
DIRECTIONS	AM	PM
1. Olongapo to San Fernando Flyover	0.17s	0.19s
2. Olongapo to Guagua	1.05s	0.85s
3. Olongapo to San Fernando Under	1.01s	3.20s
4. San Fernando to Olongapo Flyover	0.10s	0.13s
5. San Fernando to Sta. Rita	4.42s	4.73s
6. San Fernando to Olongapo Under	8.14s	10.91s
7. Sta. Rita to Guagua	1.06s	1.33s
8. Sta. Rita to Olongapo	2.96s	3.72s
9. Sta. Rita to San Fernando	2.05s	3.77s
10. Guagua to Sta. Rita	2.82s	3.01s
11. Guagua to San Fernando	0.37s	1.31s
12. Guagua to Olongapo	4.18s	5.13s

TABLE XIX
PRESENT VALUES FOR TRAFFIC LIGHT – LEVEL OF SERVICE

TRAFFIC LIGHT - LEVEL OF SERVICE		
DIRECTIONS	AM	PM
1: Olongapo to San Fernando	F	F
2: Olongapo to Guagua	E	E
3: Olongapo to Sta. Rita	F	F
4: San Fernando to Olongapo	F	F
5: San Fernando to Sta. Rita	C	C
6: San Fernando to Guagua	F	F
7: Sta. Rita to Guagua	F	F
8: Sta. Rita to Olongapo	B	B
9: Sta. Rita to San Fernando	F	F
10: Guagua to Sta. Rita	F	F
11: Guagua to San Fernando	D	D
12: Guagua to Olongapo	F	F

TABLE XX
PRESENT VALUES FOR FLYOVER – LEVEL OF SERVICE

FLYOVER - LEVEL OF SERVICE		
DIRECTIONS	AM	PM
1. Olongapo to San Fernando Flyover	A	A
2. Olongapo to Guagua	A	A
3. Olongapo to San Fernando Under	A	A
4. San Fernando to Olongapo Flyover	A	A
5. San Fernando to Sta. Rita	A	A
6. San Fernando to Olongapo Under	A	A
7. Sta. Rita to Guagua	A	A
8. Sta. Rita to Olongapo	A	A
9. Sta. Rita to San Fernando	A	A
10. Guagua to Sta. Rita	A	A
11. Guagua to San Fernando	A	A
12. Guagua to Olongapo	A	A

TABLE XXI
FIVE-YEAR PROJECTED VOLUME FOR TRAFFIC LIGHT – TRAVEL TIME

TRAFFIC LIGHT - TRAVEL TIME		
DIRECTIONS	AM	PM
1: Olongapo to San Fernando	162.52 s	163.36 s
2: Olongapo to Guagua	86.48 s	93.33 s
3: Olongapo to Sta. Rita	256.41 s	254.93 s
4: San Fernando to Olongapo	123.02 s	141.39 s
5: San Fernando to Sta. Rita	42.67 s	46.21 s
6: San Fernando to Guagua	248.73 s	260.25 s
7: Sta. Rita to Guagua	109.02 s	121.64 s
8: Sta. Rita to Olongapo	27.38 s	29.78 s
9: Sta. Rita to San Fernando	137.00 s	158.38 s
10: Guagua to Sta. Rita	154.46 s	170.14 s
11: Guagua to San Fernando	54.73 s	59.61 s
12: Guagua to Olongapo	144.13 s	160.54 s

TABLE XXII
FIVE-YEAR PROJECTED VOLUME FOR FLYOVER – TRAVEL TIME

FLYOVER - TRAVEL TIME		
DIRECTIONS	AM	PM
1. Olongapo to San Fernando Flyover	31.16 s	37.72 s
2. Olongapo to Guagua	41.41 s	45.81 s
3. Olongapo to San Fernando Under	36.90 s	43.46 s
4. San Fernando to Olongapo Flyover	29.77 s	32.76 s
5. San Fernando to Sta. Rita	35.64 s	37.43 s
6. San Fernando to Olongapo Under	45.19 s	50.42 s
7. Sta. Rita to Guagua	45.96 s	49.10 s
8. Sta. Rita to Olongapo	34.71 s	54.60 s
9. Sta. Rita to San Fernando	45.98 s	49.12 s
10. Guagua to Sta. Rita	46.35 s	48.40 s
11. Guagua to San Fernando	46.36 s	48.42 s
12. Guagua to Olongapo	42.87 s	46.18 s

IV. CONCLUSIONS

Traffic congestion is a wide-scale challenge in the development and growth of emerging cities. It has a negative impact on both automobiles and public transportation passengers, and it appears to be slowing down people's productivity. With that, we conducted a simulation-based analysis using PTV VISSIM along the JASA-Sta. Rita Road Intersection, where traffic congestion is observed. Moreover, if the projected traffic volume is added, this issue will become a greater obstacle for both passing vehicles and residents in the future, unless it is addressed promptly and appropriately. With the data that we've been collected, considering traffic lights and flyovers, parameters like travel time, level of service and delay time were obtained from the simulation using the software. In accordance with the data that was collected and analyzed in this study, considering the comparison of traffic lights and flyovers, we concluded that the possibility of constructing a flyover along the area is a more effective and more efficient design performance-wise. However, it is important to note that there may be other factors to consider when choosing between these two options, such as cost, safety, and environmental impact.

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