Proposed Signalized Traffic Lights System in The Conjunction Road of Lazatin Blvd. & Capitol Blvd. To Cabalantian Bridge Using Synchro 8 And PTV Vissim Software

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Abstract: - Traffic congestion is a significant issue in the Philippines, in addition to poverty and corruption. If there is heavy traffic then it means that there are many vehicles on the road making it difficult to move around and traverse. Traffic is a huge problem in various places around the world and including the Philippines particularly in our capital, Manila. In our locality, this problem is not only quite common but also very much prevalent in the province of Pampanga. This study aims to assess the complex traffic condition at San Fernando intersection and propose signalized traffic lights in order to reduce traffic congestion in the study area. To gather the data required to carry out a traffic assessment of the intersection, a traffic survey using a manual counting approach adapted from closed circuit video (CCTVs) was done. Using Synchro 8 software, the collected data were analyzed and evaluated using delay and level of service criteria. As per Synchro 8's findings, the intersection has a Level of Service of F for the majority of its lanes, all of its approaches, and the intersection as a whole is classified with a "Congestion" traffic condition. In order to compare the performance of the proposed signalized traffic lights to the existing road design, same conditions were then generated and simulated on the proposed signalized traffic lights using PTV Vissim. Using the findings from both analyses, it was concluded that traffic lights might be used to improve the poor traffic flow from the intersection of Lazatin Boulevard and Capitol Boulevard to the Cabalantian Bridge. The proposed system's functionality was shown to be significantly greater than the current junction through the testing carried out for the study.

Key Words: - ***Synchro 8, PTV Vissim, Level of Service, Traffic Lights, Congestion.***

I. THE PROBLEM AND A REVIEW OF RELATED LITERATURES AND STUDIES

1.1 Introduction

Our country had developed for the past years that give rise to modernity such as new buildings and premises, and upgrades in our transportation sector that helps to maintain the satisfaction for daily basis. However, the issues with the roadways and the accessibility of transportation facilities had a severe effect on some areas in our country. High traffic demand in Metro Manila has been a result of rapid motorization, high-density urban growth, population concentration, and concentration of economic activity. This has caused congestion in key arterials, particularly in major conflict areas like signalized intersections.

Nevertheless, the capacity of the roads has not greatly increased in recent years, making it impossible to keep up

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with the sharp increase in traffic volume. Accident, loading and unloading of vehicles, parking, and congestion issues are all a part of this problem. Some disruptive circumstances cause issues with traffic flow. Traffic flow disturbance during peak hours is a persistent issue that affects the community and its daily activities. It's important to have enough information to identify the problems in order to lessen its negative impact. Similarly, City of San Fernando kept progressing for the past few years that many buildings and premises are also have been built. Additional SM shopping malls, stalls, office buildings, schools and other establishments were added in the city. However, despite of these progress the city acquired, there will be always problems that is bound to emerge. Knowing that the buildings had increased, it is safe to assume that the numbers of vehicles had increased too, thus, traffic demand escalates.

Traffic demand in the roads in City of San Fernando escalates quickly especially near schools like universities and academies during peak hours. One of those roads is the conjunction road along Capitol Blvd. and Lazatin Blvd. in Brgy. San Juan and in Cabalantian Bridge in Sitio Palawe in the nearby area where public transportation vehicles and private vehicles are passing by.

Nevertheless, it is possible to forecast future traffic conditions and use that knowledge to optimize the routes taken by vehicles by conducting a thorough analysis of traffic demand. Such a strategy becomes especially effective when used with autonomous vehicles, which have more predictable behavior, allowing city management organizations to reduce the effects of traffic congestion and pollution by optimizing traffic flow in a city in a fully centralized manner. (Martinez and Luis, 2019).

Traffic simulation software is an essential tool for transportation engineers and planners to design and evaluate road networks. It is a computer-based platform that simulates the movement of vehicles on roads, intersections, and highways. The software is used to create a virtual environment that replicates the real-world traffic conditions, allowing engineers to test different scenarios and assess the impact of proposed changes.

One of the primary benefits of traffic simulation software is that it allows engineers to evaluate the effectiveness of different traffic management strategies. They can test the impact of adding new lanes, changing traffic signals, or implementing roundabouts. The software can simulate different traffic volumes and patterns, allowing engineers to assess the impact of changes on congestion, travel times, and safety.

Numerous factors contribute to traffic congestion, including increase of traffic, which is the inevitable results for increases in population, number of vehicles and equipment. Due to the poor condition of the infrastructure, individuals use private transport rather than mass transport. Using the Synchro 8 software to determine the level of service (LOS) for urban streets and intersections is important, as the first step of the analysis procedure affects the planning, design, and operational phase of transportation projects as well as the allocation of limited financial resources among competing transportation projects.

PTV Vissim is a powerful traffic simulation software tool used by transportation engineers and planners to design, analyze, and optimize traffic flow. It is a leading software in the transportation industry, providing users with a wide range of tools and features to help them manage traffic and plan for the future. One of the key features of PTV Vissim software is its ability to simulate traffic flow. The software can model complex traffic scenarios, including multiple intersecting roads, highways, and roundabouts. This allows engineers and planners to test different traffic management strategies and evaluate their effectiveness in reducing congestion, improving travel times, and enhancing safety.

In conclusion, traffic simulation software is a powerful tool for transportation engineers and planners. It allows them to evaluate the effectiveness of different traffic management strategies, identify potential problems before they occur, evaluate the impact of new developments on the road network, and support emergency planning and response. As our cities continue to grow and evolve, traffic simulation software will become an increasingly important tool for ensuring that our road networks are safe, efficient, and effective.

1.2 Background of the Study

Pampanga, a growing province, faces many challenges in the sort of congestion that occurs at intersections. Pampanga's capital city, San Fernando City, is a heavily populated area when daily large traffic volumes are often seen. In addition to traffic volume, roadwork construction and repairs contribute to the evident traffic problems present within the area. As a result of some of this volume being diverted to Lazatin Blvd. and Capitol Blvd. intersection, there is increased traffic in the study area.

Traffic demand in the roads in the City of San Fernando escalates quickly especially near schools like universities and academies during peak hours. One of those roads is the conjunction road along Capitol Blvd. and Lazatin Blvd. in Brgy. San Juan and in Cabalantian Bridge in Sitio Palawe in the nearby area where public transportation vehicles and private vehicles are passing by. Studies are occasionally carried out to offer remedies to ease the issue in various junctions that face the same challenge. Traffic is formally organized in many jurisdictions, with marked lanes, junctions, intersections, interchanges, traffic signals, or signs. The main problem with this topic is traffic during peak hours because there are too many cars passing through this route. And another problem is the lack of traffic lights at the intersection of Barangay San Juan and in the Sitio Palawe in the City of San Fernando. Due to the lack of traffic lights and the overabundance of vehicles, the traffic begins and results in the scattering of commuters who will pass through that route, and since there are not enough and no traffic lights in the San Juan area, we decide to propose a traffic signal.

To provide an efficient transportation facility and innovation in the area, this study focused on providing signalized traffic lights that will help everyone who passes through it. This traffic light can regulate traffic flow and prevent accidents in the aforementioned area.

1.3 Literature Review

This chapter primarily presents the different researches and other literatures from both foreign and local researchers, which have significant bearings on the variables included in the research. It focuses on several aspects that will help the development of this study. The study is generally concentrating on the factors that affect the traffic flow to the communities in the City of San Fernando, Pampanga. The literatures of this study came from books, journals, articles, electronic materials such as PDF or E-Book, and the other existing thesis and dissertation, foreign and local that are believed to be useful in the advancement of awareness concerning the study.

As transportation and modernization exist together, everyone's level of living rises. Traffic congestion is now a major issue due to urbanization and growing populations. The number of vehicles on roads and highways has increased rapidly over the capacity that various types of transportation infrastructures were originally intended for as a result of this constant expansion and progress.

Parking is one of the major problems that arises at every corner of street thus it must be established. In that case, we have to avoid double parking or wrongly parking of vehicles because illegal parking is our problem on a daily basis. Therefore, we have to avoid it and follow the signs placed on every corner of the road. On the contrary, Oduro & Ocloo (2014) states that double parking and street parking can play essential roles in benefitting business and has a potential to provide pedestrians a safer way to travel to avoid traffic dangers. It can also be allowed if city officials wanted to promote an effective transportation system.

Public transportation is a form of travel offered locally that enables larger groups of people to travel together along specified routes. Buses, trains, and railways are common examples of public transit modes. Elicited from Businessmirror (2022) one of the reasons why Metro Manila traffic continues to worsen is due to the poor management of public transport, which pushes public utility vehicles and jeepneys to compete for passengers. These are the main issues, particularly in urban areas. Public transit is the best and simplest way for people to go around, so the only way to tackle this issue is to encourage people to do so rather than drive their own cars if possible. The simplest way of transportation is public transportation. Additionally, using public transportation might help you save money because it is less expensive than a private vehicle and can accommodate more passengers and send them to different locations. To make use of public transport, governments and organizations must try to provide more and more facilities to the public.

Public transportation is a popular choice for many commuters, but there is no denying that the current state of the Philippines' public transportation system needs to be significantly improved in order to address both its open and hidden issues. The public transportation system is one of these infrastructures that is most notable for its literal inability to catch up. Currently, it has become commonplace for commuters to wait times for their transit, if one is available. Many people are used to spending hours on the road due to traffic, making their total travel time longer, in addition to the time they have to wait for their ride.

For the effective flow of people and products across provinces, national roadways are required. One factor contributing to the Philippines' increasing urban traffic congestion is the country's long-term lack of national road construction (see Figure 1.1). The existing demand, which continues to exceed infrastructure development, will eat up any new or expanded roadways that are constructed. The government needs to allocate adequate budgeting to road infrastructure projects, from modernizing road plans to increasing road capacity for the streets in urban areas. However, the economy is nonetheless constrained by its inadequate and outdated infrastructure. The government must make sure its expenditure is well controlled if it hopes to be successful with the infrastructure push. With the continuous development of the economy, people's living standards have continuously improved, and their purchasing power has been significantly increased (Hong Yu et al., 2019).

The intersection traffic signal control problem has become even more important as traffic congestion has been more intractable. The intersection traffic control signal seeks an efficient schedule for traffic signal settings at intersections with the goal of maximizing traffic flow while considering various factors such as real-time strategies, signal timing constraints, rapid developments in traffic systems, and practical implementation (Myungeun Eom & Byung-In Kim, 2020). Due to the influence of technological advancements, the use of numerous signs, markings, and signals in traffic control is rapidly changing. These developments enable coordinated traffic signal operation over broad areas of a city as opposed to simply a single street. Traffic signs are among the traffic control systems that are always being developed. The goal of traffic research is to improve the movement of both people and products, because vehicle flow interactions within the network, human behavioral considerations, stochastic traffic demand, and traffic accidents, is a complex issue. Through effective traffic management, it is possible to guarantee that all users of the roads and streets are safe, and that traffic moves quickly and smoothly. Roads with heavy motor vehicle traffic do not operate as barriers obstructing travel between locations; rather, they decrease local noise and pollution, protect neighborhoods and pedestrian areas from the harmful effects of heavy traffic, and lower greenhouse gas emissions.

In their study, Papamarkos and Periandros (2020) stated that there is a big impact of having traffic signs and automated traffic lights, it is concluded that the level of car traffic does not play a very significant role when it alters in street scenarios where traffic signs and traffic lights are present. The world we live in is now equipped with traffic lights, also known as traffic signals to direct or regulate the flow of vehicles such as traffic lamps, stop & go lights, which are installed at intersections in most cities around the world to control the flow of traffic. The traffic light has three colors Red, Yellow and Green (Stop, Be Alert/Proceed and Go, respectively). The signal lights have equal time at each road or intersection to regulate the flow of vehicles. As a result, the car has to wait for a long time, even when the traffic is very low. Traffic lights are created to control the movement of vehicles and lessen the possibility of accidents between vehicles and pedestrians on the road. The four-way junctions are where they are most useful. Traffic lights aren't always required for every intersection that vehicles come to, although they certainly lessen the number of accidents that occur on the road every day. There are significant advantages and disadvantages to traffic signals in terms of accidents. Traffic signals can reduce certain types of car accidents, most commonly broadside collisions. One of the primary disadvantages of traffic signals is that they lead to an increase in rear-end vehicle collisions. When a driver abruptly stops at a yellow or red light, a distracted driver behind him may crash into the back of his car, increasing the risk of a rear-end accident. Another disadvantage of traffic lights is that they can cause excessive traffic delays, which can take a long time to wait for a traffic light to turn green or for a motorist in the turn lane to properly cross an intersection. Long wait times can result in lost fuel, air pollution, and expenditures for drivers. Partially as a result of excessive delay and partially as a result of unwarranted or improperly functioning traffic signals, drivers may get unnecessarily impatient and aggressive while on the road as a result of traffic delay. However, these downsides are just results of human behaviors, thus, doesn't provide a significant effect on the system as long as the drivers will abide by it.

As stated by Kotusevski et al. (2009) computer simulation of traffic is a widely used method in research of traffic modeling, planning and development of traffic networks and systems. Vehicular traffic systems are of growing concern and interest globally and modeling arbitrarily complex traffic systems is a hard problem. In this article we review some of the traffic simulation software applications, their features and characteristics as well as the issues these applications face. The ability of traffic simulation to emulate the time variability of traffic phenomena makes it a unique tool for capturing the complexity of traffic systems. In recent years, traffic simulation and namely microscopic traffic simulation has moved from the academic to the professional world. A wide variety of traffic simulation software is currently available on the market and it is utilized by thousands of users, consultants, researchers and public agencies.

According to Blixt et al. (2020) the operational performance of a conventional four-legged crossroads and a roundabout are compared in this article for efficient management. As a result, a computer model is developed to estimate traffic emissions at two different types of crossings.

In order to plan a road intersection, this study gives a thorough analysis and modeling of traffic flow emissions utilizing PTV Vissim software and methodology. Vehicles that today are searching for a place to stop impact other vehicles in cities. It can also be seen that the number of vehicles that desire to conduct a pick-up or drop-off increases with an increased number of ride-hailing services. New technology routing advice for such vehicles could improve the overall performance of a traffic network. Therefore, this paper examines the performance effects of a routing strategy that takes curbside availability information into account. A microscopic traffic simulation model was built in PTV Vissim along with two distinct routing algorithms to investigate the implications curbside availability information might have on a network.

The complexity and randomness of the traffic system makes it challenging to study, manage, and optimize under local traffic conditions. Synchro to aid transportation engineers in network analysis and design. It has been demonstrated that using these models in the field of traffic is effective for conducting research, training, and more effectively solving problems, testing, evaluating, and demonstrating a proposed course of action before implementation. The simulation models have gotten better in terms of quality and accuracy throughout the years. Furthermore, each model has its strengths and weaknesses and it's not ideal for every situation; therefore, the analyst should select the program that satisfies the project objectives and the prevailing traffic conditions for the selected study area (Al-Omari et al., 2007).

1.4 Study Area

Junction road of Lazatin Blvd and Capitol Blvd is in barangay San Juan, City of San Fernando, Pampanga and link routes from municipalities such as Bacolor and City of San Fernando.

Pampanga Provincial Capitol, Heroes Hall of the City of San Fernando Pampanga, Don Bosco Academy-Bacolor is the place where the conjunction road of Lazatin Blvd and Capitol Blvd to Cabalantian Bridge.

Figure 1.1. Lazatin Blvd. and Capitol Blvd. City of San Fernando (Google Earth)

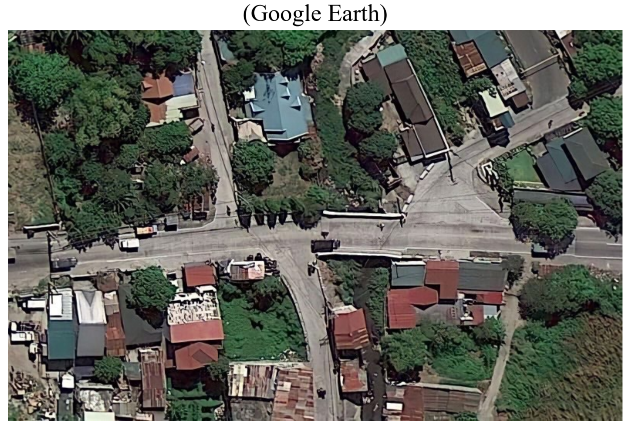


Figure 1.2. Cabalantian Bridge (Google Earth)

1.5 Objectives of the Study

1.5.1 General Objectives of the Study

The study aims to assess and alleviate the traffic congestion along the conjunction road of Lazatin Blvd and Capitol Blvd to Cabalantian Bridge, City of San Fernando Pampanga.

1.5.2 Specific Objective of the Study

- Conduct a Traffic Volume Study to determine the volume of traffic and Level of Service (LOS) of the road.
- Propose a Signalized Traffic Light System (STLS) in the conjunction road along Capitol Blvd. and Lazatin Blvd. to Cabalantian Bridge in Sitio Palawe to alleviate the traffic congestion and improve the road.
- Provide a comparative analysis between the existing road design and the road after installation of signalized traffic light system to evaluate the efficiency of the STLS.

1.6 Significance of the Study

The significance of this study addresses the traffic issue in City of San Fernando specifically in the area of the study. The data produced from this study will be used to provide insights how traffic light system will benefit the area of study which is from the conjunction road of Lazatin Blvd and Capitol Blvd to Cabalantian Bridge. This study would benefit various section as follows:

To the Municipality or *Local Government* for them to be fully aware of the case in the area of study and to provide further countermeasures that were not stated and projected in this study.

To the Transport and Traffic Management the data and alternatives offered will enable them to utilize the research as a supporting notion to examine various circumstances including traffic flow and road management. The study's contribution to traffic alleviation could reduce the need for future measures to enhance roads and traffic.

To the Commuters the results of the study will benefit both those who live in the study area and those who travel through it. Everyone will gain from the enhanced traffic flow, including students, workers, and also commuters. The site and its community as a whole will have new prospects due to a more effective control of the heavy traffic. Given these opportunities, many people will pass through this area, increasing individual participation for future businesses and projects.

To the Future Researchers this research will be a useful reference for the researchers may benefit from this study's ability to provide them with more comprehensive and convenient data on the research topic of choice. Also, the study might benefit in their understanding of traffic engineering issues, particularly those involving poor traffic flow, and help them arrive at a comparable solution and conclusion.

Furthermore, it is hoped that this study will be the outset of a proceeding body of research with respect to the Traffic flow in City of San Fernando.

1.7 Scope and Limitations

This study focused on the traffic flow in City of San Fernando, Pampanga, specifically from the junction road along Capitol Blvd. and Lazatin Blvd. in Brgy. San Juan and in Cabalantian Bridge in Sitio Palawe. Traffic Volume during peak hours and the characteristics of the road is to be identified to present explicit solutions on how to alleviate the traffic congestion in the area of study. The gathered data is to be analyzed and presented using tables. The proposal of signalized traffic lights will focus on providing a strategy to alleviate road congestion in the area of the study.

The researchers used Synchro 8, a program that incorporates HCM2010 parameters. Using the aforementioned software as a tool for evaluation, the state of the current of the area and the state of the traffic were determined.

The study does not include the bill of materials and quantities associated with the cost of the road network. Thus, such data is not included in the results of the study.

1.8 Conceptual Framework

The presentation below depicts the framework of this study. The input is about researchers identifying the traffic density and level of service of the area of study. The first step is to gather data by observing CCTV footages in the area of study as an alternative way of observing the area on site. Next, is the process where the implementation and utilization of software that will be used to identify Level of Service. Traffic volume study would be conducted by observing the CCTV footages to identify the Average Daily Traffic for the researches to determine the capacity of the road during peak hours. Lastly, the output, results that will be of use to the community of nearby areas particularly Brgy. San Juan and Sitio Palawe, and as well as to the private vehicles, public transportation vehicles, and pedestrians who pass by the area.

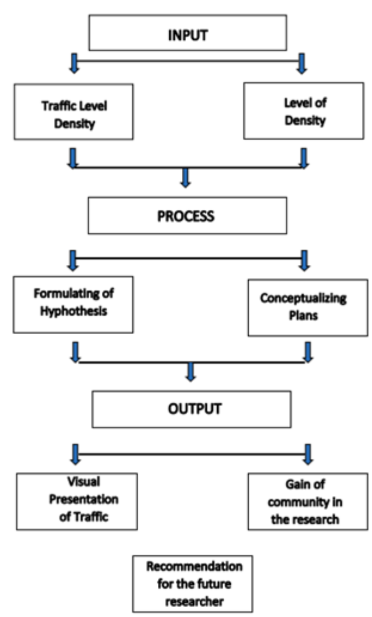


Figure 1.3. Conceptual Framework of the Study

1.9 Definition of Terms

Actuated Traffic Control. Fully-actuated signals have detectors on all of the approaches and semi-actuated signals only have detectors at some of the approaches.

Cycle Length. Is the total time to complete one sequence of all movements around an intersection.

HCM 2010. Highway Capacity Manual 2010 – Defines the capacity as the maximum howdy rate at which persons or vehicle can be reasonably expected to transverse a point or a uniform segment of a lane or roadway.

Level of Service (LOS). A mechanism for determining how well a transportation facility operates from the perspective of a traveler.

Peak Hour. The busiest hours, as during traffic, etc.

Signal Coordination. Process to synchronize start of the "green light" along the major corridor so that a group of vehicles can travel together ("platoon") through multiple signals with minimal or no stopping.

Simulation. A safe and efficient way to solve actual problems where it provides ways of analysis to verify, discuss and leads to easier visualization and comprehension of data. It allows the researcher to see the flows of traffic under various traffic conditions.

Split. An individual (movement) split is the sum of the green time + yellow interval + red clearance interval for a particular movement.

Traffic Control System. A system that controls the flow of people, products, or vehicles to guarantee traffic flow efficiency and safety.

II. METHODOLOGY

2.1 Introduction

This research is a quantitative study, which systematically explores observable events using statistical, mathematical, or computational tools. Quantitative techniques are concerned with empirical measurements and numerical analysis of data obtained by changing pre-existing statistical data using computing algorithms or employing other sorts of data collection methods such as surveys, questionnaires, and polls.

This chapter outlines the data collection and analysis methods utilized in the assessment of traffic road conditions along the conjunction road of Lazatin Blvd and Capitol Blvd to Cabalantian Bridge. This section also indicates that the existing design is inefficient and, therefore, causes traffic congestion on the site during peak hours, which is why the researchers advise redesigning the road network surrounding the facility.

2.2 Manual Counting Method

This method often needs the use of observers to collect specialized information incapable of being obtained efficiently by automated means. This is suitable for pedestrians, turning movements, and vehicle occupancy. These forms of counts may become automated as traffic data collection technology progresses. Moreover, this form of traffic data collecting can be used immediately after collection and can help to identify the crucial flow time periods, determining the influence of large vehicles or pedestrians on vehicular traffic flow. To make manual counting feasible, several means, such as tally sheets, mechanical count boards, and electronic count boards, are frequently utilized. Once they did so, the researchers manually counted the traffic flow conditions existing in the study area during peak hours, 7:00-8:00 in the morning and 4:00-5:00 in the afternoon with a 15 minutes interval through the use of close-circuit television (CCTV) records. The intersection's vehicle flow rate was gathered with the help of manual counting.

Table 2.1. Traffic Volume Count Survey (Morning Peak-Hour Summary)

Traffic Volume Count Survey (Peak-Hour Summary)													
Location			Direction			Date		Movement No.		Lane Movement		Survey Period	
Interval	Vehicle Type												15 min Traffic Volume
	1 Motor	2 Passenger Car	3 Passenger Utility	4 Goods Utility	5 Small Bus	6 Large Bus	7 Rigid Truck 2-Axle	8 Rigid Truck 3-Axle	9 Truck Semi-Trailer 3&4 Axles	10 Truck Semi-Trailer 5+ Axles	11 Truck Trailer 4+ Axles	12 Truck Trailer 5 Axle	
7:00-7:15													
7:15-7:30													
7:30-7:45													
7:45-8:00													
Total (1hr)													

Table 2.2. Traffic Volume Count Survey (Afternoon Peak-Hour Summary)

Traffic Volume Count Survey (Peak-Hour Summary)													
Location			Direction			Date		Movement No.		Lane Movement		Survey Period	
Interval	Vehicle Type												15 min Traffic Volume
	1 Motor	2 Passenger Car	3 Passenger Utility	4 Goods Utility	5 Small Bus	6 Large Bus	7 Rigid Truck 2-Axle	8 Rigid Truck 3-Axle	9 Truck Semi-Trailer 3&4 Axles	10 Truck Semi-Trailer 5+ Axles	11 Truck Trailer 4+ Axles	12 Truck Trailer 5 Axle	
4:00-4:15													
4:15-4:30													
4:30-4:45													
4:45-5:00													
Total (1hr)													

2.3 Synchro 8

A software program for macroscopic analysis and optimization is called Synchro 8. The Highway Capacity Manual (HCM), 2010 and 2000, are supported by Synchro, signalized, unsignalized, and roundabout intersections. For determining intersection capacity, Synchro also uses the Intersection Capacity Utilization approach. The signal optimization method in Synchro allows users to weigh specific phases, providing them more alternatives when creating signal timing schemes. Due to its simple and straightforward implementation, Synchro program is rated as one of the top traffic analysis applications.

The researchers used Synchro 8 since it integrates with HCM 2010 which uses Automobile Level of Service (LOS) to analyze the performance of intersection. Compared to manual calculations, the software offered calculations that were more accurate while also being easier. In operating this software, the following input settings were collected and entered: Lane Setting, Volume Setting, Timing Setting, and HCM 2010 Setting. The researchers manually collected data from governing bodies are shown in the black fonts, on the other hand the yellow-colored fonts were automatically generated by the software. Once the info has been entered, the software carried out the evaluation automatically and came up with the following values: Adjusted Flow Rate, HCM 2010 Capacity, HCM Volume/Capacity, HCM Movement Delay, HCM Movement LOS, HCM Approach Delay, and HCM Approach LOS.

2.3.1 Lane Setting

With lane settings providing a grid for lanes and regional data such as lane and sharing, traffic volume, link speed, set arterial name and speed, and lane width, values defined and provided by many sources were considered and inputted in the software.

A lane group is a set of lanes, or combination of lanes designed for each neighboring lanes that serves only one movement and each lane that serves two or more motions. To make data entry easier, the concept of movement groups was applied by the researchers. Each turn movement was figured to have one or more exclusive turn lanes, additionally, through motions had their own movement group. According to the Shared Lane Rules, Exclusive Turning Lanes were classified as turning lanes while Shared Lanes were classified as through lanes.

Traffic Volume was used to determine the turning movements in the research area during peak hours. These settings were defined by the manual traffic counting method stated in the chapter previously.

Fig.2.1. CCTV Footage Area A

Fig.2.2. CCTV Footage Area B

The following alteration has been made in light of the intersection's layout and purpose: storage length, storage lanes, right turn channelization, curb radius, and add lanes were not relevant factors. Additionally, since the governing body responsible over the study area was not able to provide the data for the grade difference, the site was considered an at-grade intersection.

After the following data were manually entered, the Synchro 8 software in reference to HCM 2010 automatically made the following adjustment factors applicable to the site: lane utilization factor, left turn factor (prot), Saturated flow rate (prot), left turn factor (perm), right ped bike factor, left ped factor, saturated flow rate (perm), link distance and ideal saturated flow (vphpl).

2.3.2 Volume Setting

In the volume setting data entry grid, various key volume data were entered such as traffic data, percentage of heavy vehicle, peak hour factor, growth rate, adjusted flow, and lane group flow. Peak hour factor determined the flow rate that represents the peak 15 minutes of rush hour and was calculated using the formula from the HCM 2010 manual.

$$P_{HF} = \frac{\text{Peak Hour Volume}}{4(15 - \text{minute volume})}$$

The Percent Heavy Vehicles was computed based on peak-hour traffic turning motions, where each traffic movement reflects the percentage of trucks and buses. Each lane was considered independently in the derivation of these values using the formula from the HCM 2010 manual.

$$P_{HV} = \frac{No. of\ Vehicles}{Total\ no. of\ Vehicles} x\ 100$$

The Adjusted flow is the entered volume modified by the peak hour factor and growth factor, while lane group flow combines the adjusted flow and traffic in shared lanes percent values resulting in net volumes for each lane group. Adjusted flow and lane group flow were automatically computed data by the Synchro 8 software in reference to HCM 2010. The growth rate factor is used to adjust traffic volume and ranges from 0.5 to 0.3; however, no value was inputted in this setting due to this stage of the study focuses on the assessment of the present traffic road condition of the intersection and does not require any traffic volume prediction.

2.3.3 Timing Settings

The timing and phasing values in the study area were the focus of this section of the procedures. These values were ascertained using manual calculations, standard values presented by synchro 8 software from HCM 2010, and inspection of CCTV footage. The software utilized the following parameters, which were computed and defined, thereby generating the data required for the intersection evaluation. Turn type is essentially created up of numerous left and right turn patterns that respect other lanes in a variety of situations, such as when it is time to stop and go or when it is free to go at any time. Both lanes with a distinct right-turn lane and lanes with a right-side limitation are always permitted to turn right with caution. There are numerous types of turns, but only two of them were primarily seen in the study area: permitted and split. When two or more motions in an approach happen at once, split is active. On the other hand, permitted turns are unprotected and must yield for approaching cars and people using crosswalks.

The control type field was used to indicate the controller setting present in the study area. Signal timings can be divided into two categories: (1) pre-timed signal timings, and (2) Actuated signal timings. The capacity of actuated signals to detect cars and regulate traffic light timing depending on the demands of the junction and the presence of vehicle movement as compared to pre-timed signals, which have a set timer, is the primary distinction between the two. Timings for actuated signals can be either partially or fully actuated, depending on whether there are signal detectors just on the minor street or on all approaches. Thus, the both areas were assumed to utilize non-coordinated, Fully Actuated signalized.

2.3.4 HCM Setting

Indicators established and determined with Synchro 8 were put to use for this part of the evaluation. HCM 2010 setting requires additional criteria, such as maximum split, to be determined in addition to the previously specified values. It is the amount of time in terms of green, yellow, and all red that is assigned to each phase. In order to attain, the maximum green time was combined with all-yellow and all-red time.

2.4 Data Analysis

Input values for lanes are then calculated and previously defined. Using the Synchro 8 software operating conditions of the study area were calculated and assessed using HCM 2010 criteria. Included in the results calculated and presented are total delays for each lane, approach, and intersection as a whole and their corresponding level of service classification which were shown in Table 2.3.

Table.2.3. LOS Identification Table

LOS	Traffic Condition	Description
A	Free Flow Traffic	Users are practically unaffected by the presence of other vehicles on a road section. The choice of speed and the maneuverability are free. The level of comfort is excellent, as drivers need minimal attention. The volume-to-capacity ratio is usually below 0.2.
B	Steady Traffic	The presence of other vehicles begins to affect the behavior of individual drivers. The choice of the speed is free, but the maneuverability has somewhat decreased. The comfort is excellent, as drivers simply need to keep an eye on nearby vehicles.
C	Steady Traffic but Limited	The presence of other vehicles affects drivers. The choice of the speed is affected and maneuvering requires vigilance. The level of comfort decreases quickly at this level, because drivers have a growing impression of being caught between other vehicles.
D	Steady traffic at High Density	The speed and the maneuverability are severely reduced. Low level of comfort for drivers, as collisions with other vehicles, must constantly be avoided. A slight increase in the traffic risks causing some operational problems and saturating the network.
E	Traffic at Saturation	Low but uniform speed. Maneuverability is possible only under constraint for another vehicle. Users are in a state of frustration.
F	Congestion	Unstable speed with the formation of waiting lines at several points. Cycles of stop and departure with no apparent pattern because created by the behavior of other drivers. A high level of vigilance is required for the user with practically no comfort. At this level, the volume-to-capacity ratio exceeds 1, implying that the road segment is used above design capacity.

2.5 Traffic Simulation

The study's findings included the results of a traffic simulation, which meant to simulate different traffic situations in order to perceive the flow of traffic. In situations where it offers a realistic approach of analysis that is simple to test, explain, and understand, simulation modelling is a secure and effective way to address problems that arise in real life.

One of the most popular traffic simulators, acknowledged for usage even by first-world PTV Vissim was utilized to give accurate traffic simulations across nations. The software of choice enables the user to move around on any road location in a manner that mimics actual traffic. This program was used by cities and highways all over the world to produce precise road traffic models and efficient traffic management strategies to help with and resolve traffic issues.

This simulator was employed in the study because it offered a thorough analysis of traffic flow and allowed the creation of numerous traffic situations and route layouts. The following procedures and input variables were followed when using this software to get the simulation results

2.5.1 Network Objective Type

The network object sidebar in this section, which includes a list of the network objects, is highlighted. The research suggested the following network item kinds.

Links. Using this option, straight links could be defined or intermediate points could be added to change the link's path. This was further chosen to enter the desired value into the Lane width box.

Vehicle Inputs. The quantity of vehicles input into the PTV Vissim network is regulated by vehicle inputs. In this section, links were created and loaded with traffic volume measured by the researchers through manual counting.

Vehicle Routes. A route for a vehicle consists of a number of interconnected links and junctions. Any length path can be utilized to connect several network nodes or to indicate a turning movement at a single junction. In this research, a static routing decision was used to direct cars from a start portion to one of the predetermined destination parts of the vehicle routes.

Signal Heads. It can be positioned in the network with lane-level accuracy at the stop line.

Accuracy. PTV Vissim displays signal heads as red lines by default. To model 3D traffic signals realistically for a simulation, 3D signal head, sign and light and 3D traffic signals were defined.

Node. Identifying the parts of the intersection as nodes was done to reduce the complexity of the network model and hence the calculation time and memory required. Nodes are places on a path where two or more paths intersect or diverge. Typically, these are the parts of the network that make up an actual intersection.

2.5.2 Signal Control

Signal Group successfully modified signal controllers' signal control. Signal groups, each of which has a unique signal controller number, make up PTV Vissim's smallest control element. Depending on its control logic, a signal controller may be allocated up to 125 signal groups. Since signal groups cannot be seen in reality, PTV Vissim distinguishes between signal heads and signal groups. One signal group can have many signal heads that consistently display the same image. This component was developed for the Signal Program's group phasing at the intersection. The stage-based signal program has a user-defined cycle period and stages with arbitrary durations. Interstage form the foundation of the signal program. For instance, PTV Vissim might use the stage duration if it distributes the participants equally. Due to the fact that optimization changes the initial stage lengths, the suggested stage length can be employed. The cycle time was discussed in this section.

2.5.3 Evaluation

During simulations, depending on the network objects that have been deployed, many sorts of data are created, such as information on automobiles, links, locations, and nodes, as well as information about traffic congestion, green time distribution, and PT waiting periods. Before the simulation started, they were set up by selecting the planned evaluation and then complying with the network object types stated earlier.

2.6 Comparison of the Intersection before and after implementing Traffic Lights

In order to demonstrate the improved effectiveness and efficiency of the selected road design, a comparative analysis using vehicular delays and their corresponding level of service (LOS) rating was conducted between the current intersection and the proposed signalized traffic lights using the current traffic volume present in the study area.

III. RESULTS AND DISCUSSION

3.1 Introduction

The purpose of this study is to verify that traffic congestion in the City of San Fernando, Pampanga is caused by the conjunction road at Lazatin Blvd. and Capitol Blvd., as well as the Cabalantian Bridge at Sitio Palawe. It also makes the hypothesis that the installation of a signalized traffic system on the site could improve traffic flow along the study area. Using closed-circuit television (CCTV) footages and HCM 2010 Criteria for Synchro 8 as a calculation and assessment tool, the researchers' methodology was followed when conducting the traffic survey. Common traffic flow characteristics were then used to interpret the results.

3.2 Defining and calculating the Node, Lane, and Volume Settings Input for Synchro 8

The control type of the intersection was the only parameter that needed to be specified for the node settings. In order to determine this, as was mentioned in a previous section, the study area was created as a fully actuated, uncoordinated intersection.

3.2.1 Identifying the Movement Groups and Traffic Volume

Using the gathered CCTV footages from LGU Brgy. San Juan, the Traffic Volume manual counting was done and divided into four categories which are the Road Bounds: Northbound; Southbound; Eastbound; and Westbound, in which were also subdivided into three subcategories which are Left Turn (LT), Right Turn (RT), and Through (T). Parameters such as Traffic Volume of each road bounds in Area A (Lazatin Blvd and Capitol Blvd) and Area B (Intersection Road at Cabalantian Bridge) are shown below.

AREA A

Fig.3.1: Movement Groups (Area A)

Table 3.1: Traffic Volume per Lane Group (Area A – Morning)

Approach	Northbound			Southbound			Eastbound			Westbound			Total
Lane Group	LT	T	RT	LT	T	RT	LT	T	RT	LT	T	RT	
Traffic Volume (veh/hr)	513			558		354	1137			483		391	3436

Table 3.2: Traffic Volume per Lane Group (Area A – Noon)

Approach	Northbound			Southbound			Eastbound			Westbound			Total
Lane Group	LT	T	RT	LT	T	RT	LT	T	RT	LT	T	RT	
Traffic Volume (veh/hr)	303			738		336	1023			450		373	3223

AREA B

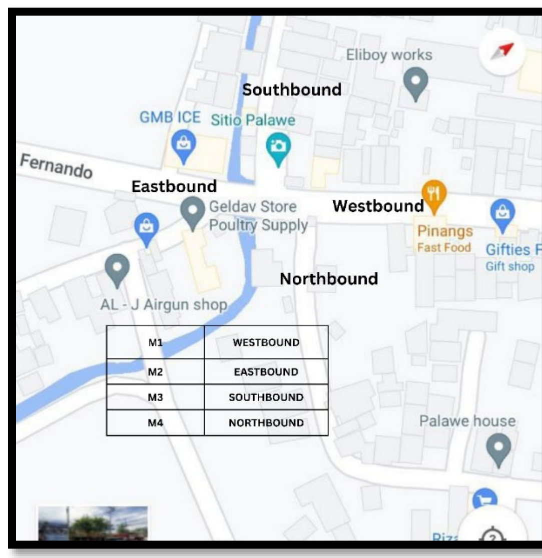


Fig.3.2. Movement Groups (Area B)

Table.3.3: Traffic Volume per Lane Group (Area B – Morning)

Approach	Northbound			Southbound			Eastbound			Westbound			Total
Lane Group	LT	T	RT	LT	T	RT	LT	T	RT	LT	T	RT	
Traffic Volume (veh/hr)	51			240			1106			1027			2424

Table 3.4: Traffic Volume per Lane Group (Area B – Noon)

Approach	Northbound			Southbound			Eastbound			Westbound			Total
Lane Group	LT	T	RT	LT	T	RT	LT	T	RT	LT	T	RT	
Traffic Volume (veh/hr)	43			223			918			918			2102

3.2.2 Lane Width (m)

Using Google Earth, Lane widths of each road bound lanes were identified and shown below:

Table.3.5. Intersection Lane Width (Area A)

Approach	Northbound			Southbound			Eastbound			Westbound		
Lane Group	LT	T	RT	LT	T	RT	LT	T	RT	LT	T	RT
Lane Width (m)	1.8			3.6		4	3			3.4		1.8

Table.3.6: Intersection Lane Width (Area B)

Approach	Northbound			Southbound			Eastbound			Westbound		
Lane Group	LT	T	RT	LT	T	RT	LT	T	RT	LT	T	RT
Lane Width (m)	2.2			2.5			2.9			3		

3.2.3Calculating the Peak Hour Factor P_{HF}

By observing the tabulated data from the Traffic Volume Count, it was determined that volume in the morning (AM) has the higher volume of vehicles for the two areas. With that, tabulated data from peak hour of morning was used and it was determined that the Cabalantian Bridge to San Fernando (Area B) and San Fernando Road to Capitol Blvd (Area A) route has the highest volume of vehicles among all the routes, thus, the researchers used the data from this lane to determine the Peak Hour Factor (PHF).

FOR AREA A

Table.3.7. Peak Lane Summary (Area A)

Peak Lane Summary	
Direction:	**Date**: March 23-29, 2023
Interval	**15-minute Traffic Volume**
7:00AM - 7:15AM	118
7:15AM - 7:30AM	131
7:30AM - 7:45AM	139
7:45AM - 8:00AM	134
Total (1-hr)	522

$$P_{HF} = \frac{\text{Peak Hour Volume}}{4(15 - \text{minute volume})}$$

$$\text{Phf} = \frac{522}{4(139)}$$

$P_{HF} = 0.9388 = 93.88\%$

FOR AREA B

Table 3.8: Peak Lane Summary (Area B)

Peak Lane Summary	
Direction:	**Date**: March 23-29, 2023
Interval	**15-minute Traffic Volume**
7:00AM - 7:15AM	30
7:15AM - 7:30AM	36
7:30AM - 7:45AM	35
7:45AM - 8:00AM	33
Total (1-hr)	134

$$P_{HF} = \frac{\text{Peak Hour Volume}}{4(15 - \text{minute volume})}$$

$$\text{Phf} = \frac{134}{4(36)}$$

$P_{HF} = 0.9306 = 93.06\%$

3.3 Defining and Calculating the Timing Settings Inputs for Synchro 8

Through observation, the researchers have identified the turn types of each movement of the road bounds that are shown below.

AREA A

Table.3.11. Intersection Turn Type (Area A)

Approach	Northbound			Southbound			Eastbound			Westbound		
Lane Group	LT	T	RT	LT	T	RT	LT	T	RT	LT	T	RT
Turn Type	S			S		Pm	S			S		Pm

AREA B

Table.3.12. Intersection Turn Type (Area B)

Approach	Northbound			Southbound			Eastbound			Westbound		
Lane Group	LT	T	RT	LT	T	RT	LT	T	RT	LT	T	RT
Turn Type	S			S			S			S		

Where:
S – Split
Pm – Permitted
Pt – Protected

3.3.1 Presentation and Evaluation of Synchro 8 results

Through the utilization of synchro 8, the delay and LOS for each road bound movement were identified, evaluated and tabulated, and are presented below.

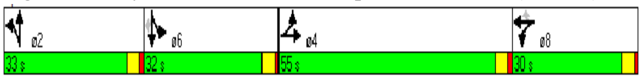
AREA A

Table 3.23 Synchro 8 Intersection Summary (Area A)

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	1137	0	0	483	391	0	513	0	0	558	354
Movement Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Queue, veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj. Factor (A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking, Bus Adj. Factors	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Sat. Flow Rate, veh/h/ln	1900	1771	1900	1900	1827	1771	1900	1788	1900	1900	1863	1918
Lanes	0	1	0	0	1	1	0	1	0	0	1	1
Lane Assignment												
Capacity, veh/h	0	602	0	0	317	261	0	346	0	0	348	304
Proportion Arriving On Green	0.00	0.34	0.00	0.00	0.17	0.17	0.00	0.19	0.00	0.00	0.19	0.19
Movement Delay, s/veh	0.0	509.4	0.0	0.0	356.3	346.8	0.0	334.4	0.0	0.0	391.3	192.7
Movement LOS		F			F	F		F			F	F
Approach Volume, veh/h		1210			930			546			970	
Approach Delay, s/veh		509.4			352.0			334.4			314.2	
Approach LOS		F			F			F			F	
Intersection Summary												
HCM Average Control Delay			391.4									
HCM Level of Service			F									

Splits and Phases: 3

Figure 3.11 Synchro 8 Intersection Splits and Phases (Area A)



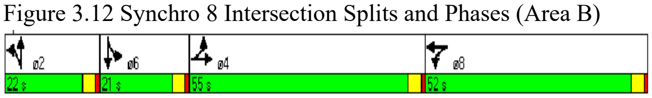
AREA B

Table 3.24 Synchro 8 Intersection Summary (Area B)

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	1106	0	0	1027	0	0	51	0	0	240	0
Movement Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Queue, veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj. Factor (A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking, Bus Adj. Factors	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Sat. Flow Rate, veh/h/ln	1900	1788	1900	1900	1771	1900	1900	1824	1900	1900	1824	1900
Lanes	0	1	0	0	1	0	0	1	0	0	1	0
Lane Assignment												
Capacity, veh/h	0	608	0	0	567	0	0	219	0	0	207	0
Proportion Arriving On Green	0.00	0.34	0.00	0.00	0.32	0.00	0.00	0.12	0.00	0.00	0.11	0.00
Movement Delay, s/veh	0.0	485.7	0.0	0.0	484.4	0.0	0.0	62.6	0.0	0.0	211.9	0.0
Movement LOS		F			F			E			F	
Approach Volume, veh/h		1189			1104			55			258	
Approach Delay, s/veh		485.7			484.4			62.6			211.9	
Approach LOS		F			F			E			F	
Intersection Summary												
HCM Average Control Delay			449.1									
HCM Level of Service			F									

Splits and Phases: 9

Figure 3.12 Synchro 8 Intersection Splits and Phases (Area B)



Synchro 8 calculated LOS (A-F) using the data values from CCTV footages reflecting peak hour traffic conditions in study areas. This was achieved by calculating the total delay and LOS per road bound lane. The researchers then used these to get the same values for each road bounds and finally intersection.

Table.3.25 LOS Identification Table

LOS	Traffic Condition	Description
A	Free Flow Traffic	Users are practically unaffected by the presence of other vehicles on a road section. The choice of speed and the maneuverability are free. The level of comfort is excellent, as drivers need minimal attention. The volume-to-capacity ratio is usually below 0.2.
B	Steady Traffic	The presence of other vehicles begins to affect the behavior of individual drivers. The choice of the speed is free, but the maneuverability has somewhat decreased. The comfort is excellent, as drivers simply need to keep an eye on nearby vehicles.
C	Steady Traffic but Limited	The presence of other vehicles affects drivers. The choice of the speed is affected and maneuvering requires vigilance. The level of comfort decreases quickly at this level, because drivers have a growing impression of being caught between other vehicles.
D	Steady traffic at High Density	The speed and the maneuverability are severely reduced. Low level of comfort for drivers, as collisions with other vehicles, must constantly be avoided. A slight increase in the traffic risks causing some operational problems and saturating the network.
E	Traffic at Saturation	Low but uniform speed. Maneuverability is possible only under constraint for another vehicle. Users are in a state of frustration.
F	Congestion	Unstable speed with the formation of waiting lines at several points. Cycles of stop and departure with no apparent pattern because created by the behavior of other drivers. A high level of vigilance is required for the user with practically no comfort. At this level, the volume-to-capacity ratio exceeds 1, implying that the road segment is used above design capacity.

By using the results presented by Synchro 8 and Table 3.9, with a Level of Service of F for most lanes, all approaches, and the intersection, the traffic condition in the junction road of Lazatin Blvd and Capitol Blvd is in barangay San Juan, City of San Fernando, Pampanga is regarded as "Congested". With these results, the researchers had to the conclusion that the area need to be systematized and organized, thus, traffic light system was presented to alleviate traffic congestion.

3.4 *Inputting PTV Vissim Parameters*

After obtaining the Synchro 8 data, which confirmed the poor traffic flow in the research region, simulation of the suggested signal lights was performed to quickly analyze and see their impacts in the area.

The results generated by the software were split with regards to the cycle lengths entered and their respective phase times and movement. The outcomes were summarized and tabulated below. This was done in order to compare the resulting performances and select the signal timing condition that yielded the best outcome

AREA A

Cycle Length: 90 seconds

Table.3.26 PTV Vissim Evaluation Results (90 seconds)

PTV Vissim Evaluation Results							
Movement	Phase Time (s)	Trial 1		Trial 2		Trial 3	
		Delay (s/veh)	LOS	Delay (s/veh)	LOS	Delay (s/veh)	LOS
Lazatin to Capitol	22	56.33	E	72.2	E	58.34	E
Lazatin to San Juan	22	37.04	D	76.99	E	42.4	D
Lazatin to San Fernando	-	0.01	A	0.01	A	0.01	A
Capitol to Lazatin	-	0.46	A	0.26	A	0.53	A
Capitol to San Juan	22	45.84	D	0.01	A	0.01	A
Capitol to San Fernando	22	33.32	C	31.01	C	33.49	C
San Juan to Lazatin	15	46.63	D	109.58	F	79.35	E
San Juan to Capitol	15	14.27	B	115.73	F	88.95	F
San Juan to San Fernando	15	46.64	D	118.19	F	85.93	F
San Fernando to Lazatin	19	42.44	D	14.21	B	37.41	D
San Fernando to Capitol	41	0.01	A	0.01	A	0.01	A
San Fernando to San Juan	41	0.01	A	0.01	A	46.16	D

Average Intersection LOS: D

Cycle Length: 120 seconds

Table.3.27 PTV Vissim Evaluation Results (120 seconds)

PTV Vissim Evaluation Results							
Movement	Phase Time (s)	Trial 1		Trial 2		Trial 3	
		Delay (s/veh)	LOS	Delay (s/veh)	LOS	Delay (s/veh)	LOS
Lazatin to Capitol	41	47.37	D	73.98	E	29	C
Lazatin to San Juan	41	47.71	D	71.38	E	55.04	E
Lazatin to San Fernando	-	0.01	A	0.01	A	0.01	A
Capitol to Lazatin	-	0.48	A	0.23	A	10.18	B
Capitol to San Juan	41	68.53	E	0.01	A	0.01	A
Capitol to San Fernando	41	46.11	D	49.71	D	56.37	E
San Juan to Lazatin	31	59.55	E	95.99	F	66.49	E
San Juan to Capitol	31	73.09	E	89.26	F	48.86	D
San Juan to San Fernando	31	58.2	E	90.61	F	58.87	E
San Fernando to Lazatin	35	13.44	B	0.01	A	8.39	A
San Fernando to Capitol	76	0.01	A	0.01	A	0.01	A
San Fernando to San Juan	76	0.01	A	0.01	A	36.12	D

Average Intersection LOS: D

Cycle Length: 160 seconds

Table.3.28 PTV Vissim Evaluation Results (160 seconds)

PTV Vissim Evaluation Results							
Movement	Phase Time (s)	Trial 1		Trial 2		Trial 3	
		Delay (s/veh)	LOS	Delay (s/veh)	LOS	Delay (s/veh)	LOS
Lazatin to Capitol	41	47.37	D	73.98	E	29	C
Lazatin to San Juan	41	47.71	D	71.38	E	55.04	E
Lazatin to San Fernando	-	0.01	A	0.01	A	0.01	A
Capitol to Lazatin	-	0.48	A	0.23	A	10.18	B
Capitol to San Juan	41	68.53	E	0.01	A	0.01	A
Capitol to San Fernando	41	46.11	D	49.71	D	56.37	E
San Juan to Lazatin	31	59.55	E	95.99	F	66.49	E
San Juan to Capitol	31	73.09	E	89.26	F	48.86	D
San Juan to San Fernando	31	58.2	E	90.61	F	58.87	E
San Fernando to Lazatin	35	13.44	B	0.01	A	8.39	A
San Fernando to Capitol	76	0.01	A	0.01	A	0.01	A
San Fernando to San Juan	76	0.01	A	0.01	A	36.12	D

Average Intersection LOS: D

Cycle Length: 200 seconds

Table.3.29 PTV Vissim Evaluation Results (200 seconds)

PTV Vissim Evaluation Results							
Movement	Phase Time (s)	Trial 1		Trial 2		Trial 3	
		Delay (s/veh)	LOS	Delay (s/veh)	LOS	Delay (s/veh)	LOS
Lazatin to Capitol	51	56.08	E	56.21	E	41.29	D
Lazatin to San Juan	51	70.17	E	65.15	E	55.27	E
Lazatin to San Fernando	-	0.01	A	0.01	A	0.01	A
Capitol to Lazatin	-	0.46	A	0.01	A	10.12	B
Capitol to San Juan	51	156.65	F	0.01	A	0.01	A
Capitol to San Fernando	51	62.4	E	60.25	E	82.98	F
San Juan to Lazatin	39	82.17	F	97.8	F	81.48	F
San Juan to Capitol	39	80.86	F	150.87	F	36.62	D
San Juan to San Fernando	39	54.38	D	96.1	F	76.34	E
San Fernando to Lazatin	45	123.44	F	95.21	F	118.41	F
San Fernando to Capitol	96	0.01	A	0.01	A	0.01	A
San Fernando to San Juan	96	0.01	A	0.01	A	156.16	F

Average Intersection LOS: E

Based on the results given by the PTV Vissim software, in using pre-timed signal timings, a cycle length of 90 seconds proved to be the most effective by yielding the lowest delay and highest level of service out of all cycle lengths considered in the study. The proposed signal light system showed improvement with most lanes having an LOS rating of D and traffic condition of "Steady at high Density". Having an average intersection LOS rating of D, the traffic road condition shows improvement compared to the results garnered by the present road design.

AREA B

Cycle Length: 90 seconds

Table 3.30 PTV Vissim Evaluation Results (90 seconds)

PTV Vissim Evaluation Results							
Movement	Phase Time (s)	Trial 1		Trial 2		Trial 3	
		Delay (s/veh)	LOS	Delay (s/veh)	LOS	Delay (s/veh)	LOS
San Fernando to Sitio Palawe	57	18.3	B	23.7	C	21.8	C
San Fernando to Cabalantian Bridge	57	15.7	B	27.8	C	24.2	C
San Fernando to San Juan	57	22.6	C	25.8	C	22.2	C
Cabalantian Bridge to San Fernando	57	43.6	D	27.1	C	71.1	E
Cabalantian Bridge to Sitio Palawe Outbound	57	26.3	C	12.5	B	45.9	D
Cabalantian Bridge to San Juan	57	24.4	C	16.9	B	46.5	D
San Juan to San Fernando	27	71.7	E	61.3	E	81.5	F
San Juan to Sitio Palawe	27	15.4	B	0	A	7.7	A
San Juan to Cabalantian Bridge	27	32.8	C	0	A	19.5	B
Sitio Palawe to San Fernando	27	59.6	E	47.9	D	60.8	E
Sitio Palawe to Cabalantian Bridge	27	33.1	C	26.6	C	10.1	B
Sitio Palawe to San Juan	27	27.6	C	19.6	B	28	C

Average Intersection LOS: C

Cycle Length: 120 seconds

Table 3.31 PTV Vissim Evaluation Results (120 seconds)

PTV Vissim Evaluation Results							
Movement	Phase Time (s)	Trial 1		Trial 2		Trial 3	
		Delay (s/veh)	LOS	Delay (s/veh)	LOS	Delay (s/veh)	LOS
San Fernando to Sitio Palawe	57	23.1	C	21.4	C	21.9	C
San Fernando to Cabalantian Bridge	57	22.8	C	23.1	C	21.6	C
San Fernando to San Juan	57	26.4	C	23.4	C	23	C
Cabalantian Bridge to San Fernando	57	45.5	D	55.2	E	68.8	E
Cabalantian Bridge to Sitio Palawe Outbound	57	29.4	C	32.8	C	42.2	D
Cabalantian Bridge to San Juan	57	18.2	B	31.7	C	44.5	D
San Juan to San Fernando	27	69	E	40.8	D	86.6	F
San Juan to Sitio Palawe	27	26.3	C	0	A	14.5	B
San Juan to Cabalantian Bridge	27	39.2	D	0	A	50.9	D
Sitio Palawe to San Fernando	27	74.9	E	57.2	E	67.1	E
Sitio Palawe to Cabalantian Bridge	27	21	C	19.3	B	42.9	D
Sitio Palawe to San Juan	27	31.7	C	21.2	C	30.2	C

Average Intersection LOS: C

Cycle Length: 160 seconds

Table 3.32 PTV Vissim Evaluation Results (160 seconds)

PTV Vissim Evaluation Results							
Movement	Phase Time (s)	Trial 1		Trial 2		Trial 3	
		Delay (s/veh)	LOS	Delay (s/veh)	LOS	Delay (s/veh)	LOS
San Fernando to Sitio Palawe	57	37.4	D	28.6	C	31.7	C
San Fernando to Cabalantian Bridge	57	30.4	C	39.3	D	23.6	C
San Fernando to San Juan	57	26.4	C	26.1	C	28.1	C
Cabalantian Bridge to San Fernando	57	60.2	E	73.9	E	83.1	F
Cabalantian Bridge to Sitio Palawe Outbound	57	45	D	54.2	D	50.4	D
Cabalantian Bridge to San Juan	57	43	D	46.6	D	52.3	D
San Juan to San Fernando	27	34.6	C	67.9	E	87.5	F
San Juan to Sitio Palawe	27	64.2	E	0	A	43.2	D
San Juan to Cabalantian Bridge	27	0	A	0	A	57.6	E
Sitio Palawe to San Fernando	27	87.2	F	68.6	E	63.3	E
Sitio Palawe to Cabalantian Bridge	27	22.1	C	38.2	D	21.5	C
Sitio Palawe to San Juan	27	45.7	D	30.8	C	39.8	D

Average Intersection LOS: D

Cycle Length: 200 seconds

Table 3.33 PTV Vissim Evaluation Results (200 seconds)

PTV Vissim Evaluation Results							
Movement	Phase Time (s)	Trial 1		Trial 2		Trial 3	
		Delay (s/veh)	LOS	Delay (s/veh)	LOS	Delay (s/veh)	LOS
San Fernando to Sitio Palawe	57	25.6	C	33.6	C	21.9	C
San Fernando to Cabalantian Bridge	57	21.4	C	12.4	B	23	C
San Fernando to San Juan	57	25	C	34.9	C	23.4	C
Cabalantian Bridge to San Fernando	57	50.8	D	65.2	E	78	E
Cabalantian Bridge to Sitio Palawe Outbound	57	32.7	C	43.2	D	42.2	D
Cabalantian Bridge to San Juan	57	30.7	C	38.4	D	46.5	D
San Juan to San Fernando	27	75.2	E	124.6	F	85.4	F
San Juan to Sitio Palawe	27	44.6	D	0	A	105.5	F
San Juan to Cabalantian Bridge	27	35.3	D	0	A	38.2	D
Sitio Palawe to San Fernando	27	130.1	F	72.1	E	70.1	E
Sitio Palawe to Cabalantian Bridge	27	61.1	E	72.1	E	53.7	D
Sitio Palawe to San Juan	27	38.8	D	46.8	D	32	C

Average Intersection LOS: D

Based on the results given by the PTV Vissim software, in using pre-timed signal timings, a cycle length of 90 seconds proved to be the most effective by yielding the lowest delay and highest level of service out of all cycle lengths considered in the study. The proposed signal light system showed improvement, with most lanes having an LOS rating of C and a traffic condition of "Steady but Limited". With an average intersection LOS rating of C in the second area, the traffic road quality increases over the present road design outcomes.

3.5 *Comparison of the Intersection before and after implementing Traffic Light*

After accomplishing the traffic assessment done by both software with their respective road systems, the resulting vehicular delay and LOS ratings were then compared to ascertain the more effective and efficient design of Traffic Lights System.

AREA A

Table 3.34 Synchro 8 Evaluation Result Summary (Area A)

Synchro 8 Evaluation Results		
Movement	Delay (s/veh)	LOS
San Juan to San Fernando Road	334.4	F
San Juan to Lazatin Blvd		
San Juan to Capitol Blvd		
Lazatin Blvd to Capitol Blvd	391.3	F
Lazatin Blvd to San Juan		
Lazatin Blvd to San Fernando Road	192.7	F
San Fernando Road to Lazatin Blvd	509.4	F
San Fernando Road to Capitol Blvd		
San Fernando Road to San Juan		
Capitol Blvd to San Juan	356.3	F
Capitol Blvd to San Fernando Road		
Capitol Blvd to Lazatin Blvd	346.8	F

Looking at the data summarized in Table 3.20, vehicular delay in seconds that occurs per lane in the present design ranges from a minimum of 334.4 with an equivalent

LOS rating of F to a maximum of 509.4 with a corresponding LOS rating of F.

AREA B

Table 3.35 Synchro 8 Evaluation Result Summary (Area B)

Synchro 8 Evaluation Results		
Movement	Delay (s/veh)	LOS
Cabalantian Bridge to Sitio Palawe	485.7	F
Cabalantian Bridge to San Fernando Road		
Cabalantian Bridge to San Juan		
San Fernando Road to Sitio Palawe	484.4	F
San Fernando Road to Cabalantian Bridge		
San Fernando Road to San Juan		
San Juan to Cabalantian Bridge	62.6	E
San Juan to Sitio Palawe		
San Juan to San Fernando Road		
Sitio Palawe to Cabalantian Bridge	211.9	F
Sitio Palawe to San Juan		
Sitio Palawe to San Fernando Road		

Looking at the data summarized in Table 3.35, vehicular delay in seconds that occurs per lane in the present design ranges from a minimum of 62.6 with an equivalent LOS rating of E to a maximum of 485.7 with a corresponding LOS rating of F.

AREA A

Table.3.36 PTV Vissim Evaluation Results (90 sec)

PTV Vissim Results		
Movement	Delay (s/veh)	LOS
Lazatin to Capitol	56.33	E
Lazatin to San Juan	37.04	D
Lazatin to San Fernando	0.01	A
Capitol to Lazatin	0.46	A
Capitol to San Juan	45.84	D
Capitol to San Fernando	33.32	C
San Juan to Lazatin	46.6	D
San Juan to Capitol	14.27	B
San Juan to San Fernando	46.64	D
San Fernando to Lazatin	42.44	D
San Fernando to Capitol	0.01	A
San Fernando to San Juan	0.01	A

AREA B

Table.3.37 PTV Vissim Evaluation Results (90 sec)

PTV Vissim Evaluation Results		
Movement	Delay (s/veh)	LOS
San Fernando to Sitio Palawe	21.3	C
San Fernando to Cabalantian Bridge	22.6	C
San Fernando to San Juan	23.5	C
Cabalantian Bridge to San Fernando	47.3	D
Cabalantian Bridge to Sitio Palawe Outbound	28.2	C
Cabalantian Bridge to San Juan	29.3	C
San Juan to San Fernando	71.5	E
San Juan to Sitio Palawe	7.7	A
San Juan to Cabalantian Bridge	17.4	B
Sitio Palawe to San Fernando	56.1	E
Sitio Palawe to Cabalantian Bridge	23.3	C
Sitio Palawe to San Juan	25.1	C

It is observed in Table 3.36 and table 3.37 that the evaluation of the proposed traffic signal system yielded vehicular delay in seconds per lane spanning from a minimum of 0.01 with an LOS rating of A to a maximum of 56.1 with an LOS rating of E.

Gauging the vehicular delay present in both designs, it is clear that the delay present in the proposed system is much less in comparison to the delay observed in the current intersection. In addition to this, with LOS ratings of most lanes as F as well as the current intersection as a whole for both areas, and the LOS rating of the proposed system as D and C respectively, a vast improvement was observed in the traffic flow of the study area's simulation. After taking these factors into account, it was determined that the proposed traffic signal system is a better substitute for the current road layout.

IV. SUMMARY, CONCLUSION AND RECOMMENDATIONS

4.1 Summary of Results

Using the gathered CCTV records from LGU Brgy. San Juan, the Traffic Volume manual counting was done, tabulated data and summary were identified such as the traffic volume and peak hour. These data were utilized on Synchro 8 to determine the LOS and delay of the study area.

Using the values summarized by tables above, Synchro 8 software assessed the intersection's performance by multiple criteria, most important of which is by vehicular or movement delay (s/veh) and its corresponding LOS rating.

After verifying the poor traffic flow in the site, simulations were done in PTV Vissim with the proposed signal light system along the intersection's main road. In order to test the performance of the planned road system under similar traffic conditions, identical data from the evaluation were utilized in the simulation. Several cycle lengths were investigated and separated into three phase periods using the traffic volume of each movement as a foundation before settling on a 90-second cycle length.

Using the LOS rating of each lane as reference, a conclusion was made confirming the initial hypothesis and objective of the researchers: a traffic signal system can be used to alleviate the poor traffic flow along the Area A intersection and Area B intersection.

4.2 Data Analysis and Conclusion

A comparison analysis was carried out using all the collected data and the evaluations that resulted to compare the effectiveness and efficiency of the road systems taken into consideration for this study.

4.3 Recommendations

As a result of this study, the initial hypothesis of the researchers can be validated. The implementation of a traffic signal system along the intersection has been proven to be a more efficient alternative than the current road system. In order to further augment the proposed road design and develop its efficacy, the following recommendations are suggested:

Supplementing the gathered data. As a consequence of time and financial constraints and lack of technological means, some data regarding the timing conditions, pedestrians, and presence of bicycles in the study areas were disregarded. By defining these missing data points, a more accurate and reflective assessment of the site may be calculated and simulated.

Utilization of the full versions of PTV Vissim and Synchro 8 software. With access being limited to the student versions of the software mentioned, there were restrictions placed on the simulations and their corresponding evaluations. Having access to the full versions of the software allows for the utilization of all the functions that it may provide.

Improved regulation of traffic rules and conditions. A certain number of drivers fail to comply with the basic traffic rules and etiquette, which affects the poor traffic in the area. The municipal government in charge of the region should enforce these restrictions more strictly and impose the appropriate penalties.

Formulating a detailed design of the traffic signal system. This study focuses on the general implementation and effects of signal lights in the chosen study areas. A detailed plan of the traffic signal system including its general program design and construction cost would make the proposal more tangible.

Providing a Traffic projection. The research presented focuses on the present situation of the intersections. In order to ascertain that the effectiveness of the proposal offers a lasting effect along the study area, a traffic projection is needed.

Applying a Feasibility study. The study area is a route mainly used by civilians on a daily basis. Adding a survey can provide supporting data and give reasons why this research should be done.

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