Traffic Flow Simulation Using PTV Vissim: A Proposed Solution on Jose Abad Santos Avenue Road and Baliwag – Candaba – Sta. Ana Road Intersection

Marvin M. Fuertez [1], Art Clarence L. Aguinaldo [1], Kenneth R. Cadungog [1], Jeanne Vincent G. Lintag [1], Jayvee B. Nicdao [1], John Irish M. Pangan [1], Jayvee C. Villanueva [1], John Vincent G. Tongol [2], Jonna May B. Mandap [2]

[1]Student, Department of Civil Engineering, Don Honorio Ventura State University, Pampanga, Philippines.

[2]Faculty, Department of Civil Engineering, Don Honorio Ventura State University, Pampanga, Philippines.

Corresponding Author: fuertezmarvinm@gmail.com

Abstract: - Access to numerous locations for businesses and individuals, for both commercial and personal movements, is transportation's major function. One of the neighboring provinces of Metro Manila is Pampanga; consequently, most parts of Pampanga are experiencing traffic congestion, including the Sta. Ana intersection. The traffic in this area is highly congested throughout the day and every day of the week. The goal of this paper is to alleviate the traffic congestion happening in Sta. Ana, Pampanga intersection using rerouting and utilizing road widening with traffic lights. The Manual Counting Method gathers the necessary information, such as peak hours, Average Daily Traffic, and Vehicular volume. The peak hours in the study area are 7 to 9 in the morning and 5 to 7 in the evening. Motor-tricycle and passenger cars have the two largest portions of the traffic congestion. PTV Vissim is used to simulate and analyze the traffic system. Vehicular Capacity Ratio (VCR) is also used to evaluate traffic conditions. Level of Service (LOS) in terms of VCR and Vehicular delay are used to determine the traffic conditions. After analysis of the data, it was proven that the intersection has very heavy traffic conditions in terms of VCR and vehicular delay. Afterward, the analysis of the two proposed solutions was conducted. Rerouting has little impact on the said problem. While utilizing road widening with traffic lights shows improvements in traffic conditions, not to the extent of eliminating traffic.

Key Words: — ***Traffic congestion, Sta. Ana intersection, rerouting, road widening, Vehicular Capacity Ratio (VCR), Level of Service (LOS), vehicular delay.***

I. INTRODUCTION

Access to numerous locations for businesses and people, for both commercial and personal movements, is transportation's major function. This pertains to interactions between companies and their clients, suppliers, and rivals in the business sector.

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Transportation for the household sector makes access to employment, educational institutions, and retail facilities possible. It connects them to public, social, recreational, and medical resources for their personal use and enjoyment. Therefore, it is undeniable that transportation may be viewed as a foundation for societal and economic development. Globally, transportation is necessary for everyone because it allows them to move from one location to another and connect and communicate with society and the community. Transportation also enables people to contribute to a country's overall economic development positively. Aside from this, transportation through different innovations in transportation technology has provided comfort and convenience to people. With this, people have become dependent on their ways of living in transportation as it progresses through time in line with the different advances and modernization.

Transportation evolved to meet the demands of the people as civilization progressed. Most economic contacts in a country are influenced by transportation, and its absence or inefficiency will impede and delay a country's economic, social, and political growth. Additionally, inadequate transportation system capacity or dependability may lead to lost or decreased opportunities and reduced quality of life. Transportation and population are inextricably linked because the need for more and better transportation parallels population growth. Over time, it is clear that the population is constantly increasing, creating a need for more efficient and sufficient transportation. As a result, ongoing road expansions and road conversions occur today in response to the ever-increasing number of vehicle users.

The Philippines is one of the countries that consistently ranks as having a terrible transportation system because every city faces traffic daily. One of the Philippines' megacities, Metro Manila, is afflicted by several issues related to excessive street traffic. Over the past three decades, these cities have witnessed phenomenal growth in the number of vehicles on their streets and an expansion into neighboring areas to become enormous megalopolises, with their urban landscapes being pushed upward by the construction of countless high-rise structures. (Cervero, 2013, as cited in Bouquet, 2013).

With 4,951,662 registered vehicles in the Philippines during 2021 (CEIC, 2021), a variety of well-known vehicles, including public utility jeepneys, cars, buses, motorbikes, UV express, and modern jeepneys, traverse the roads of Metro Manila daily to cater to the needs for transportation of the commuters. The Metropolitan Manila Development Authority's investigation indicates that 3,197,673 people traveled through Metro Manila on average daily in 2021. This has caused rapidly rising traffic congestion on the streets, especially in cities where the urban fabric often comprises narrow roadways unsuited for high traffic. Congestion significantly reduces transport efficiency and slows down other facets of the economy (Bouquet, 2013).

One of the issues commuters in Metro Manila have to deal with is traffic, which also affects commuters in the city's adjacent province. As Metro Manila's neighboring provinces work on urbanizing, they must also deal with issues associated with urbanization, including poor transportation infrastructure that causes significant traffic congestion. Pampanga is one of the neighboring provinces of Metro Manila. The province has several infrastructure projects planned by the national government; however, as it becomes more urbanized, there is a traffic congestion issue that its people are facing. The Pampanga Megalopolis Program's proposal aims to build a transportation system to ensure inclusive mobility and accessibility in the province and provide access to an urban core, manufacturing facilities, suburbs, commercial and industrial centers, and institutional and service areas. (Filipino Journal, 2019). Additionally, the Clark Freeport Zone, where the Clark International Airport is situated, has been considered for investment opportunities, and other significant transportation infrastructure projects will be the catalyst for the transformation of Pampanga into the country's next regional hub for economic growth (Gines, 2022).

Consequently, most parts of Pampanga are experiencing traffic congestion, including the Sta. Ana intersection, this place has very heavy traffic congestion all day and throughout the week. This problem affects people such as students, workers, and civilians in their daily lives. Moreover, thousands of money are being lost because of this problem, and this is the reason why it needs to be solved.

II. METHODOLOGY

This research was experimental since the researchers experimented with one variable to see if it produces changes in another variable (Cherry, 2022). Whereas in this research the independent variables were the rerouting plan and road widening with traffic lights that was designed by the researchers, and the dependent variable was the traffic congestion occurring in the Jose Abad Santos Avenue Road and Baliwag- Candaba – Sta. Ana Road intersection.

Moreover, researchers employed a quantitative research design since through the collection of quantifiable data and the application of statistical, mathematical, or computer tools, phenomena were methodically investigated (Question Pro, 2022). Additionally, quantitative procedures focus on actual measurements and numerical analysis of data that are gained by the modification of pre-existing statistical data using computer algorithms or through the use of additional types of data collection techniques including surveys, questionnaires, and polls (Baluyut, et. al, 2022). As for this study, the researchers gathered numerical data through Manual Counting Method and this numerical data was inputted on a traffic simulation software called PTV Vissim.

2.1 Data Collection

In terms of data collecting, the researchers' initial step was confirming and evaluating if there indeed was an issue with traffic congestion in the affected region by determining its Level of Service (LOS). For the purpose of gathering data for the study, the Manual Counting Method, Level of Service, and Annual Average Daily Traffic were used.

2.2.1. Manual Counting Method

Vehicle counts at junctions, determining average daily traffic, and calculating yearly average daily traffic are a few instances of traffic counting. The term "manual counting method" is used to denote the process of counting categorized traffic "manually." During traffic, the number and variety of cars are counted at specific locations and times. The basis for counting and categorizing is simple visual examination and evaluations by individual observers. The data is often recorded using tally sheets or mechanical counters. After data have been gathered for an interval, totals are calculated and stored on a data sheet that may subsequently be fed into a computer. (Zheng & Mike, 2012). In a feasibility study conducted by DPWH entitled "Consulting Services for the Feasibility Study of Arayat-Magalang Road (Turu-San Juan Road), Pampanga Doña Remedios Trinidad, Bulacan to Dingalan, Aurora Road" they carry out a traffic survey at 16 different spots over three days, specifically on Tuesdays, Wednesdays, or Thursdays, from 6:00AM to 6:00PM. The mode of transportation and direction of each vehicle will be recorded, and the traffic volume will be tallied every hour. Having said so, researchers used the traffic counting schedule utilized by the DPWH in the above study and utilized the Manual Counting Method through examining records from video recorded using cameras and through on-site counting around the areas and observed traffic conditions and vehicle types that were passing from six (6) in the morning to eight (8) in the evening for three days (Tuesday, Wednesday, Thursday. The study of the DPWH on "Consulting Services for the Feasibility Study of Arayat-Magalang Road (Turu-San Juan Road), Pampanga Doña Remedios Trinidad, Bulacan to Dingalan, Aurora Road" was the basis for choosing these days of the week. Aside from this, the researchers requested access from the local government to conduct the necessary process on data gathering. Researchers asked admission to the local government unit of Sta. Ana, Pampanga as to information relating to the traffic density that was present in the area as well as the total number of vehicles passing along the Jose Abad Santos Avenue Road and Baliwag – Candaba – Sta. Ana Road intersection during a day. In order to categorize the vehicles that passed along the Jose Abad Santos Avenue Road and Baliwag - Candaba - Sta. Ana Road intersection the Department of Public Works and Highways (DPWH) "Manual Classified Traffic Count" form was utilized. Researchers believed that the said form was helpful to strategically categorize vehicle types that was used in the latter procedure of the study.

2.2.2 Hourly Pattern of Traffic

The researchers utilized the hourly pattern to forecast the amount of traffic that may be expected on the road network at particular times. The hourly design also showed the different peaks of traffic during the 14-hour traffic survey period based on the gathered data. It showed how the characteristics of traffic flow change throughout the day and night in the two different street networks.

2.2.3 Level of Service

The traffic data that was gathered was converted into a Volume Capacity Ratio in order to assess the Level of Service for the intersection's roadways, which gave a clear picture of the existing traffic circumstances in the study area, and which validated the current inefficiency in terms of traffic. The level of service is a categorization of the severity of traffic congestion from the perspective of commuters. Each intersection Level of Service was used to determine whether or not there was a reason for modifying the traffic system.

The metrics from the DPWH Planning Manual can be used to determine the Level of Service. The collected traffic data was interpreted in terms of vehicle capacity ratio, as shown in Table 1. It demonstrated the density of the traffic situation.

Vehicle Capacity Ratio (VCR)

$$VCR = PCU^{*} \, 0.08/BHCC$$

Table.1. 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 trailers, 5+ axles	2.5

Passenger Car Unit

$$PCU = (AADT\ v_1 \times PCEF) + (AADT\ v_2 \times PCEF)$$

Legend:

AADT = Annual Average Daily Traffic
BHCC = Basic hourly car capacity (in PCU)
Hourly Design Volume = 8% of AADT in PCU
PCU = passenger car unit
PCEF = passenger car equivalent factors
VCR = Traffic Volume Capacity Ratio

Table.2. Calculation of Capacity (BHCC) Basic Hourly Car Capacity

Carriageway Width	Hourly PCU	
	Rural	**Urban**
Single 4 meters	600	600
4-5 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

Table.3. Level of Service Based on VCR

Vehicle Capacity Ratio	Description	Traffic Condition	LOS Rating
0 – 0.20	Free flow, Low Volume and Densities; Drivers can maintain their desired speeds with little or no delay and are unaffected by other vehicles.	Very Light	A
0.21 – 0.50	Reasonably free flow, operating speeds beginning to be restricted somewhat by traffic conditions. Drivers still have reasonable freedom to select their speeds.	Light	B
0.51 – 0.70	Speeds remain near free flow speeds, but freedom to manoeuvres noticeably restricted	Moderate	C
0.71 – 0.85	Speeds begin to decline with increasing volume. Freedom to manoeuvre is further reduced and traffic stream has little space to absorb disruptions.	Moderately Heavy	D
0.86 – 1.00	Unstable flow, with volume at or near capacity. Freedom to manoeuvre is extremely limited and level of comfort afforded the driver is poor. Heavy Traffic	Heavy	E
> 1.00	Saturation traffic volumes, stop and go situations	Very Heavy	F

2.2.4 Annual Average Daily Traffic

One of the most crucial elements in transportation engineering for categorizing traffic flow is obtaining the Annual Average Daily Traffic (AADT) of a particular route or junction. The amount of traffic flow measured in hours will be converted to 14 hours flow, and then the necessary factors will be applied to get the AADT. AADT conversion factors will be used in the computations.

Annual Daily Traffic (ADT) = 7 days 24-hour traffic flow/ 7

Convert Annual Daily Traffic into Annual Average Daily Traffic.

Annual Average Daily Traffic (AADT) = Annual Daily Traffic × conversion factors

Table 4. AADT Scenarios

Scenarios	Urban	Inter-urban	Recreation
High	1.016	1.115	1.271
Medium	1.000	1.060	1.141
Low	0.989	1.016	0.962

2.3 Data Analysis and Evaluation

First, after collecting the necessary data, the LOS of the current road network was identified based on VCR rating. The researchers also used a software called PTV Vissim for the simulation and evaluation of LOS based on second's delay. This served as confirmation that there was really traffic congestion.

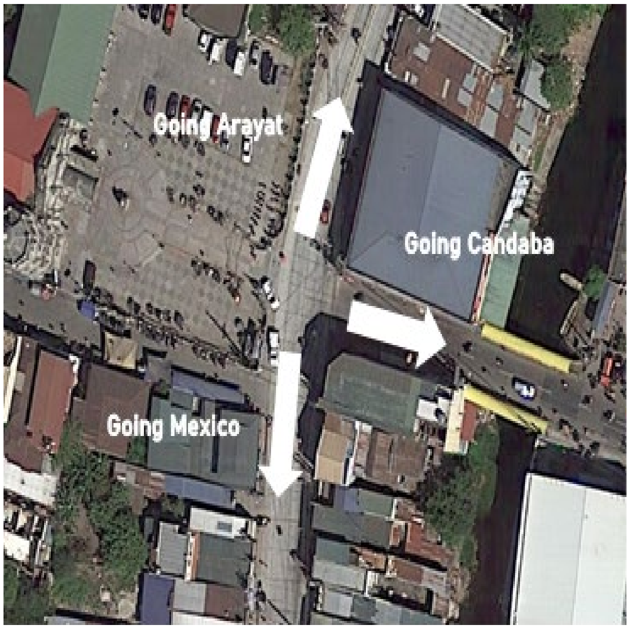


Fig.1. Present Road Network (Google Earth)

The present road network is shown in figure 1. This is the existing road network that was evaluated by means of VCR and simulated on PTV Vissim to confirm if there was really traffic congestion.

2.3.1 Proposed Solution

2.3.1.1 Rerouted Road Plan with One-way traffic system

Figure 2 shows the proposed rerouting road plan. The orange line corresponds to a one-way traffic system coming from Arayat and can be used to go to Mexico, and Candaba. While blue line corresponds to the JASA road two-way traffic system coming and going from Mexico and Arayat. It can also be used to go to Candaba. Moreover, the violet line corresponds to the Baliwag – Candaba – Sta. Ana road two-way traffic system for Candaba. Lastly, red line corresponds to the Magalang – San Agustin – Sta. Ana road two-way traffic system coming from Arayat and can be used to go to Magalang, Maxico, and Candaba.

Fig.2. Proposed Rerouted Road Plan (Google Earth)

Legends:

- (Orange) - One - Way Traffic System
- (Blue) - Jose Abad Santos Avenue Road (Two-Way T.S.)
- (Violet) - Baliwag - Candaba – Sta.Ana Road (Two-Way T.S.)
- (Red) - Magalang – San Agustin – Sta.Ana Road (Two-Way T.S.)

2.3.1.2 Utilizing Road Widening with Traffic Lights

Figure 3 shows the proposed utilization of road widening with traffic lights. This proposed solution utilized the spaces currently occupied by parking lots and vendors. Additionally, installation of traffic lights was also suggested that is not now available. These proposed solutions, rerouted road plan and utilized road widening with traffic lights, were simulated on the PTV Vissim. This was analyzed, and the LOS was identified. Finally, the LOS of the present road network and the two proposed solutions were compared. This was the basis if the proposed rerouted road plan and the utilized road widening with traffic lights have significant differences compared to the current road network. This also revealed which of the two proposed solutions is more effective.

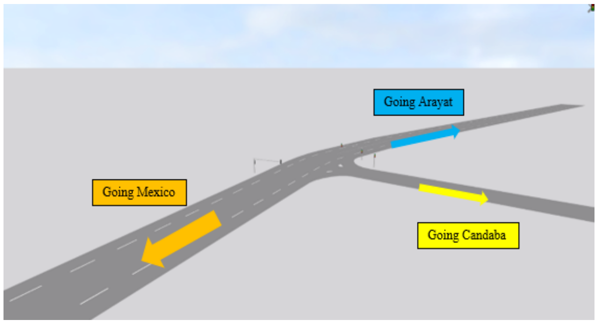


Fig.3. Proposed One-Way Traffic Management System (PTV Vissim)

2.3.2 PTV VISSIM

The researchers used the PTV Vissim program to simulate traffic after entering the appropriate data in order to evaluate the efficacy of the suggested rerouting. As regulating the high vehicular traffic on important thoroughfares and maximizing the degree of complexity of the road networks' architecture are two benefits of traffic simulation, researchers employed it in data analysis and assessment. Recent years have seen a significant increase in its application to examine, simulate, and predict traffic behavior at many levels of complexity, from congested metropolitan areas to rural models at the macro and micro scales. (Alghamdi, 2022) Additionally, PTV Vissim is great on traffic simulation as realistic traffic simulations were delivered using PTV Vissim. Modeling traffic flows for automobiles, motorbikes, trucks, buses, and pedestrians may be done effectively with the help of VISSIM. Vehicles (cars, buses, lorries), public transportation (trams, buses), cycles (bicycles, motorbikes), pedestrians, and rickshaws may all be simulated in VISSIM (Nugroho and Falah, 2022). As stated in a study conducted by Baluyut, et. al (2022), PTV Vissim can make user simulate traffic on any road location using the software that mimics real-world movement. This software can be used by cities and freeways all over the world to develop precise road traffic models and efficient traffic management strategies to help with and resolve traffic issues. As for this, researchers used this software for its excellent function for traffic simulation that was beneficial in assessing the effectivity of the proposed rerouting that was conducted by the researchers.

2.3.3 HCM 2010 SETTINGS

The planning level analysis in this study was based on the utilization of HCM. HCM is an essential tool for planning, designing, and making decisions related to transportation. The HCM is employed to deliver the best assessment of service quality for a highway under specified circumstances. Decision-making objectives based on quality analysis are directly tied to the HCM methodologies for measuring level of service. This implies that any attempts to enhance the level of service approaches may enhance the HCM's planning analysis. (Ensley, 2012). The proposed rerouting, utilizing road widening with traffic lights, and current road network design were all further evaluated for effectiveness using the HCM 2010 Level of Service scale, which is used to measure a road or intersection's capacity to handle traffic under various conditions. Below is the Level of Service table:

Table.5. Level of Service for Unsignalized Intersections

Level of Service	Average Control Delay (second/vehicle)
A	0 – 10
B	> 10 - 15
C	> 15 -25
D	> 25 – 35
E	> 35 -50
F	> 50

Table.6. Level of Service for Signalized Intersections

Level of Service	Average Control Delay (second/vehicle)
A	0 – 10
B	> 10 - 20
C	> 20 -35
D	> 35 – 55
E	> 55 -80
F	> 80

III. RESULTS AND DISCUSSION

The researchers aimed to improve the traffic congestion in Sta. Ana, Pampanga main road located at Jose Abad Santos Avenue road and Baliwag – Candaba - Sta. Ana road Intersection. To be able to do this, traffic and necessary data were gathered using manual counting method as stated in Chapter II: Methodology. Through these data, analysis of traffic of both existing road system and the proposed solutions, utilizing road widening with traffic lights and rerouting, are shown as well as the interpretation and discussion in this chapter.

3.1 Main Intersection Data Analysis Result

The main road (Intersection D) was divided into three entry point namely Candaba, Mexico and Arayat. Each point was interpreted into graphs.

Fig.4. Entry points at Intersection D

3.1.1 Hourly Pattern Result

Hourly distribution of each entry point of the vehicles at intersection D passing through within an hour interval. Candaba as the entry point has the highest volume compared to the other two entry point. It has 7am-8am as its peak hour and has its most dense time. Mexico as the entry point has volume ranging from 800-1000. It can also be noticed that the volume in the afternoon is higher than in the morning. It has 6pm-7pm as its peak hours. Arayat as the entry point has volume ranging from 800-1000. It has 7am-8am and 6pm-pm as its peak hour. The hourly distribution of traffic in the three entry points of the main road shows that motorcycle and passenger car have the two most significant portion of the total vehicles counted. Moreover, the peak hour on the main road is 7am-8am in the morning and 6pm-7pm in the afternoon. Most importantly, the main road has a very high volume of vehicles, and a solution is needed to alleviate the traffic congestion.

3.1.2 Computation of Level of Service at the Main Road

- *Candaba as entry point*

Table.7. Calculation of AADT and PCU: For Candaba as entry point

Type	ADT	SCENARIO	AADT	PCEF	PCEF x AADT
Motor-Tricycle	10410	1.06	11034.6	2.5	27586.5
Passenger Car	1474	1.06	1562.44	1	1562.44
Passenger Utility	37	1.06	39.22	1.5	58.83
Passenger Goods	273	1.06	289.38	1.5	434.07
Small Bus	0	1.06	0	1.5	0
Large Bus	0	1.06	0	2	0
Light Truck	142	1.06	150.52	2	301.04
Truck / Trailer	83	1.06	87.98	2.5	219.95
				AADT=	13164.14
				PCU=	30162.83

Vehicle Capacity Ratio (VCR)

VCR = PCU* 0.08/BHCC

BHCC = Single 4 meters = 600

VCR =	4.02	
LOS Rating	Very Heavy	F

The VCR for Candaba as entry point is 4.02 which is higher than 1 to be considered Very Heavy traffic. Therefore, Candaba as entry point is very heavy traffic congestion.

- *Mexico as entry point*

Table.8. Calculation of AADT and PCU: For Mexico as entry point

Type	ADT	SCENARIO	AADT	PCEF	PCEF x AADT
Motor-Tricycle	6405	1.06	6683.3	2.5	16973
Passenger Car	2276	1.06	2412.56	1	2412.56
Passenger Utility	41	1.06	43.46	1.5	65.19
Passenger Goods	371	1.06	393.26	1.5	589.89
Small Bus	39	1.06	41.34	1.5	62.01
Large Bus	123	1.06	130.38	2	260.76
Light Truck	310	1.06	328.6	2	657.2
Truck / Trailer	367	1.06	389.02	2.5	972.55
				AADT=	10528
				PCU=	21993

Vehicle Capacity Ratio (VCR)

VCR = PCU* 0.08/BHCC

BHCC = Single 4 meters = 600

VCR =	2.93	
LOS Rating	Very Heavy	F

The VCR for Mexico as entry point is 2.93 which is higher than 1 to be considered Very Heavy traffic. Therefore, Candaba as entry point is very heavy traffic congestion.

- *Arayat as entry point*

Table.9. Calculation of AADT and PCU: For Arayat as entry point

Type	ADT	SCENARIO	AADT	PCEF	PCEF x AADT
Motor-Tricycle	7868	1.06	8234.08	2.5	20850
Passenger Car	2210	1.06	2342.6	1	2342.6
Passenger Utility	56	1.06	59.36	1.5	89.04
Passenger Goods	117	1.06	124.02	1.5	186.03
Small Bus	21	1.06	22.26	1.5	33.39
Large Bus	98	1.06	103.88	2	207.76
Light Truck	307	1.06	325.42	2	650.84
Truck / Trailer	83	1.06	87.98	2.5	219.95
				AADT=	11406
				PCU=	24580

Vehicle Capacity Ratio (VCR)

VCR = PCU* 0.08/BHCC

BHCC = Single 4 meters = 600

VCR =	3.28	
LOS Rating	Very Heavy	F

The VCR for Arayat as entry point is 3.28 which is higher than 1 to be considered Very Heavy traffic.

Therefore, Candaba as entry point is very heavy traffic congestion. Based on the VCR of each entry point on the Main Road and the corresponding Level of Service, we can conclude that there is really Very Heavy traffic on the main road. The three-entry point has greater than 1 VCR which means that their LOS is Very Heavy with Candaba as the entry point having the highest VCR.

3.2 Sub-Intersection Data Analysis Result

Analyzed traffic data collected from the six intersection which are considered as the possible alternative routes. Northbound as the entry point in Intersection A has volume ranging from 350-400. It is noticeable that 6pm-7pm is its peak hour. Westbound as the entry point in Intersection A has volume ranging from 200-250. It is noticeable that 6pm-7pm is its peak hour. Southbound as the entry point in Intersection A has volume ranging from 300-350. It is noticeable that 8am-9am and 6pm-7pm are its peak hours. While, Southbound as the entry point in Intersection B has volume ranging from 200-300. It is noticeable that 7am-8am is its peak hour. Westbound as the entry point in Intersection B has volume ranging from 250-300. It is noticeable that 7am-8am is its peak hour. Eastbound as the entry point in Intersection B has volume ranging from 250-300. It is noticeable that 6pm-7pm is its peak hour. Moreover, Northbound as the entry point in Intersection C has volume ranging from 1000-1200. It is very high because these are the vehicles going to the main intersection.

It can be noticed that 6pm-7pm is its peak hour. Southbound as the entry point in Intersection C has volume ranging from 250-300. It is noticeable that 6pm-7pm is its peak hour. Eastbound as the entry point in Intersection C has volume ranging from 350-400. It is noticeable that 6pm-7pm is its peak hour. As for the Northbound, the entry point in Intersection E has volume ranging from 1000-1200. It is very high because these are the vehicles going to the main intersection. It can be noticed that 5pm-6pm is its peak hour. Southbound as the entry point in Intersection E has volume ranging from 1000-1200. . It is very high because these are the vehicles coming from the main intersection. It can be noticed that 7am-8am is its peak hour. Eastbound as the entry point in Intersection E has volume ranging from 600-700. It is noticeable that 6pm-7pm is its peak hour. Furthermore, Northbound as the entry point in Intersection F has volume ranging from 500-600. It is noticeable that 6pm-7pm is its peak hour. Westbound as the entry point in Intersection F has volume ranging from 400-500. It is noticeable that 6pm-7pm is its peak hour. Eastbound as the entry point in Intersection F has volume ranging from 450-500. It is noticeable that 5pm-6pm is its peak hour. Thus, the hourly distribution of traffic in the sub-intersections showed that motorcycles have the most significant portion of the total vehicles counted. Moreover, the data revealed that the peak hour on the main road is 7am-8am in the morning and 6pm-7pm in the afternoon. Most importantly, the sub-intersections have a low volume of vehicles compared to the main intersection. Furthermore, these show that the sub-intersection can be used as alternative routes.

3.2.1 Level of Service (LOS)

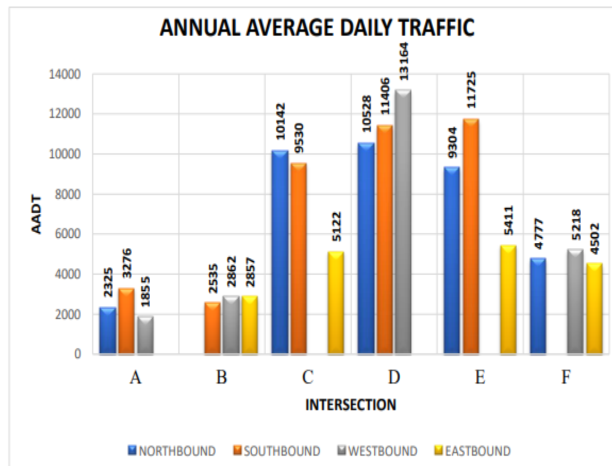


Fig.5. AADT of 6 Intersections

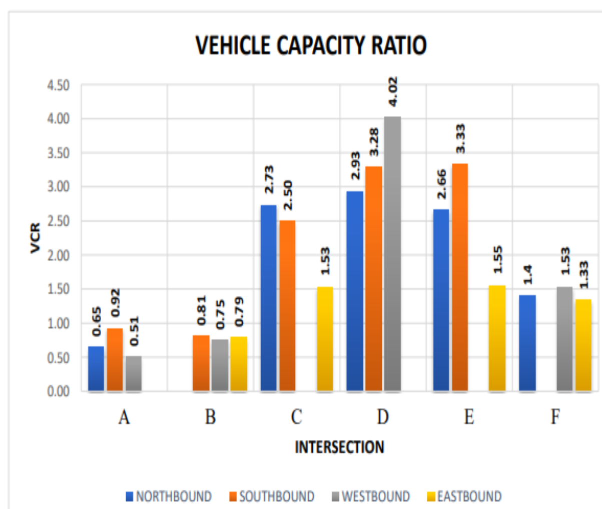


Fig.6. VCR of 6 Intersections

Table 10. LOS Rating of All Intersections

	Junction	Direction	VCR	Traffic Condition	LOS Rating
1	Intersection A	Northbound	0.65	Moderate	C
		Southbound	0.92	Heavy	E
		Westbound	0.51	Moderate	C
		Eastbound	-	-	-
2	Intersection B	Northbound	-	-	-
		Southbound	0.81	Moderately Heavy	D
		Westbound	0.75	Moderately Heavy	D
		Eastbound	0.79	Moderately Heavy	D
3	Intersection C	Northbound	2.73	Very Heavy	F
		Southbound	2.50	Very Heavy	F
		Westbound	-	-	-
		Eastbound	1.5	Very Heavy	F
4	Intersection D (Main Intersection)	Northbound	2.93	Very Heavy	F
		Southbound	3.28	Very Heavy	F
		Westbound	4.02	Very Heavy	F
		Eastbound	-	-	-
5	Intersection E	Northbound	2.66	Very Heavy	F
		Southbound	3.33	Very Heavy	F
		Westbound	-	-	-
		Eastbound	1.55	Very Heavy	F
6	Intersection F	Northbound	1.4	Very Heavy	F
		Southbound	-	-	-
		Westbound	1.53	Very Heavy	F
		Eastbound	1.33	Very Heavy	F

LOS of all intersections as shown in table 1.10 indicates that Intersection D has the highest VCR and corresponds to a very heavy traffic and needs solution. Intersection A has the lowest VCR and corresponds to moderate to heavy traffic. While intersection B only has moderate traffic at all entry points. Moreover, intersection C and E have very heavy traffic specifically on Northbound and Southbound directions but only because these are the directions coming and going to the main intersection. Lastly, sub-intersections that have very heavy traffic conditions have relatively lower VCR as compared to the main intersection.

As a conclusion, the sub-intersections were used as alternative routes for motor-tricycle, since it has the largest portion of the traffic, and was tested on PTV VISSIM to see the effectiveness.

3.3 Inputting PTV Vissim Parameters

To accurately compare the proposed solutions and the existing road system, PTV Vissim was utilized to simulate the solutions and existing road network. PTV Vissim parameters were inputted using the gathered data.

3.3.1 Defining the Network Object Type of the Actual Traffic System

The network object sidebar was utilized to imitate the current road system present on the site. With this setting, the following factors were designed and used. Using the intersection layout plan provided by the DPWH, the arrangement of the approaches and lanes, including the lane widths of the junction, were properly imitated and mapped with the add-links option. Moreover, 200m were used for the length of each road at the intersection. Links that merely overlap have no interaction with one another. Since the road was an intersection that was being reproduced, connectors were used in the following order to imitate a network with linked connections that provide continuous traffic. The actual main intersection layout as imitated on PTV Vissim using the actual width of each road with added connection per lane. Consequently, the software inputted the volume of each type of vehicle per entry point using the data gathered through on-site manual counting and video-recorded manual counting. Accordingly, the path or direction of each vehicle was also inputted using the data collected from manual counting with corresponding relative flow percentages, as shown in Figure 7.

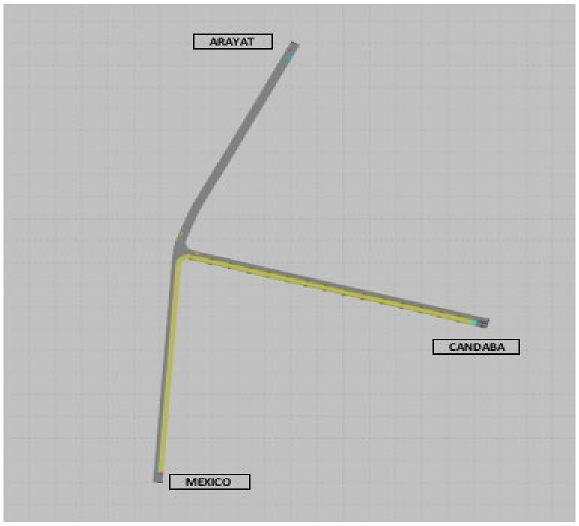


Fig.7. PTV Vissim Vehicle Routes Input

3.3.2 Defining and Inputting Node Setting and Evaluation of PTV Vissim Results

By appointing the intersecting network segments of the study area as a node, the evaluation of the whole current road network could then be started. After finishing the configuration of the designed road network, PTV Vissim then starts its simulation. The software then showed its assessment of the configured road network. Considering the variety of aspects, including fuel consumption, but more importantly, the study's acknowledged factor, the delay, and the Level of service (LOS) of every approach and lane. The outcomes were summarized and tabulated below using three trials to accurately determined the LOS of Main intersection in PTV Vissim.

Table.11. PTV Vissim Result on Main Intersection

PTV VISSIM EVALUATION RESULTS						
JUNCTION	TRIAL 1		TRIAL 2		TRIAL 3	
	Delay (s/veh)	LOS	Delay (s/veh)	LOS	Delay (s/veh)	LOS
Arayat – Mexico	103.52	F	146	F	115.23	F
Arayat – Candaba	102.45	F	144.23	F	104.92	F
Candaba – Arayat	125.91	F	120.9	F	107.67	F
Candaba – Mexico	119.21	F	108.75	F	123.77	F
Mexico – Arayat	146.84	F	142.08	F	115.44	F
Mexico – Candaba	102.41	F	173.03	F	128.44	F

PTV Vissim result on the main intersection shown in Table 11 shows that the main intersection has Very Heavy traffic conditions in all entry points, the same as when the basis is VCR. Furthermore, solutions were needed.

3.3.3 Rerouted Road Plan with One-way Traffic System

Using PTV Vissim, rerouted plan using the sub-intersection was simulated with the same parameters as the main intersection. This served as the basis of rerouting the vehicles on the sub-intersection, effectively achieving this research's goal.

Fig.8. PTV Vissim Rerouted Road Design Evaluation

As reflected in Table 12, a simulated rerouted road plan using the sub-intersection can result in LOS D-F but mostly LOS F, corresponding to Heavy traffic conditions.

Table.12. PTV Vissim Result on Rerouted Road Design

PTV VISSIM EVALUATION RESULTS						
JUNCTION	TRIAL 1		TRIAL 2		TRIAL 3	
	Delay (s/veh)	LOS	Delay (s/veh)	LOS	Delay (s/veh)	LOS
Arayat – Mexico	20.35	C	28.37	D	32.52	D
Arayat – Candaba	70.15	F	51.9	F	71.85	F
Candaba – Arayat	74.9	F	149.55	F	75.18	F
Candaba – Mexico	111.26	F	139.48	F	103.34	F
Mexico – Arayat	48.39	E	24.63	C	45.34	E
Mexico – Candaba	35.21	E	25.36	D	42.14	E

3.3.4 Utilizing Road Widening and Installation of Traffic Lights

Using the same parameters for the present road network but only the width of the road was modified as one of the proposed solutions. Following the completion of the road system setup, the timing and phasing were then settled to demonstrate the flow of traffic. Signal groups outlined the group phasing considered for the redesigned road system. Values for red, red amber, green and yellow amber portraying the red time, all-red time, green time, and yellow time respectively, were entered. In order to generate a broader range of datum to analyze, different cycle lengths (80, 120, 150, and 200 seconds) and varying phase times were considered and simulated. These different cycle lengths were tested to determine the most effective. The movements per phasing of the intersection were defined using the function of the signal head while keeping non-conflicting routes in mind. The phases were described in the following way to optimize each green time:

Table.13. Movement per Phase

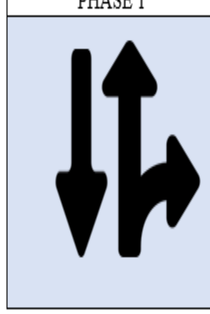
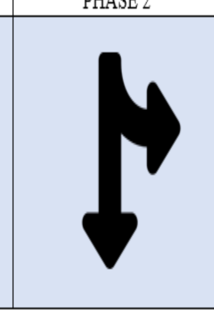
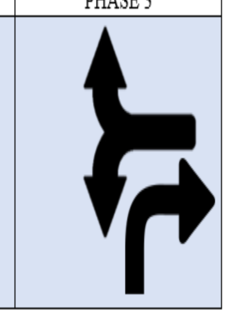
PHASE 1	PHASE 2	PHASE 3
		

Fig.9. PTV Vissim Design Intersection Evaluation

As shown by the PTV Vissim evaluation results of different length cycles below, it was concluded that the most effective cycle length is the 80 seconds length cycle. It was then used for the interval of traffic signal simulation and road widening final simulation.

Cycle Length: 80 seconds

Table.13. PTV Vissim Evaluation Results (80secs)

PTV VISSIM EVALUATION RESULTS							
JUNCTION	Phase Time (s)	TRIAL 1		TRIAL 2		TRIAL 3	
		Delay (s/veh)	LOS	Delay (s/veh)	LOS	Delay (s/veh)	LOS
Arayat - Mexico	24+26	10.23	B	10.35	B	11.6	B
Arayat - Candaba	26	54.35	D	74.6	E	39.83	D
Candaba - Arayat	30	75.43	E	62.76	E	83.91	F
Candaba - Mexico	30	72.66	E	72.84	E	81.38	F
Mexico - Arayat	24	33.4	C	63.99	E	38.39	F
Mexico - Candaba	24+30	11.88	B	8.3	A	8.71	A

Average Intersection Level of Service: D (45.26)

Cycle Length: 120 seconds

Table.14. PTV Vissim Evaluation Results (120secs)

PTV VISSIM EVALUATION RESULTS							
JUNCTION	Phase Time (s)	TRIAL 1		TRIAL 2		TRIAL 3	
		Delay (s/veh)	LOS	Delay (s/veh)	LOS	Delay (s/veh)	LOS
Arayat - Mexico	36+38	16.33	B	17.02	B	12.46	B
Arayat - Candaba	38	60.68	E	64.73	E	38.85	D
Candaba - Arayat	46	76.1	E	65.56	E	76.53	E
Candaba - Mexico	46	75.9	E	71.7	E	77.99	E
Mexico - Arayat	36	46.47	D	65.17	E	46.25	D
Mexico - Candaba	36+46	17.51	B	13.63	B	12.08	B

Average Intersection Level of Service: D (47.50)

Cycle Length: 150 seconds

Table.15. PTV Vissim Evaluation Results (150secs)

PTV VISSIM EVALUATION RESULTS							
JUNCTION	Phase Time (s)	TRIAL 1		TRIAL 2		TRIAL 3	
		Delay (s/veh)	LOS	Delay (s/veh)	LOS	Delay (s/veh)	LOS
Arayat - Mexico	46+48	13.33	B	16.16	B	26.47	C
Arayat - Candaba	48	54.81	D	68.19	E	51.28	D
Candaba - Arayat	57	79.91	E	72.34	E	83.23	F
Candaba - Mexico	57	88.05	F	80.39	F	82.21	F
Mexico - Arayat	46	55.99	E	53.31	D	54.16	D
Mexico - Candaba	46+57	19.86	B	18.7	B	17.9	B

Average Intersection Level of Service: E (52.015)

Cycle Length: 200 seconds

Table.16. PTV Vissim Evaluation Results (200secs)

PTV VISSIM EVALUATION RESULTS							
JUNCTION	Phase Time (s)	TRIAL 1		TRIAL 2		TRIAL 3	
		Delay (s/veh)	LOS	Delay (s/veh)	LOS	Delay (s/veh)	LOS
Arayat - Mexico	60+64	13.33	B	16.16	B	26.47	C
Arayat - Candaba	64	54.81	D	68.19	E	51.28	D
Candaba - Arayat	76	79.91	E	72.34	E	83.23	F
Candaba - Mexico	76	88.05	F	80.39	F	82.21	F
Mexico - Arayat	60	55.99	E	53.31	D	54.16	D
Mexico - Candaba	60+76	19.86	B	18.7	B	17.9	B

Average Intersection Level of Service: E (59.64)

3.4 Comparison of the Main Intersection and the Proposed Rerouted Road Plan

A comparison of the existing road network and the proposed rerouted road plan is shown in the table below. The LOS is similar, especially in Arayat-Candaba, Candaba-Arayat, and Candaba- Mexico. The only entry points that benefitted from the proposed solution were Arayat-Mexico and Mexico-Candaba. With this, it was concluded that rerouting, especially on the selected sub-intersection, was not an effective solution to be used on the said problem.

Table.17. PTV Vissim Evaluation Result Summary

PTV VISSIM EVALUATION RESULT SUMMARY					
JUNCTION	ACTUAL	LOS	DESIGN	LOS	DIFFERENCE
Arayat - Mexico	121.58	F	27.08	D	94.50
Arayat - Candaba	117.2	F	64.63	F	52.57
Candaba - Arayat	118.16	F	99.88	F	18.28
Candaba - Mexico	117.24	F	118.03	F	-0.79
Mexico - Arayat	134.79	F	39.45	E	95.34
Mexico - Candaba	134.63	F	34.24	D	100.39

3.5 Comparison of the Main Intersection and Utilized Road Widening and Installation of Traffic Lights

The researchers maximized the total width of the road and virtually installed traffic lights on PTV Vissim. After receiving the traffic assessment done by the software, the resulting vehicular delay and LOS ratings were then compared to ascertain the more effective and efficient design performance-wise using Table 11. Table 18 summarizes the comparison in terms of vehicular delay between the existing road wide and the utilized road wide with traffic lights. The table shows that utilizing road widening and traffic lights can save up to 110 seconds of travel and a minimum of 42 seconds of travel time. The corresponding LOS of the actual and proposed solution is shown in the table and clearly shows that utilizing road widening and traffic lights can improve the traffic condition in the main intersection at all entry points.

Table.18. PTV Vissim Evaluation Result Summary

PTV VISSIM EVALUATION RESULT SUMMARY					
JUNCTION	ACTUAL	LOS	DESIGN	LOS	DIFFERENCE
Arayat - Mexico	121.58	F	10.73	B	110.85
Arayat - Candaba	117.20	F	56.26	E	60.94
Candaba - Arayat	118.16	F	74.03	E	44.13
Candaba - Mexico	117.24	F	75.63	E	41.61
Mexico - Arayat	134.79	F	45.26	D	89.53
Mexico - Candaba	134.63	F	9.63	A	125

3.6 Comparison of The Two Proposed Solution

Rerouting and utilizing road widening with traffic lights were the leading two solutions selected by the researchers. Upon the analysis of the data, the effectiveness of the solutions was tested using PTV Vissim. It was clearly shown in this chapter that rerouting was not effective on most entry points and can only improve so little on other entry points. On the other hand, utilizing road widening with traffic lights was shown to be beneficial in most entry points and can significantly improve the traffic congestion in the study area.

Table.19. PTV Vissim Evaluation Result Comparison Summary

PTV VISSIM EVALUATION RESULT SUMMARY						
JUNCTION	ACTUAL	LOS	DESIGN 1	LOS	DESIGN 2	LOS
Arayat - Mexico	121.58	F	27.08	D	10.73	B
Arayat - Candaba	117.2	F	64.63	F	56.26	E
Candaba - Arayat	118.16	F	99.88	F	74.03	E
Candaba - Mexico	117.24	F	118.03	F	75.63	E
Mexico - Arayat	134.79	F	39.45	E	45.26	D
Mexico - Candaba	134.63	F	34.24	D	9.63	A

IV. SUMMARY, CONCLUSION AND RECOMMENDATIONS

Confirming that there was actual traffic congestion in the study area was the first objective of this study. To do this, data gathering was conducted using a manual counting method. After consideration of the substantial amount of data collected, analyzed, simulated, and projected, traffic congestion is evident along Jose Abad Santos Avenue Road and Baliwag – Candaba – Sta. Ana Road. This problem will only grow to be more of a hindrance to both passing vehicles and residents of the area in the future if not addressed in a timely and suitable manner. With the gathered and calculated data presented in this study as support, the researchers concluded that rerouting was not the best choice to improve traffic congestion. On the other hand, utilizing road widening and installing traffic lights along the main intersection is beneficial and will favorably assuage the subsisting traffic congestion along the study area.

The gathered data and consequent results were generalized in order to outline the key points determined in the study. The following are the results of the study:

- Main intersection (Intersection D) has the most vehicle volume compared to other intersections (A, B, C, E, F), and a solution is necessary.
- Motor-tricycles and passenger cars have the most significant proportion of the volume of vehicles.
- 7am-9am and 5pm-7pm are the peak hour in the study area.
- Main intersection has a very heavy traffic conditions (LOS F) regarding VCR and PTV Vissim simulation.
- The proposed rerouted road plan has very heavy traffic conditions (LOS F), which is not practical to alleviate the traffic congestion in the study area.
- Utilizing road widening and installing traffic lights with 80 seconds cycle can result in low vehicle delay and up to LOS B to D.
- Utilizing road widening and traffic lights can improve the traffic condition in the main intersection at all entry points.

The detailed and step-by-step quantitative analysis of all the necessary data gathered shows that road widening combined with the right time-cycle of traffic lights could moderately improve the traffic congestion in the study area. The researcher recommends utilizing this solution to alleviate the said problem. The following are recommendations to further improve the traffic congestion:

- PTV Vissim - It is recommended that future researchers use the full version of the software.
- Trials – Using more trials on the simulation.
- CCTV – The use of CCTV for manual counting.
- Further teaching of traffic rules and regulations - Some drivers are not fully knowledgeable about transportation/driving etiquette, which can further improve good traffic circumstances.
- Parking regulation - Banning parking on the road widening area could be beneficial.

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