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Traffic Optimization Through Geometric Design and Signal Timing Assessment of Mayapyap Sur Junction in Cabanatuan City Using Vissim Simulation

Jimuel A. DIZON[1], Jan Ellis M. LAPADA[2], Angelyn T. QUIZON[3], Amor Judith A. CABANESAS[4], Alelie Joy C. ALEJO[5], Derick Aldrin L. ESTEBAN[6], Ronald D. DANAN[7],

[1,2,3,4,5,6,7] Nueva Ecija University of Science and Technology, Sumacab Este, Cabanatuan City, Nueva Ecija, Philippines

ABSTRACT: Traffic congestion at the Mayapyap Sur Junction in Cabanatuan City has become a persistent issue due to increasing traffic demand and limitations in the existing intersection design and signal control system. This study evaluates the traffic performance of the junction using PTV VISSIM microscopic simulation based on collected traffic volume, vehicle composition, and signal timing data. Results show that congestion is caused by inefficient signal timing, unbalanced traffic flow, roadside loading and unloading, and geometric deficiencies that reduce roadway capacity. Several improvement scenarios involving signal timing optimization and geometric enhancements were simulated and compared. Findings indicate significant reductions in vehicle delay and improved traffic flow efficiency, with the Level of Service (LOS) improving from LOS E–F to LOS A–D. The study demonstrates the effectiveness of combining traffic signal optimization and geometric improvements in enhancing intersection performance and supporting sustainable urban traffic management.

KEYWORDS: Traffic congestion, intersection performance, PTV VISSIM, signal timing optimization, geometric design, Level of Service (LOS)

I. INTRODUCTION

Traffic congestion is one of the major transportation problems affecting rapidly urbanizing cities, particularly in areas where increasing traffic demand exceeds the capacity of existing road infrastructure. Intersections with inadequate geometric design, inefficient signal timing, roadside obstructions, and mixed traffic conditions often experience excessive vehicle delay, long queues, reduced Level of Service (LOS), and increased risks of road accidents. These challenges are more evident in developing urban centers where population growth and rising vehicle ownership continue to intensify traffic conditions. As a result, traffic simulation and intersection optimization have become essential tools in developing effective and sustainable traffic management strategies.

Microscopic traffic simulation software such as PTV VISSIM has been widely used in traffic engineering studies to evaluate intersection performance, analyze traffic behavior, optimize signal timing, and assess geometric improvements. Previous studies demonstrated that VISSIM can effectively simulate traffic flow conditions and predict the operational impacts of roadway and signal modifications (Kutlimuratov & Mukhitdinov, 2022; Firmansyah et al., 2022). In the Philippines, similar simulation-based approaches have been implemented in major urban areas such as Metro Manila and Cebu City to improve signalized intersections and roadway efficiency. However, limited design and signal timing optimization have been conducted in Cabanatuan City, resulting in insufficient data-driven assessments for urban traffic management.

Cabanatuan City, recognized as the "Tricycle Capital of the Philippines," serves as a major commercial and transportation hub in Nueva Ecija. The city's road network accommodates high volumes of private vehicles, motorcycles, public utility vehicles, and tricycles. Among its critical intersections, the Mayapyap Sur Junction has been consistently identified as one of the most congested locations due to inefficient signal timing, mixed traffic composition, roadside loading and unloading activities, and geometric deficiencies that reduce roadway capacity. Increasing traffic demand within the city further emphasizes the need for effective and sustainable traffic management solutions.

This study evaluates the traffic performance of the Mayapyap Sur Junction using PTV VISSIM microscopic simulation through the assessment of its existing geometric layout and signal timing operations. Furthermore, the study supports SDG 3: Good Health and Well-being, SDG 9: Industry, Innovation and Infrastructure, and SDG 11: Sustainable Cities and Communities by promoting safer, more efficient, and sustainable urban transportation systems.

II. OBJECTIVES

A. General Objective

To optimize the traffic operations of the Mayapyap Sur

Junction in Cabanatuan City through the assessment of geometric design and signal timing using PTV VISSIM microscopic simulation.nt.

B. Specific Objective

1. To analyze the existing traffic volume, geometric design, and signal timing conditions at the Mayapyap Sur Junction.
2. To evaluate the current intersection performance in terms of vehicle delay, queue length, and Level of Service (LOS) using PTV VISSIM simulation.
3. To identify the geometric and operational factors contributing to traffic congestion at the intersection.
4. To assess the effects of proposed geometric design and signal timing improvements through simulation analysis.
5. To compare the Level of Service (LOS) and overall traffic performance between the existing and improved intersection conditions.

III. METHODOLOGY

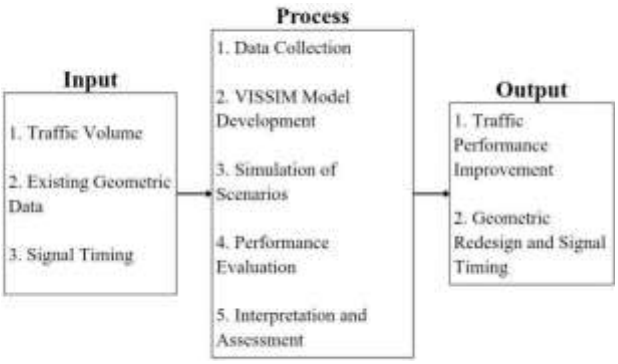

FIGURE III-I. Research Flow

The study used a quantitative–experimental approach to evaluate the traffic performance of the Mayapyap Sur Junction in Cabanatuan City through geometric design and signal timing assessment using PTV VISSIM simulation. Traffic volume data were collected through manual traffic counting during peak-hour periods, while geometric measurements such as lane widths, turning radii, and approach lengths were obtained through direct field measurements and site observation. Existing signal timing parameters including cycle length, phase sequence, and green time allocation were also recorded.

The collected traffic, geometric, and signal timing data were encoded into PTV VISSIM to develop a microscopic simulation model representing the existing intersection condition. The simulation model was calibrated and validated using observed traffic conditions to ensure accuracy and reliability.

Different traffic optimization scenarios involving geometric improvements and signal timing adjustments were simulated and evaluated. Traffic performance was analyzed using vehicle delay, queue length, and Level of Service (LOS) to determine the effectiveness of the proposed improvements.

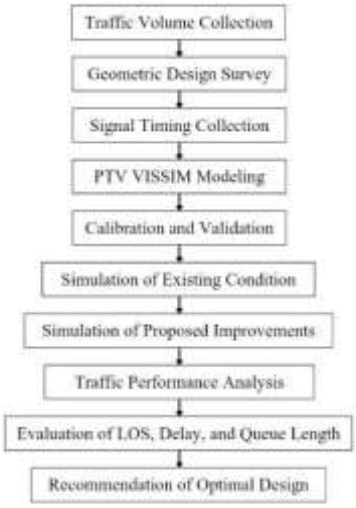

FIGURE III-II. Procedure in the Determination of Traffic Performance

IV. RESULT AND DISCUSSION

Traffic observations conducted at the Mayapyap Sur Junction revealed that weekday traffic demand was significantly higher than weekend conditions, particularly during the afternoon peak period. The highest recorded traffic volume reached 1,422 vehicles during Friday afternoon observations, indicating critical congestion conditions at the intersection.

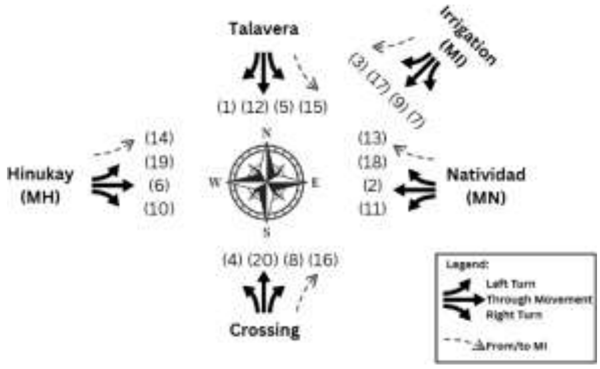

FIGURE IV-I. Presentation of Turning Movement

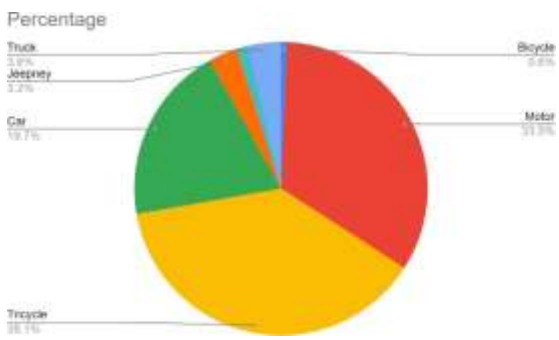

FIGURE IV-II Traffic Composition by Vehicle Type

The Talavera–Crossing and Crossing–Talavera approaches generated the highest traffic movements, contributing significantly to queue formation and operational delay. Traffic composition analysis showed that tricycles (38.12%) and motorcycles (33.48%) dominate the traffic stream, followed by cars (19.70%). The dominance of mixed vehicle types affects traffic flow stability, turning operations, and lane utilization within the intersection.

FIGURE IV-III Existing Model of Mayapyap Sur Junction from PTV Vissim

Field assessment identified geometric and operational deficiencies contributing to congestion at the intersection. Inadequate turning radii caused larger vehicles to encroach into adjacent lanes, while roadside obstructions and the absence of loading and unloading bays reduced effective lane width. Signal timing analysis revealed inefficient phase distribution and green time allocation, resulting in excessive queue buildup and delays, particularly on minor approaches. Limited green time for left-turning movements and insufficient pedestrian crossing intervals further reduced signal efficiency and increased movement conflicts.

TABLE IV-1 Existing Traffic Condition Results of Mayapyap Sur Junction

Flow No.	Area of Flow	EXISTING CONDITION		
		LOS	LOS Value	VEH DELAY
1	Talavera-MH	F	6	81.21
2	MN-MH	F	6	91.22
3	MI-MH	A	1	2.54
4	Crossing-MH	D	4	50.70
5	Talavera-MN	F	6	149.97
6	MH-MN	F	6	204.10
7	MI-MN	A	1	0.00
8	Crossing - MN	F	6	107.20
9	MI-Crossing	A	1	0.99
10	MH-Crossing	F	6	135.11
11	MN-Crossing	E	5	72.40
12	Talavera-Crossing	F	6	86.76
13	MN-MI	F	6	124.22
14	MH-MI	F	6	131.60
15	Talavera-MI	A	1	1.44
16	Crossing-MI	A	1	0.00
17	MI-Talavera	A	1	3.02
18	MN-Talavera	F	6	84.09
19	MH-Talavera	F	6	134.54
20	Crossing-Talavera	E	5	67.22

PTV VISSIM simulation results showed that the existing intersection operates under highly congested conditions. Most traffic movements were classified under LOS E and LOS F, with excessive vehicle delays exceeding acceptable Highway Capacity Manual (HCM) standards. Several critical movements, including Talavera–MN and MH–MN, recorded delays exceeding 130 seconds per vehicle. The results confirm that the existing geometric layout and signal timing configuration are inadequate to accommodate current traffic demand at the intersection.

Several improvement scenarios involving geometric redesign and signal timing optimization were evaluated using PTV VISSIM. The proposed improvements included widening critical approaches, improving turning radii, relocating loading and unloading activities, and optimizing signal phasing and green time allocation.

FIGURE IV-IV Enhanced Model of Mayapyap Sur Junction from PTV Vissim

TABLE IV-2 PTV Vissim Simulation Results on Level of Service (LOS)

Flow No.	Area of Flow	Existing Condition		Enhanced Condition ((Final Design and Signal Timing)	
		Level of Service	LOS Value	Level of Service	LOS Value
1	Talavera-MH	F	6	D	4
2	MN-MH	F	6	D	4
3	MI-MH	A	1	A	1
4	Crossing-MH	D	4	C	3
5	Talavera-MN	F	6	E	5
6	MH-MN	F	6	E	5
7	MI-MN	A	1	A	1
8	Crossing to MN	F	6	D	4
9	MI-Crossing	A	1	A	1
10	MH-Crossing	F	6	D	4
11	MN-Crossing	E	5	D	4
12	Talavera-Crossing	F	6	D	4
13	MN-MI	F	6	E	5
14	MH-MI	F	6	C	3
15	Talavera-MI	A	1	A	1
16	Crossing-MI	A	1	A	1
17	MI-Talavera	A	1	A	1
18	MN-Talavera	F	6	E	5
19	MH-Talavera	F	6	E	5
20	Crossing-Talavera	E	5	D	4

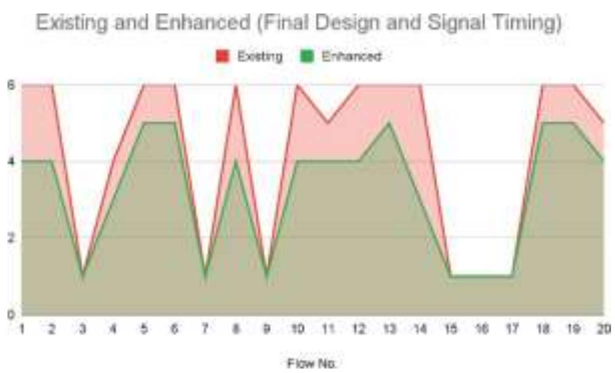

FIGURE IV-V Final Design and Signal Timing LOS

Simulation results demonstrated substantial reductions in queue lengths and vehicle delay. The combined geometric and signal timing improvement scenario achieved the best operational performance, improving overall intersection conditions from LOS E–F to LOS A–D for most traffic movements. These findings indicate that integrating physical roadway improvements with optimized signal control significantly enhances traffic flow efficiency and reduces congestion at the intersection.

V. CONCLUSIONS

The study revealed that the Mayapyap Sur Junction currently operates under congested conditions characterized by high vehicle delays, long queue lengths, and poor Levels of Service (LOS). Findings showed that the existing geometric design and signal timing are no longer sufficient to accommodate the increasing traffic demand and mixed vehicle composition. Congestion was primarily caused by inefficient signal timing, uneven traffic distribution, roadside loading and unloading activities, limited turning radii, and roadway obstructions that reduce effective lane capacity.

Simulation results using PTV VISSIM demonstrated that the proposed signal timing optimization and geometric improvements significantly enhanced traffic performance by reducing delays, shortening queue lengths, and improving LOS. The optimized signal plan reduced the total cycle time from 181 seconds to 172 seconds through the conversion of the existing 5-phase system into a more efficient 4-phase system. Green time reallocations were also implemented, wherein the left-turn green time was increased from 10–12 seconds to 20 seconds, while the signal timings for Talavera, Crossing, Hinukay, and Natividad approaches were adjusted from 77 to 85 seconds, 79 to 95 seconds, 20 to 40 seconds, and 52 to 40 seconds, respectively. Pedestrian timing was likewise improved from 6 seconds to 12 seconds, including the provision of a 10-second all-red push button interval for safer pedestrian crossing movements.

In addition, the proposed geometric improvements, including increasing the turning radius to 9 meters, relocating roadside loading and unloading activities through the implementation of a designated bay area, and removing physical roadway obstructions, further enhanced lane capacity and traffic flow efficiency. Overall, the study highlights the effectiveness of integrating operational and geometric enhancements in improving intersection performance and emphasizes the value of simulation-based approaches in developing sustainable and data-driven traffic management solutions.

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