# Level of Service and Swept Path Analysis of J.P. Rizal St. - Bonifacio St. Intersection in Gumaca, Quezon, Philippines

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**Abstract**: An analysis of the current traffic condition at the J.P. Rizal–Bonifacio St. intersection in Gumaca, Quezon, was conducted using simulation tools such as PTV Vistro, PTV Vissim, and AutoRUN. Key factors assessed include road capacity, intersection delay, level of service (LOS), and queue length. Signal warrant analyses were carried out, and PTV Vistro's mitigation feature was used to test alternative designs. The second configuration added one lane in all directions and increased the curb radii to 7 meters. The third introduced an exclusive right-turn channel from east to north. Swept path analysis revealed that the existing geometry leads to heavy vehicle encroachment into the opposing lanes while turning, contributing to heavy delays. Comparison between setups, using microsimulations results from PTV Vissim, showed that the third configuration produced the lowest delays and highest LOS in all directions, identifying it as the most effective solution for improving the intersection performance.

*Keywords*: Unsignalized Intersection, Traffic Analysis, Intersection Geometry, Swept Path Analysis

## 1. INTRODUCTION

Urbanization has spurred the construction of commercial establishments, generating jobs and accelerating development. However, it has also led to increased traffic congestion, longer travel times, and worsening air pollution. Efficient transportation is essential for sustaining this growth, as it influences fuel use, goods movement, and quality of life. Traffic management, involving traffic control devices (TCDs) and transportation demand management (TDM) strategies, is therefore increasingly necessary. The TCDs, standardized by the DPWH and based on the Vienna Convention, guide the drivers and ensure the overall road safety. TDM strategies aim to reduce trip demand and improve travel options and air quality.

Despite growing interest in intersection performance analysis through simulation, the role of geometric design, particularly curb radius, remains underexamined. This factor affects vehicle turning behavior and congestion, especially where heavy vehicles are involved. Addressing such geometric elements is vital for a developing municipality like Gumaca, Quezon. Gumaca, a first-class municipality in Quezon province with a population of 71,942 (2020 Census), has experienced significant economic growth due to its strategic coastal location. Positioned 66.6 km from Lucena City (the provincial capital) and 76.4 km from Tagkawayan (the last town before Bicol), Gumaca has emerged as a regional trade center. This growth has coincided with a sharp decline in poverty, from 38.62% in 2000 to 13.1% in 2016, according to the Philippine Statistics Authority. The urbanization of Gumaca has created an urgent need for effective traffic management to support its economic trajectory. Traffic signals, if properly timed and placed, can enhance intersection capacity, reduce accidents, and streamline vehicle and pedestrian flow. Yet, studies often overlook the impact of vehicle turning radii, especially for heavy vehicles, on the intersection performance and Level of Service (LOS).

This study aims to fill that gap by aligning with the United Nations Sustainable Development Goals (SDGs) and proposing resilient traffic infrastructure at a key intersection in Gumaca, Quezon. The research focuses on the intersection of J.P. Rizal and Bonifacio Street. It evaluates several measures such as installing traffic signals and reconfiguring geometric features to improve LOS and reduce delays. Specific objectives include assessing current traffic conditions, analyzing delay and queue lengths in relation to road geometry, proposing traffic solutions, and modeling future scenarios with enhanced designs. The study utilized PTV Vistro for initial analysis, PTV Vissim for microsimulation of both existing and proposed conditions, and AutoCAD AutoRUN for geometric design alternatives. This focused on fixed-time signal systems and demand management strategies. Data collection was conducted for seven days. Local government CCTV footage of the four-legged J.P. Rizal–Bonifacio intersection served as the basis for manual counting of vehicles. This comprehensive approach aims to deliver practical, data-driven solutions for sustainable transportation planning in Gumaca, Quezon.

## 2. LITERATURE REVIEW

### 2.1 Unsignalized Intersections

Unsignalized intersections present unique challenges, particularly in areas with mixed traffic composed of motorized and non-motorized vehicles. While existing research predominantly focuses on signalized intersections, there remains a significant gap in methodologies and empirical data for unsignalized setups. The study by Prasetijo et al. (2014) emphasized the importance of accounting for geometric design elements and non-motorized traffic in capacity analysis. Traditional frameworks, such as the Highway Capacity Manual (HCM), offer foundational insights but often fail to fully address the influence of geometric features, including curb radii and turning angles, on intersection performance. There is a clear need for the development of analytical tools tailored to mixed-traffic conditions, particularly to assess the turning behavior of heavy and long vehicles and their impact on efficiency and safety.

### 2.2 Intersection Performance Study Using PTV Vistro

PTV Vistro is a widely used transportation modeling software for evaluating intersection performance and optimizing signal timings. It excels at reducing delays and providing comprehensive reports for traffic scenarios. However, its reliability in analyzing unsignalized intersections remains questionable, as highlighted by Kriswardhana and Sulistyono (2022). Their research points to inconsistencies in Vistro outputs when applied to non-signalized settings, especially when applied to the context of developing countries. Moreover, the literature reveals a lack of in-depth studies exploring PTV Vistro’s effectiveness across diverse urban contexts. Further research is required to validate its performance in local settings, such as Philippine municipalities, and to compare simulation results with real-world traffic data for accuracy and calibration.

### 2.3 Analysis Using PTV Vissim

PTV Vissim, a microsimulation tool, is known for its ability to model detailed and complex traffic conditions, including unsignalized intersections in diverse regions. Studies such as Hadi & Khairurrasyid (2024) and Samuel et al. (2022) demonstrate its effectiveness in simulating traffic flow and evaluating sustainable transport strategies. Vissim can simulate interactions between vehicles, pedestrians, and cyclists, making it suitable for mixed-traffic environments. However, a research gap persists in its application to rural or developing settings where infrastructure limitations and unique traffic patterns exist. There is a need to explore cost-effective traffic control strategies within Vissim and integrate non-motorized traffic into simulations to develop comprehensive, context-sensitive solutions.

### 2.4 Analysis of Intersection Delay

The study conducted by Tumamao (2015) on the Lopez Avenue–National Highway intersection in Los Baños, Laguna, highlights the impact of signal timing and infrastructure inadequacies on vehicle delay. The study identified prolonged waiting times and congestion resulting from suboptimal intersection control. It suggests exploring adaptive traffic signal systems and intelligent transportation technologies to improve performance. Importantly, the research calls attention to the often-overlooked role of non-vehicular traffic, such as pedestrians and cyclists, in contributing to intersection delay. The researcher recommended broadening the scope of intersection analyses to include these elements in analysis and management strategies.

### 2.5 Median-Turn Lane Markings Performance Evaluation

Median-turn lane markings, or two-way left-turn lanes (TWLTLs), have been shown to improve intersection safety and mobility by reducing vehicle conflict points. In a comparative study by Villegas (2017), the performance of TWLTLs at signalized intersections in the Philippines and Japan was evaluated. The study concluded that such markings positively affect traffic flow and reduce collision risks. Despite this, limited research exists on their specific impact in urbanized provincial towns.

## 2. METHODOLOGY

### 2.1 Preliminary Observation

An initial survey was conducted through a visual inspection of the J.P. Rizal Street–Bonifacio Street intersection. The assessment involved documenting the intersection's configuration, including the number of lanes per approach, pavement conditions, surrounding terrain, and road grade. Observations also included the existing type of intersection control, prevailing traffic flow patterns, and pedestrian movements.

### 2.2 Data Collection

CCTV footage provided by the local government of Gumaca (LGU) was utilized to gather traffic data, including traffic volume and behavior. The following describe the parameters that were utilized.

*Vehicle's Roadway Speed* - the statutory speed limits were set according to the standards established by the LGU.

*Hourly Vehicular Approach Volume on a Typical Weekday* - the study conducted a detailed analysis of the hourly vehicular volume on a typical weekday at the intersection. This data is essential for warrant analysis and mitigation strategies. The counting process involved several considerations, including counting only a single traffic direction for each approach, recording the exact number of vehicles, and using equivalency factors for passenger car units. The data collection took place over at least 16 hours, with counts compiled in hourly increments. To represent significant road volume, the sum of the opposite direction of travel was considered. Additionally, adjustments were made for changes in the highest volume approach direction during the day. Turning movements and vehicle types were also factored into the vehicular volume data.

*Number of Lanes per Approach.* The number of lanes per approach was determined to manage vehicular volume warrants and mitigation.

*Roadway Characteristics.* Warrant analysis and mitigation strategies necessitated the identification of major routes based on specific criteria. These included being part of the principal roadway network for traffic flow, serving rural and suburban highways that enter, exit, or pass through the town, and being designated on an official plan as a major route in urban area traffic and transportation studies. These criteria helped in determining the importance and traffic significance of different roadways within the study area, which is crucial for developing effective traffic management and mitigation strategies.

## 2.3 Intersection Analysis (Intersection Delay and Level of Service)

PTV Vistro was used to determine road capacity, intersection delay, and level of service. The software processed data on road traffic composition, traffic volume counts, turning movements, road geometric characteristics, and current traffic controls to provide qualitative and quantitative assessments of existing traffic conditions.

*Base Scenario (Actual Condition).* The current unsignalized configuration was analyzed using observed values input into PTV Vistro. The resulting intersection delay and level of service were compared to field data.

*Signalized Scenario.* Various alternative plans were considered to find the optimal solution to the existing problem using PTV Vistro's mitigation feature. This included shifting the control type from unsignalized to signalized, incorporating fixed-time control, and adjusting traffic signal phasing. The changes were analyzed for their feasibility and impact on traffic conditions.

*Reconfigured Unsignalized Scenario 1.* If no improvement was observed in the signalized setup, a new design was proposed. This included adding an additional lane in all directions, making each a 2-lane road, and adjusting the curb radius based on the design vehicle. The reconfigured intersection was then analyzed as unsignalized intersection.

*Reconfigured Unsignalized Scenario 2.* Another configuration focused on prioritizing major traffic flows. This setup added a dedicated lane in the eastern road for right-turning vehicles towards Manila and set the curb radius for the remaining corners to 7 meters. The reconfigured intersection in this setup was also analyzed as unsignalized intersection.

## 2.4 Analysis of Vehicle Trajectories

Vehicle trajectories were analyzed using CCTV footage and modeled in AutoCAD. The AutoRUN feature of AutoCAD helped analyze the movement of heavy and extended vehicles, particularly the Intermediate Trailer trucks. The turning speed and radius's impact on intersection performance were evaluated, and conflict points were identified to adjust geometric conditions.

### 2.5 Traffic Simulation of the Intersection through PTV Vissim

PTV Vissim was calibrated to match actual intersection conditions through trial and error. Data from the actual setup was used to test new configurations, and the percent difference in intersection delay between actual and modified setups was computed for comparison.

## 3. RESULTS AND DISCUSSION

### 3.1 Roadway Characteristics and Conditions

As shown in Figure 3-1, the intersection between J.P. Rizal and Bonifacio Street, in Gumaca, Quezon features two lanes per direction with each lane measuring 3.35 meters in width and a total carriageway width of 6.7 meters. The terrain is flat, with 0% grade, and the pavement is reported to be in good condition. The intersection is classified as an All-Way Stop-controlled (AWSC) type, indicating that all approaches to the intersection must stop before proceeding. The green line as shown in the figure is the direction of the major traffic flow.


Figure 3-1. Intersection along J.P. Rizal, Cor. Bonifacio St., Gumaca, Quezon (Google Maps, 2023)

The local government policies were reviewed, including a tricycle ban on the national highway from 6 am to 8 pm. The intersection connects the major routes towards Manila and Bicol, forming part of the Pan-Philippine Highway. These policies and connections are crucial for designing an effective traffic control system to support the municipality's growth.

## 3.2 Traffic Volume

The vehicle count during the AM and PM peak hours was recorded, and the corresponding passenger car units (PCUs) were calculated. As illustrated in Figures 3-2 and 3-3, private vehicles account for most of the traffic passing through the intersection, followed by motorcycles. The primary traffic flow occurs in the southbound and westbound directions, largely due to the intersection serving as a convergence point with the Maharlika Highway—a major route connecting vehicles traveling between the Southern Tagalog and Bicol Regions. Notably, a significant proportion of heavy vehicles (buses and trucks) were observed in both the southbound and westbound directions, comprising 28% and 26% of the traffic flow, respectively.

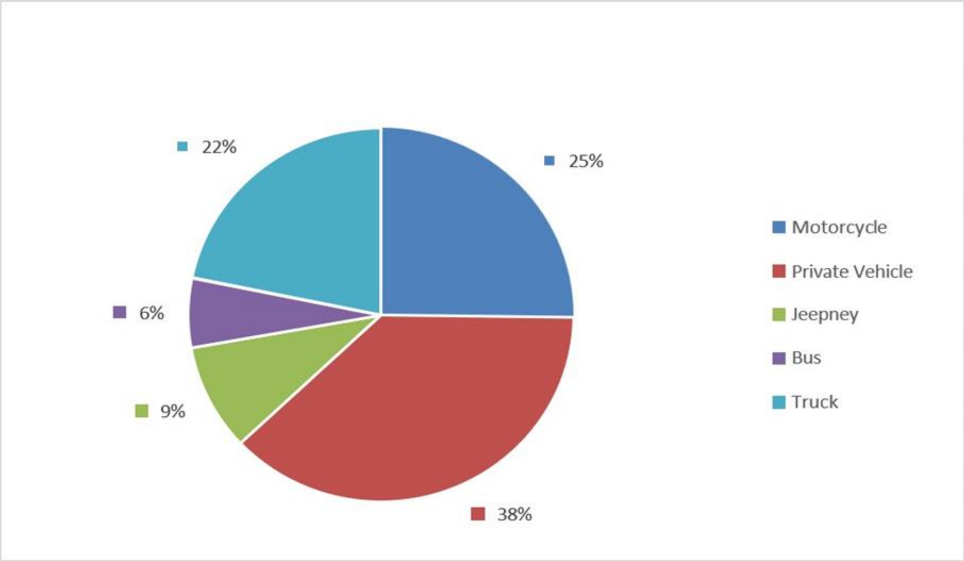


Figure 3-2. Distribution of southbound vehicles during the peak hour period.

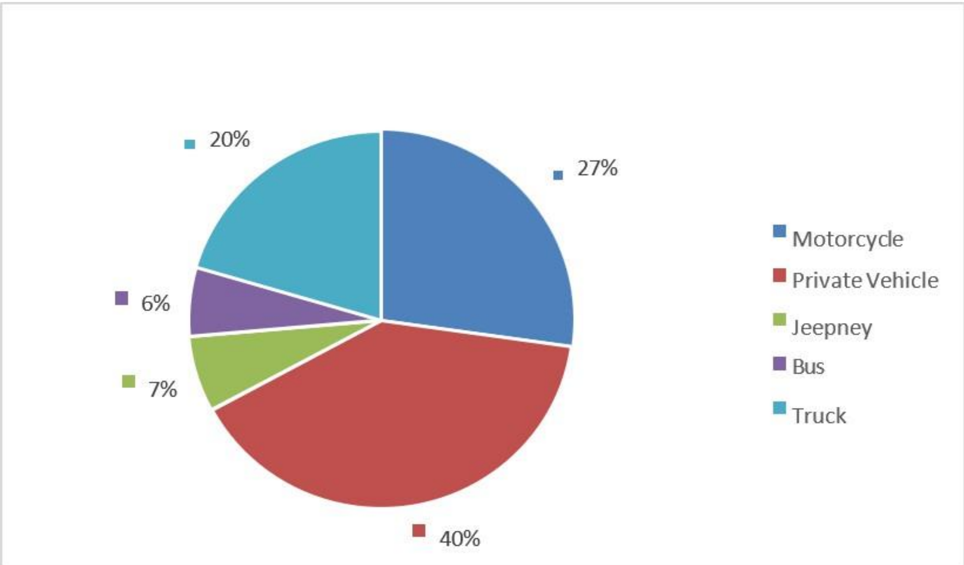


Figure 3-3. Distribution of westbound vehicles during the peak hour period.

Traffic data collection was conducted over a one-week period, from 15 July 2022 to 21 July 2022. Counts were taken from 6:00 am to 6:00 pm for the afternoon survey period. The recorded traffic volumes for the seven-day period are presented in Figure 3-4.

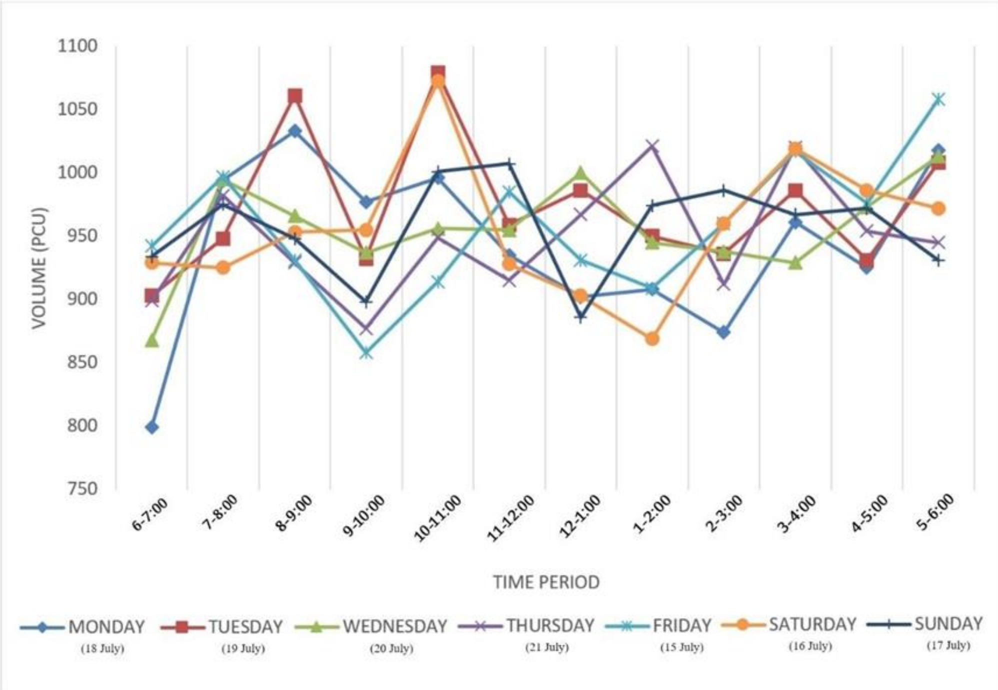


Figure 3-4. Hourly traffic count volumes for the 7-day survey

The morning and afternoon peak-hour volumes are presented in Table 3-1. Although each day exhibits different peak-hour periods, it is evident that, for most days, the morning peak occurs from 7:00 a.m. to 8:00 a.m., while the afternoon peak typically occurs from 5:00 p.m. to 6:00 p.m.

Table 3-1 Morning and afternoon peak hour volumes for the seven-day traffic count

| Day | Morning | Volume (pcu/hr) | Afternoon | Volume (pcu/hr) |
|---|---|---|---|---|
| Monday | 8:00 – 9:00 am | 1258.2 | 5:00 – 6:00 pm | 1288.0 |
| Tuesday | 10:00 –11:00 am | 1300.1 | 5:00 – 6:00 pm | 1271.2 |
| Wednesday | 7:00 – 8:00 am | 1268.3 | 5:00 – 6:00 pm | 1285.5 |
| Thursday | 7:00 – 8:00 am | 1195.3 | 1:00 – 2:00 pm | 1292.3 |
| Friday | 7:00 – 8:00 am | 1229.2 | 5:00 – 6:00 pm | 1347.4 |
| Saturday | 10:00 – 11:00 am | 1317.1 | 3:00 – 4:00 pm | 1299.9 |
| Sunday | 11:00 – 12:00 nn | 1233.5 | 2:00 – 3:00 pm | 1240.3 |

### 3.3 Traffic Simulations

### 3.3.1 Base Case Scenario using only HCM

Using the geometric properties of the intersection and the peak hour volumes, the intersection delay and corresponding LOS were calculated. The results were summarized in Table 3-2.

Table 3-2. Intersection delay and LOS during the AM and PM peak hour

| DAY | INTERSECTION DELAY (s/veh) | | LOS | |
|---|---|---|---|---|
| | AM | PM | AM | PM |
| Monday | 15.81 | 16.11 | C | C |
| Tuesday | 17.32 | 14.84 | C | B |
| Wednesday | 14.87 | 15.74 | B | C |
| Thursday | 14.7 | 15.38 | B | C |
| Friday | 14.85 | 16.41 | B | C |
| Saturday | 16.41 | 15.78 | C | C |
| Sunday | 15.29 | 14.87 | C | B |

For the unmitigated (unsignalized) setting, the shortest and longest intersection delays during the AM peak hour were recorded on Thursday and Tuesday, with delays of 14.7 s/veh (LOS B) and 17.32 s/veh (LOS C), respectively. During the PM peak period, the shortest delay was observed on Tuesday at 14.84 s/veh (LOS B), while the longest occurred on Friday at 16.41 s/veh (LOS C).

These results suggest that the intersection is not operating under severely congested conditions, as it still achieved a Level of Service (LOS) of B on certain days, even without signalization. However, this does not fully align with on-ground observations, which indicate significant traffic buildup during peak hours. This discrepancy suggests that the simulation or delay calculations may not fully capture the actual operational challenges of the intersection. Simulation of operational alternatives are therefore necessary.

### 3.3.2 Signalized Intersection using only HCM

This study used mitigation in PTV Vistro, where potential mitigation measures could be evaluated, such as installing a traffic signal system on intersections where operational standards are not reached. The resulting traffic installation at the intersection along J.P. Rizal cor. Bonifacio St. for every day's AM and PM peak hours is shown in Table 3-3 below.

Table 3-3. Intersection delay and LOS with traffic signals during the AM and PM Peak Hour

| DAY | INTERSECTION DELAY (s/veh) | | LOS | |
|---|---|---|---|---|
| | AM | PM | AM | PM |
| Monday | 15.62 | 16.16 | B | B |
| Tuesday | 16.10 | 15.54 | B | B |
| Wednesday | 15.42 | 16.14 | B | B |
| Thursday | 15.50 | 15.72 | B | B |
| Friday | 15.65 | 16.07 | B | B |
| Saturday | 15.62 | 15.79 | B | B |
| Sunday | 15.65 | 15.49 | B | B |

Based on the results, the LOS for all days was at level B. However, compared to the results of the unsignalized intersection, the intersection delay per vehicle decreased. On the other hand, the LOS for most of the days increased from C to B.

To determine the optimal intersection design, the study employed the mitigation feature of PTV Vistro, converting the existing unsignalized intersection into a signalized setup. Based on the simulation results, the AM peak period showed the shortest delay on Wednesday at 15.42 seconds per vehicle (LOS B) and the longest on Tuesday at 16.10 seconds per vehicle (LOS B). During the PM peak, the least delay was observed on Sunday at 15.49 s/veh (LOS B), and the highest on Monday at 16.16 s/veh (LOS B).

The percent difference in the highest intersection delay between the unsignalized and signalized setups was calculated as 7.30% for the AM peak and 1.54% for the PM peak. These results indicate that the signalized and unsignalized configurations show minimal difference in delay and LOS based on Vistro simulations.

### 3.3.3 Evaluation of the Results from the PTV Simulation using only HCM

The results of simulation do not fully reflect the actual traffic conditions at the intersection. PTV Vistro utilizes standard parameters and assumes straight major flows, whereas the dominant traffic movements at the site are from east to north and north to east, being part of the Maharlika National Highway System. The software's limitations in modeling non-linear major flows affect its ability to accurately simulate such scenarios.

Field observations revealed that the existing intersection geometry is inadequate for safely accommodating long vehicles, such as semi-trailer trucks. These vehicles often require encroachment into the opposite lane when making right turns, leading to additional delays. Unlike an All-Way or Two-Way Stop-Controlled intersection, typically used in low-volume areas, this intersection experiences high volumes from non-standard major directions (e.g., southbound and westbound), causing further delay for vehicles on minor approaches due to imbalanced priority and geometric constraints.

### 3.3.4 Swept Path Analyses in AutoRUN

The turning radius of a WB-40 truck was simulated to assess the adequacy of the existing curb radii. The results revealed that the current intersection geometry does not support safe and efficient turning movements for large vehicles. This geometric limitation is a primary contributor to traffic congestion at the site—an issue not captured by PTV Vistro, which lacks the capacity to fully model heavy vehicle dynamics in constrained turning environments. As illustrated in Figure 3-5, the simulation clearly shows the trailer truck encroaching into the opposing lane during a turning maneuver. This lane overshoot leads to traffic disruptions and increased delays, particularly during peak periods.

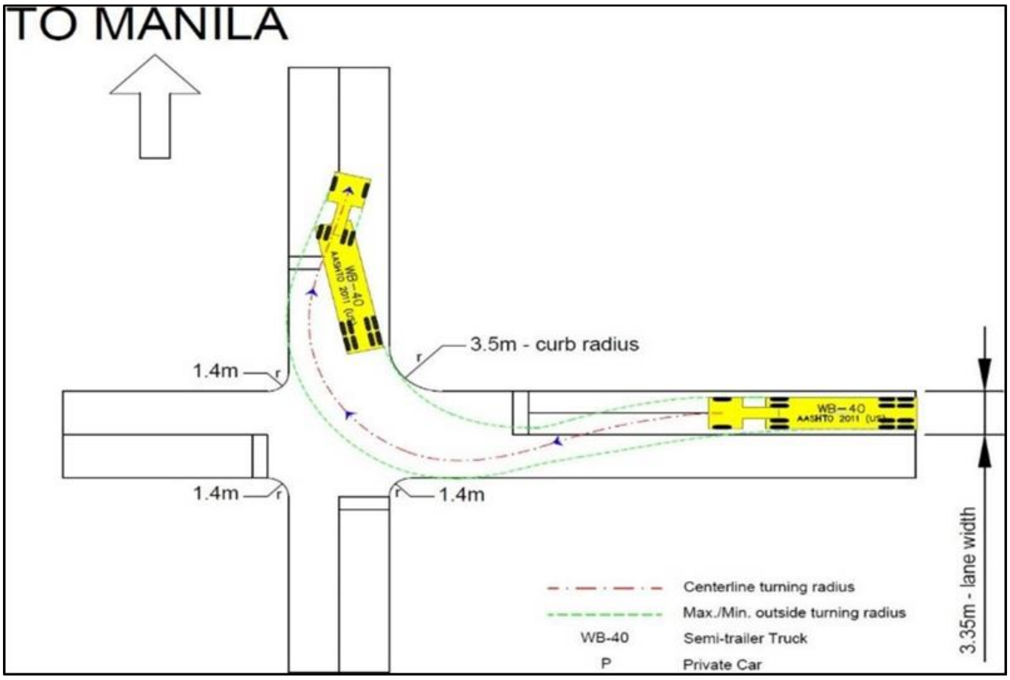


Figure 3-5. WB-40 Truck 90-degree turning radius plotted on the intersection

#### 3.3.4.1 Swept Path Analysis of the Reconfigured Scenario 1

The geometric design of a roadway network is heavily influenced by the type and size of vehicles that traverse it. In particular, the design must accommodate the largest and heaviest vehicle types, such as trucks and buses, to ensure safe and efficient movement. In this study, observed traffic conflicts at the intersection are primarily attributed to the inadequate turning radius for large vehicles. For this study, the curb radii were redesigned as shown in Figure 3-6 to align with the turning requirements of the largest expected vehicle type, in accordance with the Department of Public Works and Highways (DPWH) guidelines.

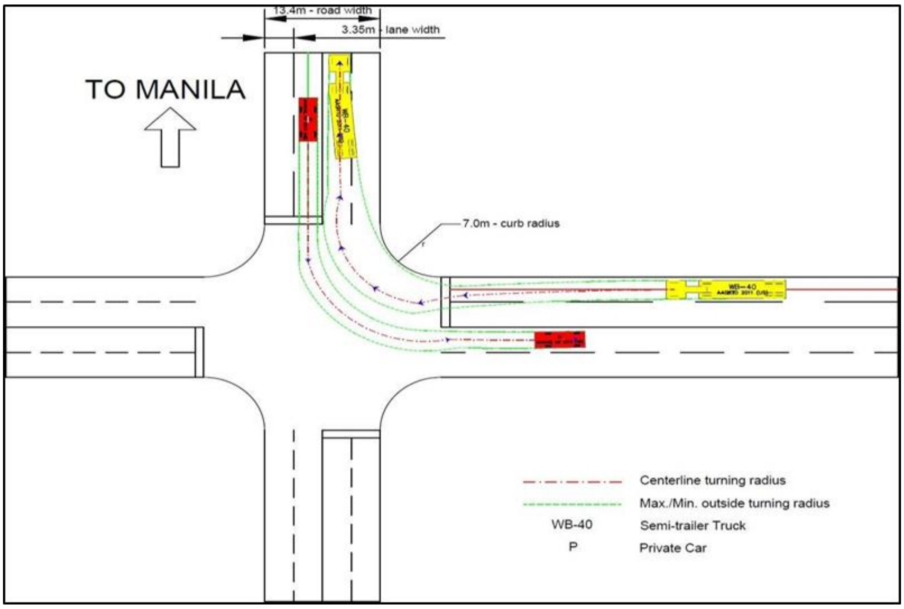


Figure 3-6. WB-40 Truck 90-degree turning radius plotted
on the redesigned intersection (Scenario 1)

### 3.3.4.2 Swept Path Analysis of the Reconfigured Scenario 2

Further modifications can be done as shown in Figure 3-7 showing a dedicated right-turn channel for vehicles traveling from Bicol to Manila, enhancing the intersection's capacity and safety for heavy vehicles. This configuration showed improved vehicle flow and reduced conflict points.

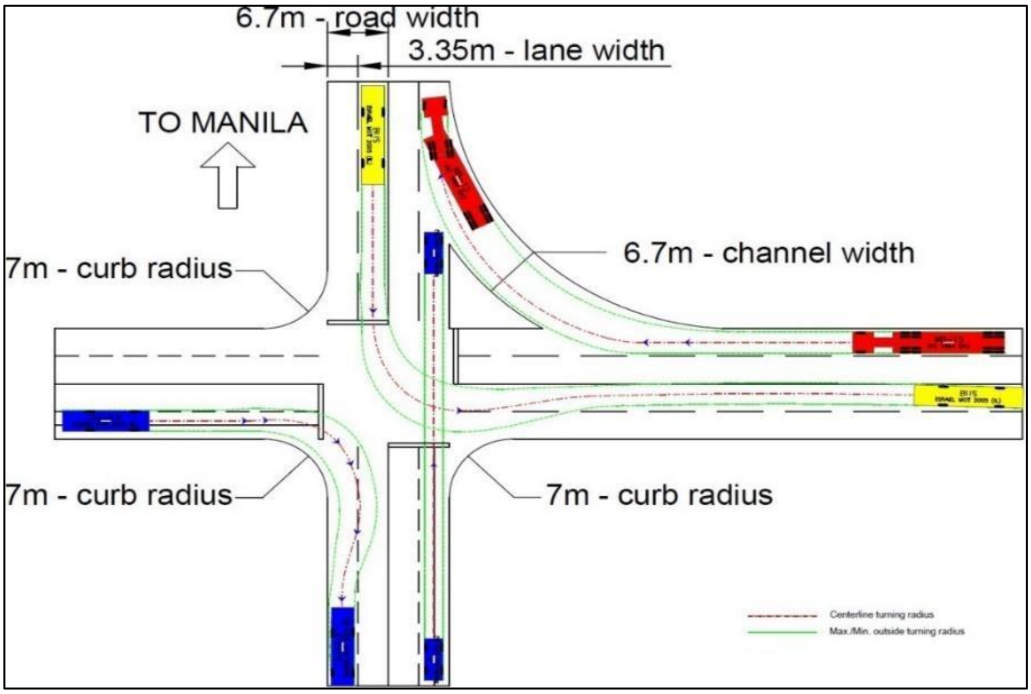


Figure 3-7. Reconfigured intersection design with a dedicated right
turn for the major traffic flow of Bicol to Manila (Scenario 2)

### 3.3.5 Microsimulations in PTV Vissim using HCM and Swept Path Analysis

#### 3.3.5.1 New Adjusted Base Case Scenario

A new simulation was conducted to accurately represent the intersection's current conditions. PTV Vissim was employed for this purpose, as it is capable of replicating real-world traffic conditions. The simulation utilized the Level of Service (LOS) values outlined in the Highway Capacity Manual by the Transportation Research Board (2010), ensuring consistency and reliability in the analysis. This approach provides a robust foundation for evaluating the intersection's performance and identifying potential improvements. Table 3-4 shows the base case scenario with the actual Intersection Delay and Queue Length.

Table 3-4. Actual intersection delay and queue length of the intersection from the simulation

| DIRECTION | INTERSECTION DELAY (s/veh) | MAX QUEUE LENGTH (m) | LOS |
|---|---|---|---|
| Southbound | 58.08 | 60.62 | E |
| Westbound | 12.13 | 44.51 | B |
| Northbound | 29.38 | 65.09 | D |
| Eastbound | 17.67 | 16.67 | C |

Simulations in PTV Vissim indicated an average delay of 29.32 seconds per vehicle in the Eastbound Direction with a maximum queue length of 65.09 meters and overall LOS of D. These results suggest that the intersection experiences significant delays and congestion.

#### 3.3.5.2 Intersection Delay and LOS of the Reconfigured Unsignalized Scenario 1

Using the reconfigured scenario 1, the PTV Vissim was used to simulate the modified traffic conditions in the intersection. The same data for traffic volume and vehicle route from PTV Vistro were used. After the program’s settings and parameters were calibrated, the results from PTV Vissim’s simulation using the modified intersection condition are tabulated in Table 3-5.

Table 3-5. Intersection delay and queue length of the reconfigured scenario 1 of the intersection from the simulation

| DIRECTION | INTERSECTION DELAY (s/veh) | MAX QUEUE LENGTH (m) | LOS |
|---|---|---|---|
| Southbound | 32.97 | 56.17 | D |
| Westbound | 8.47 | 33.39 | A |
| Northbound | 2.37 | 0 | A |
| Eastbound | 7.73 | 45.80 | A |

The percent difference in intersection delay between the base case and Reconfigured Scenario 1 was calculated as follows: 55.16% for southbound, 35.53% for westbound, 152.69% for northbound, and 116.68% for eastbound vehicles. With an average reduction of 90.01%, the results indicate a significant improvement in traffic conditions. The substantial decrease in delay confirms that the modified intersection performs more efficiently than the current setup.

#### 3.3.5.3 Intersection Delay and LOS of the Reconfigured Unsignalized Scenario 2

As shown in Table 3-6, the maximum intersection delay and queue length occurred in the eastbound direction, with values of 9.34 seconds per vehicle and 41.01 meters, respectively. Despite this, the level of service (LOS) for all directions remained at A, indicating a stable and efficient traffic flow at the intersection.

Simulation results show that adding an exclusive right-turn channel for vehicles from east to north significantly reduced delays—particularly for westbound vehicles, with delays dropping from 8.47 s/veh in Configuration 1 to 5.57 s/veh. The percent difference in intersection delay between the actual and modified Configuration 2 per direction is as follows: 158.91% (southbound), 74.12% (westbound), 149.38% (northbound), and 103.51% (eastbound), yielding an average percent difference of 120.86%. This indicates a substantial improvement in intersection performance compared to the base scenario. Notably, Configuration 2 outperformed Configuration 1, which had an average percent difference of 90.01%, confirming the effectiveness of the right-turn channel in reducing overall delays.

Table 3-6. Intersection delay and queue length of the reconfigured scenario 2 of the intersection from the simulation

| DIRECTION | INTERSECTION DELAY (s/veh) | MAX QUEUE LENGTH (m) | LOS |
|---|---|---|---|
| Southbound | 6.65 | 25.35 | A |
| Westbound | 5.57 | 31.24 | A |
| Northbound | 2.56 | 0 | A |
| Eastbound | 9.34 | 41.01 | A |

The current study highlights the importance of evaluating the appropriateness of intersection geometry in relation to vehicle lengths. The results can be directly utilized by the LGU to help decongest the intersection and support more effective traffic management.

## 4. SUMMARY AND CONCLUSIONS

The municipality of Gumaca, Quezon, known for its rapid urbanization, has recently faced growing traffic congestion, particularly around major roads and intersections such as J.P. Rizal Street. This study aimed to evaluate intersection performance, focusing on delay and level of service (LOS), to identify effective mitigation strategies. The current unsignalized intersection (base scenario) was compared with a signalized configuration. Results showed an improvement in LOS from C to a consistent B across all surveyed days under the signalized setup. However, this came with only marginal delay reduction, suggesting limited operational gains.

The analysis also highlighted that the existing geometric layout poses challenges for heavy vehicles, especially during right turns toward Manila, leading to lane encroachments and delays. To address this, alternative intersection designs were proposed using AASHTO (2001) guidelines, including adjusted curb radii and dedicated turn channels. Simulation results demonstrated substantial reductions in intersection delays under these reconfigured layouts. Overall, the study underscores the importance of geometric enhancements alongside signal control in managing urban traffic efficiently and accommodating increasing vehicular volumes. Furthermore, the findings of this study can provide valuable guidance to the LGU in improving traffic operations at the intersection.

## 5. RECOMMENDATIONS

It is recommended to convert the modified configurations from an unsignalized to a signalized setup to better assess the impact of signalization on intersection performance. This will enable a more accurate analysis of how traffic signals influence vehicle movement, delay, and overall efficiency. Various signal system types should also be evaluated to identify the most appropriate option, considering traffic volume, vehicle types, and pedestrian activity. This comprehensive assessment will help optimize intersection design, enhance safety, and improve traffic flow.

It is also noteworthy that although the intersection lies along the Maharlika Highway, it is situated within the center of a commercial district. Therefore, future studies may compare the cost implications of implementing various intersection improvements, considering both short-term and long-term scenarios.

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