Determining an Optimal Intersection Traffic Management Scheme Through Microsimulation

Jaybee COCHERO [a], Yedda Vania DOTILLOS [b], Lawrence Melbien PETILOS [c],
Evanne Neil TAÑOLA [d], Lindy Jane ANDO [e], Hanzel MEJIA [f]

[a,b,c,d,e,f] *Department of Civil Engineering, Faculty of Engineering, Visayas State University, Baybay City, 6521, Philippines*
[a] *E-mail: jebscochero@gmail.com*
[b] *E-mail: yeddadotillosvania@gmail.com*
[c] *E-mail: lmpetilos@gmail.com*
[d] *E-mail: evanneneil11@gmail.com*
[e] *E-mail: lindyjane.ando@vsu.edu.ph*
[f] *E-mail: hanzel.mejia@vsu.edu.ph*

Abstract: In 2019, the United Nations launched its Road Safety Strategy which aligned with the Sustainable Development Goals (SDG) 3 and 11, emphasizing infrastructure safety management. Using PTV VISSIM, this study evaluated an existing intersection at Tacloban-Baybay South Road and Baybay City Diversion Road based on Level of Service (LOS), safety, and cost-effectiveness. Its alternatives were then examined. Results show that the current intersection can handle projected traffic for the next decade with an acceptable LOS, but safety concerns and poor geometry suggest interim improvements are needed. Among the alternatives, the proposed roundabout showed the best performance, with lower delays, shorter queues, and a higher level of service rating of A, making it the most effective long-term solution as supported by statistical analysis. For another alternative, a four-phased signalized intersection presents enhanced safety benefits due to reduced conflict points. However, improved unsignalized intersections with additional lanes provided the highest value-to-cost ratio, making it the most economically viable option.

Keywords: Roundabout, Signalized, Intersection, VISSIM, Microsimulation, Level of Service (LOS)

1. INTRODUCTION

Urban transport has become a pressing concern across the Philippines due to rapid motorization and insufficient infrastructure planning. These issues are particular in small-midsized cities where development has not able to keep with mobility demands.

Baybay City, Leyte has experienced a growing number of transport vehicles resulting to significant traffic congestion, delays, and heightened road safety concerns. These issues significantly hinder the efficient movement of goods, services, and commuters, thereby affecting socio-economic activities and overall urban mobility.

One critical area of concern is the Tacloban - Baybay South Road and Baybay City Diversion Road, which has been identified as a high-risk zone for vehicular accidents.

According to a study conducted by Alfante et al. (2019), the intersection's current design contributes to frequent crashes and inefficient traffic flow. The study recommended a redesign of this intersection to address these safety and congestion challenges.

Given the growing operational and safety concerns at a major intersection in Baybay City, Leyte, there is a need to evaluate alternative management strategies that can improve efficiency and reduce conflict. This study develops an evidence-based assessment of intersection performance under existing and projected traffic conditions through engineering analysis and microsimulation. Its overall objective is to evaluate traffic intersection management schemes using microsimulation to enhance efficiency, safety, and sustainability in urban transport systems. Specifically, the study aims (1) to assess the Level of Service of the intersection using Highway Capacity Manual (HCM) 2010 criteria through VISSIM simulation, and (2) to compare the existing configuration with proposed management alternatives based on Level of Service, conflict points, queue lengths, and cost–benefit outcomes.

2. BACKGROUND

2.1 Traffic Management and Simulation

Traffic microsimulation software is widely used for analyzing, simulating, and optimizing traffic flow. VISSIM, developed by PTV Group of Germany, is known for its detailed microscopic analysis of vehicle interactions, making it suitable for studies focused on individual vehicle behavior. VISSIM is widely used around the world, particularly in the US by its Department of Transportation.

In the Philippines, the University of the Philippines developed LocalSim, a microscopic simulation tool tailored to Filipino driving behavior. It supports local governments in managing traffic through evidence-based analysis rather than trial-and-error methods.

Several studies have previously explored the effects of traffic management schemes using microsimulation software. Borlagdan, et al. (2021) used LocalSIM microsimulation to evaluate the effects of signalization at Lopez Avenue-National Highway, Laguna, Philippines. Using VISSIM, Fabianova et al. (2020) created alternative scenarios which achieved a reduction of queue lengths demonstrating effectiveness of modifications.

2.2 Tacloban Baybay South Road and Baybay City Diversion Road Intersection

Completed in 2016, the Tacloban Baybay South Road and Baybay City Diversion Road Intersection (Figure 1) was completed as part of the Baybay City Diversion Road project. It was constructed to decongest central traffic inside Baybay City by redirecting through-traffic, especially heavy vehicles, between major cities and municipalities on Leyte Island such as Bato, Maasin, Tacloban, and Ormoc.
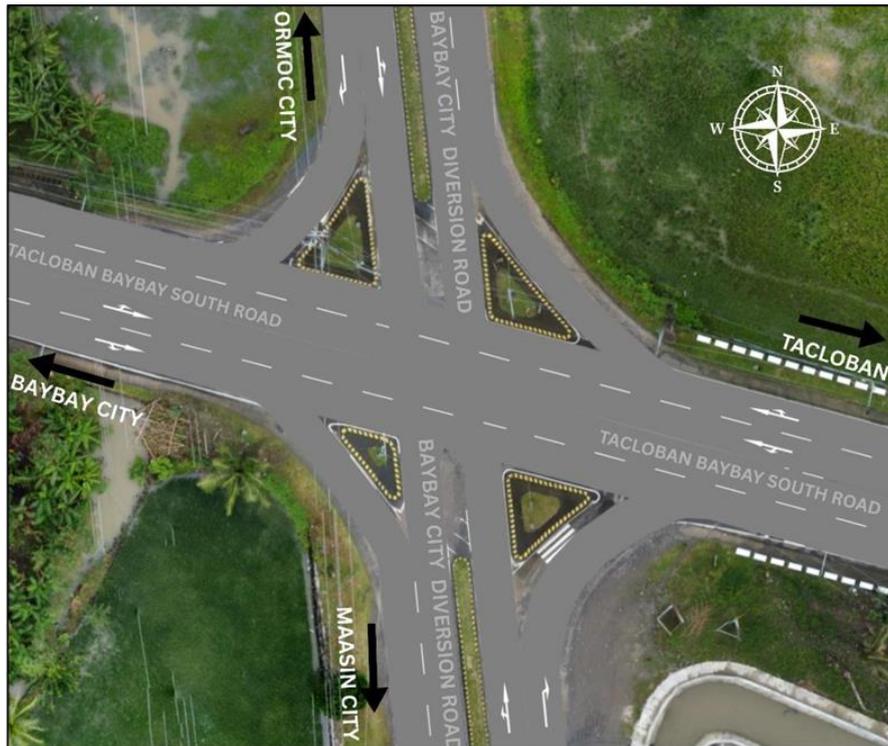
Figure 1: Current Intersection

The project has drawn criticism due to its history of accidents and has been informally dubbed as having "killer intersections" by local stakeholders. Technical evaluations conducted by the Regional Project Monitoring Committee (RPMC) in 2019, revealed significant design flaws, notably to the road segments with gradients exceeding the Department of Public Works and Highways (DPWH) maximum allowable slope of 8%, as well as tight horizontal curves unsuitable for long vehicles (Philippine News Agency (PNA), 2019). These geometric inconsistencies were found to contribute to a pattern of accidents along the corridor.

2.3 Road Safety Challenges

The high incidence of accidents, particularly at specific junctions and curves, has led to mounting concerns about road safety and infrastructure resilience in the region. In response to these safety concerns, the RPMC and DPWH recommended urgent redesign measures, such as the regrading of slopes, curve widening, and alignment with the DPWH Highway Safety Design Standards (DPWH, 2016). However, progress on these recommendations has reportedly been slow, with safety issues persisting several years after the road's opening. Comparative cases, such as the Sagonsongan Diversion Road in Marawi City, according to Sumndad (2024), illustrate how noncompliance with geometric safety standards can result in similar safety failures, reinforcing the necessity of proper planning and audit in public road infrastructure.

2.4 Looking at Alternatives

One alternative is implementing a roundabout. Roundabouts significantly improve safety due to their design, which reduces vehicle speeds and eliminates severe conflict points like head-on or right-angle collisions common in traditional intersections. Studies have shown

dramatic reductions in crash rates, with Isebrands (2009) reporting up to 67% fewer crashes and 89% fewer injury crashes after roundabout conversions. The continuous flow of vehicles without the need for full stops reduces travel time, congestion, and vehicle emissions, enhancing overall performance. Roundabouts also support walkability and aesthetic enhancements like green spaces, or landmarks, making them a sustainable and pedestrian-friendly option.

Alternatively, signalization is a viable solution, particularly in urban or high-volume traffic areas where control over traffic movements is crucial. Properly implemented traffic signals help regulate conflicting movements, improve driver and pedestrian safety, and optimize intersection operations during peak hours. Traffic signals can be employed to minimize pedestrian-vehicle and vehicle-vehicle conflicts. Using tools like the Webster formula, signal systems can be designed to minimize delay and queue lengths effectively. Studies such as those by Dang et al. (2022) and Kalašová et al. (2024) affirm that tailored signal timing based on local traffic conditions enhances intersection performance. While signals involve ongoing operational costs, they offer high control and adaptability, making them suitable when coordinated movement and predictability are necessary.

3. METHODOLOGY

3.1 Overview

The research method for this study adopted a mixed methods approach, integrating both quantitative analysis and qualitative understanding to comprehensively evaluate the intersection's performance and safety. Quantitative data collection involves geometric, traffic, and safety information, including accident history. A map of the intersection was generated using an aerial photograph. Traffic survey data was then collected from Closed-circuit Television (CCTV) footage over a 16-hour period for two consecutive days to determine peak hours. These peak hours were incorpareted as basis to accurately capture traffic characteristics and driver behavior.

The traffic count consisted of 2 consecutive regular workdays (April 7 and 8, 2025) and recorded the quantity and vehicle types moving from all directions at 15 min intervals.

3.1 Location of Study

Baybay City (Figure 2) is part of Region VIII (Eastern Visayas) in the Philippines. It is located on the western coast of the Island of Leyte with Albuera to its North, Inopacan bordering its South, and the Camotes Sea to the West.
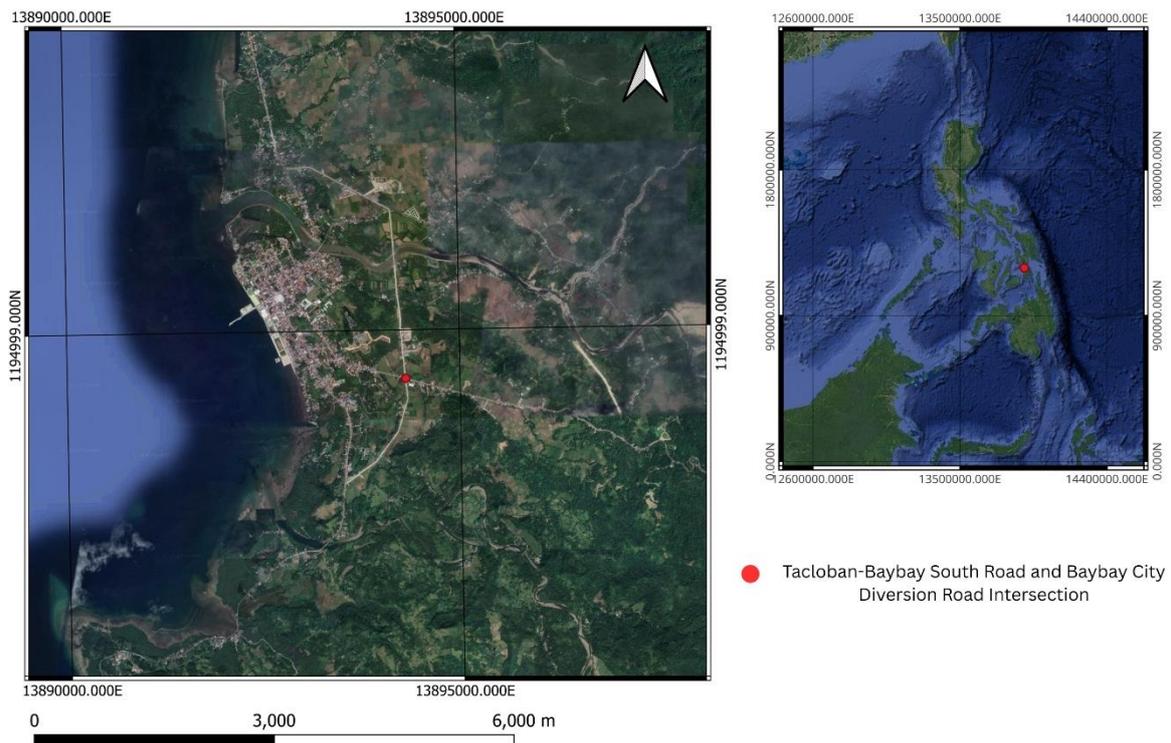
Figure 2. Location of Intersection Evaluated (Tacloban-Baybay South Road and Baybay City Diversion Road)

3.2 Microsimulation

Data from the traffic survey, including vehicle volumes, turning movements, classifications, and observed behaviors, were used as key input parameters for the microsimulation model. After developing a model of the existing intersection, alternative geometric and control schemes were subsequently created for comparison.

PTV Vistro was first utilized to construct the initial network model, incorporating traffic volumes, signal timing information, and geometric details. This model provided preliminary performance estimates for the existing intersection. Using the Vistro-generated layout as a guide, a detailed microsimulation model was then developed in PTV Vissim, with links and connectors configured to accurately represent all lane configurations and turning movements.

The Vissim model was calibrated using field data. Parameters such as approach speeds, control speeds, vehicle classifications, and flow distributions were assigned based on the traffic survey, while additional behavioral elements, including speed profiles and acceleration patterns, were derived from direct observation of driver behavior on site. The calibrated simulation outputs served as the basis for comparing the performance of the existing intersection with the proposed alternative schemes.

Due to software version limitations, signal timings in Vissim required manual adjustment. Initial cycle lengths were estimated using Webster's method, although pedestrian phases could not be modeled and remain a recommendation for future, more detailed analyses. Simulation animations were reviewed to identify issues such as spillback, long queues, and excessive delay, after which green times were manually refined to mitigate these operational problems.

For scenarios employing a four-phase signal sequence, opposing directional movements were assigned to consecutive phases to reduce conflicts. In contrast, the two-phase scheme combined opposing directions within a single phase, allowing simultaneous straight and left-turn movements. While suitable under low traffic demand, this configuration may create conflicts for left-turning vehicles and increase delay. Finally, the signal timing templates applied in Vissim were initially generated in Vistro, which provided the foundational phase logic and delay estimates for the microsimulation.

Table 1 presents the driving-behavior parameters used in the Vissim model. These default settings were retained without modification, as they sufficiently reflected the driving patterns observed in the study area.

Table 2. Default Parameters and Adjustments Based on Driving Behavior

PARAMETER	DRIVING BEHAVIOR	
	Default	Adjustment
Average Standstill Distance	2 meters	-
Add. Part of Desired Safety Distance	2 meters	-
Add. Part of Desired Safety Distance	3 meters	-
No. of Observed Vehicle	2.00	-
Lane Change Rule	Free Lane Selection	-
Desired Lateral Position	1 meter	-
Lateral Distance Driving	1 meter	-
Lateral Distance Standing	1 meter	-
Safety Distance Reduction Factor	0.6 meter	-
Minimum Headway	0.5 second	-

3.3 Calibration and Validation

The Geoffrey E. Havers (GEH) statistic was employed to assess the accuracy of the intersection's simulated traffic volumes. The GEH test is a widely used goodness-of-fit measure for comparing observed and simulated traffic counts in transportation modeling (Friedrich et al., 2019). It is also adopted by the U.S. Department of Transportation Federal Highway Administration as a calibration criterion to ensure close agreement between modeled performance estimates and field-measured traffic conditions (FHWA, 2004).

$$GEH = \frac{\sqrt{2(q_{simulated} - q_{observed})^2}}{(q_{simulated} - q_{observed})}$$

(1)

where,

$q_{simulated}$ = average traffic flow volume in simulation (vehicles/hour) and

$q_{observed}$ = traffic flow volume in the field (vehicles/hour).

The specific results of the GEH analysis for the current study were detailed in Table 2, which illustrates how well the simulation model aligns with observed traffic volumes across various segments or intersections under consideration.

Table 2. Description of the Criteria Used for GEH Analysis

GEH RANGE	DESCRIPTION
GEH<5.00	Accepted
$5.00 \leq GEH \leq 10.00$	Caution; model error or insufficient data
GEH>10.00	Denied

3.4 Selection of Performance Metrics

Performance measures for evaluating the intersection schemes were selected based on the Traffic Analysis Toolbox Volume III: Guidelines for Applying Traffic Microsimulation Modeling Software (2019 update). The measures were chosen according to how effectively they addressed the key considerations in performance evaluation: (1) whether the measure can be reliably observed in the field; (2) whether it can be produced from simulation outputs, and (3) whether it can meaningfully differentiate the alternative designs. The primary performance indicators used in the comparison were, total travel time and delay per vehicle, queue length and level of service.

In addition to the indicators derived from the microsimulation, performance metrics related to cost and safety were incorporated to provide a more comprehensive assessment. These included factors such as the maintenance requirements of traffic control systems and the safety of pedestrians and cyclists. Such qualitative measures were identified through visual assessment of the intersection layouts and operational conditions.

3.5 Statistical Analysis

To compare the Level of Service between the proposed alternatives and existing intersections, a paired t-test was conducted to analyze differences in delay under both current traffic conditions and projected future demand. The future scenario applied a 10-year growth factor of 1.6, derived from the 2025 traffic survey, which recorded a 1.6-fold increase in traffic volume relative to the baseline data reported by Alfante et al. (2019). The results of each simulation run were used as data subject for t-test. Before conducting the t-test, testing for normalcy of data was conducted using Shapiro Wilk Test.

The hypotheses were formulated as follows:

H_o – there is no significant difference between current and alternative intersection schemes.
H_a – there is significant difference between current and alternative intersections.

With p-value greater than or equal to confidence level of 0.05, we fail to reject the null hypothesis indicating there is no significant difference. Alternatively, a p-value less than 0.05 would result in the rejection of the null hypothesis indicating a significant difference. The paired t-test was conducted between existing control and alternatives for both current and future traffic loads using the average peak hour traffic loads of 2 consecutive regular workdays.

3.5 Economic Criteria

As road networks evolve to accommodate increasing traffic demand, it becomes essential to evaluate whether proposed improvements offer benefits that justify their costs. Economic criteria is a fundamental tool in offering a quantitative basis for evaluating economic viability of the proposed interventions. For this study, cost-benefit analysis was conducted. The cost includes the construction and maintenance cost, and the benefit includes the savings from the cost of accidents, lost time of vehicle users due to vehicle delays, and additional vehicle operating costs (VOC).

Travel Time Cost (TTC) represents the monetary valuation of time savings experienced by vehicle users. This concept is crucial in the economic appraisal of transport investments, as it often constitutes a significant portion of the total user benefits (Ho et al., 2016). The TTC is normally calculated based on the average labor productivity in the Philippines. To estimate TTC, the DPWH distinguishes between working time and non-working time per person-hour for a representative vehicle type and estimate the passenger time cost per person.

The savings were calculated as the difference in travel time between base road network and with the proposed interventions. Table 3 shows the unit travel time cost in 2008 from the records of JICA, and Table 4 shows the travel time cost when inflation is applied.

Table 3.   Unit Travel Time Cost in 2008 (Peso/min/veh)

Van/Car/AUV	PUJ	PUB	Medium Truck	Large Truck	Tricycle	Motorcycle
6.81	7.44	12.69	1.02	2.10	1.37	1.37

Table 4. Adjusted Travel Time Cost in 2025 (Peso/min/veh)

Van/Car/AUV	PUJ	PUB	Medium Truck	Large Truck	Tricycle	Motorcycle
7.02	7.68	13.08	1.08	2.16	1.44	1.44

The maintenance cost is assumed to be 1% - 2% of construction costs for roundabout and improved intersection, and 10% - 15% for signalized intersection according to JICA (JICA, 2009). The cost-benefit analysis was based on the value-to-cost ratio (VCR). For all the cost and value, an inflation rate is applied to account for future changes in monetary value. According to Statista, the inflation rate is projected to reach 3.65% in 2026 (Statista, 2025). Meanwhile, the latest Monetary Policy Report (MPR) from the Bangko Sentral ng Pilipinas (BSP) indicates that the risk-adjusted inflation forecast for 2025 has increased to 3.5%, while the 2026 forecast remains at 3.7% (BSP, 2025). Despite these projections, inflation expectations continue to fall within the government's official target range of 3.0% ± 1.0 percentage point. For the projected costs and benefits from year 2 to year 20, values are calculated using the formula F=P (1+0.03), where P is the cost of the previous year and 3% is the applied annual inflation rate.

Economic costs and value throughout the project's life span are compared by a discount cash flow analysis. The discount rate (DR) is 10% which is based on the social benefit discount rate set by the National Economic Development Authority (NEDA, 2016). For economic evaluation, two indicators are calculated: Value-to-Cost ratio (V/C) which is defined in Equation 2 and Value-Cost which is defined in Equation 3. In addition, while the maximum

life expectancy might be longer, 20 years is used as a practical standard for planning and economic assessment, according to the JICA report on road design (JICA, 2009).

$$Value-to-Cost\ ratio\ \left(\frac{V}{C}\right) = \sum \frac{V_n}{(1+DR)^n} \div \sum \frac{C_n}{(1+DR)^n} \qquad (2)$$

$$Value-Cost\ = \sum \frac{V_n-C_n}{(1+DR)^n} \qquad (3)$$

where,

V_n = Value or benefit such as Time Travel, Vehicle Operating and Accident Savings

C_n = Total construction cost including operations and maintenance cost

DR = Discount rate (3%) based on Social Benefits Rate of National Economy and Development Authority (NEDA)

n = number of projected years

4. RESULTS AND DISCUSSION

4.1 Vehicle Swept Path Analysis

The swept path analysis demonstrates that when a single truck or bus executes a turning maneuver at the studied intersection, the required turning radius is substantial, resulting in a wide swept path envelope. The simulation indicates that for the left-turning movement, the design vehicle encroaches into the adjacent lane by approximately 30.87%, suggesting that the current geometric layout does not adequately accommodate large vehicles. This creates a potential operational and safety concern, particularly for opposing traffic approaching from the Baybay City Diversion Road (Maasin–Baybay/Ormoc direction), as illustrated in Figure 2.

A similar condition is observed for the right-turning movement, where the design vehicle again requires a considerable lateral clearance. Although the encroachment is reduced compared to the left turn, the simulation shows that the vehicle still utilizes about 66.52% of the adjacent lane width, indicating insufficient turning space. To mitigate these conflicts, an additional apron or widening at the curbside, shown in Figure 3, is necessary to safely accommodate heavy vehicle operations without compromising the adjacent traffic lane.
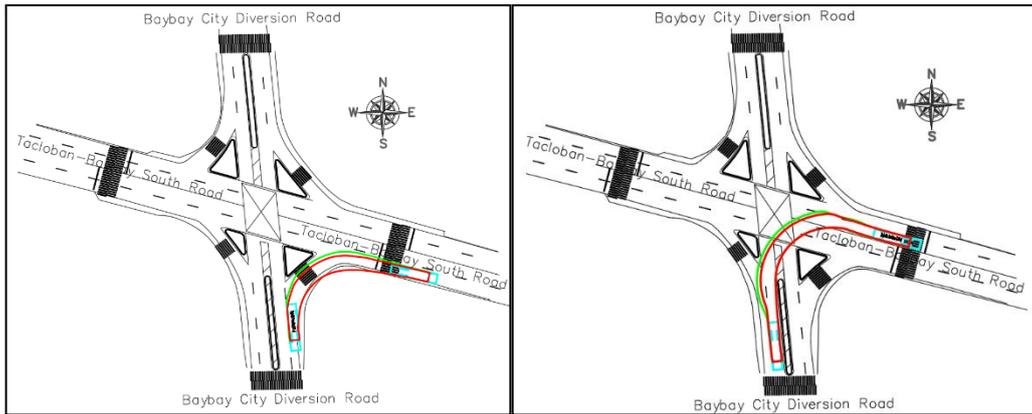
Figure 3. Left-Turning (Left) and Right-Turning (Right) for Single Truck/Bus

4.2 Comparative Analysis Based on Performance Metrics

4.2.1 Current Traffic Demand

Under existing traffic conditions, the roundabout configuration emerges as the most efficient alternative, registering an average delay of 2.68 seconds and an average queue length of 0.25 vehicles, as shown in Figure 4. These values are slightly better than those of the current unsignalized intersection, which records an average delay of 2.78 seconds and a queue length of 0.62 vehicles. Despite the minimal numerical difference, both maintain Level of Service (LOS) A, reflecting smooth operations and minimal congestion.

The improved unsignalized intersection (with an added lane) similarly achieves LOS A, with an average delay of 3.00 seconds and a maximum queue length of 39.74 meters. Although the delay remains low, the extended queue suggests that the operational improvement is modest and dependent on how traffic distributes across the added lane.

In contrast, the signalized alternatives exhibit reduced efficiency under current demand. The four-phase signalized intersection performs the poorest, with an average delay of 25.18 seconds (LOS C) and an average queue of 5.16 vehicles, reflecting operational inefficiency under light traffic conditions. The two-phase signalized design performs better with 13.51 seconds of delay (LOS B) and an average queue of 3.09 vehicles, but still does not match the performance of the unsignalized or roundabout configurations. These results suggest that signalization, especially more complex phasing, is unnecessary and inefficient when traffic volumes are low to moderate.
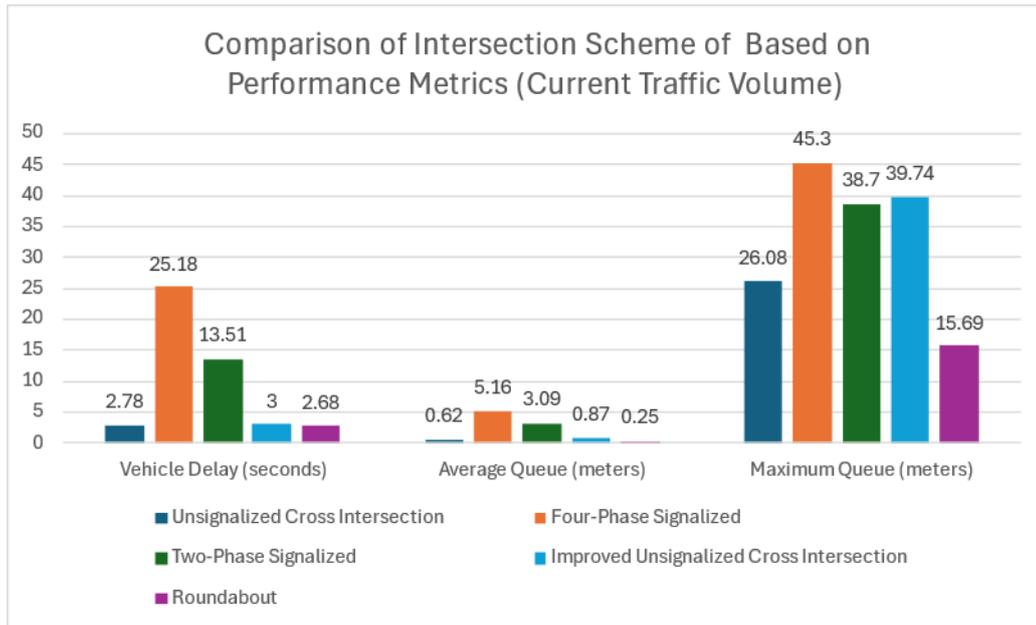
Figure 4. Comparison of Intersection Schemes (Current Traffic Volume)

4.2.2 Future Traffic Demand

Under projected traffic conditions, all alternatives exhibit increased delays and queue lengths; however, their relative performance shifts more distinctly, as shown in Figure 5. The roundabout continues to outperform all other options, maintaining a relatively low average delay of 7.96 seconds and an average queue of 2.40 vehicles, retaining LOS A. This aligns with established findings that roundabouts handle moderate increases in traffic more efficiently due to continuous flow operations and reduced conflict points (Roach et al., 2016; Retting et al., 2006).

Both the current and improved unsignalized intersections show notable degradation in performance, with delays increasing to 14.62 seconds and 16.38 seconds, respectively, and queues rising to 7.06 and 9.96 vehicles. Despite these increases, both alternatives remain within LOS B, indicating acceptable, though no longer optimal, operations under future demand. This suggests that while still functional, unsignalized control becomes less effective as traffic volumes rise.

The signalized alternatives show the greatest decline in efficiency. The two-phase signalized intersection drops to LOS C, with an average delay of 24.18 seconds. The four-phase design exhibits the poorest performance, with delays increasing to 46.77 seconds and queues exceeding 17.86 vehicles, corresponding to LOS D. The degradation in signalized operations can be attributed to increased saturation levels, longer red cycles, and inefficiencies in multi-phase coordination, which become more pronounced as volumes approach capacity.
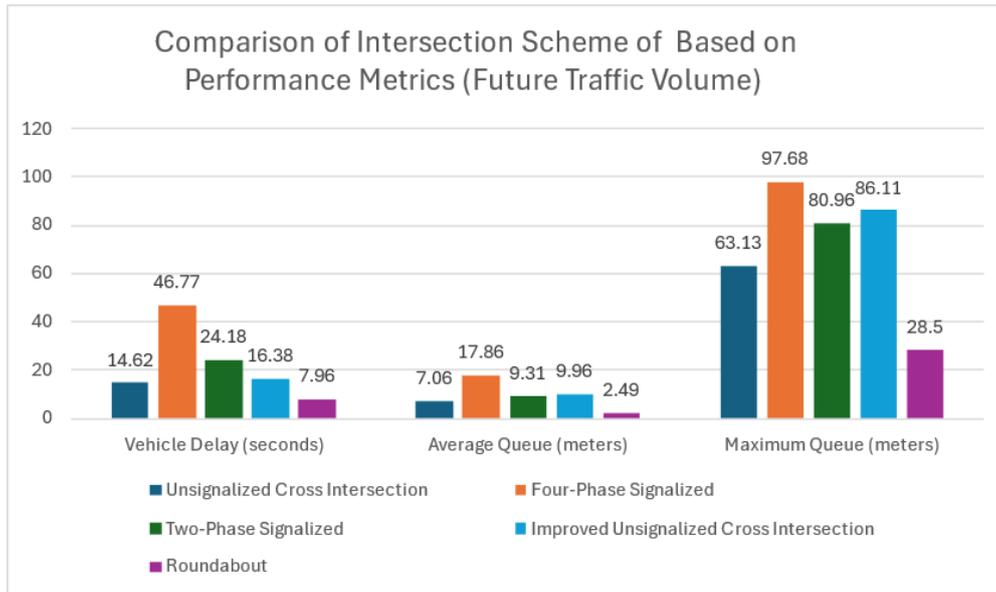
Figure 5. Comparison of Intersection Schemes (Future Traffic Volume)

Across both current and future traffic scenarios, the roundabout consistently demonstrates superior operational performance, delivering the lowest delays, smallest queue lengths, and maintaining LOS A. The unsignalized intersections remain functional under future demand but show clear declines. Overall, the results indicate that the roundabout is the most robust and adaptable design solution for both present and projected traffic conditions, provided that geometric refinements, particularly for large vehicle accommodation, are incorporated.

4.3 Comparative Analysis Based on Conflict Points

Safety consideration plays a critical role in evaluating intersection designs. Theoretically, among the evaluated schemes, signalization offers a significant safety advantage compared to others because this scheme has the lowest conflict points (see Table 5), resulting to lesser possible incidents, such as collision. A signalized intersection regulates vehicle movements at each approach, allowing only specific directions to proceed at a given time. Additionally, it minimizes the driver's guesswork, a gap of judgement often causing major vehicular crashes. It also reduces the simultaneous cross-traffic, lessening the potential angle of collisions, and enhances pedestrian safety.

Thus, signalization with lower conflict points as presented in Figure 6 offers significantly greater safety as compared to other proposed schemes. Further supported by Federal Highway Administration (FHWA), signalized intersections account for approximately one-third (1/3) of all intersection-related fatalities, with a significant number resulting from beating the red light or red-light running incidents (FHWA, 2025). This proves to be the safest among the proposed schemes, followed by roundabout, due to its smaller conflict points.

Table 5. Number of Conflict Points of the Intersection Scheme

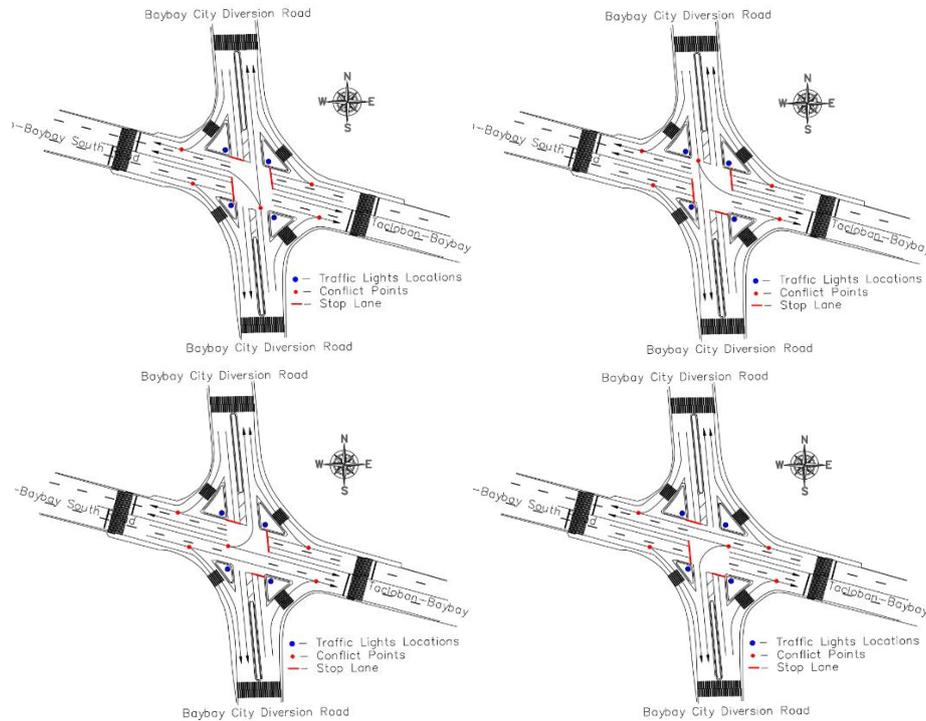| Traffic Scheme	No. of Conflict Points
Current Unsignalized Intersection	36
Improved Unsignalized Intersection	52
Signalized Intersection (4 Phase)	5

Figure 6. Conflict Points Diagram of the Current Signalized (Four-Phase)

4.4 Statistical Analysis Results

The results of the t-test show that the roundabout is the most effective alternative in reducing both delay and queue length, particularly under projected traffic. Signalized controls may increase congestion as shown in Table 6, while the additional lane appears to offer minimal improvement. However, it is important to note that while signalization increases delays, it controls traffic and decreases conflict points. As a control measure, signalization increases delay to minimize the risk of vehicle collision by alternating right-of-way between vehicles and pedestrians.

Table 6. Paired t-test between alternative controls and current intersection controls for average queue length at projected volume (Future)

Alternative Intersection Control	Existing Intersection Avg. Queue Length (meters)	Average Queue Length (meters)	t-stat	p-value	Significance (vs No-Change)
2 Phase Signalized		9.31	1.486	0.086	Not Significant
4 Phase Signalized	7.06	17.859	6.749	4.19×10^{-5}	Significant
Roundabout		2.494	-3.780	0.002	Significant
Additional Lane		9.963	1.152	0.139	Not Significant

4.5 Comparative Analysis Based on Benefit-Cost

Based on Table 7, it is evident that among the proposed schemes, the improved unsignalized intersection with added lane, roundabout, and signalized (2-phase) outweigh the cost with the discounted benefits, resulting in a net benefit of ₱6,671,507.48, ₱2,706,570.26 and ₱616,034.47, respectively, which is equivalent to a value-cost ratio (V/C ratio) of 1.47, 1.09, and 1.05, accordingly. These ratios are greater than 1, which indicate that for every peso spent, the project returns slightly more than one peso in benefits. Although this margin is small, it suggests that these alternative designs are economically viable and can be justified as feasible investments. Notably, a V/C ratio which has a value greater than 1 generally means that the project generates more benefits than its costs, which supports long-term traffic efficiency and safety improvements.

In contrast, the signalized scheme with four-phases has a negative net benefit of ₱5,382,159.78 with a V/C ratio of less than 1. This means that for every peso spent on this alternative, the return in benefits is less than one peso which signals that this option would result in a net economic loss. The implication of this result is that this scheme is not economically justifiable as its benefits fail to recover the costs involved. Pursuing this alternative may lead to wasted resources and missed opportunities for more efficient solutions.

Thus, the roundabout, improved unsignalized, and signalized with two-phase signal control stand out as the options meeting the basic economic criterion (V/C ratio $\geq$ 1), marginally indicate as economically feasible designs.

Table 7. Summary of Discounted Value-Costs

Traffic Scheme	Discounted Total Cost (₱)	Discounted Value Cost (₱)	Value-Cost (₱)	Value-to-cost Ratio (₱)
Improved Unsignalized	14,147,402.21	20,818,909.69	6,671,507.48	**1.47**
Roundabout	30,483,513.07	33,190,083.33	2,706,570.26	**1.09**
Signalized (2 Phase)	12,854,606.65	13,470,641.12	616,034.47	**1.05**
Signalized (4 Phase)	12,854,606.65	7,472,446.87	-5,382,159.78	**0.58**

5. CONCLUSION

This study evaluated the operational and safety performance of the existing intersection using microsimulation, swept path analysis, conflict point assessment, statistical comparison, and a value-to-cost (V/C) framework. The findings show that the current unsignalized cross intersection continues to operate within acceptable limits for both present and projected traffic volumes, indicating that immediate modification is not required solely on the basis of capacity.

However, geometric limitations and the presence of documented safety concerns, particularly the high number of conflict points, vehicle encroachments identified in the swept path analysis, and the intersection's crash history, highlight the need to consider reconfiguration as a safety intervention rather than a purely capacity-driven upgrade.

Among the alternatives analyzed, the roundabout consistently demonstrated the best

overall performance, maintaining low delays, short queues, and LOS A under both current and future conditions. It also aligns well with the site's geometric characteristics and accommodates the design vehicle efficiently. While the four-phase signalized intersection theoretically offers fewer conflict points, its operational performance is notably weaker. The improved unsignalized alternative showed economic viability based on its higher V/C ratio, although its operational gains were limited.

To strengthen the methodological rigor of future intersection assessments, it is recommended to incorporate field-measured driver behavior parameters to improve microsimulation calibration. The use of video-based conflict analysis tools like SSAM can provide deeper insight into near-miss events and time-to-collision indicators, while expanding the crash analysis to include severity weighting, contributing factors, and spatial clustering would yield a more comprehensive understanding of safety issues. Additionally, evaluating pedestrian and cyclist operations, as these activities are expected to increase in the future. Finally, incorporating stakeholder consultations can help ensure that proposed design solutions are aligned with local conditions, community needs, and practical feasibility.

Overall, while the existing intersection remains serviceable at present, the study indicates that a roundabout offers the most balanced and long-term solution, providing substantial safety improvements and strong operational performance under projected demand. Should redesign be pursued in the future, the roundabout represents the most effective and sustainable option

6. REFERENCES

Bangko Sentral ng Pilipinas. (2025, August). Monetary Policy Report. Retrieved from https://www.bsp.gov.ph/Price%20Stability/MonetaryPolicyReport/FullReport_August2025.pdf

BORLAGDAN, P. A. P., LIM, Ma. B. B., MAUNAHAN, H. S., & CRUZ, A. R. (2022, July 1). Evaluation of the effects of traffic signalization at the Lopez Avenue-National Highway, Los Baños Laguna intersection using Philippines local simulation software. Journal of the Eastern Asia Society for Transportation Studies. https://www.jstage.jst.go.jp/article/easts/14/0/14_1939/_article/-char/ja/

Dang, T., Donzé, A., & Maler, O. (1970, January 1). Verification of analog and mixed-signal circuits using hybrid system techniques. SpringerLink. https://link.springer.com/chapter/10.1007/978-3-540-30494-4_3

DPWH. (2016). *DPWH-Baybay Diversion Road (2016)*.

Fabianova, J., Michalik, P., Janekova, J., & Fabian, M. (2020). Design and evaluation of a new intersection model to minimize congestion using VISSIM software. *Open Engineering, 10*(1), 48–56. https://doi.org/10.1515/eng-2020-0019

Federal Highway Administration. (2004). Traffic Analysis Toolbox Volume III: Guidelines for Applying Traffic Microsimulation Modeling Software. Research, Development, and Technology Turner-Fairbank Highway Research Center 6300 Georgetown Pike. Retrieved from https://highways.dot.gov/media/6916.

Federal Highway Administration. (2025). FHWA Highway Safety Programs. Retrieved from https://highways.dot.gov/safety/intersection-safety/intersection-types/signalized-intersections

Friedrich, M., Pestel, E., Schiller, C., & Simon, R. (2019). Scalable GEH: A Quality Measure for Comparing Observed and Modeled Single Values in a Travel Demand Model Validation. *Transportation Research Record, 2673*, 722 - 732.

Google. (n.d.). *Alfante et al - what causes vehicle crashes at Baybay City Diversion Road Intersection.pdf*. Google Drive. https://drive.google.com/file/d/1y1q8faqah_4CWMOwvjHvdUnIuReJJEjf/view?usp

=drive_link

Ho, C. Q., Mulley, C., Shiftan, Y., & Hensher, D. A. (2016). Vehicle value of travel time savings: Evidence from a group-based modelling approach. Transportation Research Part A: Policy and Practice, 88, 243–256. https://doi.org/10.1016/j.tra.2016.03.016

Japan International Cooperation Agency (JICA). (2009). The Study on the Road Network Development Plan for Metro Manila and Surrounding Areas. JICA.

Isebrands, H. (2009). Crash analysis of roundabouts at high-speed rural intersections. *Transportation Research Record, 2096*, 1–7. https://doi.org/10.3141/2096-01

Kalašová, A., Poliak, M., Škorvánková, L., & Fabian, P. (2024, November 18). Optimization of traffic at uncontrolled intersections: Comparison of the effectiveness of roundabouts, signal-controlled intersections, and Turbo-roundabouts. MDPI. https://www.mdpi.com/2413-8851/8/4/217

National Economic and Development Authority. (2016, September 30). *Revisions On Icc Guidelines and Procedures (Updated Social Discount Rate For The Philippines)* [Memorandum].

Philippine News Agency. (2019, March 25). Diversion road in Baybay City tagged as accident-prone. Retrieved from https://www.pna.gov.ph/articles/1065767

Retting, R. A., Mandavilli, S., McCartt, A. T., & Russell, E. R. (2006). Roundabouts, traffic flow and public opinion. *Traffic Engineering and Control, 47*(7), 268–272.

Roach, D., Christofa, E., & Knodler, M. A. (2016). Safety assessment before and after implementation of roundabouts through microsimulation. *Advances in Transportation Studies, 2016*(Special Issue), 77–88.

Sumndad, J. (2024). Assessment of Road Safety Through Geometric Design Analysis: The Case of Sagonsongan Diversion Road in Marawi City. Retrieved from https://www.researchgate.net/publication/382351135_Assessment_of_Road_Safety

Statista. Global inflation rate from 2000 to 2024, with forecasts until 2030. Retrieved from https://www.statista.com/statistics/256598/global-inflation-rate-compared-to-previous-year.