

Proposing of a Shuttle Bus System Connecting Mactan-Cebu International Airport to Tourist Attractions: A Transportation Engineering Approach

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Abstract – Airport-to-city mobility in Cebu City remains fragmented due to the absence of a structured transport system connecting Mactan-Cebu International Airport to major tourist attractions. Despite increasing passenger arrivals, existing transportation services are often costly, inconsistent, and inconvenient for travelers, particularly tourists unfamiliar with local transport systems. This study aimed to propose a shuttle bus system connecting the airport to selected tourist attractions in Cebu City through a transportation engineering approach. Data collection involved survey questionnaires administered to 100 respondents and manual traffic volume counts conducted along three alternative routes during peak hours. Key traffic parameters including service flow rate, average speed, density, volume-to-capacity ratio, travel time, and transport cost were analyzed to evaluate route performance. Results showed that passenger demand was primarily concentrated at the airport and directed toward the Cebu City Highlands, with convenience and accessibility identified as major travel priorities. Among the evaluated alternatives, Route C demonstrated more favorable operating conditions characterized by higher average speed, lower density, and more stable traffic flow. The proposed shuttle bus system offers a practical transport solution for improving airport accessibility and tourist mobility in Cebu City.

Index Terms – Shuttle Bus System, Transportation Engineering, Airport Mobility, Traffic Analysis, Tourist Transportation, Cebu City.

I. INTRODUCTION

Mactan-Cebu International Airport (MCIA) serves as one of the primary gateways to the Visayas region and plays a significant role in supporting tourism and economic activity in Cebu. In 2024, MCIA recorded approximately 11.32 million passengers, reflecting the continuous increase in domestic and international travel demand within the province (Philstar, 2025). The steady growth of passenger arrivals has increased the need for an efficient and reliable transportation system connecting the airport to major destinations in Cebu City, particularly tourist attractions frequently visited by travelers. However, despite the continuous development of tourism infrastructure, transportation services connecting the airport to these destinations remain limited and fragmented.

Existing transportation services from MCIA primarily rely on taxis, ride-hailing services, private rentals, and public utility vehicles. Although these modes provide accessibility, they are often associated with high transportation costs, inconsistent availability, and inconvenience for first-time travelers unfamiliar with the city's transportation system (GeckoRoutes, 2025). In addition, increasing traffic demand and congestion along major urban corridors continue to affect travel efficiency and accessibility within Cebu City (Daily Tribune, 2024). These transportation conditions highlight the need for a more organized and reliable transport system that can improve airport-to-city mobility.

International transportation systems demonstrate that structured airport shuttle services improve passenger accessibility and operational efficiency through organized routing and scheduling systems. In several countries, airport shuttle operations are integrated into urban transportation networks to provide direct and reliable connections between airports and key destinations (SAGE Journals, 2020). Similar transportation approaches have also been implemented in Asian cities, including Seoul's airport transport modernization initiatives and Singapore's airport shuttle systems connecting Changi Airport to urban transport nodes (Seoul Metropolitan Government, 2023; Changi Airport Group, 2024). These systems demonstrate the importance of structured transportation planning in improving travel convenience and mobility.

In Cebu, transportation developments surrounding MCIA have largely focused on infrastructure expansion and commuter-oriented transportation projects. Existing initiatives mainly address urban commuting and traffic management, with limited emphasis on tourism-oriented airport transportation systems (Daily Tribune, 2024). As a result, airport-to-tourist-destination mobility remains largely dependent on informal and market-driven transportation services that lack standardized routes, predictable fares, and integrated operations. This condition highlights a significant gap in Cebu's transportation planning framework, particularly in relation to tourism mobility and airport accessibility.

This study, titled *Proposing a Shuttle Bus System Connecting Mactan-Cebu International Airport to Tourist Attractions in Cebu City: A Transportation Engineering Approach*, aims to address these transportation issues by evaluating alternative shuttle routes and identifying the most suitable route based on transportation engineering principles. The study utilizes survey questionnaires, manual traffic volume counts, and operational traffic analysis to assess route performance using parameters such as service flow rate, average speed, density, volume-to-capacity ratio, travel time, and transport cost. Through this approach, the study seeks to propose a practical shuttle bus system that can improve airport accessibility, tourist mobility, and transportation efficiency within Cebu City.

Theoretical Framework

This study is anchored on transportation planning and traffic engineering theories that explain the relationship between travel demand, route performance, accessibility, and transportation

efficiency. These theories provide the foundation for evaluating the operational performance of the proposed shuttle bus system connecting Mactan-Cebu International Airport (MCIA) to selected tourist attractions in Cebu City. The theories guided the analysis of passenger travel behavior, traffic conditions, and route efficiency in identifying the most suitable shuttle route.

Four-Step Transportation Planning Model (FSM)

The study is primarily grounded on the Four-Step Transportation Planning Model (FSM), which explains how transportation systems are analyzed through trip generation, trip distribution, modal split, and traffic assignment. According to Mukherjee (2022), FSM provides a structured framework for understanding the relationship between land use, socioeconomic activities, and travel patterns. The model is widely applied in transportation planning to evaluate travel demand and transportation system performance.

In this study, FSM was used in analyzing passenger travel behavior and evaluating alternative shuttle routes based on accessibility, travel time, route efficiency, and observed traffic conditions. The model also explains how passengers select transportation routes and modes depending on service reliability and convenience. Through the application of FSM concepts, the study systematically evaluated the operational performance of the proposed routes and identified the most suitable route for the shuttle bus system.

Travel Demand Management (TDM) Theory

The study is also supported by Travel Demand Management (TDM) Theory, which focuses on improving transportation efficiency by influencing travel behavior instead of expanding roadway infrastructure. According to Transport for NSW (2020), TDM promotes the use of efficient and shared transportation systems through improved accessibility, affordability, and service reliability.

This theory is relevant to the study because the proposed shuttle bus system serves as an alternative to fragmented and private transportation modes currently operating between MCIA and Cebu City tourist attractions. Factors such as travel time, accessibility, transport cost, and service reliability were considered in evaluating the attractiveness and operational efficiency of the proposed shuttle service. The application of TDM principles supports the development of a transportation

system that encourages shared mobility, reduces dependence on private vehicles, and improves overall transportation efficiency.

Level of Service (LOS) Theory

The study further considers the Level of Service (LOS) Theory, which evaluates roadway and transportation performance based on operational conditions and passenger experience. According to Hassan (2019), LOS utilizes indicators such as travel time, speed, reliability, and traffic conditions in assessing transportation efficiency and service quality.

In this study, LOS principles were applied using measurable traffic engineering parameters including average speed, density, travel time, and volume-to-capacity ratio in comparing the operational performance of the alternative routes. Improvements in traffic conditions and travel efficiency contribute to better passenger experience and increased attractiveness of public transportation systems. The use of LOS indicators allowed the study to evaluate route performance in a practical and systematic manner consistent with transportation engineering practices.

Conceptual Framework

The study presents the relationship between existing transportation conditions, passenger travel behavior, and route evaluation in developing the proposed shuttle bus system connecting MCIA to selected tourist attractions in Cebu City. Transportation factors such as accessibility, traffic conditions, travel time, and transport cost were analyzed through traffic engineering methods and operational performance evaluation to identify the most suitable shuttle route.

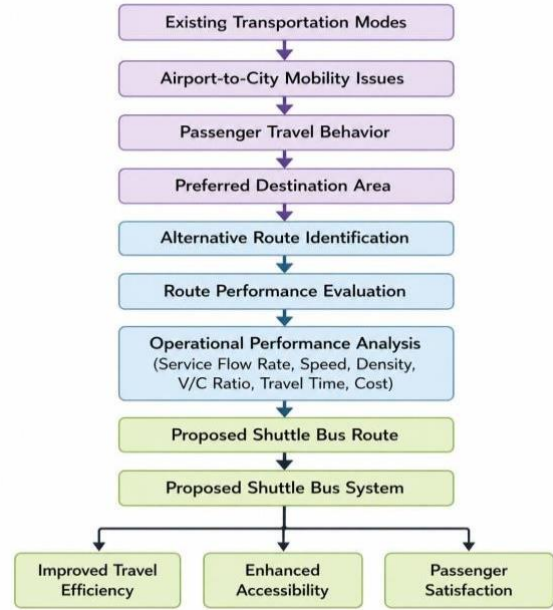


Figure 1. Conceptual Framework

II. METHODOLOGY

Research Design

The research design illustrates the systematic approach used in evaluating transportation conditions and identifying the most suitable shuttle bus route connecting MCIA to tourist attractions in Cebu City. The study integrates passenger travel analysis, traffic data assessment, and operational performance evaluation to develop a transportation solution that improves accessibility, mobility, and travel efficiency within the study area.

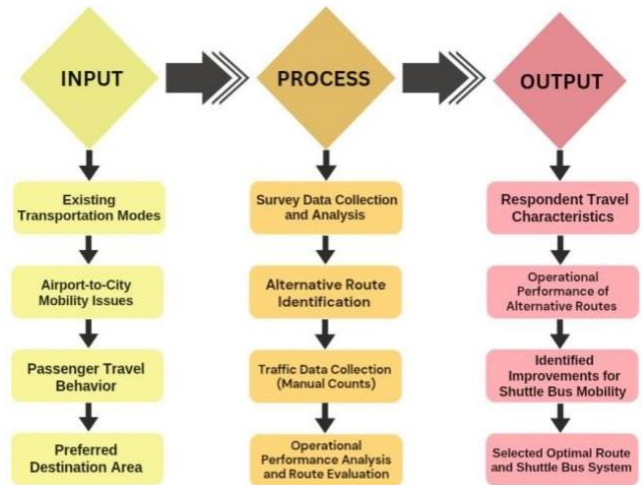


Figure 2. Flow of Study

Research Environment

The study was conducted within Cebu Province, specifically targeting the transport corridor between MCIA in Lapu-Lapu City and major tourist destinations in Cebu City Highlands, particularly the Temple of Leah, Sachiko's Little Kyoto, and Sirao Flower Garden. This locale is characterized by high-density traffic and accessibility challenges, providing a practical setting for evaluating route alternatives and travel conditions. The area was selected based on respondent preferences gathered during the survey phase, as the geographical features and current transport conditions aligned with the study's objective of improving mobility between the airport and selected tourist attractions.

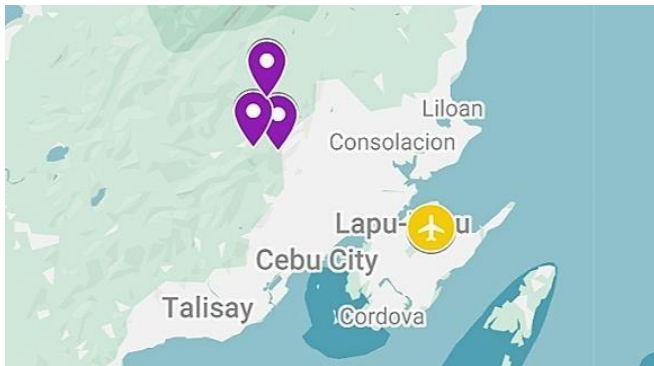


Figure 3. Location of the Proposed Shuttle Bus Route

Gathering of Data

Data were gathered through a combination of survey questionnaires and primary and secondary data collection to assess airport-to-city mobility conditions. The primary data were collected from domestic and international passengers, as well as local commuters traveling between MCIA and Cebu City.

The survey questionnaire captured information on existing transportation modes, common travel problems, and passenger preferences. It evaluated key transport factors, including traffic congestion, transport cost, accessibility, and travel conditions. In addition, the survey collected data on preferred shuttle bus features, type of vehicle, and acceptable fare range.

Primary traffic data were also collected through manual traffic volume counts conducted along selected routes during specified observation periods. These data included vehicle volume and classification, which were used to analyze traffic conditions and compute operational performance parameters.

Secondary data were obtained from credible sources to support the analysis. These included route distance derived from digital navigation tools.

All collected data were organized to support the analysis of transportation conditions and the identification of the most suitable route for the proposed shuttle system.

Treatment of Data

All survey responses were compiled and organized for analysis. Data cleaning was performed to remove incomplete or inconsistent entries. Descriptive statistical techniques, including frequency counts, percentages, and weighted means, were applied to summarize the responses.

Data analysis was conducted using Microsoft Excel. Tables were used to present the distribution of responses and to compare transportation-related variables. The results were interpreted based on the identified factors such as transportation mode, travel problems, and passenger preferences.

Transportation engineering analysis was applied using standard formulas to compute service flow rate, density, and volume-to-capacity ratio based on the collected traffic data. Parameters such as travel time, average speed, and transport cost were also used in evaluating and comparing the selected routes.

The analyzed data were used to identify the most efficient route and to develop recommendations for improving airport-to-tourist attraction mobility in Cebu City.

III. RESULTS AND DISCUSSION

2.1 Operational Performance of Alternative Routes

This section presents the operational performance of Route A, Route B, and Route C based on observed traffic conditions and computed operational values, including service flow rate, average speed, density, volume-to-capacity ratio, travel time, and transport cost. These values are used to evaluate and compare the overall efficiency of the selected routes.

Table 1: Traffic Volume Count for Route A (2 Lanes)
During Peak Hour

Time (P.M.)	Motor.	P. C.	Jeep	Buses/ Trucks	Total
4:30 – 4:45	800(0.5) = 400	173	10(1.5) = 15	31(1.5) = 46.5	634.5
4:45 – 5:00	1250(0.5) = 625	226	7(1.5) = 10.5	43(1.5) = 64.5	926
5:00 – 5:15	897(0.5) = 448.5	294	5(1.5) = 7.5	39(1.5) = 58.5	808.5
5:15 – 5:30	1036(0.5) = 518	232	6(1.5) = 9	14(1.5) = 21	780

Table 2: Traffic Volume Count for Route B (2 Lanes)
During Peak Hour

Time (P.M.)	Motor.	P. C.	Jeep.	Buses/ Trucks	Total
4:30 – 4:45	483(0.5) = 241.5	401	13(1.5) = 19.5	42(1.5) = 63	725
4:45 – 5:00	578(0.5) = 289	463	11(1.5) = 16.5	25(1.5) = 37.5	806
5:00 – 5:15	505(0.5) = 252.5	422	16(1.5) = 24	37(1.5) = 55.5	754
5:15 – 5:30	432(0.5) = 216	414	14(1.5) = 21	40(1.5) = 60	711

Table 3: Traffic Volume Count for Route C (4 Lanes)
During Peak Hour

Time (P.M.)	Motor.	P. C.	Jeep.	Buses/ Trucks	Total
4:30 – 4:45	976(0.5) = 488	597	62(1.5) = 93	96(1.5) = 144	1322
4:45 – 5:00	1155(0.5) = 577.5	822	120(1.5) = 180	81(1.5) = 121.5	1701
5:00 – 5:15	1059(0.5) = 529.5	781	104(1.5) = 156	119(1.5) = 178.5	1645
5:15 – 5:30	711(0.5) = 355.5	623	81(1.5) = 121.5	86(1.5) = 129	1229

Tables 1 to 3 present the traffic volume counts for Routes A, B, and C during the observed peak hour period. The data show variations in traffic volume and

vehicle composition among the three routes. It can be observed that certain routes exhibit higher traffic demand, as reflected by greater vehicle counts, while others show relatively lower volumes. Differences in vehicle distribution also indicate varying traffic characteristics, which influence the overall flow conditions along each route. These observed traffic patterns serve as the basis for computing the operational performance indicators presented in the succeeding subsection.

Table 4: Summary of Operational Performance of the Evaluated Routes

Operational Metric	Route A	Route B	Route C
Service Flow Rate	1144.604 veh/hr	1002.582 veh/hr	1070.091 veh/hr
Average Speed	14.900 mph	14.900 mph	16.001 mph
Density	76.819 veh/mile	67.287 veh/mile	66.972 veh/mile
Volume-Capacity Ratio	0.572	0.501	0.535
Travel Time	1 hr and 9 min	1 hr and 11 min	1 hr and 9 min
Transport Cost	₱241.50	₱245.75	₱244.25

The table above presents the computed operational values of the evaluated routes based on the selected performance indicators. The results show variations in the operational conditions of Route A, Route B, and Route C, which serve as the basis for assessing and comparing their overall performance and efficiency.

2.2 Route Performance Analysis and Optimization Strategies

This section evaluates the performance level of the existing routes using key traffic engineering parameters and identifies possible measures to improve shuttle bus mobility between the airport and tourist destinations.

To provide a more rigorous assessment, the performance of each route was classified using the Level of Service (LOS) based on the computed volume-to-capacity (V/C) ratio.

Table 5: Level of Service Classification of Existing Routes

Route	V/C Ratio	Level of Service	Description
A	0.572	C	Stable flow with restrictions
B	0.501	B	Stable flow
C	0.535	B	Stable flow

The Level of Service classification presented in Table 5 indicates that all three routes are operating within capacity and under generally stable traffic conditions. However, variations in density, speed, and flow rate provide further insight into their operational efficiency.

Route A, classified under LOS C, operates under stable but increasingly restricted conditions. Its relatively higher density and flow rate indicate increased vehicle interaction, which may lead to reduced maneuverability and potential delays, especially during peak hours. Despite its advantage in transport cost and travel time, its susceptibility to congestion may affect reliability.

Route B, classified as LOS B, reflects stable flow with sufficient roadway capacity. However, its longer travel time and lower speed suggest inefficiencies not directly related to congestion, but possibly due to route length, alignment, or intersection conditions. This indicates that available capacity is not being effectively translated into efficient movement.

Route C, also classified under LOS B, demonstrates more favorable operational characteristics. Its lower density and higher average speed indicate smoother traffic flow and reduced interaction among vehicles. These conditions contribute to more consistent travel time and overall route efficiency.

Based on the observed operational characteristics of the evaluated routes, several technical measures may be considered to improve shuttle bus mobility and overall traffic performance.

1. Traffic Signal Coordination. Signal timing adjustments may be considered along high-density segments, particularly those observed in Route A, to improve traffic flow continuity and reduce unnecessary delay.
2. Provision of Priority Measures for Shuttle Bus Operations. Priority treatments, such as designated bus lanes or signal priority, may be

explored to improve travel time consistency and operational reliability.

3. Geometric and Operational Improvements. Roadway and intersection enhancements may be considered along routes exhibiting lower operational efficiency, particularly Route B, to improve traffic movement.
4. Optimization of Route Utilization. Greater operational emphasis may be placed on routes demonstrating favorable traffic conditions, particularly those with lower density and higher speed characteristics.
5. Adaptive Traffic Monitoring. The integration of traffic monitoring systems may support more responsive shuttle scheduling and improved adaptation to changing traffic conditions.

These measures may contribute to improved route efficiency, reduced travel variability, and enhanced service reliability for the proposed shuttle bus system.

2.3 Selection and Specification of the Preferred Shuttle Bus Route

This section identifies the most suitable route for the proposed shuttle bus system based on the combined evaluation of operational performance and respondent travel characteristics. The selection process considers both the efficiency of traffic flow and the ability of the route to support existing travel demand patterns.

Table 6: Comparative Evaluation of Route Alternatives

Criteria	Route A	Route B	Route C
Average Speed	Good	Good	Very Good
Density	Fair	Good	Very Good
Level of Service	Fair	Good	Very Good
Travel Time	Good	Very Good	Good
Transport Cost	Very Good	Fair	Good
Overall Rating	Fair	Good	Very Good

The comparative evaluation table indicates that Route C demonstrates the most balanced performance among the three alternatives. While Route A offers advantages in transport cost, its higher density and lower level of service suggest greater traffic interaction, which may affect reliability. Route B operates under stable conditions but exhibits higher transport cost.

In relation to respondent characteristics, the dominance of airport-origin trips and the preference for destinations such as the Cebu City Highlands emphasize the need for routes that provide consistent and efficient connectivity. Additionally, the preference for convenient transport modes highlights the importance of reliable travel conditions. Route C, with its stable flow, higher speed, and lower density, aligns more closely with these observed travel patterns.

Based on the overall evaluation, Route C is selected as the most suitable route for the proposed shuttle bus system due to its ability to provide stable, efficient, and consistent operating conditions while supporting the identified travel demand. These attributes indicate that the route is capable of supporting efficient and reliable shuttle bus operations while meeting the mobility needs of users traveling between the airport and key destinations.

IV. SUMMARY OF FINDINGS

The major findings of the study are summarized as follows:

1. The distribution of respondents indicates that the majority are domestic travelers, with most trips originating from the airport. This highlights that transportation demand is primarily centered on airport-based mobility. Respondents show a preference for convenient and accessible transportation modes, particularly ride-hailing and taxi services, reflecting the importance of reliability and ease of travel. In terms of destination, the Cebu City Highlands emerged as the most preferred area, indicating a concentration of travel demand. Travel frequency varies among respondents, showing a mix of first-time, occasional, and frequent travelers, which reflects diverse mobility patterns.
2. The operational assessment of the evaluated routes shows that all routes operate within

acceptable capacity limits. However, differences in operational parameters such as speed, density, and travel time influence their efficiency. Some routes exhibit higher traffic interaction and more restricted flow conditions, while others demonstrate lower efficiency due to longer travel time. These variations indicate that route performance is influenced not only by capacity but also by the quality of traffic flow.

3. The evaluation of route performance indicates that traffic conditions vary across the routes, with some experiencing more constrained flow due to higher vehicle interaction. Routes that maintain stable flow conditions, lower density, and consistent travel time provide more favorable conditions for shuttle bus operations. The findings also emphasize the importance of aligning transportation services with observed travel behavior to ensure efficient and reliable mobility.
4. The overall evaluation of route performance identifies Route C as the most suitable option for the proposed shuttle bus system. This route demonstrates a balanced combination of operational efficiency, traffic stability, and reliability. Its characteristics align with the dominant travel patterns observed among respondents, particularly in terms of airport-based trips and preferred destinations, making it the most appropriate route for airport-totourist destination mobility.

V. CONCLUSION

The suitability of routes for shuttle bus operations is determined by both traffic conditions and user travel characteristics. While all evaluated routes operate within acceptable capacity levels, variations in speed, density, and travel time significantly influence their efficiency and reliability. The findings show that travel demand is largely airport-centered, with users preferring convenient and reliable transportation and favoring specific destination areas. These results highlight the need for routes that provide stable traffic flow, reduced congestion, and consistent travel performance.

Among the evaluated alternatives, Route C is identified as the most suitable route for shuttle bus implementation. It demonstrates higher average speed,

lower density, and more stable traffic flow, resulting in more efficient and reliable travel conditions. These operational advantages align with observed user preferences and dominant travel patterns. While transport cost contributes to route selection, its influence is minimal compared to travel time and traffic conditions.

VI. RECOMMENDATIONS

Based on the data gathered and findings of the study, the researchers suggest the following:

- 1. Enhancement of Travel Demand Analysis.** Future studies may further examine passenger demand characteristics, including variations in origin, destination, and travel behavior, to better support the planning of shuttle bus systems.
- 2. Inclusion of Temporal and Operational Variability.** Additional data collection across different time periods may be conducted to better understand how traffic conditions affect shuttle bus system performance.
- 3. Refinement of Data Collection Methods.** Improvements in survey design and data gathering procedures may be considered to enhance the accuracy and consistency of both travel behavior and operational data.
- 4. Integration of System-Level Evaluation Parameters.** Future research may incorporate additional factors relevant to shuttle bus systems, such as service reliability and accessibility, to provide a more comprehensive assessment.
- 5. Further Validation of the Proposed Shuttle Bus System.** Additional studies may be conducted to validate the proposed route and its suitability within the overall shuttle bus system under varying traffic and demand conditions.

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