Optimizing Route-based Fleet Size Computation through Network-Based Modeling for Puerto Princesa City, Philippines

Ann Camille FAJARDO[a], Erris SANCIANGCO[b], Lester Jay OLLERO[c], Jaztin Robert ALTEA[d], Carlos Alfredo CASTILLO[e], Noriel Christopher TIGLAO[f], Pamela CUNANAN[g], Harley Davidson SIPASIP[h], Niki Jon TOLENTINO[i]

[a,b,c,g,h] *SafeTravelPH Mobility Innovations Organization Inc., National College of Public Administration and Governance, University of the Philippines Diliman, 1101 Quezon City, Philippines*
[a] *Email: camillefajardo@safetravel.ph*
[b] *Email: errisssanciangco@safetravel.ph*
[c] *Email: lesterjayollero@safetravel.ph*
[g] *E-mail: pamelacunanan@safetravel.ph*
[h] *E-mail: harleysipasip@safetravel.ph*
[i] *E-mail: nikitolentino@safetravel.ph*
[d,e] *Office of the City Planning and Development Coordinator, City Government of Puerto Princesa, Philippines*
[d] *Email: jrobertaltea@gmail.com*
[e] *Email: castillo.carlos.aa@gmail.com*
[f] *National College of Public Administration and Governance, University of the Philippines Diliman, 1101 Quezon City, Philippines*
[f] *Email: nctiglao@up.edu.ph*

Abstract: This study focused on the application of network-based modeling in optimizing public transport services in Puerto Princesa City, Philippines. Departing from traditional route-based planning methods, the study applies Bentley OpenPaths CUBE software to transition into a network-level analysis framework. Utilizing origin-destination data from household interview surveys, vehicle trip records, and crowdsourced data from the SafeTravelPH mobile platform, the study constructs a comprehensive multimodal transport model. Key outputs include route rationalization, fleet size computation, and optimal stop placements. Results demonstrate significant improvements in demand forecasting and operational planning, offering a scalable model for other urban cities.

Keywords: *Network Modeling, Public Transport Planning, Bentley OpenPaths, CUBE Voyager, Transit Assignment, SafeTravelPH*

1. INTRODUCTION

1.1 Background of the Study

In the Philippines, public transport vehicles are assigned to routes based on a formula developed by the existing Road Transport Planning Division of the Department of Transportation and Communications (DOTC), now known as the Department of Transportation (DOTr). It considers passenger demand, seasonal variations, load factors, seating capacity, and the average daily frequency of round-trip vehicle trips. This method of determining the fleet size was implemented across all transportation modes, including buses, jeepneys, UV Express (utility vehicle), and in some areas, tricycles. The DOTr transmits the number of proposed vehicles that the department recommends for allocation on each route to the LTFRB, which, upon making a decision, issues franchises to the operators (Manresa et al., 2015). It was also in the same study that they identified several flaws in the surveys and their outcomes, which are the following:

- Data Accuracy and Integrity: Previous research relied on survey data, which were not always accurate or reliable. Additionally, most fleet size formulas relied on input variables provided by public transport operators, which introduced associated biases.
- Inconsistencies in Fleet Size Determination: The calculation and application of Route Measured Capacity (RMC) equations have revealed marked inconsistencies, sometimes resulting in very arbitrary estimates for fleet size. The discrepancies appear to arise primarily from the assumption, which was rarely recorded uniformly, of what the viable load factor might be.
- Policy Shift: In 2010, a moratorium was established for new RMC values for existing routes. However, the RMC approach remained a guiding principle in franchise approvals and fleet size calculations, though it was implemented differently in different contexts.

The Public Utility Vehicle Modernization Program (PUVMP), now known as the Public Transport Modernization Program (PTMP), was initiated in 2017 through Joint Memorandum Circular 2017-001, issued by the Department of the Interior and Local Government (DILG) and the Department of Transportation (DOTr). This circular outlines the guidelines for local government units to develop their Local Public Transport Route Plans (LPTRPs). This critical reform enables local governments in the Philippines to plan and strategically enhance their public transportation systems.

Tiglao et al.'s study (2024) shows how applying Participatory Action Research (PAR) is a promising method for initiating improvement in local public transport planning through collaboration among stakeholders who assess the consistency and feasibility of the LPTRP. PAR is a collaborative and democratic research approach that actively involves stakeholders such as community members, local authorities, and transport operators in the research process. PAR is designed to bridge the gap between knowledge production and practical application by aligning research with the goals of social change, mutual learning, and collective action (Baum et al., 2006). In the context of transport planning, it enables participants not only to contribute to data collection and validation, but also to influence decision-making processes through co-production of knowledge. While PAR refers to the overarching methodological approach that centers on stakeholder collaboration, co-learning, and iterative planning, the Simulation Exercise (SimEx) refers to a specific activity within that approach used to gather operational and demand-side data. In this study and in prior work such as Bacolod City, SimEx served as the operationalization of PAR principles engaging transport operators, commuters, and local officials in participatory data collection using both traditional surveys and digital tools like SafeTravelPH. Thus, PAR frames the participatory intent and design, while SimEx denotes the practical implementation of those methods in real-world settings.

One such instance was the Bacolod City SimEx where local stakeholders participated in data collection to inform the determination of fleet size and service plans outlined in the LPTRP. This project was complemented by the SafeTravelPH application, which acted as a mobile crowdsourcing tool for capturing accurate data on travel times, wait times, turnaround intervals, boarding and alighting events, and passenger ridership numbers. The successful rollout of this data collection tool largely hinged on engagement and support from stakeholders, including national and local government officials, representatives from local public transportation operators, and academic collaborators.

These advances point to a critical opportunity: transitioning from route-based planning to a network-level modeling approach. By capturing city-wide travel behavior and operational characteristics, network modeling enables planners to assess inter-route interactions, optimize service design, and stimulate multiple planning scenarios. This study leverages that opportunity through the application of a public transport network model using Bentley OpenPaths (formerly Citilabs CUBE), providing a more systematic and evidence-based foundation for planning reliable, efficient, and responsive public transport services.

1.2 Research Objectives

This study focuses on optimizing local public transport planning through data-driven route network analysis, with particular reference to estimating the fleet sizes of PUVs (four-wheeled public transport vehicles) in Puerto Princesa City, Philippines.

The research objectives are stated as follows: 1) To demonstrate the applicability of smartphone-based data collection in obtaining accurate measurements of travel time, dwell time, turnaround time, boarding and alighting events, stopping patterns, and passenger ridership; 2) To illustrate the application of public transport network modeling in making a transition from route capacity-specific analysis to network-level analysis through comprehensive interaction analysis and origin-and-destination calibration between different routes and PUV trip tracks; and 3) To estimate fleet size computation given the data results from the software.

2. STUDY AREA

2.1 Puerto Princesa City, Palawan

Puerto Princesa City is a highly urbanized area that includes 36 urban barangays and 31 rural barangays. Most of the urban barangays are on a peninsula, where 76% of the population lives, and most city services and facilities are located. As the capital of Palawan Province, it serves as the center of economic activities, including banking, education, trade, and government functions. The city mainly has residential, commercial, and institutional areas in its urban core. This concentration has made the urban core the focal point for transportation and services.

In the urban core, there are about 4,000 tricycles and around 700 filcabs or multicabs (which are smaller public utility vehicles than jeepneys). These vehicles are essential for meeting the transportation needs of residents.

The city also acts as a gateway for public transport routes in Palawan. Recently, the city government moved the transport terminal to the northern edge of the urban core to better accommodate intermunicipal buses and other transport services, like utility vans. This change has clarified the difference between intermunicipal public transport and urban transport services, helping to reduce traffic congestion in the urban core. This initiative also supports the national government's Public Transport Modernization Program (PTMP), which was formerly called the Public Utility Vehicle Modernization Program (PUVMP).

2.2 Puerto Princesa LGU LPTRP

The national government's transportation agenda has transferred public transport planning responsibilities to local government units (LGUs), requiring each LGU to create a Local Public Transport Route Plan (LPTRP) to rationalize public transport routes. Puerto Princesa City began preparing its LPTRP in December 2018, submitting its first draft in April 2019. The city government's proposal aims to consolidate seven major public transport routes into two trunklines, addressing congestion caused by an oversupply of vehicles.

The draft LPTRP suggests a dedicated urban terminal and rationalizes tricycle operations as feeders to the trunkline service. While the LPTRP received a notice of compliance for urban routes, the city requested a deferment due to the exclusion of rural routes. Challenges faced in drafting the LPTRP included outdated demand data, limited stakeholder involvement, and the lack of formal public transport stops and facilities. The "one route, one operator" policy raised concerns about possible fare increases and displacement of transport service entities (TSEs).

2.3 Simulation Exercise

While the DOTr reviewed the city’s draft LPTRP, LTFRB Region IV endorsed SM Shopping Center Management Corporation (SCMC) Terminal Management’s request for a dry-run of the urban routes using the proposed terminal on SCMC property. With LTFRB Region IV's guidance, the city government conducted a simulation exercise (SimEx) from December 7-9, 2023, similar to Bacolod City’s approach, also initiated by DOTr and LTFRB, with technical assistance from SafeTravelPH Mobility Innovations Organization. The SimEx aimed to update passenger demand data, validate household travel demand surveys, gather commuter feedback, and evaluate service plan feasibility. Eight TSEs, including consolidated and individual operators with valid Provisional Authority, participated in the exercise. The Office of City Planning & Development Coordinator (OCPDC) conducted the following surveys in collaboration with the above partners: 1) license plate survey, 2) passenger feedback survey, and 3) PT ridership, boarding/alighting and travel surveys using the SafeTravelPH mobile application. As the city government’s lead office for land use and infrastructure planning, the OCPDC played a key role in organizing data collection efforts for evaluating the feasibility of the proposed LPTRP.

2.4 Household Interview Survey

The review and evaluation of the last submission to the DOTr and before the SimEx activity were pending. The city government conducted a Household Interview Survey (HIS) also in the middle of 2023 to gather comprehensive data to revise the LPTRP. The collection of this new data presented an opportunity for the city government to shift the approach to local transport planning from route-based/corridor-level analysis to network-level analysis, allowing the generation of Origin-Destination (OD) data for the entire city. With OD data, the city government can make more informed decisions by applying public transport modeling.

3. LITERATURE REVIEW

3.1 Route Measured Capacity (RMC) Concept

The Omnibus Franchising Guidelines (OFG), promulgated under DO 2017-011, established a comprehensive regulatory framework for the modernization of public utility vehicle (PUV) operations in the Philippines. The directive aimed to enhance transport safety, operational efficiency, and environmental sustainability by prescribing updated standards for vehicle specifications, franchise issuance, and service performance evaluation. A key provision of the OFG was the mandatory implementation of the Local Public Transport Route Plan (LPTRP), requiring local government units (LGUs) to adopt a data-driven, demand-responsive approach to route planning. Additionally, the policy mandated fleet consolidation, compelling operators to transition into cooperatives or corporations to optimize service management, improve regulatory compliance, and ensure greater accountability.

However, challenges in implementation, particularly concerns from stakeholders regarding route rationalization, franchise consolidation, and financial burdens on operators, prompted amendments under DO 2023-022, Guidelines on the Implementation of Public Transport Modernization Program (PTMP). This amendment provided policy adjustments to address transition issues and extend compliance timelines, particularly for small operators. The updated guidelines also refined the LPTRP framework by allowing greater flexibility in route planning, ensuring a balance between modernization goals and stakeholder adaptability. Furthermore, under the said amendment new regulatory provisions to facilitate financing mechanisms and improve equity among transport service providers are introduced.

Manresa et al. (2015) stated that the concept of Route Measured Capacity (RMC) was designed by the Road Transport Planning Division, former Department of Transportation and Communications. The RMC subsumes the definition of "public necessity" through the franchising process. It shall demonstrate the level of service needed for any specific route, measured in bus or public utility jeepney (PUJ) units. Conversely, in other countries, the term "headway" is usually associated with service preference, while the RMC highlights demand based on the number of units needed. It should be emphasized that changes in the Utilization Rate, Viability Load Factor, Average Seating Capacity, and Number of Round Trips, correlates to the Fleet Size (RMC) or number of new vehicles being required by the government to be purchased by TSEs (with some subsidies) in the modernization effort. These factors, however, are highly sensitive to policies (sizes and capacity of vehicles), road congestions (travel speed, round trips), and availability of business planning values (viability load factor). The authors found no publicly available approved LPTRP that demonstrates how these data were gathered and/or assumed.

$$RMC = \frac{PD \; x \; SF}{UR \; x \; VLF \; x \; ASC \; x \; NRT} \tag{1}$$

Where:

PD: Passenger Demand of a proposed route obtained from OD table (Network Analysis) or Passenger Load Check Survey (Route Analysis)

SF: Seasonality Factor (converts the daily passenger demand from the survey into annual average daily passenger (AADP)

UR: Utilization Ratio

VLF: Viable Load Factor

ASC: Average Seating Capacity (Output from the occupancy Survey)

NRT: Number of Round Trips (Average of inputs by operator during survey) or determined using route length and average travel speed

The inputs to the RMC formula are as follows:

Utilization Ratio:
$$UR = \frac{Units \; in \; operation}{Actual \; fleet \; size} \tag{2}$$

Viable Load Factor for PUB operation:
$$VLF = \frac{Ca + Ra}{ASC \; x \; f} \tag{3}$$

Where:

Ca: Average Cost/ veh-km/ day
Ra: Reasonable Profit/ veh-km/ day
ASC: Average Seating Capacity/bus
f: Fare/ seat-km

Viable Load Factor for PUJ operation:

$$VLF = \frac{Gross\ Revenue}{f\ x\ RL\ x\ ASC} \tag{4}$$

$$Gross\ Revenue = Operating\ Expense + Net\ Income \tag{5}$$

$$Operating\ Expense = \frac{Average\ Vehicle\ Operating\ Cost}{Total\ Distance\ Travelled\ /\ Day} \tag{6}$$

Where:

RL: Passenger Demand of a proposed route obtained from OD table (Network Analysis) or Passenger Load Check Survey (Route Analysis)

Public transport operators provide the financial documentation to obtain Net Income and Average Vehicle Operating Costs. The VLF is calculated from revenue data reported by bus companies for buses. On the other hand, jeepneys are appraised based on the daily income realized by drivers. The technique used here reveals the prevailing tradition in jeepney ownership, where jeepneys are generally rented or leased to drivers under a daily contract.

NRT Computation:

$$NRT = \frac{Service\ Period}{TAT} \tag{7}$$

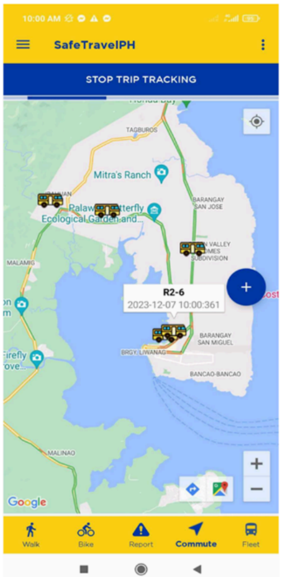
$$TAT = \frac{Route\ Length\ x\ 2}{Average\ Travel\ Speed} + Terminal\ Waiting\ Times \tag{8}$$

Where:

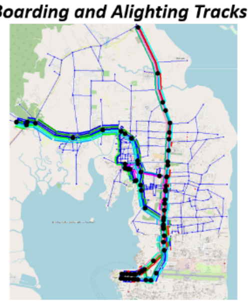
TAT: Turn Around Time

3.2 Public Transport Crowdsourcing

Pending the review and evaluation of the city's draft LPTRP by the DOTr, the LTFRB Region IV endorsed SafeTravelPH is a real-time data capture platform developed at the University of the Philippines (UP) aiming to track vehicle locations and occupancy. It makes it possible to analyze, visualize, and report on public transport. It captures nearly every second of vehicle positions if a cellular data signal is available. The application collects PUV occupancy data using the interactive features of the passenger boarding and alighting used by the surveyors. From mobile GPS data, one can derive critical information about fleet size and traffic assessment–travel time, stop time, turnaround time, and speed on different corridors or route sections during peak and non-peak hours. Figure 2 illustrates a sample of standard real-time information on PUV fleet monitoring from the SafeTravelPH application.



Boarding and Alighting Tracks



Average Peak Hour Speed during the SimEx

Route	Speed (kph)
R1	13.3
R2	15.4
R3	13.8
R4	15.4
R12	14.2
R13	14.2

Figure 2. Real-time PUV Fleet Tracking using SafeTravelPH platform

4. METHODOLOGY

4.1 Analytical Framework

This study employed data gathered during a three-day Simulation Exercise (SimEx) organized by the LTFRB IV-B in collaboration with the City Government of Puerto Princesa, the Department of Transportation (DOTr), and the SafeTravelPH Mobility Innovations Organization. The SimEx illustrated the integration of traditional data collection methods for counting Public Utility Vehicle (PUV) trips along key corridors, alongside travel data sourced from the mobile crowdsourcing application, SafeTravelPH (Tiglao et al., 2023). This comprehensive approach facilitates a more accurate estimation of supply and demand parameters, which are essential for determining the optimal fleet size for each route.

For the supply-side analysis, data from the SimEx was utilized to update critical operational parameters, such as travel speed, turnaround time, and the number of round trips per route, while taking into account current traffic conditions. This assessment considered various scenarios, including weekends, weekdays, peak hours, and non-peak hours in Puerto Princesa City.

In terms of demand-side analysis, passenger volume for each route was calculated using occupancy load factors derived from the number of passengers recorded via the mobile application for selected vehicles. These factors were correlated with total ridership data obtained from a boarding and alighting survey. Furthermore, as the app geotags the actual locations of boarding and alighting events, an estimation model utilizing Exploratory Data Analysis (EDA) was developed to analyze origin-destination (OD) pairs from the household surveys, supporting the optimization of network-level routes. EDA was employed to identify travel patterns and detect anomalies within the dataset. Finally, K-means clustering through machine learning tools in R statistical programming was used to identify formal PT stops using the SafeTravelPH app-collected boarding and alighting points, shifting away from paratransit stopping patterns unregulated loading and unloading of passengers. This approach informed data-driven decisions regarding route planning and operational enhancements. In an effort to overcome the dependency on tricycles alone, the routes modeled in CUBE covered some areas that are prevalent with tricycle use according to Tolentino et al. (2024).

By leveraging data from household interview surveys, vehicle trip records collected during the SimEx, and crowdsourced PUV travel characteristics from SafeTravelPH, this study aims to develop a transit assignment model using Cube Voyager (Sachan and Mathew, 2020). This model will integrate travel demand and operational parameters to improve network efficiency and route optimization.

To improve analytical clarity, data used in this study are categorized into three groups: Pre-SimEx data (historical LPTRP drafts and household interview surveys), SimEx data (field data collected during the simulation activity), and CUBE-modeled outputs (transport simulation results based on the integrated datasets). These categories are used consistently in the results discussion.

Table 1. Summary of Data Sources Used in the Study

Data Category	Data Source	Description	Application
Pre-SimEx	Household Interview Survey	Travel behavior, OD pairs, trip purposes	Baseline OD matrices, route coverage
	LPTRP Draft	Legacy planning assumptions	Comparison & scenario validation
SimEx	License Plate Surveys	Number of public transport vehicles per day	Ridership validation
	SafeTravelPH GPS Traces	Real-time vehicle speeds, boarding & alighting locations	Speed profiling, turnaround time
	Passenger Feedback Surveys	User experience data	Route acceptability, stop usability
CUBE Modeled	Bentley CUBE Outputs	OD assignments, passenger loads, travel times	Route evaluation, fleet size simulation

4.2 Transit Assignment using CUBE

Bentley CUBE is an advanced multimodal transportation and land-use modeling software. At the macroscopic level, CUBE supports strategic and multimodal planning, enabling a comprehensive analysis of major roadway networks and public transportation systems with a high level of detail.

The CUBE application developed for the SimEx includes four primary functional modules:

1. OD Matrix Preparation – This module utilizes Origin-Destination (OD) data derived from a Household Interview Survey (HIS) conducted by the city government in 2023 to establish baseline OD matrices.
2. Traffic Assignment – This module performs highway assignment procedures to

compute link volume across the road network.

3. Public Transport (PT) Assignment – This module performs transit assignment to generate forecasts for public transport ridership.

Figure 3 illustrates the primary application of the CUBE transport model for the Puerto Princesa SimEx, along with its critical input parameters.

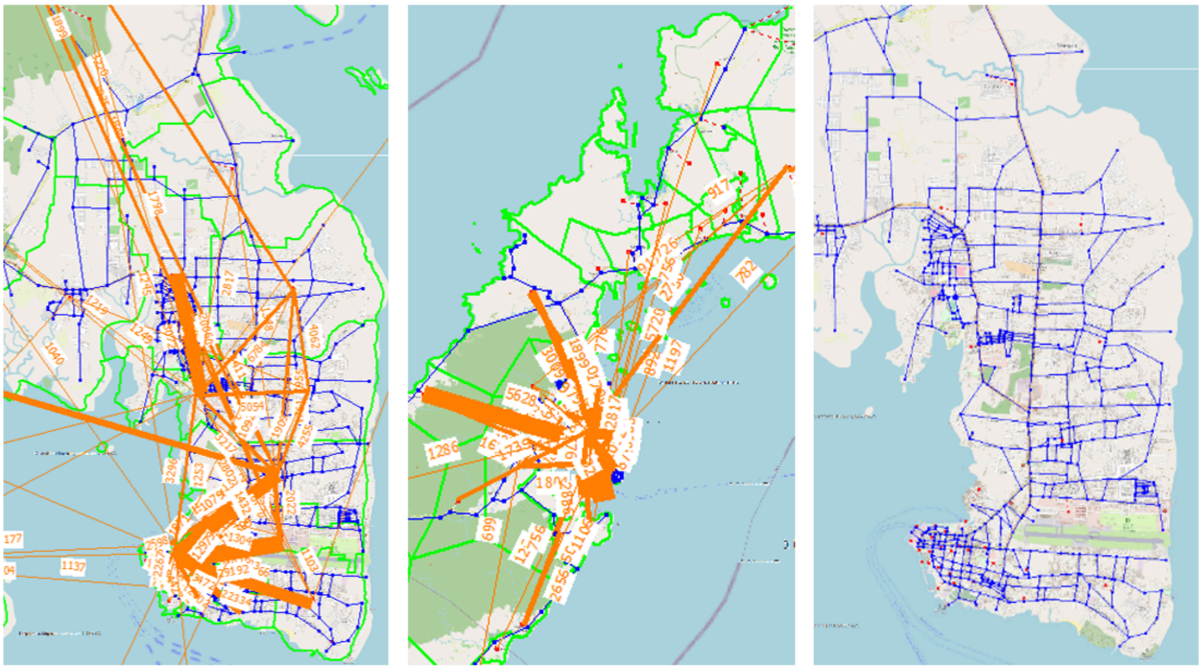


Figure 3. Puerto Princesa City. Origin-Destination Desire Lines and Road Network Map in CUBE

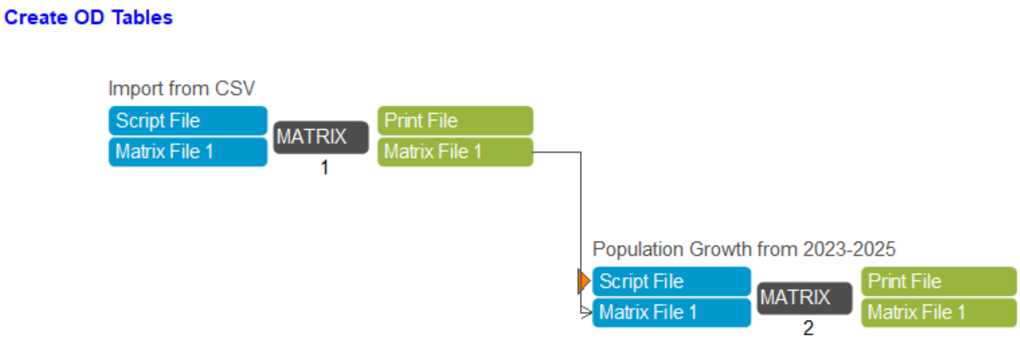


Figure 4. OD Matrix Calibration

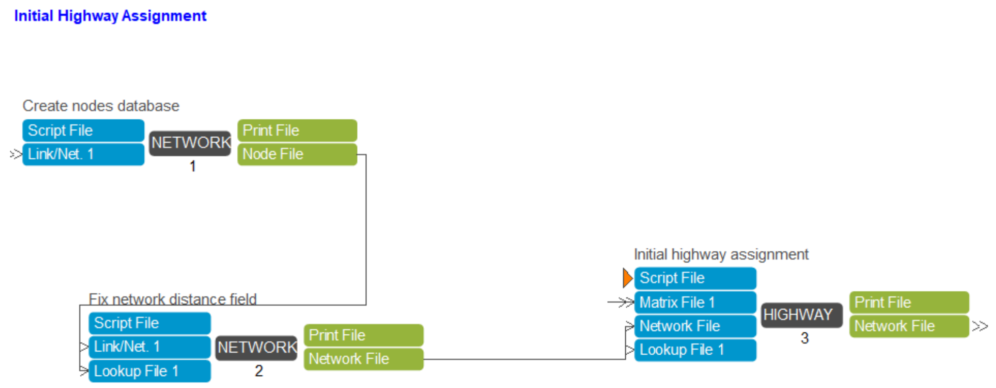


Figure 5. Highway Assignment

The PT Assignment Application developed for the Puerto Princesa City SimEx is illustrated in Figure 6. It is important to note that travel demand modeling software generally follows a computational framework, wherein route enumeration is first conducted based on the encoded public transport network. Subsequently, person-trips are assigned to the network by optimizing for the lowest travel cost on the PT network.

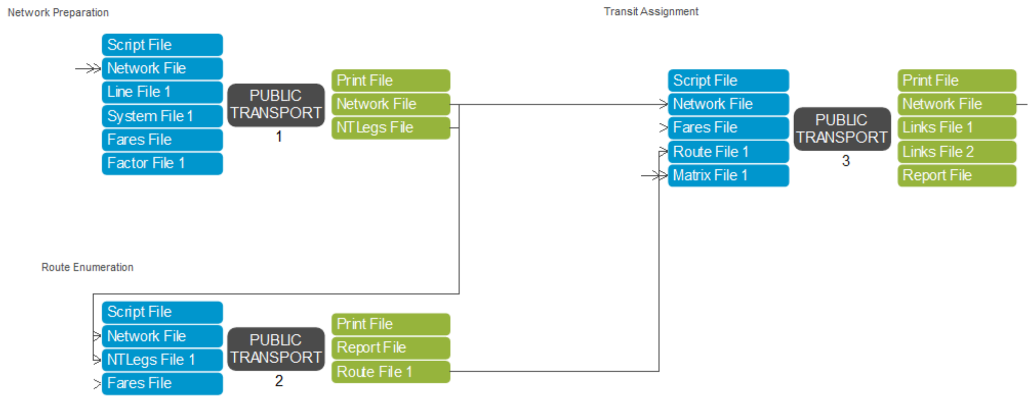


Figure 6. PT Assignment Application

A distinctive feature of Bentley CUBE is its capability to model non-transit legs, allowing analysts to define commuter access and transfer behavior based on a set of factors. Additionally, the specification of stop and non-stop nodes is a critical aspect of the PT assignment process. However, it is common practice to model all points in the PT alignment as stop nodes due to the absence of designated or strictly enforced formal loading and unloading areas within our local public transport system.

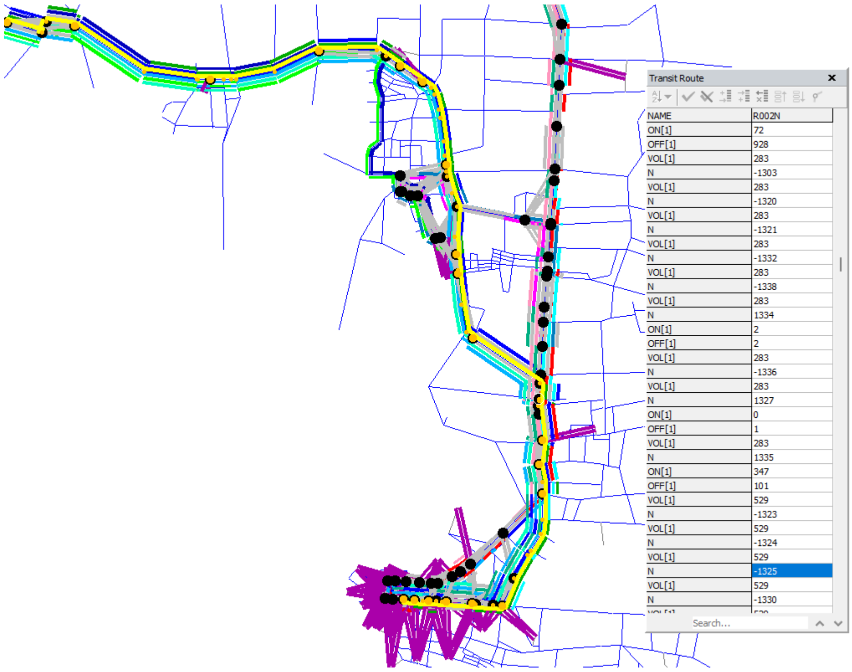


Figure 7. Public Transport Routes and Assigned Stops with OD Lines

5. RESULTS AND DISCUSSION

5.1 Analysis of the Household Interview Survey Results

The mode share of person-trips illustrates the distribution of different travel modes used by residents in the city, based on data collected from the household interview survey (Pre-SimEx) as shown in Figure 8. Survey results indicate that 43.14% of the total trips are attributed to public transportation followed by walking, while smaller proportions are allocated to private vehicles and cycling. The dominance of public transportation suggests a potential demand for enhanced transit services. Taxis are the most used form of public transport accounting for about 50.84% of the total share of public transportation. This can be attributed to their perceived comfort compared to other modes of public transport. Taxis offer a direct service without the need for multiple mode transfers, reducing travel time, and making them more attractive for passengers seeking efficiency. The flexibility of taxis in terms of routes and schedules further enhances their appeal compared to fixed-route services.

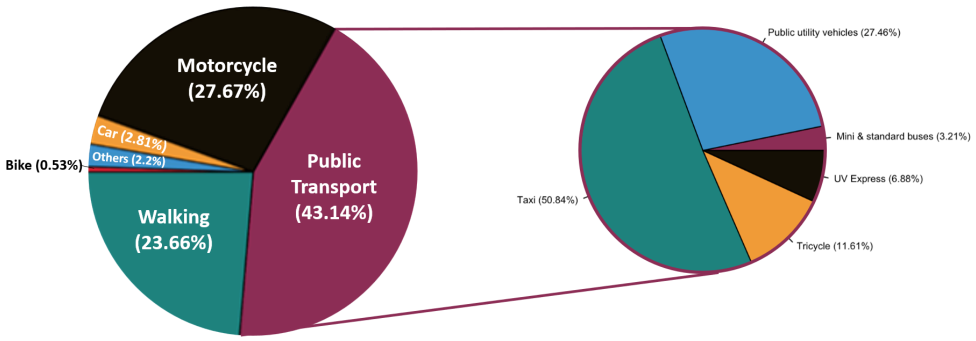


Figure 8. Mode Share per Person-Trips

Figure 9 illustrates the average duration of person-trips across different public transport modes. UV Express exhibits the highest average trip duration, followed by buses, suggesting that these modes primarily serve longer-distance routes. The extended travel times for UV Express and buses highlight the need for route efficiency enhancements, dedicated lanes, or priority measures to minimize delays and improve service reliability. Tricycles and public utility vehicles (PUVs) show comparable average travel durations, reflecting their role as last-mile connectivity options. Tricycles, in particular, operate on some routes not covered by PUVs, offering door-to-door services and reinforcing their function as a supplementary mode for high-demand corridors. Taxis, on the other hand, have the shortest average trip duration, attributed to their flexible routing, limited stops, and direct service characteristics compared to fixed-route public transport.

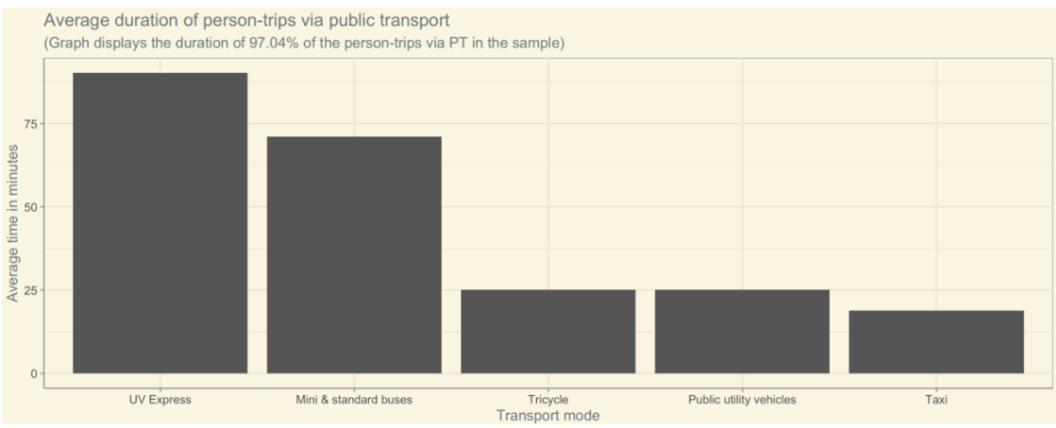


Figure 9. Average Travel Duration of Person-Trips via Public Transport

5.2 Network-level Analysis

Figure 10 illustrates the standard PT assignment outputs generated in CUBE, showcasing the passenger load profile, boarding and alighting volumes, and the onboard passenger count for each PT route. Meanwhile, Table 2 summarizes the assignment results for all proposed PT routes identified in the LPTRP of Puerto Princesa City.

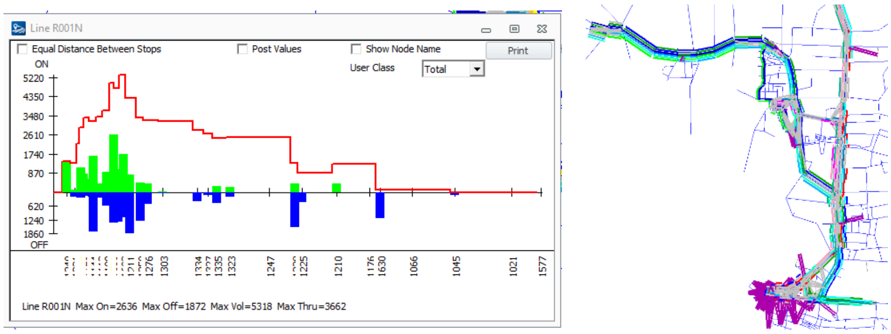


Figure 10. Typical PT Assignment Result in CUBE

The six public transport routes analyzed in this study, R1, R2, R3, R4, R12, and R13, are core components of Puerto Princesa City's LPTRP. Visual representations of these routes are provided in Appendix A (Figures 12-14). These were selected based on data availability, route importance, and inclusion in the LPTRP.

Table 2. Summary of PT Assignment Results

Route Name	No. of Stops	Distance (km)	Time (mins)	Passenger	Passenger-km	Passenger-hr
R1 North	29	14.86	87.44	15524	24855	2332
R1 South	29	14.86	36.26	8085	12649	710
R2 North	18	14.18	95.79	1389	2287	342
R2 South	18	14.18	34.97	1826	2266	152
R3 North	30	13.42	65.81	11714	10546	744
R3 South	16	11.23	32.61	575	879	82
R4 North	18	12.65	68.74	361	344	50
R4 South	15	12.65	30.73	29	110	3
R12 East	11	7.7	17.88	5	8	0
R12 West	8	7.72	36.18	530	2268	226
R13 East	14	4.63	14.43	687	810	51
R13 West	10	4.55	26.85	738	1056	117

5.2 Network Evaluation

Figure 11 represents the spatial visualization of the recommended transit stops in Puerto Princesa city which are clustered based on boarding and alighting activities using the SafeTravelPH mobile application (SimEx), and inputted in the CUBE transit network model. Each data point is assigned to a cluster based on its calculated “nearness” to other stops, using K-means clustering that considers the mean boarding and alighting events within the group. Transit stops are grouped in areas with high boarding and alighting activities, ensuring service is concentrated where passenger demand is highest. By strategically placing stops within clusters, PT operations can reduce redundant stops, improve travel times, and enhance PT service reliability.

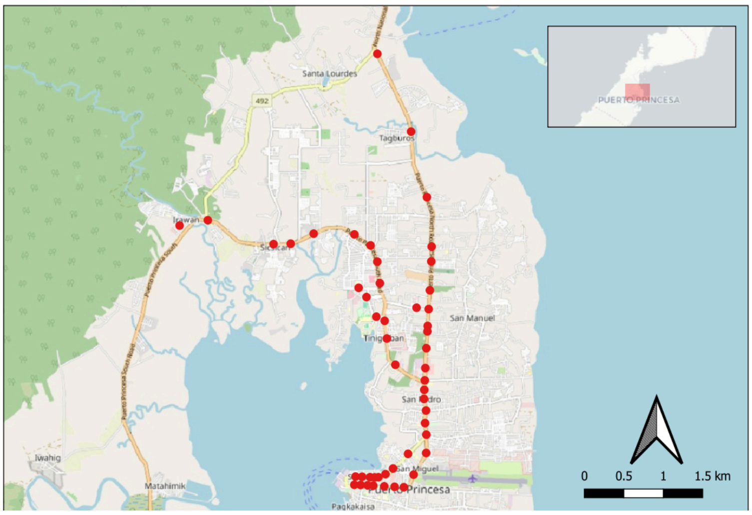


Figure 11. Recommended Optimal Transit Stops (analyzed using mobile app data)

Although Figure 11 presents a unified view of all clustered stops, the analysis was conducted at the individual route level. The consolidated map was used to identify overlapping stop areas, reduce redundancy, and guide optimized stop placements across the complete LPTRP network.

Table 3 presents the aggregated vehicle speed data derived from crowdsourced trip records collected through the SafeTravelPH app’s driver module, along with the corresponding speed estimates generated by CUBE. Speed profiling is a critical parameter in determining the minimum required PUV fleet size per route, as it directly influences vehicle turnaround time and the feasible number of roundtrips within a given operational period. The difference between the CUBE simulation results and the SimEx lies in the formalization of PUV stops, which significantly impacts average peak-hour speeds. In the CUBE simulation, PUVs adhere to designated station stops and minimize disruptions to traffic flow, leading to higher average speeds. Conversely, the SimEx reflects the existing condition where PUVs can stop anywhere to board and alight passengers, resulting in frequent stop-and-go movements, increased dwell times, and traffic bottlenecks. This operational inefficiency is evident in the speed comparison, where the SimEx speeds are consistently lower than those in CUBE, which was simulated with formal stops.

Table 3. Speed Comparison per Route (kph)

Route Number	Average Peak Hour Speed (SimEx-Actual)	Average Peak Hour Speed (CUBE-Simulated)
R1	13.3	18.7
R2	15.4	25.2
R3	13.8	20.7
R4	15.4	24.7
R12	14.2	12.8
R13	14.2	10.2

5.3 Route-based Fleet Size Calculation

The fleet size calculations summarized in this section were derived based on key assumptions informed by key informant interviews and technical group discussions with DOTr and the LTFRB, and the government LPTRP Manual (2017). A conservative approach, aligning with the prevailing operational conditions within the LGU, was determined in evaluating and selecting the most appropriate fleet size model, as different sets of data used (pre-SimEx, SimEx, and CUBE-modelled) and assumptions produce different fleet sizes.

To address this, the assumptions established for the fleet size calculation formula are as follows:

- For Peak Hour calculations, VLF = 1.0
- For Whole Day calculations, VLF = 0.80
- Utilization Rate: 0.85 (As stated in Section 3.3.1 of the LPTRP Manual, a maximum allowance of 15% is designated for vehicle downtime and maintenance. Hence, an 85% utilization rate is considered)

Table 4 presents the ridership summary detailing the total boardings recorded across the three routes covered by the SafeTravelPH app-based survey. These were the only routes for which continuous mobile-based data collection was operational during the entire simulation period. For the remaining routes (R4, R12, and R13), traditional survey data and CUBE modeling results were used for fleet sizing computations (see Table 5). The passenger demand indicators were further analyzed and disaggregated into 'per kilometer' and 'per hour' factors. These factors are key metrics for assessing whole-day passenger demand based on route-specific boarding and alighting patterns. Given that the average hourly whole-day passenger load is relatively low, ranging from 10 to 13 passengers per hour, utilizing a fully 22-seater modern PUV fleet may not be economically viable. A more efficient approach would involve a strategic mix of large-capacity vehicles during peak periods and smaller-capacity vehicles during off-peak times. This would optimize service frequency during peak and off-peak periods.

Table 4. Ridership and Passenger Demand Indicators per PUV Unit

Route Number	Average of Whole Day Ridership	Average of Peak Passenger Load	Maximum of Peak Passenger Load	Average of Whole Day Passengers per Hour	Average of Whole Day Passengers per KM	Average of Passenger per Hour Per direction (15 hrs)
R1	90	11	15	10	1	606

R2	75	12	14	10	1	289
R3	121	14	17	13	2	858

The Passenger Per Hour Per Direction (PPHD) values, derived from occupancy rates obtained through license plate survey, are presented in Table . These PPHD values serve as the primary input for passenger demand estimation in Equation 1, which is utilized to determine the actual fleet size requirements. The computed fleet sizes will then be analyzed in comparison to PPC derived fleets prescribed in the LPTRP manual.

Table 5. PPHD Values using the Occupancy Data

Route Number	CUBE Peak PPHD	CUBE Off-Peak PPHD
R1	1830	374
R2	736	91
R3	138	25
R4	88	17
R12	278	21
R13	343	61

The calculated fleet size requirements, based on both the ideal speed for public transportation and the speed generated from CUBE, are summarized in Table 6. Under the LPTRP, the LTFRB may necessitate the number of authorized vehicles required to issue a Certificate of Public Convenience (CPC). The difference in fleet sizes across routes is primarily driven by the discrepancy between the assumed speed (30 kph) in the LPTRP and the results of the CUBE simulation speeds (10-25 kph). Since fleet size is influenced by turnaround time (Equation 8) and the number of round trips (Equation 7), lower actual speeds lead to longer journeys, requiring more vehicles to maintain service levels.

Given the existing authorized units from consolidated entities and operators holding provisional authorities to operate, the LGU may adopt the minimum fleet requirement as a starting point for the conservative choice to avoid overinvestment and underutilization of fleets during off-peak periods.

Table 6. Comparison of Modern PUV Fleets

Route Number	Ideal Speed for Public Transportation (kph)	FS using Ideal Speed	CUBE Speed (kph)	Peak Hour FS (CUBE)	Off-Peak FS (CUBE)	Conservative Choice
R1	30	66	18.68	96	20	66
R2	30	26	25.16	30	4	26
R3	30	4	20.66	5	1	4
R4	30	2	24.70	2	1	2
R12	30	5	12.80	11	1	5
R13	30	5	10.17	10	2	5

However, this conservative fleet sizing may lead to insufficient capacity during peak demand, resulting in longer passenger waiting times and reduced service reliability. Several strategies can be considered to mitigate peak-period shortages. First, measures such as dispatching control, headway management, and reduced dwell time variability at transit stops can improve the fleet size and reduce the need for a larger peak fleet size. Second, allow sharing of assets among operators. This will address demand spikes without permanently expanding authorized units. The LGU and LTFRB may allow operators to deploy additional units during peak periods either through temporary fleet authorizations or conditional CPC allocations tied to demand thresholds. To sustain the 20 to 30 kph assumption and reduce the fleet requirement, the LGU must implement traffic management strategies such as loading and unloading discipline, intersection signal optimization, and enforcement to minimize delays at transit stops.

6. CONCLUSION AND RECOMMENDATIONS

The study has demonstrated that Participatory Action Research (PAR) serves as a reliable framework for enhancing local public transport planning by utilizing stakeholder collaboration in assessing the reliability and consistency of the Local Public Transport Research Programme (LPTRP). This was effectively operationalized through the Puerto Princesa City Simulation Exercise (SimEx), where local stakeholders actively contributed to data collection for evaluating the determination of fleet size. SimEx was further supported by the deployment of the SafeTravelPH mobile crowdsourcing application, which enabled the precise acquisition of key operational data, including travel times, dwell times, turnaround times, boarding and alighting events, and passenger ridership.

Furthermore, the study illustrated the applicability of public transport network modeling as a means of transitioning from route-specific analysis to a network-level framework. By analyzing overlap interactions between different routes and PUV trip tracks, the study highlighted the importance of comprehensive network assessment in improving public transport system efficiency. The study has demonstrated the value of network-based modeling in local public transport planning. By transitioning to a data-driven, network-level analysis framework, Puerto Princesa City can better align its LPTRP with real-world demand and operational conditions. The modeling approach presented herein offers a scalable solution for enhancing transport service delivery in similar urban contexts.

Lastly, with a network-based model, data was generated to estimate fleet size computation for the different routes, based on CUBE-modeled travel speeds and demand profiles. Results showed significant variation from the existing LPTRP assumptions due to more realistic estimates of speed and turnaround time. Addressing these constraints through data-driven planning and stakeholder collaboration will be essential for effectively deploying the LPTRP.

Overall, this study underscores the value of integrating advanced data collection methodologies and network-level analysis in public transportation planning. The insights derived provide a foundation for refining fleet size determination and optimizing route configurations, ultimately contributing to a more efficient and reliable public transport system.

7. ACKNOWLEDGEMENTS

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APPENDIX A. ROUTE MAPS FOR MODELED ROUTES

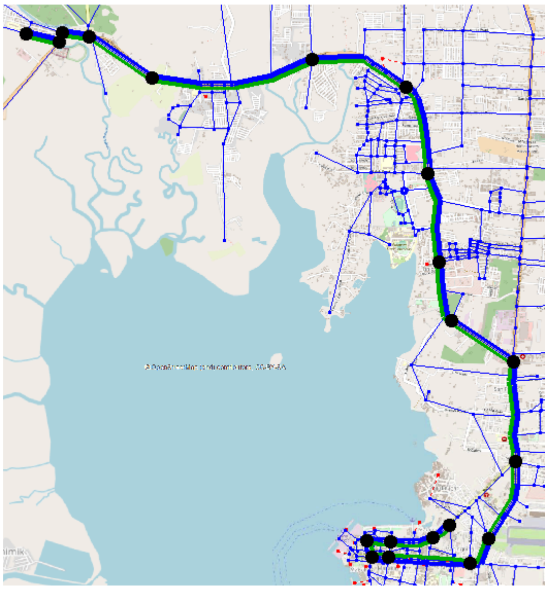
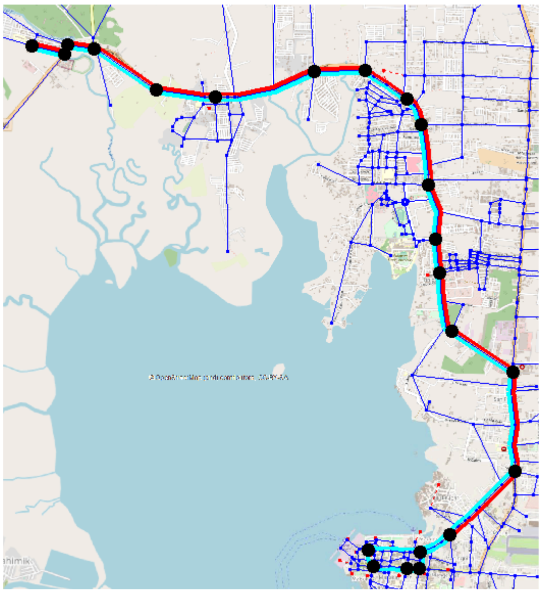

Figure 12. Route R1 (L) & Route R2 (R)

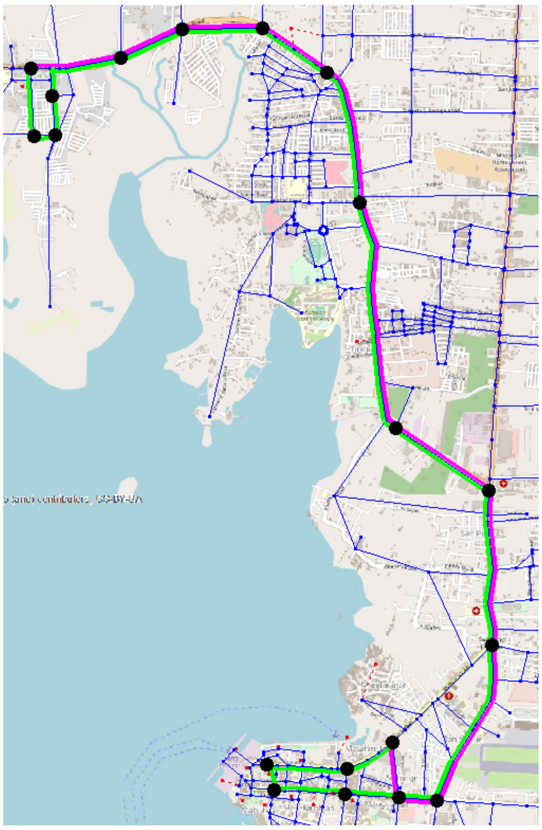
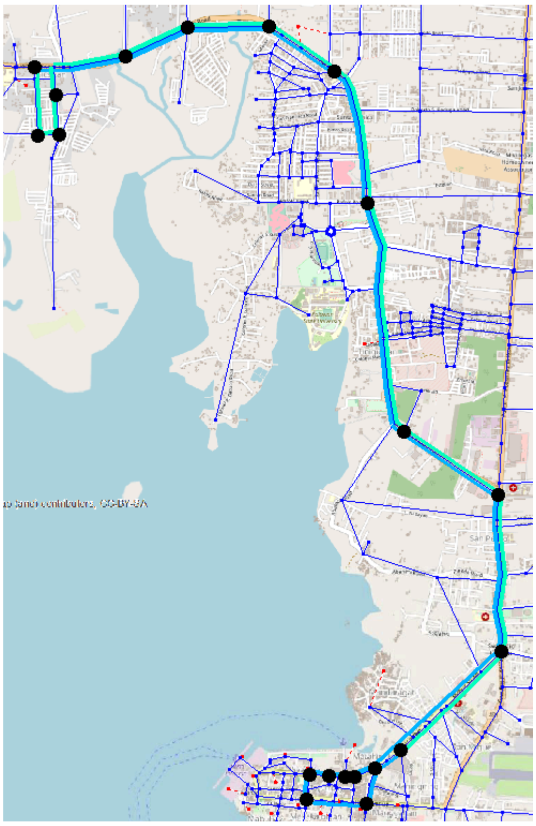

Figure 13. Route R3 (L) & Route R4 (R)

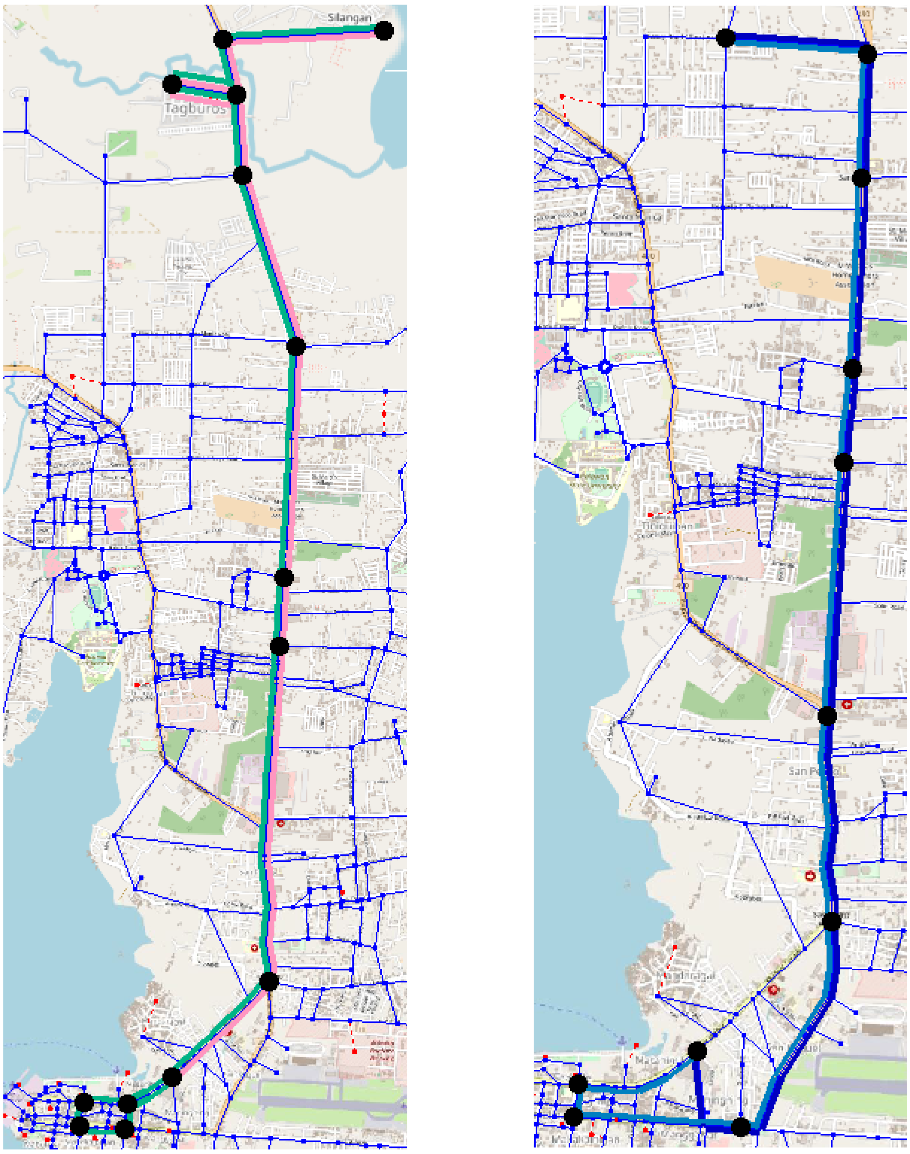

Figure 14. Route R12 (L) & Route R13 (R)