Enhancing Public Transport Planning through Participatory Action Research: The Bacolod City Simulation Exercise (SimEx) Experience

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Abstract: The Public Utility Vehicle Modernization Program (PUVMP) was launched in 2017 with the issuance of the Joint Memorandum Circular issued by the Department of Interior and Local Government (DILG) and the Department of Transportation (DOTr) which lays out the mandates all local government units to craft their respective Local Public Transport Route Plan (LTPRP). The LPTRP identifies the the routes to be opened for new franchises and determines the number of authorized units for each route. The LPTRP is subjected to review and approval by the DOTr and LFTRB, respectively, and once approved the concerned local government unit is expected to enact a local legislation to enforce the LPTRP. Moreover, the Omnibus Franchising Guidelines (OFG) was released by the DOTr which enforces a hierarchy of public transport modes where higher capacity transportation modes have priority. Bacolod City submitted its Draft LPTRP in July 2019 but the local ordinance was mandated only in October 2021 due to the COVID-19 pandemic. In 2022, the implementation of the Bacolod City's LPTRP was met with requests for enhancement and upgrading which prompted the LTFRB to conduct a Simulation Exercise in order to the validate the passenger demand and transport supply characteristics and confirm the viability of the approved LPTRP routes and confirming the determined number of authorized units in the respective routes. This paper demonstrates the use of participatory action research (PAR) approach together with public transport crowdsourcing and network-level analysis of public transport operations in enhancing public transport planning under the context of evaluating the LPTRP route structure and fleet size determination.

Keywords: PUV Modernization, Transport Planning, Participatory Action Research, Simulation

1. INTRODUCTION

1.1 Background

Prospective operators or companies proposing to operate road public transport services are

required to services are required to: 1) Prove that they are Filipino citizen or Filipino dominated corporation; 2) financially capable to operate public transport services; and 3) that there is public necessity in pursuance to pertinent provisions of the Public Service Act (Commonwealth Act No.146). Prior to its amendments, the Public Service Act (Commonwealth Act No.146)[1] obligated operators of "public services" to secure a Certificate of Public Convenience or Certificate of Public Necessity and Convenience as required by the relevant government agency and were subject to foreign investment restrictions. Under the 1987 Philippine Constitution, all operators of "public utilities" were required to be Filipino or entities that are at least 60% owned by Filipinos.

Manresa, et al. (2015) first documented the government's efforts in determining the number of units required as part of operationalizing the concept of "Public Necessity". The Route Measured Capacity (RMC) method was conceptualized in 1981 by the then Ministry of Transportation and Communications (MOTC) but was only operationalized in 1986 upon the creation of the Land Transportation and Franchising Regulatory Board (LTFRB) which is an attached agency under the Department of Transportation and Communications (DOTC). They identified several challenges that hamper fleet size estimation and effective route planning as follows:

- Data Validity and Integrity: Previous studies often relied on survey data, which might have limitations in terms of accuracy and validity. Additionally, input variables used in fleet size formulas, at times, were provided by public transport operators, potentially introducing biases.
- Variability in Fleet Size Determination: The interpretation and application of Route Measured Capacity (RMC) formulas have exhibited significant variations, sometimes leading to arbitrary fleet size determinations. This variation could be attributed to assumptions, such as the viable load factor, which were not consistently documented.
- Shift in Policy: In 2010, a moratorium was placed on the issuance of new RMC values for existing routes. Nevertheless, the use of RMC remained prevalent in guiding franchise approvals and fleet size calculations, albeit with variations in implementation[2].

The Public Utility Vehicle Modernization Program (PUVMP) was launched in 2017 with the issuance of the Joint Memorandum Circular 2017-001 of the Department of Interior and Local Government (DILG) and the department of Transportation (DOTr) which lays out the guidelines for the local government units to craft their respective LTPRPs. The LPTRP is an important public transport reform that enables local governments in the Philippines to plan their public transportation systems. As a planning document, it influences key strategic, tactical, and operational planning decisions. It is worth noting that this effort to modernize the country's public transport has been long in coming since the imposition of a moratorium on the issuance of new franchises in 2003 (Tiglao, et al., 2023).

A related policy referred to as the Omnibus Franchising Guidelines or OFG was released by the DOTr which enforces a hierarchy of public transport modes where higher capacity transportation modes have priority in terms of Certificate of Public Convenience (CPC) allocation. Certain modes are designated to operate on corridors based on passenger demand expressed in terms of passenger per hour per direction (*pphpd*) as follows:

- Public Uility Buses (PUBs) – higher than 5,000 *pphpd*
- Mini-buses – more than 1,000 up to 5,000 *pphph*

[1] Republic Act 11659 or "An Act Amending Commonwealth Act No. 146 otherwise known as the Public Service Act" which was signed into law on March 21, 2020, limits the scope of a public utility to persons who operate, manage and control for public use including public utility vehicles.

[2] For example, an RMC of 15 units is generally assumed for developmental routes.

- Public Utility Jeepneys (PUJs) and Utility Vehicle (UV) Express – more than 500 up to 1,000 *pphpd*
- Filcab Service – up to 500 *pphpd*

It is noted that tricycles are noted clearly addressed in the OFG. On the other hand, tricycle operations are covered by a 2008 joint circular that only confined their operations along or municipal roads and limited to routes not traversed by higher modes of public transport.

Due to the high cost and long turn-around time of deploying city-level travel demand surveys, and demanding requirements for detailed network analysis, the RMC-based framework continues to be used by the government to determine the fleet size of each route.

1.2 Research Objectives

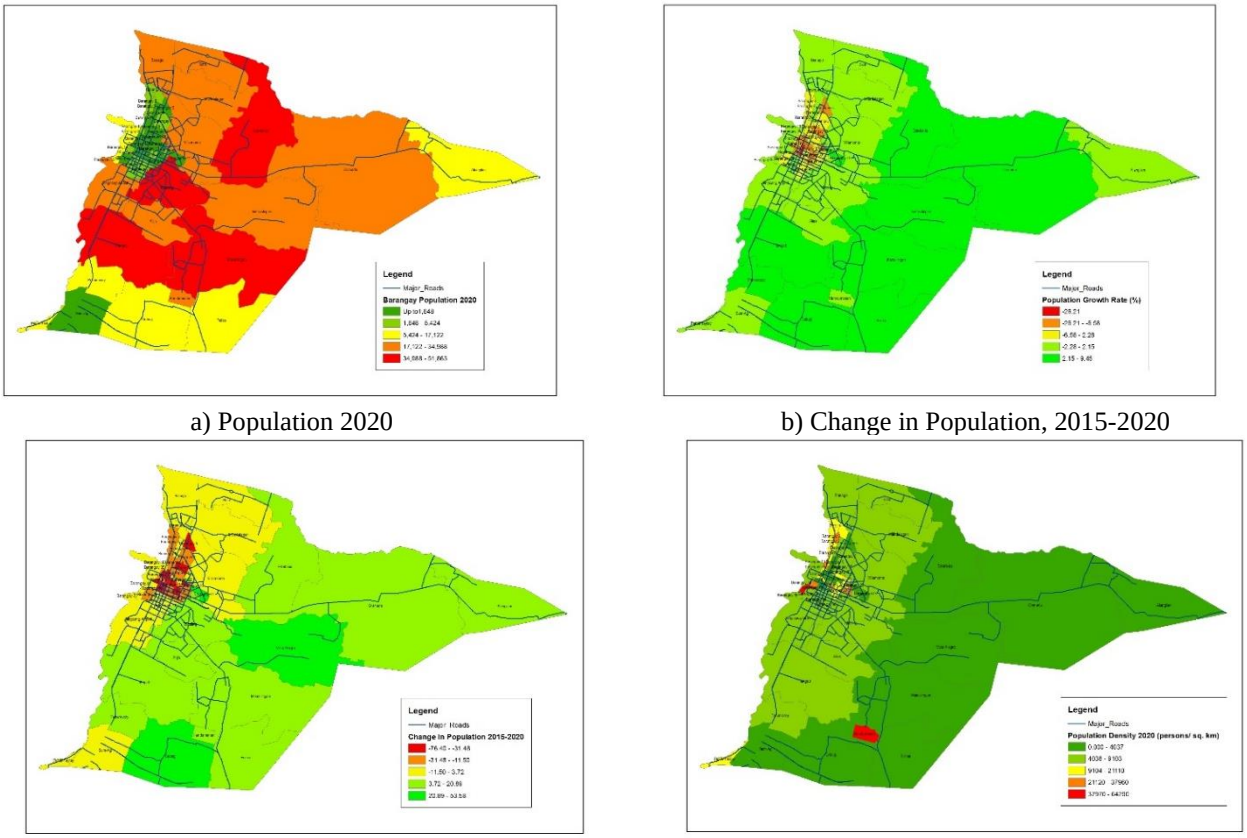
This paper endeavors to enhance local public transport planning through participatory action research. With particular focus on fleet size estimation, the study aims to achieve the following: 1) To demonstrate the use of smartphone-based data collection to gather more precise data on travel times, dwelling times, turn-around times, boarding/alighting events, and passenger ridership; 2) To demonstrate the use of public transport network modeling to enable shift from route-specific analysis to a network-level perspective by comprehensively studying the interactions and overlaps between different routes and PUV trip tracks; and 3) To develop calibration and validation processes will help mitigate potential biases arising from the partial datasets.

2. STUDY AREA

2.1 Bacolod City, Negros Occidental

Bacolod City is composed of 41 urban and 20 sub-urban barangays. The 41 barangays simply known as numbered barangays can be found at the westernmost part of the city, adjacent to the Reclamation area and also situated approximately at the center between the northern and southern city boundaries. It is also known to be the Central Business District (CBD) where most of the economic activities occur. It has a total land area of 542.57 hectares or 3% of the total land area of the city. The 20 sub-urban barangays, also known as named barangays are spread in the eastern portion of the city comprise the bigger portion of the city and has a total area of 15,073.45 hectares of 97% of the total land area.

Although most of the sub-urban barangays that are adjacent to the Central Business (CBD) are experiencing rapid urbanization, there are still remaining agricultural area and haciendas in the far-flung areas that partially support food sufficiency in the city. Figure 1 presents the barangay population trend for Bacolod City. It is noted that barangays beyond the Poblacion area have relatively higher number of residents. Also, available official census data points to negative population growth in the Poblacion area which reflects the outward direction of population growth for the city. On the other hand, some areas around the Poblacion continue to exhibit high population density which provides an indication of urban congestion in the city center. This also partly explains the outward direction of population growth of the city.



a) Population 2020

b) Change in Population, 2015-2020

c) Population Growth Rate

d) Population Density

Figure 1: Bacolod City Population Trend

2.2 Bacolod LGU LPTRP

The compliance of Bacolod City to the requirements of the OFG is evidenced by its submission of the draft Local Public Transport Route Plan (LPTRP) last July 15, 2019. Upon evaluation of the DOTr-National Project Management Office (DOTr-NPMO), the Bacolod City LPTRP approved and the LGU was given Notice of Compliance (NOC) by the Regional Franchising Regulatory Office 6 (RFRO 6) on October 28, 2019. The City Ordinance #966 Approved the Routes in Bacolod City LPTRP was enacted and approved only on October 13, 2021 due to the COVID-19 pandemic. The LTFRB issued the Memorandum Circular (MC No. 2022-010) signed on 02 February 2022 approving and implementing the proposed routes in Bacolod City LPTRP. Figure 2 presents the public transport route maps identified under the city's LPTRP. On the other hand, Table presents the list of approved routes and respective fleet size,

The LTFRB proceeded with the franchising process in accordance with its mandate under EO 202. In compliance to MC 2022-010 which approved and implemented the proposed routes in Bacolod City, the RFRO 6 proceeded with the selection process pursuant to the existing guidelines issued by the Board and routes were awarded to compliant Transport Service Entities (TSEs), whom by MC 2022-033, are required to provide the modern units within the timeline given.

On 09 May 2023, the Local Government Unit (LGU) of Bacolod City communicated to the Board, requesting for the suspension of implementation of its LPTRP and to allow ample time to address concerns of their local transport sector. On the other hand, the TSEs that were awarded the LPTRP routes, having complied to the LTFRB circulars, are also experiencing difficulty and incurring financial losses due to the limited enforcement and delayed

implementation of the LPTRP. These consolidated entities claim that there are routes wherein 100% of the required number of authorized units (NAU) of modern units have already been provided. Out of the 1,099 modernized units required for the 24 LPTRP routes in Bacolod City, the consolidated TSEs have already complied 560 units or around 51% while 49% are still traditional utility vehicles.

The presence of unconsolidated operators in the awarded routes have been extended until 31 December 2023, this posed a challenge to the LGU, the consolidated entities and the rest of the public transport operators. During the recent meeting of the LGU of Bacolod City with the Board, the City Administrator, requested for the enhancement of their LPTRP citing the need to increase the approved (NAU) in particular routes under the approved LPTRP.

Consequently, traditional jeepney operators are concerned about being displaced on their respective routes. On the other hand, TSEs that operate modern units and have been granted CPCs (Certificate of Public Convenience) and complied with the LPTRP implementation are also worried that the routes they currently serve may not be financially viable due to increased competition with individual operators.

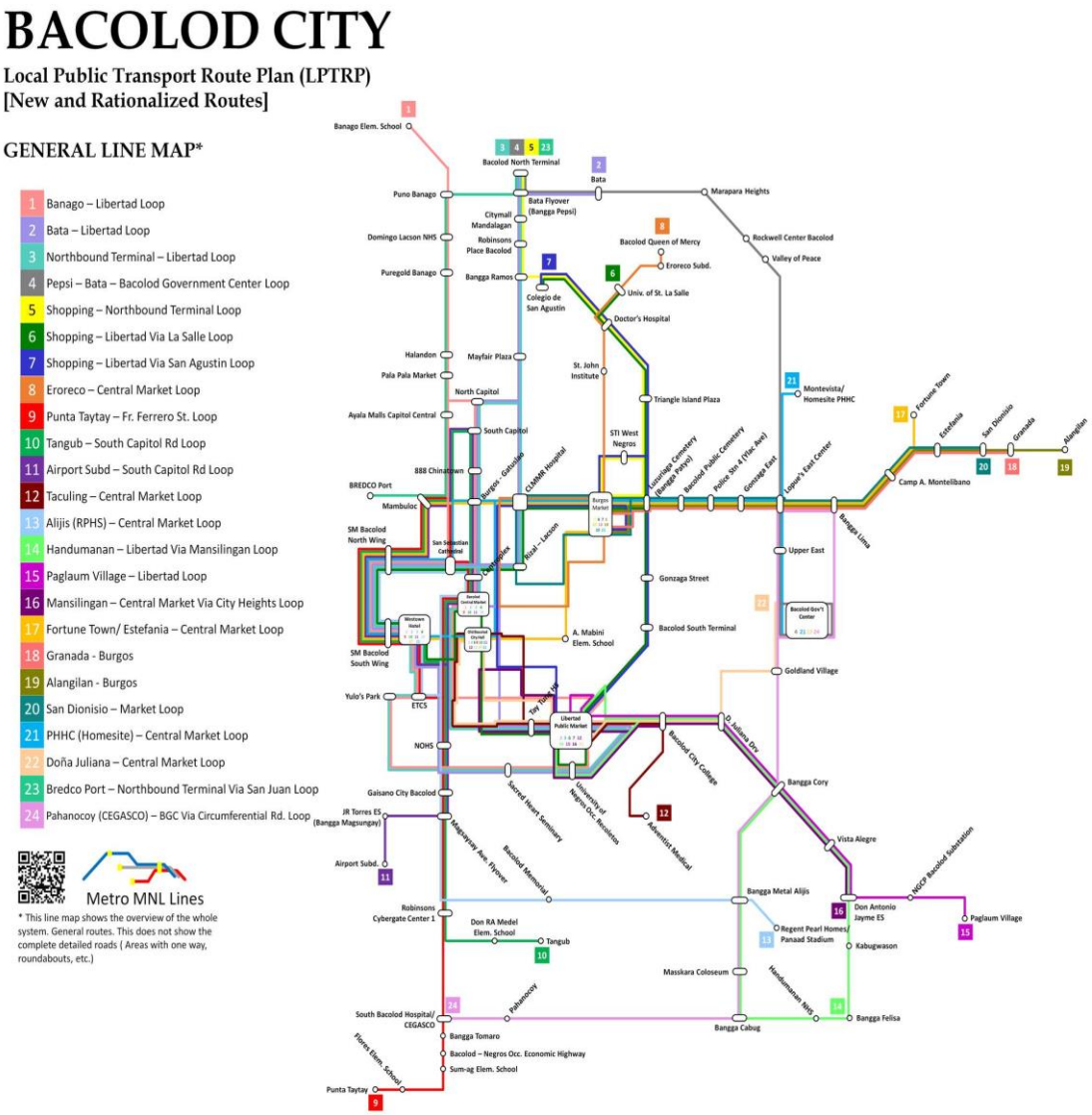


Figure 2: Bacolod City LPTRP Routes

Table 1. Approved Routes and Fleet Size in Bacolod LPTRP

No.	Route Name	Length (km)	Fleet Size
1	Banago-Libertad Loop	17	63
2	Bata-Libertad Loop	16.9	98
3	Northbound Terminal-Libertad Loop	15.23	98
4	Pepsi-Bata-Bacolod Government Center Loop	16.61	13
5	Shopping Northbound Terminal Loop	8.305	26
6	Shopping Libertad via La Salle Loop	10.9	38
7	Shopping Libertad via San Agustin Loop	13.46	54
8	Eroreco-Central Market Loop	7.14	11
9	Punta Taytay-Fr. Ferrero St. Loop	24.35	130
10	Tangub-South Capital Rd. Loop	16.02	39
11	Airport Subd.-South Capitol Rd. Loop	13.57	59
12	Taculing-Central Market Loop	7.56	29
13	Alijis (RPHS)-Central Market Loop	14.95	80
14	Handumanan-Libertad voa Mansilingan Loop	15.79	70
15	Paglaum Vilage-Libertad Loop	16.42	10
16	Mansilingan-Central Market via City Heights Loop	10.54	84
17	Fortune Towne/Estefania-Central Market Loop	16	60
18	Granada-Burgos	7.6	14
19	Alangilan-Burgos	18	10
20	San Dionisio-Central Market Loop	9.33	59
21	PHHC (Homesite)-Central Market Loop	9.09	21
22	Dona Juliana-Central Market Loop	8.4	13
23	Bredco Port-Northbound Terminal via San Juan St. Loop	12.72	10
24	Pahanocoy (Cegasco)-Bacolod Government Center via Circumferential Rd. Loop	18.12	10

The pandemic situation as well as the change in administration, affected the pace of public transportation services throughout the country. One of which is the full implementation of some of the approved LPTRPs. Recognizing the impact of these situations on the ground, the Board extended the full implementation of some LPTRPs and approved some request for enhancement and upgrading at the same time for the LGU to improve their local public transport situation to be more adaptive, inclusive and sustainable.

Implementing the LPTRP is important to determine whether there is oversupply of current public transport units; whether there is a need to increase the NAU in the LPTRP; or whether transfer plan for the existing operators to the LPTRP routes are effective as planned. This situation has given rise to various issues, particularly the significant reduction in the approved NAU compared to the existing NAU for routes in the LGU, according to RFRO6 records.

2.3 Simulation Exercise

The LTFRB, in the exercise of its mandate, proposes to conduct a simulation or pilot testing of all approved LPTRP routes in Bacolod City in June 2023 which will be a convergence of intervention and a collaborative activity. This activity is similar to the disaster preparedness and earthquake drills, to gauge the appropriateness of the actions, identify operational challenges and eventually lead to enhancement in the plan, practices and response should there be

disruptions in public transport operations.

The conduct of the Simulation Exercise (SimEx) has the following objectives:

1) To validate the passenger demand and transport supply characteristics (boarding and alighting details, location of loading and unloading, travel time, terminal dwell time, etc.) through the use of an online application;
2) To confirm the viability of the approved LPTRP routes and confirming the determined NAU in the respective routes
3) To provide basis for the requested enhancement; and
4) To determine operational problems that may arise from the implementation of the LPTRP that requires planning, economic, social, technical, legal and environmental interventions

Figure 3 presents the process flow of the SimEx activity. Figure presents some photos of field activities conducted prior to the conduct of the actual SimEx event which involved online coordination meetings through online platforms, training activities in the use of the mobile crowdsourcing app as well as PUV operator interviews.

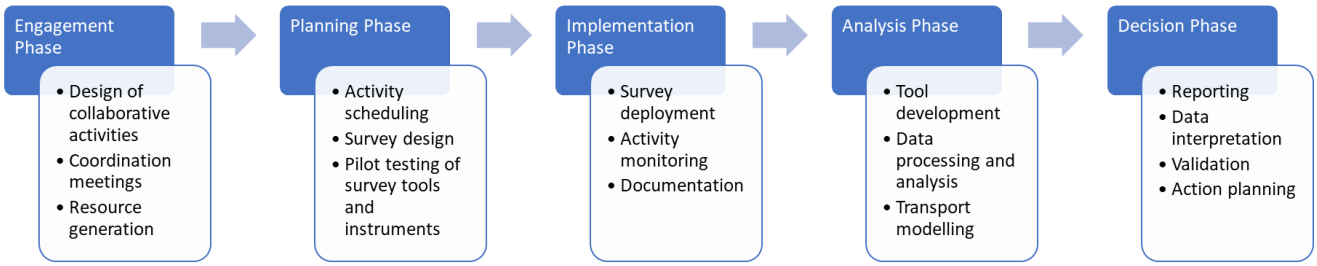


Figure 3: Simulation Exercise Process Flow

Figure 4. Field Activities with Participating PUV Operators

On June 26-28, 2023, a simulation activity was conducted by DOTr, LTFRB, and SafeTravel PH Mobility Innovations Organization, Inc. (SafeTravelPH) in Bacolod City. The main objective is to validate the routes, especially the fleet sizes, in the city's LPTRP which was approved and issued with a Notice of Compliance last June 2020, and was opened for route applications (operator selection) last February 2022.

From 25 to 27 June 2023 (Sunday to Tuesday), using the SafeTravelPH mobile application (74 deployed, with 68 active most of the time), information on the 24 approved LPTRP routes were gathered: 1) number of boarding and alighting passengers per area; 2) actual loading and unloading locations; and 3) actual terminal dwelling time. It was complemented with a commuter survey which was done in strategic areas, and was also launched online after the survey dates, to gather feedback, particularly on the performance of the modern units already

operational in the city. Tables 2 to 4 present the key aspects of the SimEx activity during pre-simulation, simulation stage and post-simulation stages.

Table 2: Pre-Simulation Activities

Tasks	Action Needed	TimeFrame	Resources Needed	Responsible Office
Creation of an Inter- Agency Committee for LPTRP Simulation (IACLS) Organization	To pass an executive order creating an IACLS Organization for the SimEx	Two (2) weeks before Actual SimEx	Communication Platform (Viber, Google Meet, etc)	IACLS Organization for the SimEx
Coordination Meetings	To conduct a series of meetings to update the status of the preparation ensuring that all the aspects of the SimEx is covered.	A day after the signing of executive order	Communication Platform (Viber, Google Meet, etc)	IACLS Organization
Coordination with Bacolod City Public Transport Groups	To coordinate with Bacolod City Public Transport Groups and to prepare the list of Transport Service Entities (TSE) / Operators that will participate in the SimEx and will be submitted to the RFRO6.	Three (3) days after signing of executive order	Venue, Existing LTFRB Database (List of TSEs with Provision authorities, List of consolidated entities)	Bacolod City LGU (City Planning and Devt. Office) ; LTRFRB RFRO6
Inventory of Participants / Route in the SimEx	To prepare and finalize a list of operators that will be participating in the simulation exercise, distributed per approved routes in the LPTRP and as provided in the Transfer Plan.	Five (5) days after signing of executive order	List of Participating TSEs/Operators, and Routes that will be part of the SimEx	LTFRB RFRO6
Briefing on the Safe Travel PH Application	To orient the survey teams on how to use the application. Personnel from the CPDO, Traffic Engineering and Enforcement will also be briefed by the technology partner to assist also in monitoring, troubleshooting and data processing.	A week before the Simulation exercise (05 June 2023)	Mobile Phone, Communication Platform (Zoom, Google Meet, etc)	Representative, SafeTravelPH
Finalization of Fleet Management and PUV Schedule for the SimEx	To submit a Fleet Scheduling Plan of the TSEs/Operators that will be participating in the SimEx to practice the implementation of the Fleet Management System in the operation of routes.	A week before the simulation exercise	PUV Schedule Plan of participants in the SimEx	LTFRB RFRO6 (with coordination to the participants, and the Bacolod City LGU - City Planning and Devt. Office)
Route Mapping and Drive-Through for Routes that will be part of SimEx	To create a consolidated route map, and preparation of the route structure of the approved routes in the LPTRP of Bacolod City that will be part of the SimEx.	Four (4) days before the SimEx	Mapping Software (QGIS etc.)	LTFRB RFRO6
Issuance of Office Orders and Deployment Plan	To issue necessary officer orders, and deployment plan	Three (3) days before the SimEx	Information Dissemination platform	Bacolod City LGU (Office of the City

Tasks	Action Needed	TimeFrame	Resources Needed	Responsible Office
	that is needed to properly conduct the SimEx.			Administrator); LTFRB RFRO6
Public Information and Call for Community Participation	To inform the public regarding the SimEx and call for the participation of the community using different kinds of information platforms (newspaper, social media, etc.)	Two (2) days before the SimEx	Information Dissemination platform	Bacolod City LGU (Public Information Office)

Table 3: Simulation Stage Activities

Tasks	Action Needed	TimeFrame	Resources Needed	Responsible Office
Start of the SimEx	To mark the start of the SimEx by the AICLS Organization, and doing the same at the end of SimEx for the day.	Simulation days	Color coded Flag/marker for Participating units	Bacolod City LGU (Office of the City Administrator)
Conduct of the Simulation of Survey	To deploy traffic enforcers to apprehend violators during the simulation but keeping it minimum and informing those who will not be participating to operate only after the simulation period , and survey teams to conduct the necessary surveys.	Simulation days	SafeTravelPH Application (installed on the mobile device), survey forms	IACLS Organization's survey team; traffic enforcers
IACLS Monitoring and Coordination	To ensure the smooth and ongoing operation of the SimEx from the start up until the end of the simulation for the day.	Simulation days	Venue (for Face-to- face coordination), Online Communication Platform (for online coordination)	IACLS Organization
Daily Evaluation Huddle	To evaluate/check the progress of the SimEx every end of the day and determine what are the achievements, and problems that arise during the simulation period.	Every end of the SimEx day		IACLS Organization
Standby by Deployment of Transport Augmentation	To monitor the ongoing operation of SimEx and provide support to different areas where augmentation is needed.	Simulation days		IACLS Organization
Consultation on PUVMP Enhancement and Orientation on Cooperatives	To create a response and/or support Plan for those operators that cannot operate on the date of the pilot run and will affect their daily wage/salary.	Simulation days		Bacolod City LGU; RFRO 6; OTC; CDA

Table 4: Post-Simulation Activities

Tasks	Action Needed	TimeFrame	Resources Needed	Responsible Office
IACLS wrap-up meeting	To conduct a wrap-up meeting discussing all the gathered data and	Two days after the SimEx	Online Communication Platform (Viber,	IACLS Organization

Tasks	Action Needed	TimeFrame	Resources Needed	Responsible Office
	information from the 3-day SimEx.		Google Meet, etc)	
Report Preparation	To document and prepare a report from the gathered information and data, discussed in the wrap-up meeting, and processed by the technical team.	Three days after the SimEx	Survey results (from SafeTravelPH Application and survey forms);	Secretariat/ Documenter (to be assigned by Bacolod City LGU)
Submission of Report and Presentation to IACLS, the City Mayor and City Council	To submit and present the prepared Report to the City and the Local Sanggunian.	3 weeks after the SimEx	Simulation Exercise Report	Secretariat/ Documenter (to be assigned by Bacolod City LGU)
Endorsement of Report to LTFRB and DOTr	To endorse the Report to the LTFRB and DOTr.	4 weeks after the SimEx	Simulation Exercise Report	Bacolod City LGU

3. LITERATURE REVIEW

3.1 Route Measured Capacity (RMC) Concept

According to Manresa, et al. (2015), the RMC concept was designed by the Road Transport Planning Division (RTPD) of the then Department of Transportation and Communications (DOTC). The RMC represents the "public necessity" requirements in the franchising procedure as it represents the number of services required in a given route in Bus or PUJ units, while in other countries it is represented as preferred "headway". Contrastingly, the RMC attempts to represent the demand in terms of units required.

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

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 passengers (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:

$$VLF = \frac{C_a + R_a}{ASC \times f} \tag{3}$$

Where:

C_a : Average Cost/ veh-km/ day

R_a : Reasonable Profit/ veh-km/ day

S_c : Average Seating Capacity/bus

f : Fare/ seat-km

Viable Load Factor for PUJ operation:

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

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

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

Where:

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

Net Income and *Average Vehicle Operating Cost* are based on financial data submitted by the operation of public transport vehicles. For buses, VLF is computed based on operators' (i.e., bus companies) revenues while for jeepneys it is based on the driver's daily income. The latter is applied because of the prevalent practice of jeepneys being rented or leased to the driver by owners on a daily basis.

NRT Computation:

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

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

Where:

TAT : Turn Around Time

3.2 Public Transport Crowdsourcing

SafeTravelPH is an application that captures real-time vehicle location and occupancy data monitoring for public transport data analysis, visualization and reporting. The platform provides measurements of vehicle locations at most every second when cellular data signal availability is optimal. The PUV occupancy is generated from the surveyor's interaction with the SafeTravelPH app's passenger boarding and alighting buttons. From the mobile GPS data, the required data for fleet size and traffic estimation can be derived for both peak and non-peak hours such as travel time, dwelling time, turnaround time, and speeds at different corridors or road segments in the network or route. Figure 5 depicts the typical real-time PUV fleet tracking data from the SafeTravelPH app.

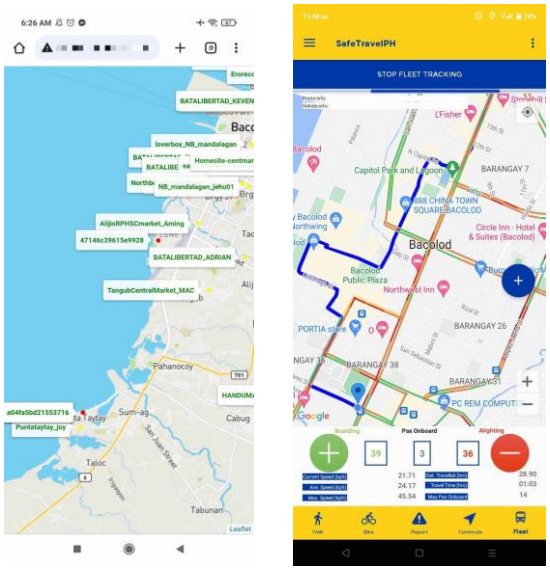


Figure 5. Real-time PUV Fleet Tracking using SafeTravelPH platform

4. METHODOLOGY

4.1 Analytical Framework

This study utilized the data generated and collected from the 3-day Simulation Exercise (SimEx) conducted from June 26 to 28, 2023, organized by the LTFRB together with the partners from the Bacolod City Government, DOTr, and SafeTravelPH Mobility Innovations Organization, as the non-government partner. This exercise demonstrated how traditional data collection methods for PUV trip counting at key corridors can be combined with PUV travel data from the mobile crowdsourcing application SafeTravelPH developed at the University of the Philippines (Tiglao et al, 2023) to estimate the supply and demand parameters needed to calculate the Fleet Size per route. The supply side of the analysis focused on the currently approved LPTRP routes (Bacolod LPTRP, 2020) with SimEx to update the travel speed, turnaround time, and number of roundtrips per route under the current traffic conditions–for weekend, weekday, peak hours, and non-peak hours–in Bacolod City.

For the demand side, calculating the passenger volume per route, the number of passengers recorded through the SafeTravelPH app for the sampled vehicles were used to get the occupancy load factors for peak and non-peak hours, and related them to the total ridership based on boarding and alighting survey, which was also done through the mobile app. Meanwhile, since the actual location of boarding and alighting are geotagged through the use of the mobile app, an estimation model using Exploratory Data Analysis (EDA) for the origin and destination pairs for the network-level analysis of the proposed routes was also developed to help describe and explore potential improvements in the planning of the routes. EDA helps initially investigate patterns and spot anomalies in the datasets, specifically by using K-means clustering method through machine learning tools in *R* statistical programming.

From available travel demand survey for Bacolod City (JICA, 2003) and the vehicle trips recorded during the SimEx at different counting stations, and other PUV travel characteristics crowdsourced through SafeTravelPH, this study will also attempt to build a transit assignment model using *Cube Voyager* (Sachan and Mathew, 2020).

4.2 Transit Assignment using CUBE

Bently CUBE is a Multimodal Transportation and Land-Use Modeling Software. At the macroscopic level, CUBE is used for strategic and multimodal planning, including studying major roadway networks and public transport systems with a great level of detail. Figure 6 shows the main application of CUBE transport model developed for the Bacolod SimEx.

The CUBE application developed for the SimEx consists of four (4) main application groups, namely:

1) OD Matrix Preparation – utilize available OD data from the past JICA study for Metro Bacolod;
2) OD Matrix Calibration – perform matrix estimation to calibrate the prior OD tables to the present year using available traffic counts as screenline data;
3) Traffic Assignment – perform highway assignment to determine link volumes on the road network; and
4) Public Transport (PT) Assignment – perform transit assignment to determine public transport ridership forecasts.

Figure 7 below presents the various key inputs to the CUBE transport model.

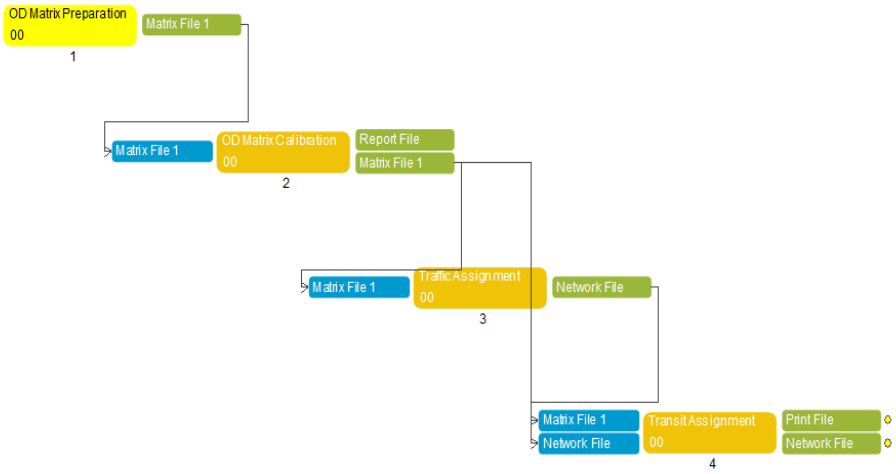
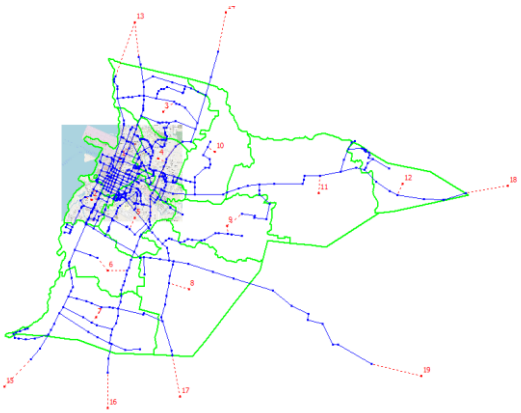
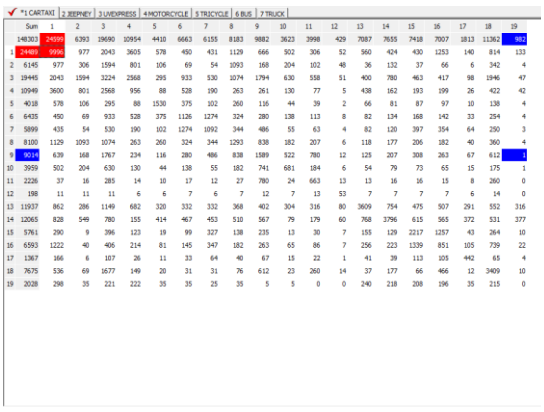


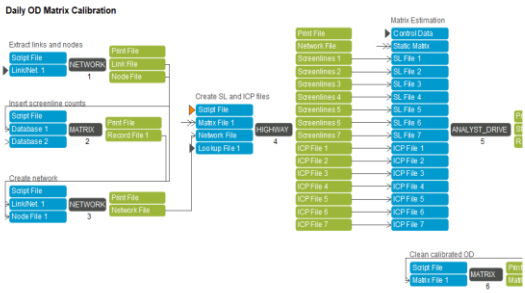
Figure 6: Main CUBE Application



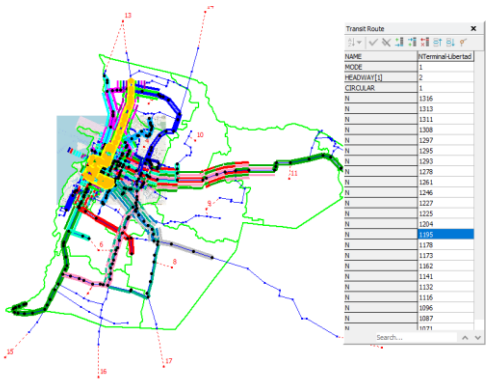
a) Road Network



b) OD Trip Table



c) OD Matrix Calibration Application



d) Public Transport Line Data

Figure 7: CUBE Model Inputs

Figure 8: Transit Assignment Application

Figure 8 presents the PT Assignment Application developed for the SimEx. It is noted that travel demand software packages generally follow a computation flow of performing route enumeration based on encoded public transport lines in the network then person-trips are assigned based on lowest cost on the PT network. Notable in the case of Bentley CUBE is its ability to model non-transit legs wherein the analyst can specify commuter access and transfer behavior based on a set of factors. Finally, it is important to note that the specific of stop and non-stop nodes is quite critical in the PT assignment process. However, it is a local practice to model all points in the PT alignment as stop nodes since there are no designated or strictly-enforce formal loading/unloading areas in our local public transport system.

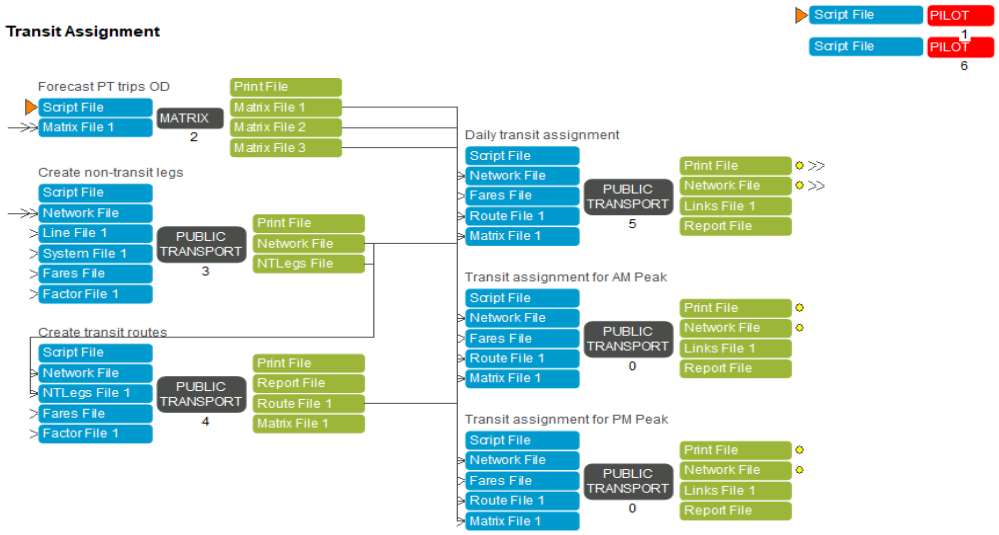


Figure 8: PT Assignment Application

5. INITIAL RESULTS AND DISCUSSION

5.1 Route-based Fleet Size Calculation

Fleet size calculation for 20 out of the 24 approved routes were conducted as part of the SimEx. The 4 other routes namely Paglaum Village (R15), Alanginan-Burgos (R19), Dona Juliana

(R22), and Bredco (R23) were not included in the simulation due to lack of enough operating units for the new or developmental routes, or non-participation of the current operators. Out of the 20 routes with enough sampled trips, the dataset for PUV trips made to estimate the passenger demand are still under validation. This is due to the presence of colorum vehicles, around 20% of the 10,170 total trips recorded, that can inflate the demand calculation. Overall, the cleansed dataset for 20 routes out of the 24 in the LPTRP have total rows or observations of 2,591,300 datapoints.

The summary of fleet size calculations presented in this section utilized the following assumptions based on key informant interviews and technical group discussions with DOTr and LTRFB. In comparing and deciding for which FS must be used, a conservative approach has been determined to best fit the current circumstances of operations in the LGU.

The agreed assumptions for the formula are:

- For Peak Hour calculations, VLF = 1.0
- For Whole Day calculations, VLF = 0.8
- Utilization Rate: 0.85
- Average Travel Speed: 20 kph

It should be noted that the actual speeds of the PUVs per route in Bacolod City is below optimal. This is summarized in Table 2 using the data from the SafeTravelPH mobile GPS data.

Table 2: Average Vehicle Speed per Route

Route	Average of Peak Hour Speed	Average of Whole Day Speed
Airport-SouthCapitolRd	14.8	11.9
Alijis-CentralMarket	13.9	11
Banago-Libertad	14.7	11.4
Bata-Libertad	15.8	11.9
Cegasco	16.8	7.1
Eroreco-CentralMarket	10.4	5.4
FortuneTowne-CentralMarket	9.8	9.1
Granada-Burgos	17	11.4
Handuman-Libertad	12.2	9.2
Homesite-CentralMarket	9	8.7
Mansilingan-CentralMarket	11.9	9.2
Northbound-Libertad	12.9	11.1
PepsiBata-GovernmentCenter	14.5	8.7
PuntaTaytay-FrFerrero	16.4	12.6
SanDionisio-CentralMarket	16.4	12
Shopping-Lasalle	11.2	9.1
Shopping-Northbound	9.7	9.7
Shopping-SanAgustin	7.5	7.5
Taculing-CentralMarket	10.8	6.8
Tangub-CentralMarket	13.6	8.9

The key observations here are that there were very low speeds for both Peak and Off-Peak hours, with maximum value of 17 kph at Granada-Burgo route and as low as 7.5 kph on Shopping-San Agustin route. However, Off-Peak speeds are less than the Peak speeds primarily due to these hours having less passenger demand, so the PUV drivers tend to wait more. Under the conservative approach: the report used the DOTr-set speed, since lower speeds from the actual will result in a higher Fleet Size, since the turnaround time is low for very congested

roads. Maintaining the speed of 20 kph therefore must include proposing in the LPTRP Service Planning for operators and planning for engineering and traffic management interventions by the LGU to make the PUVs travel faster than the current values.

Table 3 presents the summary of calculations under the different scenarios. This will provide the LGU the decision support in transitioning to the new fleet size of their proposed routes. The LGU can freely select which of the Peak Hour FS or Whole Day FS can be more feasible in the transition period. Also, since there are already allowed units from the consolidated entities and operators with provisional authorities to operate, the LGU can consider the minimum value among these as a starting point for the conservative choice. For routes with SimEx-calculated FS to be lower than the 2019 approved LPTRP and where the consolidated entities on the said routes have completed the required modern PUV units, a transfer or transition plan must be also considered based on the approved unit in 2019 that are already operating.

Note that routes in rows highlighted in gray are those routes that require additional work in validation for passenger demand estimation mentioned earlier.

Table 3: Fleet Size Computations

Route Name	LPTRP 2019 Fleet Size	Peak SimEx - FS (VLF = 1.0)	Whole Day SimEx - FS (VLF = 0.8)	Current Allowed Units	Conservative Choice	Difference from current LPTRP
Banago-Libertad Loop	63	198	348	88	88	25
Bata-Libertad Loop	98	301	1,438	205	205	107
Northbound Terminal-Libertad Loop	98	325	1,739	186	186	88
Pepsi-Bata-Bacolod Government Center Loop	13	64	0	13	13	0
Shopping Northbound Terminal Loop	26	42	12	30	26	0
Shopping Libertad via La Salle Loop	38	88	631	45	45	7
Shopping Libertad via San Agustin Loop	54	70	73	116	70	16
Eroreco-Central Market Loop	11	25	32	28	25	14
Punta taytay-Fr. Ferrero St. Loop	130	468	364	244	244	114
Tangub-South Capital Rd. Loop	39	112	76	58	58	19
Airport Subd.-South Capitol Rd. Loop	59	188	78	68	68	9
Taculing-Central Market Loop	29	57	8	55	29	0
Alijis (RPHS)-Central Market Loop	80	206	79	145	80	0
Handumanan-Libertad voa Mansilingan Loop	70	196	196	115	115	45
Mansilingan-Central Market via City Heights Loop	84	184	305	159	159	75
Fortune Towne/Estefania-Central Market Loop	60	154	1,489	140	140	80
Granada-Burgos	15	82	27	20	20	5
San Dionisio-Central Market Loop	59	210	215	98	98	39
PHHC (Homesite)-Central Market Loop	21	41	538	62	41	20

5.2 Network-level Analysis

Figure 8 depicts the typical PT assignment results in CUBE which provides a passenger load profile, boarding and alighting passenger as well as number of passengers on board for each of the public transport line. Table 4 presents the summary for all PT lines identified in the LPTRP of Bacolod City.

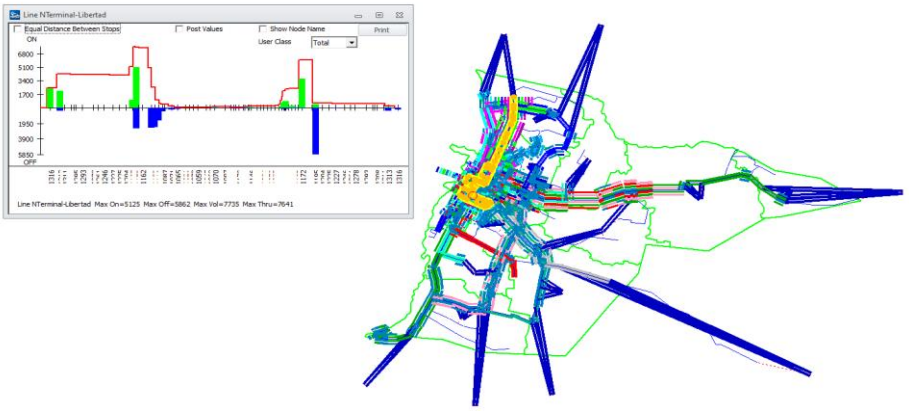


Figure 8: Typical PT Assignment Result in CUBE

Table 4. Summary of PT Assignment Results

No.	Route Name	No. of Stops	Distance	Time	Pax	Pax-Km	Pax-Hr
1	Banago-Libertad Loop	63	15.25	24.42	8,589.3	19,947.1	531.7
2	Bata-Libertad Loop	73	18.14	29.09	28,335.5	57,299.7	1,532.1
3	Northbound Terminal-Libertad Loop	74	15.72	25.24	18,292.4	30,909.2	827.9
4	Pepsi-Bata-Bacolod Government Center Loop	45	17.45	27.9	58,672.3	209,558.9	5,579.1
5	Shopping Northbound Terminal Loop	53	8.42	13.45	7,428.0	9,536.2	254.8
6	Shopping Libertad via La Salle Loop	67	10.18	16.27	5,423.5	5,008.5	133.6
7	Shopping Libertad via San Agustin Loop	45	10.34	16.55	5,588.4	14,535.4	388.4
8	Eroreco-Central Market Loop	62	10.04	16	1,086.1	632.2	16.8
9	Punta taytay-Fr. Ferrero St. Loop	103	24.75	39.66	20,905.7	75,359.3	2,009.5
10	Tangub-South Capital Rd. Loop	71	13.59	21.78	6,975.8	11,838.2	315.2
11	Airport Subd.-South Capitol Rd. Loop	55	10.14	16.27	2,937.0	3,211.6	85.3
12	Taculing-Central Market Loop	52	6.67	10.67	8,995.2	12,170.1	325.8
13	Alijis (RPHS)-Central Market Loop	74	15.25	24.42	11,057.7	15,679.7	418.1
14	Handumanan-Libertad voa Mansilingan Loop	66	17.27	27.63	25,107.9	119,107.3	3,175.4
15	Paglaum Vilage-Libertad Loop	49	15.77	25.24	11,445.7	36,355.6	970.2
16	Mansilingan-Central Market via City Heights Loop	50	10.98	17.56	3,754.3	6,596.3	176.1
17	Fortune Towne/Estefania-Central Market Loop	50	12.81	20.43	10,278.7	20,760.1	551.0
18	Granada-Burgos	39	18.53	29.62	2,504.5	9,015.3	240.1
19	Alangilan-Burgos	57	29.74	47.57	23,988.3	233,272.9	6,223.1
20	San Dionisio-Central Market Loop	46	17.33	27.66	2,658.3	4,845.6	128.8

No.	Route Name	No. of Stops	Distance	Time	Pax	Pax-Km	Pax-Hr
21	PHHC (Homesite)-Central Market Loop	52	10.39	16.58	13,663.4	32,036.5	848.6
22	Dona Juliana-Central Market Loop	58	9.08	14.5	3,964.9	5,834.2	155.2
23	Bredco Port-Northbound Terminal via San Juan St. Loop	37	11.98	19.2	814.2	589.4	15.8
24	Pahanocoy (Cegasco)-Bacolod Government Center via Circumferential Rd. Loop	67	18.89	30.23	42,512.6	145,365.0	3,872.4

5.3. Network Evaluation

Figure 9 presents the route length comparison between the LPTRP-specified route length and the one reported under the PT Assignment model in CUBE. It is quite clear that there is a major disparity between them. As such, there is a need to establish a more reliable database on route length for each of the proposed LPTRP route as this is critical in conducting network-level analysis as basis for determining the optimal number of authorized units as well as the reasonableness of service plans.

Figure 10 presents the comparison of fleet size with various passenger demand parameters extracted from the CUBE model, namely, passenger and passenger-km based on linear model. It is quite intuitive to recognize that fleet size should increase in proportion to overall passenger demand. However, there seems to be no general correlation that will support this notion. Of course, there may be other factors to consider such as vehicle size and service characteristics such as headway and like but still there seem to be a disconnect between the fleet size determination from the LPTRP. A quick comparison between the SimEx computed fleet size results in better consistency as indicated in Figure 11.

Overall, there is a need to improve the reliability of fleet size computation to ensure that the LPTRP routes are responsive to passenger demand on the one hand and provides feasible route operations for prospective operators who will invest in modern PUV units. The concerned local government should also invest manpower and resources to ensure that local public transport planning are supportive of transitions in the local public transport sector.

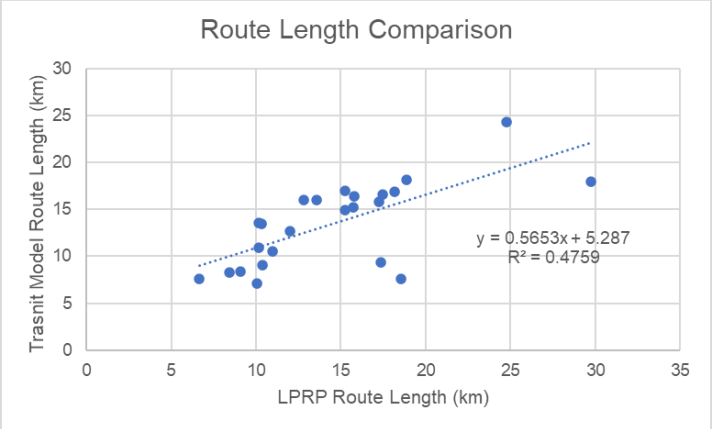


Figure 9: Route Length Comparison

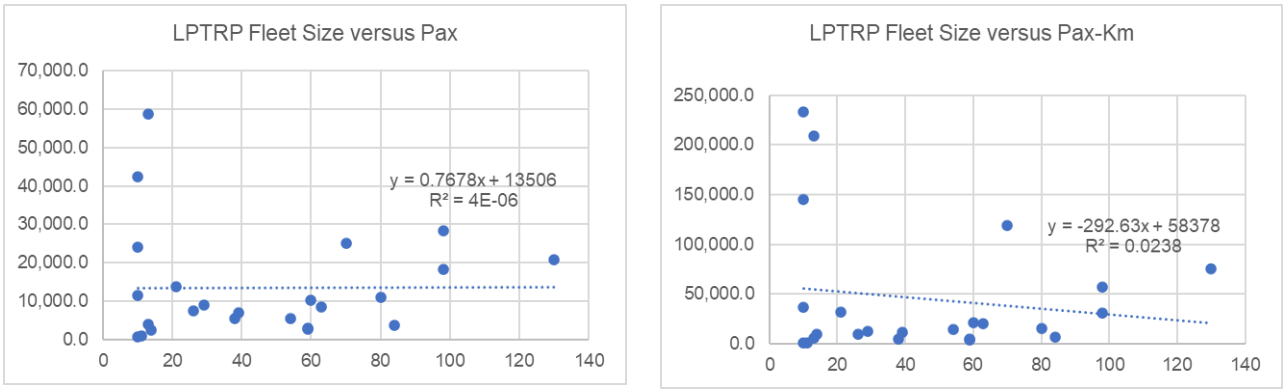


Figure 10: LPTRP Fleet Size versus Passenger Demand

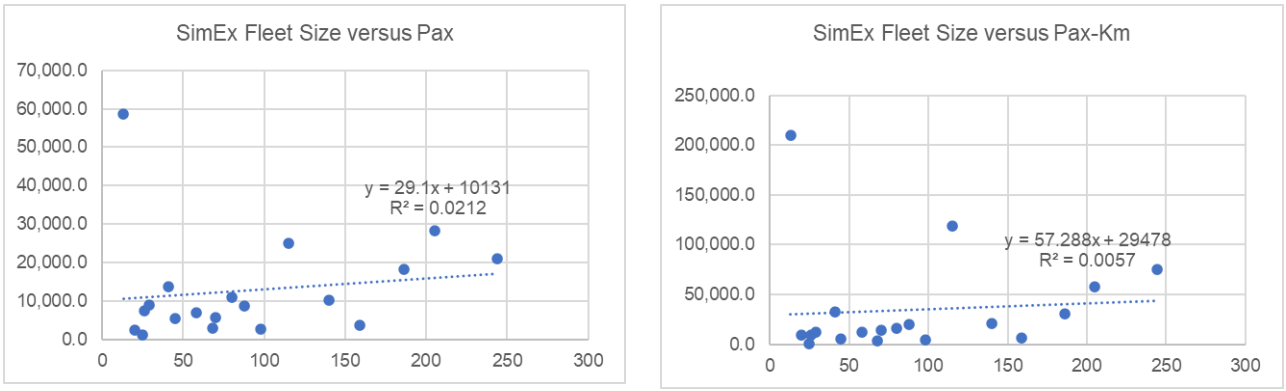


Figure 11: SimEx Fleet Size versus Passenger Demand

6. CONCLUSION

The study has demonstrated that participatory action research (PAR) can provide avenues for enhancing local public transport planning by harnessing the potential of collaboration among concerned stakeholders in evaluating the reasonableness and consistency of the LPTRP. This was clearly actualized in the conduct of the Bacolod City SimEx where local stakeholders took part in gathering the needed data to evaluate the fleet size determination and service plans in the LPTRP. The SimEx was supported by the deployment of the SafeTravelPH app which facilitate the gathering of precise data on travel times, dwelling times, turn-around times, boarding/alighting events, and passenger ridership. Being a mobile crowdsourcing app, the use of the SafeTravelPH application could not have been successful without the support and cooperation of stakeholders from the national government, local government, local public transport operators and academe partners.

The study has also outlined the need for network-level analysis of public transport operations in the context of fleet size determination among others. The development of a full-fledged PT assignment model is possible with the use of reading-available data from past transport planning studies and the conduct of actual field traffic surveys for model calibration.

Finally, the study points to the need to validate the results of the fleet size computations, technical as they are. The results of the Bacolod City SimEx have been transmitted to the LGU for their review and further actions. Moving forward, there is a need to develop better tools to assist decision-makers in making evidence-based decisions. For sure, the Bacolod City SimEx is just a very good starting point for succeeding applications of participatory action research in local public transport planning.

7. ACKNOWLEDGMENTS

The authors would like to thank the support of SafeTravelPH Mobility Innovations Organization Inc. for providing the necessary data and resources for the research. Also, we would like to acknowledge the support and cooperation provide by the Department of Transportation, the Land Transportation Franchising and Regulatory Board (LTFRB) and the local public transport stakeholders in Bacolod City for the successful conduct of the SimEx activity.

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