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RESEARCH ARTICLE OPEN ACCESS

Bus User Satisfaction Through Integrated Application (BUSINA): A Road for Sustainable Bus Management System

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Abstract:

In the modernization of transportation, bus management is outdated and ineffective to most commuters, especially along Jose Abad Santos Avenue (JASA). The improper pick-up and drop-off locations of buses are experienced since they stop anywhere the passenger is located for them to board and alight. These locations and times where the passenger's board and alight were pre-recorded were the baseline data to compare and see if there would be any improvements regarding the updated bus management system. The updated system will have a new plotted pick-up and drop-off location to maximize the effectiveness and efficiency of bus transportation. The proposed system will utilize guidelines, considering passenger demand, traffic patterns, and geographical constraints to dynamically improve passengers' experience using the bus as their mode of transportation. Along with this design is the Anylogic simulation tool, which indicates significant improvement, such as reduced travel time, congestion, and enhanced accessibility that the passengers may experience throughout their travel. In addition, a user-friendly application, BUSINA Mobile Application, was generated to further enhance passengers' experience through effortless navigation and tracking of the bus's arrival time. The proposed approach has provided new pick-up and drop-off areas that will ultimately enhance urban mobility and passenger satisfaction.

Keywords ***—bus management system, pick-up and drop-off locations, urban mobility, passenger satisfaction, travel time, accessibility***

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I. INTRODUCTION

A. Introduction and Review of Related Literatures

Public transportation is one key factor in urban mobility, impacting economic development and quality of life [1][2]. Factors influencing the use of public transport include accessibility, cost, and convenience [3]. Reference [4] highlights the economic implications of public transport systems. According to the American Public Transportation Association [5], Americans board public transit 34 million times each weekday, where 71% are employed and 7% are students. It reflects that riding public vehicles is included in their everyday lifestyle. Locally, only 22% of the whole population of the Philippines takes public utility vehicles (PUV), where 8.69 million use jeepneys, while 1.87 million hops on buses [6].

Urbanization sharply contributes to economic growth, particularly in Africa and Asia [7]. Arguments and evidence by Cheng and Chen [8] assert that better public transportation systems enhance urban connectivity and mobility.Accessibility to public transportation is an important variable affecting travel satisfaction [9]. several studies showed that the most appreciated characteristics of such

transportation systems are real-time information and quality of service [10][11]. The problem of sustainable urban transport may be answered with Agent-Based Models (ABM). Studies noted that the most critical key is a workable, effective, and efficient transport system. this methodology optimizes for minimal path and travel time, leading to better productivity and attention from workers [12][13]. The study findings have presented a contributory relationship between a well-functioning transport system and the general improvement of mobility and productivity at large [14]. Additionally, a review in public transport economics elaborated on the role of policies in shaping the transport system comprehensively [15]. Based on this fact, dimensions of sustainable development can be introduced into urban transportation system strategies by adopting advanced technologies that improve the level of service and satisfy commuters of public transport [16][17]. Furthermore, it highlights the increased need for the expedited and efficient construction of public transportation systems from triple vantage points: Urbanization, Economic Development, and Ecological Sustainability. overcoming such limitations by increased investment in knowledge and technology transfer to enhance their efficiency and accessibility would have to be well-advised by short-to-medium-term policymaking to satisfy a burgeoning demand from urban populations [18] [2].

B. Background of the Study

The study highlights issues of disorganized pick-up and drop-off (PUDO) locations, leading to traffic congestion and longer bus travel times [19]. To address this, a systematic approach is needed, starting with the identification of specific bus routes, exemplified by the selection of Jose Abad Santos Avenue (JASA) in Central Luzon, Philippines. JASA experiences congestion, requiring effective urban planning and transportation management strategies. The lack of proper PUDO points exacerbates the problem, necessitating enforcement of traffic regulations and service quality control [6].

C. Statement of the Problem

The efficiency of bus routes on the Jose Abad Santos Avenue (JASA) is significantly affected by disorganized pick-up and drop-off locations and a lack of management in waiting areas, directly impacting passengers' satisfaction and operational efficiency. Having no designated pick-up and drop-off locations is very time consuming, causing a delay for commuters because buses suddenly stop everywhere. In line with this, commuters do not know the exact time of arrival and real time location of buses. Other concerns have arisen regarding the interval travel time of buses in every terminal. Buses consume their respective interval time to wait for the possible commuters in terminal, but they do not know how many passengers will ride causing inefficiencies such as varying passenger counts, extended waiting times, and prolonged travel times.

D. Objectives of the Study

This study aims to obtain a sustainable public transportation system, particularly in buses, by plotting bus stop locations and managing bus system through BUSINA Bus Management System Mobile Application.

Specifically, this research aims to:

a.) Propose a layout of identified pick-up and drop-off locations in attaining the passengers' satisfaction using simulation tool.
b.) Develop a mobile application integrating application notification for passenger counting in the management of bus systems to attain operational efficiency for commuters.
c.) Assess the usability and acceptability of the mobile application to obtain the sustainable bus management system along JASA.

E. Scope and Limitations

This study aimed to enhance the bus management system along the Olongapo to Gapan City route. Passenger boarding and alighting data were employed to identify optimal pick-up and drop-off (PUDO) locations. This method spanned a week, starting at eight in the morning until the completion of a bus trip. An application was also introduced to provide real-time bus location tracking and estimated arrival times, improving management efficiency. Additionally, application notifications were employed to monitor passenger counts at terminals and PUDO locations. This study only focused on buses traveling along Jose Abad Santos Avenue (JASA) Road, excluding jeepneys, tricycles, and other transportation methods. However, this study did not formulate new traffic management schemes or existing guidelines set by the local traffic management authority.

METHODOLOGY

This chapter covered the methodological framework and specific research methodsused in conducting the study. The following sections comprised the research design, thesystem design, the research instrument and its validity, a list of materials/equipment, testingand procedure, data collection, data analysis, and ethical considerations.

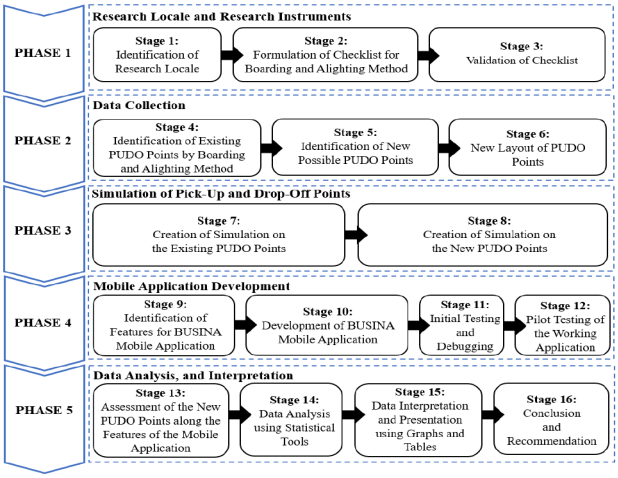


Figure 1: Methodological Framework

Figure1 illustrated the methodological framework of the study, which consists offive (5) phases:

For Phase 1, it discussed the research method and research instruments, where in quantitative research was used in the study. Specifically, an experimental design was utilized. A sample bus onboard checklist was used to gather information needed to complete thestudy's objective, including whether the plotted new layout of the PUDO locations alongthe features of the Bus Stop User Satisfaction through Integrated Application (BUSINA)Mobile Application was efficient and satisfied the commuters.

For Phase 2, it talked about the data collection, where the number of passengers who boarded and alighted the bus in specific pick-up and drop-off locations were counted manually. This was performed over seven days, during which passengers were counted in one round trip along the Olongapo to Gapan route and vice versa. After manually counting, the data were encoded, aiding the study in identifying potential areas for new PUDO locations. Then, the newly plotted pickup and drop-off locations along JASA Road were based on guidelines that contained various standard distances for every PUDO point, depending on the type of location.

Phase 3 discussed the simulation of pick-up and drop-off (PUDO) points, where the new pickup and drop-off locations, the data from the existing and new locations were encoded in the AnyLogic simulation tool. AnyLogic was used as a simulation tool to determine the difference between travel time, the current pickup and drop-off locations, and the newly designed points. The goal is to ensure that the newly designed pickup and drop-off locations meet passenger satisfaction and have less travel time than the current pickup and drop-off points.

Phase 4 was about mobile application development, which the new PUDO locations were rendered in the mobile application. This application, named BUSINA, was designed for the passengers and to operators. This mobile application had the following features:

a. Pick-up and drop-off points
b. Estimated time of arrival of the bus in each PUDO point.
c. The real-time location of the bus via Google Maps
d. Passenger count in every PUDO point, and
e. Application notification

Lastly, phase5 was about to the assessment of the new PUDO points along the features of the BUSINA mobile Application, where the mobile application was tested through the Accuracy Metrics Testing to ensure the system's performance. It was performed in several random locations around the study area, and numerous trials were conducted to assess the mobile application's usability and performance. The percent accuracy was calculated by dividing the number of correct predictions by the total number of predictions, then the quotient of the two was multiplied by 100%.

II. RESULT AND DISCUSSION

This chapter presented the results, discussion, and interpretation based on the data gathered using the instrument. The results and their interpretation were shown based on the identified specific problems.

A. Results on the Manual Counting of Passengers over a week

The findings were based on the seven-day manual counting of passengers on Jose Abad Santos Avenue (JASA) Road using the boarding and alighting method. These data were presented using line graphs that visually illustrated the number of passengers who boarded and alighted in a bus over a week, considering the time the bus stopped and moved.

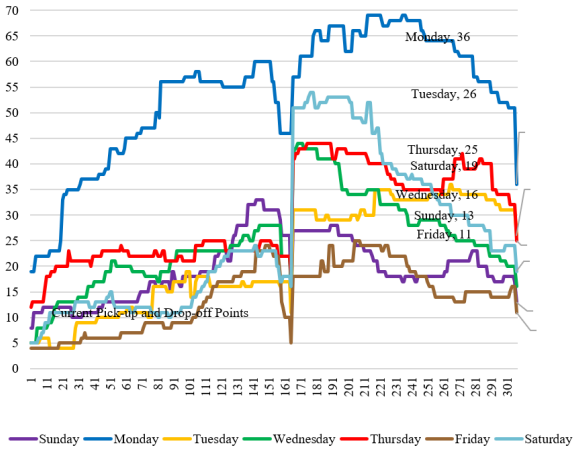


Figure 2: Line Graph about the Number of Passengers Boarded and Alighted the bus along JASA Road from Olongapo to Gapan over a Week

The result of the manual counting of passengers over a week along Jose Abad Santos Avenue (JASA) Road from Olongapo to Gapan was presented in Figure 2. It contained the number of passengers on the bus while traversing the current pick-up and drop-off (PUDO) locations along JASA Road from 8:30 a.m.to 3:00 p.m. Monday contained the most passengers on the bus over the week, which had almost 70 passengers inside the bus. In contrast, Friday had the least number of recorded passengers, with only 11 individuals remaining as it reached Gapan City. In addition, there was a sudden drop and rise in passengers between PUDO 161 and 171 as the bus reached SM City Pampanga, and some passengers got on and got off the bus in that location. It also stayed in that location for minutes, waiting for passengers to ride. It was noticeable in the figure that the number of passengers before reaching SM City Pampanga was fewer than the number of passengers after passing that location over a week.

The result of the manual counting of passengers over a week along Jose Abad Santos Avenue (JASA) Road from Gapan to Olongapo was presented in Figure 3. It contained the number of passengers on the bus while traversing the current pick-up and drop-off (PUDO) locations along JASA Road from 7:30 a.m. to 3:00 p.m. As shown in the figure, Monday contained the most passengers on the bus over the week, which had almost 56 passengers inside the bus. However, Friday had the least number of passengers recorded over the week, which contained 15 passengers inside the bus. There was a sudden drop in passengers between PUDO 134 and 141 as the bus reached SM City Pampanga, and many passengers got off the bus in that location. It also stayed in that location for minutes, waiting for passengers to ride. It was noticeable in the figure that the number of passengers before reaching SM City Pampanga was more than the number of passengers after passing that location over a week. Lastly, as the bus reached Olongapo City, all the passengers remained dropped off as it

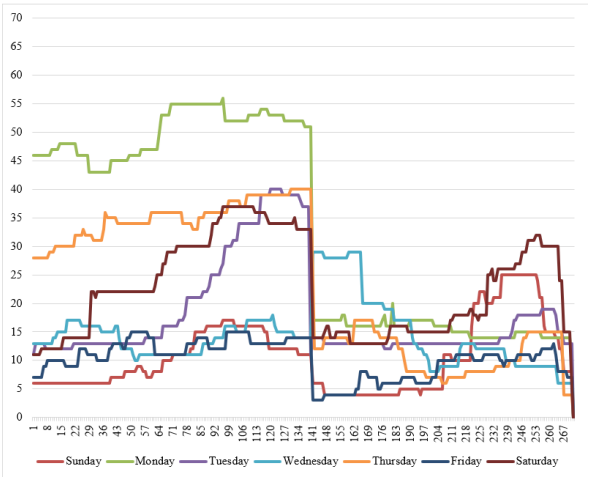


Figure 3: Line Graph about the Number of Passengers Boarded and Alighted the bus along JASA Road from Gapan to Olongapo over a Week

was the destination or the end of the bus trip.

Throughout the week of data collection, it appeared that most commuters on Jose Abad Santos Avenue (JASA) Road were centered in Olongapo City, SM City Pampanga, the Arayat Area, and the San Isidro-Cabiao-Gapan Area. These areas had the highest population density relative to the other towns along the JASA Road. Passenger activities in these high-concentration locations were dominated by SM City Pampanga and Robinsons Starmills, as well as their nearby areas in San Fernando, Pampanga.

These places had high passenger drop-off and pick-up rates for a reason. These places had a distinct status, with SM City Pampanga being one of the country's largest malls, attracting many people for leisure and shopping throughout the week. Moreover, San Fernando City was a Regional Government Center, housing key government offices and serving as a passenger hub, particularly with the presence of SM City Pampanga and Robinsons Starmills, which hosted terminals for various bus companies, jeepneys, and other modes of transportation connecting passengers to Manila and other economic centers in region 3 and Pampanga, such as Clark and Angeles.

Passengers from Olongapo and Gapan frequently stopped at SM City Pampanga and other locations in the City of San Fernando to take connecting trips to the National Capital Region and other parts of the province and region. There were also commuters from Zambales and Nueva Ecija provinces working in the City of San Fernando, which contributed to heavy passenger traffic, particularly on Mondays when these workers returned to the city (NEDA Regional Report 2020).

Gapan and Olongapo also had high passenger traffic since they functioned as transit hubs for their respective regions. Olongapo was the entryway to Zambales province, whereas Gapan served the province of Nueva Ecija. Dinalupihan and Lubao served as departure hubs for passengers from Bataan province. Passengers from Bataan might had wished to travel to Olongapo, Subic, or San Fernando, which were accessible via public utility buses on JASA, such as Arayat Express. Because of the concentrated population along JASA, the areas of Arayat and Mexico saw a significant volume of passenger pick-up and drop-off. This portion of JASA, which passed between Mexico and Arayat, was the narrowest segment of the highway, making it easy to pick up and drop off passengers.

Furthermore, Jose Abad Santos Avenue (JASA) was one of the country's largest significant highways, and being Region 3's principal road artery, it contributed significantly to its entire economic output. With the rapid development of communities and areas along JASA, the number of vehicles and passengers traveling on it continued to rise.

B. Results on the Proposed Layout of Pick-Up and Drop-Off Locations

After the manual counting of passengers along JASA Road for over a week, the proposed layout of pick-up and drop-off locations was generated based on the guidelines introduced in the previous chapter.

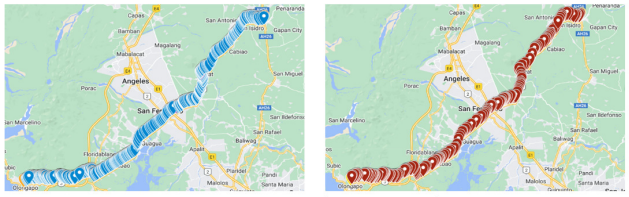


Figure 4: Point Maps showing the Proposed Pick-Up and Drop-Off Locations along JASA Road

Figure 4 presents the proposed pick-up and drop-off (PUDO) locations in the two routes along Jose Abad Santos Avenue (JASA) Road. There was a total of 324 points in the Olongapo to Gapan Route and a total of 217 points in the Gapan to Olongapo route. The proposed PUDO points were based on the guidelines mentioned in the previous chapter. Specifically, all streets along Jose Abad Santos Avenue (JASA) Road were designated as pick-up and drop-off points. An example was along the Lubao and Bacolor areas, where all

the major streets were pinned for pick-up and drop-off. Other contributing factors for these assigned PUDO points were Institutions or Facility Buildings located along JASA Road, such as churches, schools, hospitals, etc. Furthermore, certain distances were considered when plotting the proposed pick-up and drop-off points. There are two points had an interval distance of two kilometers measured between two points, particularly in the Bataan and Guagua areas.

The following scenarios were based on the guidelines, specifically Report 19 of the Transit Cooperative Research Program (TCRP), which stated that the ideal PUDO locations should be placed after the intersections. It was also stated that schools, churches, markets, and other significant locations should be given a specific spot to board and alight when PUDO locations were designed.

These guidelines also showed ideal specifications for the separations of PUDO between each intersection. Some areas in Bataan, specifically in Dinalupihan, could be considered rural, as they were sloped and no houses or establishments were built. Looking at Table 1, it could be possible to designate pick-up and drop-off locations in a minimum spacing of 800 meters.

These guidelines aim to design pick-up and drop-off locations that facilitate safe and effective bus operations while improving the transit experience for passengers. Most of the passengers who are using the public transport system along JASA Road are students and churchgoers. There are several churches and schools in the study area, as they are densely populated areas, which is the effect of economic attraction. Many other shops and restaurants, including convenience stores, are near these churches and schools. Businesses are attracted to these areas due to the high concentration of people, which will further contribute to a much higher rate of people in these areas. As a result, it is necessary to install a PUDO location in these areas. These points in these areas are also essential for the convenience of students and churchgoers who are always actively searching for available transport, which may result in illegal and unmonitored passenger activities, which can heavily affect the traffic in these areas. Designated PUDO points near churches and schools can help monitor passenger activity and organize traffic flow. According to an article by the Philippine News Agency on June 3, 2019, churches and schools are areas where heavy traffic flow is recorded in the Philippines. For this, designated and organized PUDO points in these areas are essential.

Having numerous streets, churches, schools, and business areas like markets along or connected to Jose Abad Santos Avenue, it was necessary to plot suggested pick-up and drop-off points along the highway from Olongapo City to Gapan City and vice versa. This condition affected the highway flow and traffic, hindering the development in areas and towns along JASA Road. According to the Local Traffic Management Authorities that manage the highway, JASA Road is next to Mc Arthur Highway, which has a high rate of traffic congestion that affects the region's economic activities and commuters. Installing PUDO points along the whole stretch of the highway can help ease the chaotic and unplanned PUDO points on the JASA road.

C. *Results on the AnyLogic Simulation Tool*

After plotting the proposed pick-up and drop-off (PUDO) locations along Jose Abad Santos Avenue (JASA) Road in two routes, the existing and the proposed PUDO locations were simulated using the Anylogic Simulation tool. This tool would determine if there was an improvement in the travel timebetween the two variables.

TABLE 1:
CASES AND SCENARIOS THAT CONSIDERED IN SIMULATING IN OLONGAPO TO GAPAN ROUTE

Case Number	Bus Terminal	Bus Stop	Daily Average Speeds
1	Without waiting time	Without waiting time	Actual daily average speed
2	With 15-minute waiting time	With 10-minute waiting time	Actual daily average speed
			Plus 2.5 kph to actual speed
			Plus 5 kph to actual speed
3	With 20-minute waiting time	With 10-minute waiting time	Actual daily average speed
			Plus 2.5 kph to actual speed
			Plus 5 kph to actual speed
4	With 30-minute waiting time	With 10-minute waiting time	Actual daily average speed
			Plus 2.5 kph to actual speed
			Plus 5 kph to actual speed

Table 1 showed the cases and scenarios that were considered in simulating the new pick-up and drop-off along Olongapo to Gapan Route.

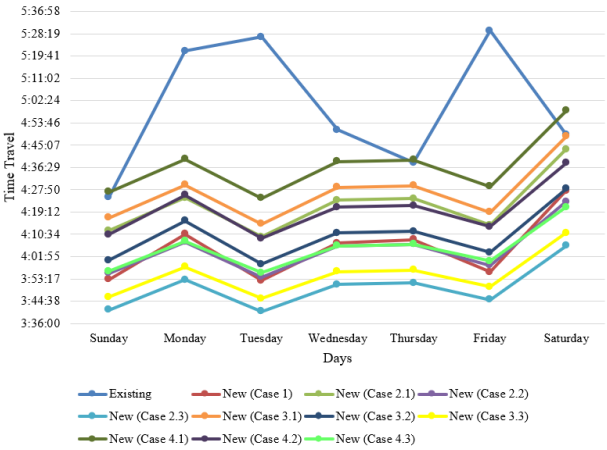


Figure 5: Travel Time for Existing and Proposed New PUDO Points from Olongapo to Gapan along JASA Road

Figure 5 showed the travel time for current and proposed new pick-up and drop-off locations from cases 1 through 4.3 along Jose Abad Santos Avenue Road in one week. All the proposed new pick-up and drop-off points offer significant time savings for passengers most days of the week, especially on Tuesdays. Each case shows a percentage improvement in travel time: Case 1 had 28.90%, Case 2.1 had 23.70%, Case 2.2 had 28.28%, Case 2.3 had 32.54%, Case 3.1 had 22.17%,

Case 3.2 had 22. 92%, Case 3.3 had 31.01%, Case 4.1 had 19.11%, Case 4.2 had 23.87%, and Case 4.3 had 27.96% with the new pick-up and drop-off Points. Implementing the new proposed pick-up and drop-off points along Jose Abad Santos Avenue Road could reduce passenger travel time. Case 2.3 appeared to be the most promising, offering the highest improvement of 32.54%.

After presenting the travel time of the existing and the different cases of proposed new pick-up and drop-off points from Olongapo to Gapan along Jose Abad Santos Avenue (JASA) Road, Table 2 showed the cases and scenarios that considered in simulating the new pick-up and drop-off along Gapan to Olongapo Route.

TABLE 2:
CASES AND SCENARIOS THAT CONSIDERED IN SIMULATING IN GAPAN TO OLONGAPO ROUTE

Case Number	Bus Stop	Average Daily Speed
1	Without waiting time	Actual daily average speed
2	With 10-minute waiting time	Actual daily average speed
3	With 10-minute waiting time	Plus 2.5 kph to actual speed
4	With 10-minute waiting time	Plus 5 kph to actual speed

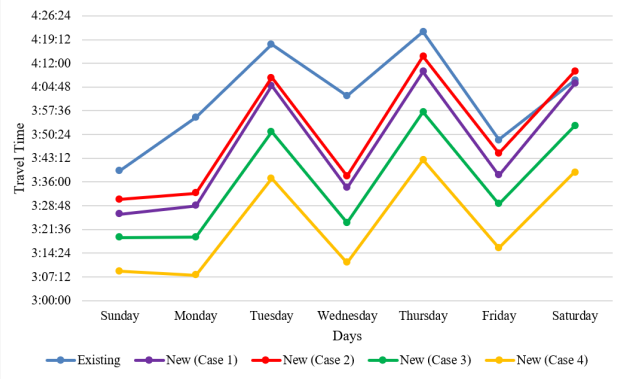
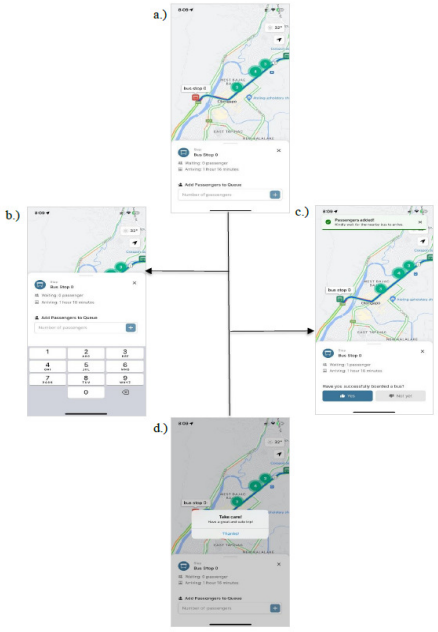


Figure 6: Travel Time for Existing and Proposed New PUDO Points from Olongapo to Gapan along JASA Road

Figure 6 visually explained the travel time for current and proposed new pick-up and drop-off locations along Jose Abad Santos Avenue Road in one week with Different Cases. The four proposed new pick-up and drop-off points offered significant time savings for passengers, especially on Mondays and Wednesdays. Each case showed a percentage improvement in travel time: Case 1 had 11%, Case 2 had 10%, Case 3 had 15%, and Case 4 had 20%. Out of the four proposed pick-up and drop-off points, the fourth proposal showed the most promising improvement, with a 20% improvement. Although the gaps were close to the existing and the four proposed new pick-up and drop-off points, the new pick-up and drop-off point from proposal four appeared to be the best choice for weekday commuters on Jose Abad Santos Avenue Road.



D. *Mobile Application Features*

After presenting the line graphs about the travel time of the existing and the new pick-up and drop-off locations, considering different cases in simulating along JASA Road, it was concluded that there was an improvement in travel time of the proposed new pick-up and drop-off points plotted. Therefore, the proposed points were rendered and put in a mobile application, BUSINA Mobile Application.

For user interface:

Figure 7: Creation and Verification of Account

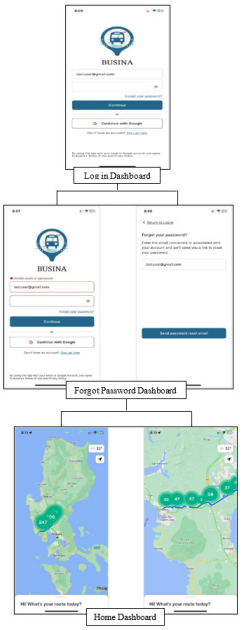


Figure 8: Log in and Forgot Password Dashboard

For bus operator interface:

Figure 10: Creation and Verification of Account

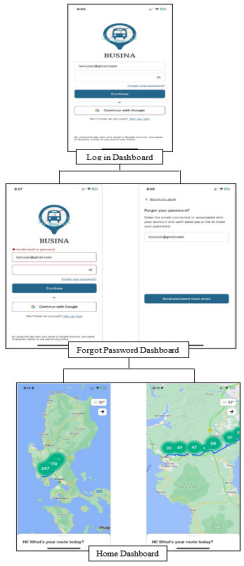


Figure 11: Log in and Forgot Password Dashboard

Figure 12: BUSINA Mobile Application Usage

The features and steps on how to use the BUSINA mobile application were presented and explained. Therefore, it could be tested for usability and the accuracy of it. Upon using the BUSINA mobile application, its accuracy was determined and calculated.

E. Accuracy Metrics Testing Results

The accuracy test for the mobile application was performed to see how precise it was regarding the estimated time of arrival (ETA) and real-time location (RTL). The estimated time of arrival on the application should be the same as when the bus will arrive at the commuter's pick-up and drop-off point. This was the crucial point of the application since this

would be its most important feature: seeing the duration of waiting time. Multiple trials were conducted for the mobile application testing to ensure its performance.

The formula used was:

$$Percent\ Accuracy = \frac{Number\ of\ Correct\ Prediction}{Total\ Number\ of\ Trials} \times 100\%$$

In testing the mobile application, there were a total of 25 trials and 24 of them got a correct prediction. Only 1 trial got an inaccurate of estimated time of arrival.

To solve it:

$$Percent\ Accuracy = \frac{24\ correct\ predictions}{25\ trials} \times 100\%$$

$$Percent\ Accuracy = 96\%$$

Therefore, the accuracy of using the BUSINA Mobile Application was 96%.

The following figures showed a sample of correct prediction and the one who got an inaccurate of estimated of arrival.

For correct prediction:

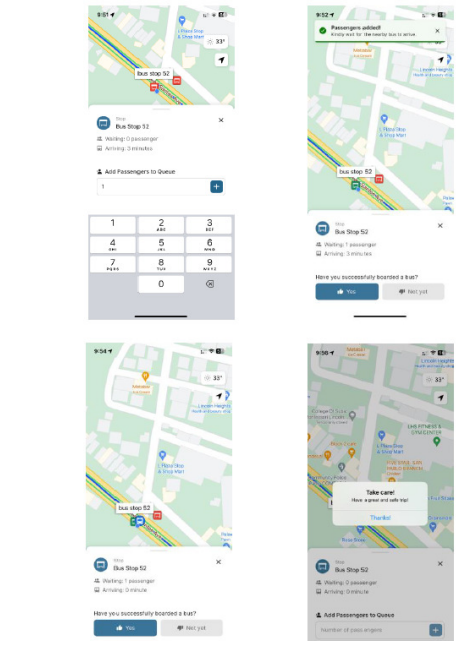


Figure 13: Correct Prediction in Testing

The passenger input one passenger for PUDO 52, and the ETA was calculated for the nearby bus; it was set at 3 minutes, as shown in Figure 13. After 2 minutes, the bus arrived, and it was ready to pick up the commuters in that PUDO. The trial was successful as the predicted arrival time aligned with the actual arrival of the bus.

For wrong prediction:

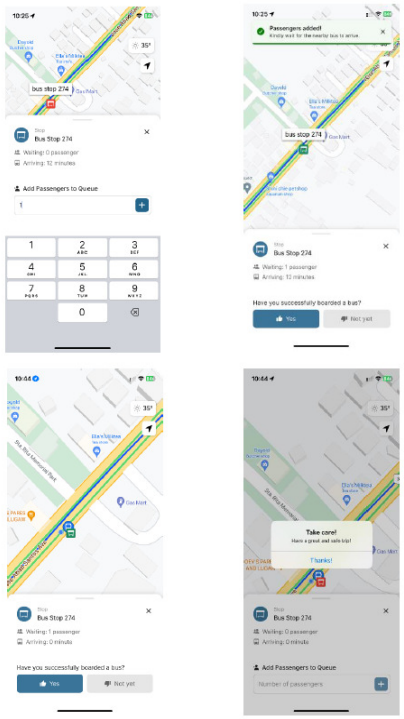


Figure 14: Wrong Prediction in Testing

In Figure 14, one passenger added and waited at the PUDO 274 as of 10:25 a.m. The application calculated the arrival of the nearby bus, and it showed that it would arrive in 12 minutes. The bus should have been there by 10:37, but unfortunately, the bus arrived at 10:44 a.m. It was inaccurate data since the bus was late by 7 minutes.

III.CONCLUSION

The Philippines faces different challenges of a growing population and economy, the need for reliable, accessible, and faster public transportation becomes even more noticeable. The efficient movement of goods, services, and people can improve by prioritizing technology, infrastructure, and policy reform funding. Wherein, improving the system for commuters and operators by providing mobile application for the efficient transportation system can be a major benefit.

The study compared the existing and new pick-up and drop-off point by AnyLogic as the simulation tool. Based on the findings, case 2.3 shows the most promising result with a 32.54% improvement on the Olongapo City to Gapan route. Case 2.3 is calculated with daily average speeds plus 5kph and includes a 10-minute waiting time at bus stops and a 15-minute waiting time at the terminal. On the other hand, for Gapan to Olongapo City route, case 4 shows the most significant time saving with a 20% improvement. Case 4 is calculated with daily average speeds plus 5kph and includes a

10-minute waiting time at the bus stops. Case 2.3 is the most recommended among the other cases.

For the recommendations to adapt, look for more reliable sources of actual speed time, minimize the number of PUDO, find advanced simulation tool, inclusivity, ensure security, improve accessibility, upgrade mobile app, and finally, the physical device at the bus stops.

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