Analysis of Customers' Expectations and Perceptions on the EDSA Carousel through Factor Analysis and Analytical Hierarchy Process

Reina Stefanie H. Aguilar
Department of Industrial Engineering
University of Santo Tomas
España Boulevard, Sampaloc, Manila, 1008, Philippines
reinastefanie.aguilar.eng@ust.edu.ph

Sofia Jeuel V. Alcoran
Department of Industrial Engineering
University of Santo Tomas
España Boulevard, Sampaloc, Manila, 1008, Philippines
sofiajeuel.alcoran.eng@ust.edu.ph

Alyzza Bianca G. Lopez
Department of Industrial Engineering
University of Santo Tomas
España Boulevard, Sampaloc, Manila, 1008, Philippines
alyzzabianca.lopez.eng@ust.edu.ph

Mardi Pauleann V. Taguines
Department of Industrial Engineering
University of Santo Tomas
España Boulevard, Sampaloc, Manila, 1008, Philippines
mardipauleann.taguines.eng@ust.edu.ph

Gabriel C. Bucu
Department of Industrial Engineering
University of Santo Tomas
España Boulevard, Sampaloc, Manila, 1008, Philippines
gcbucu@ust.edu.ph

Abstract

The Bus Carousel is one of the primary modes of transportation in EDSA. The factors identified were affordability, reliability, accessibility, environment, tangibility, comfortability, and safety. This study examines the relationship between variables identified to improve the public transportation service and establishes a recommendation for the problems to be discovered from the data collected via an online survey among passengers within a year. Through Factor Analysis, it was identified that the sub-factors that are relevant to each are pricing and budgeting for affordability, journey satisfaction for reliability, ease of access for accessibility, pollution exposure for the environment, customer service for tangibility, bus stop and bus conditions for comfortability, and personal safety and security for safety. 2-3 alternatives were determined for each sub-factor/criterion. Using AHP, the best decisions are to implement an automated payment system, create an incentive platform for e-payment, implement a real-time estimated time of journey from one station to another, provide/improve elevators and escalators that can accommodate

PWDs and Senior Citizens, invest in zero-emission buses and an emission tracker, implement a rush hour system, improve pathways with standard dimensions and ensure safety during loading and unloading, implement KPIs for buses status, and add security personnel and CCTVs on different stations.

Keywords
Customer Satisfaction, Expectation, Perception, Factor Analysis, Analytical Hierarchy Process

1. Introduction
The EDSA Carousel is a mode of public transportation service located in the Epifanio de los Santos Avenue (EDSA) where buses strictly operate in the innermost lanes (called the EDSA Busway) of EDSA with designated bus stops. Initially, the EDSA Carousel operates from 4:00 AM to 10:00 PM from Mondays to Sundays. However, as of June 22, 2022, the Department of Transportation announced that it will operate for 24 hours. The EDSA Carousel is a collaborative project of the Department of Transportation (DOTr), Land Transportation Franchising and Regulatory Board (LTFRB), Metropolitan Manila Development Authority (MMDA), and the Department of Public Works and Highways (DPWH). The bus companies allowed on this route are Mega Manila Consortium Corporation and ES Transport and Partners Consortium. It consists of 18 bus stops between MCU Median Stop (Monumento) and PITX Southbound while PITX to MCU Median Stop (Monumento) Northbound. As the Carousel operates in the innermost lane of EDSA, 13 bus stops (Monumento up to Buendia Station) are in the middle of the highway, where most are located underneath the MRT-1 line and LRT-1 line. 4 stops (Ayala, Taft, MOA, and Macapagal stations) have a curbside location while the PITX stop is near the PITX terminal. To access the said public transportation, passengers are to use footbridges and stairs inside the MRT to go up the bridge and use another set of stairs to go down to the actual platform. Manlifts or elevators are only available usually if the bus stop location is within the MRT station.

The project had its partial operations from June 1, 2020, to June 30, 2020, while it started its full operations on July 1, 2020. As this route has fixed bus stations, passengers are struggling with their revised route as some stations have bigger gaps in between, forcing passengers to find an alternative route. Queueing lines can also stretch up to thousands of meters as this is the only convenient public transportation that can be used within the said route. Initially, the cashless mode of payment forced passengers to purchase beep cards was eventually abolished. Underutilization of buses in the Carousel, with only around 200 out of 440 buses are deployed during rush hours, have also been identified as one of the major issues that needs to be addresses immediately. Furthermore, many accidents of buses hitting concrete and plastic barriers in the bus lane have been reported since its launch in 2020. Various Government programs such as the Libreng Sakay were also implemented.

Efficient operation of mass public transportation is a key in improving the living conditions of citizens in Metro Manila. Given that, this study aims to help authorities and lawmakers to utilize the results to weigh the advantages and disadvantages of urban transportation to improve service quality by providing well-researched data that concentrates on the passengers of EDSA Carousel. Through this study, improvement in transportation could help reduce the use of private vehicles that cause traffic congestion. This study aims to understand the factors that are relevant in achieving customer satisfaction as well as the problems/challenges the passengers of the EDSA Bus Carousel experience in relation to each factor identified. Considering these factors and corresponding challenges, the researchers need to determine and prescribe an intervention that address them accordingly.

1.1 Objectives
As thousands of commuters in Metro Manila use the EDSA Carousel as a mode of transportation, the study aims to identify the factors affecting the satisfaction of commuters during waiting periods, onboard, up to the unloading and getting off the actual station. Once all significant factors are identified, an effective intervention is to be proposed. The intention of this study is to make relevant and credible solutions that could help improve the quality of public transportation services in the Philippines.

Specifically, the researchers seek to identify the following objectives:
1. Identify the problems with the execution of EDSA Carousel.
2. Identify the methodologies, research design, mode of analysis, and tools to be used in measuring the satisfaction factors of EDSA Carousel passengers.
3. Gather information through surveys to identify the passenger's feedback to address the gap between passengers and the public transportation service.

4. Examine the relationship between variables identified to improve public transportation service.
5. Establish a recommendation to the problems to be discovered from the data collected via online survey among passengers within a year.

This study considered the dissatisfaction (non-attainment) of the intended service and outcomes of the EDSA Bus Carousel Service to its commuting experience. Figure 1 shows both the service, and its commuting experience is to be related. An analysis of their causal relationship is to be established based on the intended service and commuter satisfaction/experience factors identified earlier in this study through existing literatures and preliminary study. Once the relationship is established and all primary and significant factors are identified, the proposed service strategy was formulated through the identification and establishment of an effective intervention following the results of data gathering and analysis to be done in this study.

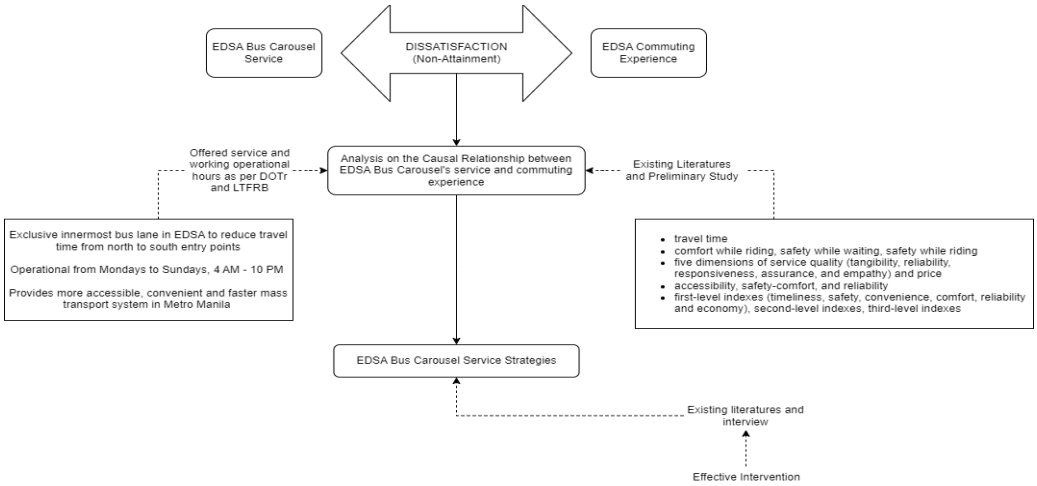

Figure 1. Research Paradigm

2. Literature Review

Compared to other bus routes in Metro Manila, EDSA Carousel has the most agreed number of allowable units (NAU) with 550 buses, according to LTFRB Chairman Martin Delgra. On June 17, 2021, LTFRB chairman Martin Delgra stated that only less than 400 units are operating on the EDSA Carousel out of the 550 NAU with an average of 182,000 passengers a day. However, on DOTr-LTFRB press release on October 18, 2021, only an average of 120-150 units were deployed causing longer queues in EDSA Monumento. The EDSA Carousel is far from being ideal despite its positive results. It is still low-capacity and low-quality as the plans were backed by obsolete information (Philstar 2021). The busway is still a work-in-progress, conforming to the basic acceptable global standards according to the Management Association of the Philippines Chairman Committee, Eduardo Yap.

There are 31 bus routes in Metro Manila. Figure 2 is the geographical map that outlines all Metro Manila bus routes including the EDSA Carousel where it is called Route. It runs between MCU Median Stop, EDSA, Monumento and PITX with an operating schedule of 4:00 AM to 11:00 PM, Mondays to Sundays. As the name suggests, the route passes through EDSA, complementing MRT as several MRT stations will have the same station as EDSA Carousel stops. There are also 2 LRT stations, Munoz and Balintawak that are accessible by the EDSA Carousel. However, even if it is connected to the MRT/LRT station, chances are that the EDSA Carousel could be accessible from one side only. Majority of the stations, if not connected to an MRT/LRT station, an existing overpass is the only way to enter the platform. Based on the researchers' observations, the stairs are steep, and long where PWDs and Senior Citizens might find it inaccessible as there is a lack of manlifts or escalators. According to DOTr communications and commuter affairs head Goddes Hope Oliveros-Libiran, MMDA and DPWH are planning to install lifters in certain areas only.

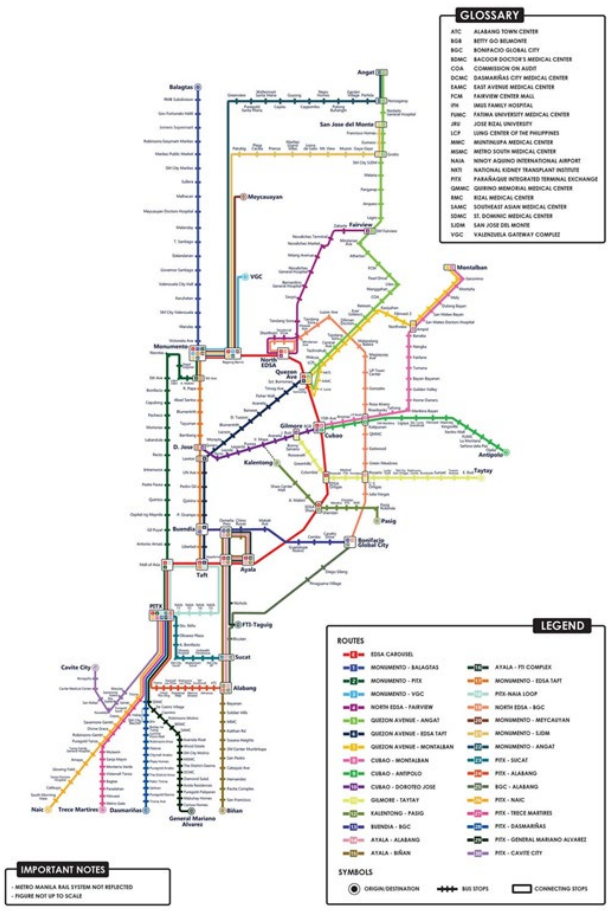

Figure 2. Rationalized Bus Transit Map (Metro Manila)

There are about 10% BRT systems located in lower-middle income and low-income countries (Malik et al. 2021). A comparison between importance-performance analysis and three-factor theory was conducted in assessing rider satisfaction with transit in Guangzhou, China, (J. Cao & X. Cao 2017) where the two alternative IPA, explicit and implicit IPA, identified service attributes differently but the improvement priorities were similarly produced. They were able to identify that comfort while riding and safety while waiting are two common basic factors, and safety while riding is a common key performance factor. Another method was used using satisfaction evaluation indicator systems from the point of view of passengers' perception with 6 first-level indexes (timeliness, safety, convenience, comfort, reliability, and economy) and 21 second-level indexes and evaluation was executed using multivariate analysis of variance (Weng et al. 2018). Boquet (2019) analyzed BRT as a potential solution to the traffic problems in Manila and Cebu wherein BRT was utilized to radiate routes outward from EDSA. The implementation of BRT in Metro Manila requires intensive planning and reorganization of the already existing transportation networks and services in the area. For EDSA alone, planned integration of BRT must be planned intensively according to the current transportation system. Further studies and analysis must be conducted to ensure proper integration.

A case study for MRT-3 user satisfaction was conducted by Mijares et. Al. in 2016 where the passenger satisfaction was modeled through ordered logit, with factors such as waiting time, in-vehicle time, fare levels, risk perception, and air quality perception that were considered significant explanatory variables while mental adaptation was also considered through surveys in MRT-3. As there are higher satisfaction ratings on medium/high income groups, a part of its suggestions is to improve bus services to serve as an alternative public transportation along EDSA and other parts of Metro Manila.

For Malik et. al. factors affecting BRT users' (dis)satisfaction are usually set aside, not attaining the priority it deserves until the issues become worse and costlier to control. Still, their team conducted a study on the BRT system located in the megacity of Lahore, Pakistan. Primary data was obtained through on-site structured interview surveys using intercept method and the 5-level Likert scale from BRT passengers. The extraction method was conducted through principal axis factoring, and varimax with kaiser normalization was used for the rotation method. The researchers utilized 3D and 2D visual comparisons of the extracted factors that were based on scree plot's elbow cutoffs for easier understanding. To focus more on the preference factor in using the BRT, the users' priority was according to the 'saves money' factor, scheduling, comfort, other unspecified reasons, then avoids congestion. In 2015, Mouwen conducted a study which aimed to further analyze the relevant factors that influence customer satisfaction with public transport. It was revealed in the study that public transport users found certain attributes the most important in determining satisfaction with public transport services which is on-time performance, travel speed, and service frequency, followed by personnel/driver behavior and vehicle.

Given the restrictions and limitations on the capacity of public transportation during the pandemic, passengers are having a harder time commuting. Due to the halt of the pre-existing public transportation and restrictions, only a few commuters (mostly frontliners) are availing and in need of the service causing drivers and operators to temporarily stop service resulting to an agonizing commute for passengers. A reinforcement done by the government is the EDSA Carousel. However, as early as its development, issues have risen regarding the service. Marquez (2020) discussed the payment system of the service since it only accepts payments using Beep cards. Due to this, DOTr suspends this mandatory payment system and allows cash payments until further notice. Long queues have always been a problem with the service, especially during rush hour. In April 2022, a 2-km long queue was recorded for the commuters waiting to avail the service (G. M. A. News 2022).

Factor Analysis is a multivariate statistical technique used to reduce large numbers of variables into fewer numbers of factors. This tool extracts maximum common variance from all variables and puts them into a common score. Cabacungan and German (2021) presented a study on customer awareness and satisfaction analysis on the use of motorcycle taxi in the Philippines which identified significant factors and determining the level of satisfaction of customers. Meng, et.al (2016) introduced a study on public transport service satisfaction using factor analysis focused on a case study of Jiangsu Long-Distance Passenger Transport. A variable system was constructed to evaluate the public transport service satisfaction and data was collected through questionnaires and processed by factor analysis.

Analytical Hierarchy Process (AHP) is a tool for multi-criteria decision making which allows individuals to objectively weigh attributes and factors, and evaluate alternatives presented. In a 2019 study (Mayo & Taboada), analytical hierarchy process was used in ranking factors affecting public transport mode choice of commuters in an urban city (Metro Cebu) of a developing country. A recent study by Lam, et.al (2021) evaluated customer satisfaction in bus transportation using AHP model to propose a conceptual framework in order to identify the priority of decision criteria in the selection of intercity bus transportation companies among passengers. The study also determined the most preferred intercity bus transportation companies using the AHP model. The journal of Zhang, et.al (2020) focused on the evaluation of passenger satisfaction of urban multi-mode public transport used a combination of the analytical hierarchy process (AHP), entropy weight method (EWM), and fuzzy comprehensive evaluation (FCE) to improve the accuracy of customer satisfaction evaluation for public transportation.

3. Methods

The study analyzes the dissatisfaction of passengers as it relates to the non-attainment of the EDSA Bus Carousel service and EDSA Carousel Commuting Experience. An analysis of the causal relationship between these two facets is to be conducted. This considered the offered service of the EDSA bus carousel as well as existing literature and preliminary studies. Once this relationship is established, the factors affecting the dissatisfaction were identified. An evaluation and redesign of the service are provided based on the analysis and responses of the passengers. As shown in Figure 3, the research starts by identifying the underlying problem in EDSA Carousel, specifically the factors that influence customer satisfaction. By identifying the problem, a review of related literature was conducted to bridge the gap between the problem and existing studies. Past studies are a crucial point to the study as these serve as the basis for the methodology. The researchers conducted surveys online and in-person interviews. Factor Analysis, Customer Satisfaction Index (CSI), and Analytical Hierarchy Process model were used for analyzing the data. Lastly, conclusions and recommendations were drawn out from the results.

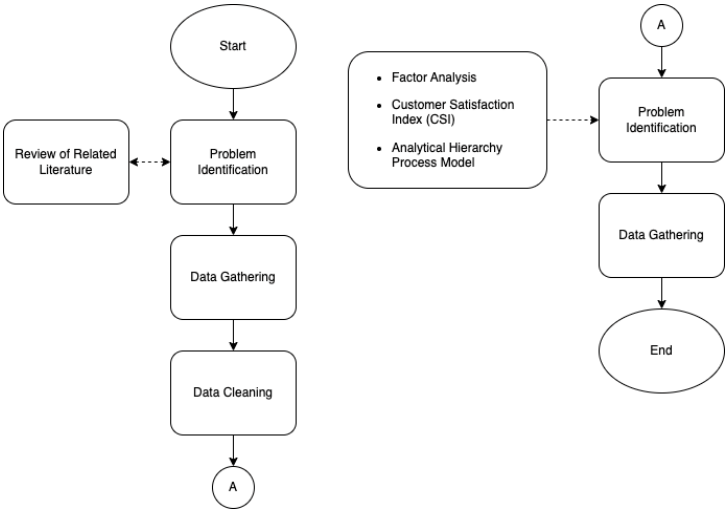

Figure 3. Research Design

3.1 Hypothesis Testing

This study adopted the hypotheses stated below:

H_i: factor i of the bus services in EDSA Carousel has
a significant positive relationship with customer satisfaction.

where:
i: general dissatisfaction factors (1 = affordability, 2 = reliability, 3 = accessibility, 4 = environment, 5 = tangibility, 6 = comfortability, 7 = safety)

4. Data Collection

The study focuses on the riders using the EDSA Bus Carousel as a mode of public transportation. The respondents chosen for this study are from the Philippines, specifically those who are in the working age population class whose age ranges from 15-64 years old. To examine the factors that affect rider satisfaction, the researchers obtained data from commuters of the EDSA Bus Carousel. For this study, the focus was on the workers commuting/availing of the service. The criteria for qualifications of the respondents of this study are age, last experience riding the service, frequency of use of the service (ridership), and monthly income.

Table 1. Respondents' descriptive statistics (N = 201)

Characteristic	Category	n	%
Age	Below 15 years old	2	1.0%
	15 - 25 years old	110	54.7%
	26 - 41 years old	66	32.8%
	42 - 57 years old	21	10.4%
	58 - 64 years old	1	0.5%
	65 years old and above	1	0.5%
Last experience riding the service	Before March 2020 lockdown	30	14.9%
	During March 2020 to May 2020	1	0.5%
	During Partial Operations of EDSA Bus Carousel	7	3.5%
	During Full Operations of EDSA Bus Carousel	163	81.1%
Frequency of use of the service (ridership),	Once or twice a month	104	51.7%
	Once or twice a week	32	15.9%
	Thrice a week or more	65	32.3%

Monthly Income	Below PhP 10,957	82	40.8%
	PhP 10,957 - PhP 21,914	59	29.4%
	PhP 21,914 - PhP 43,828	44	21.9%
	PhP 43,829 - PhP 76,698	5	2.5%
	PhP 76,699 - PhP 131,484	7	3.5%
	PhP 131,483 - PhP 219,140	0	0.0%
	PhP 219,140 and above	4	2.0%

5. Results and Discussion

5.1 Factor Analysis

For the first stage of the study, the proponents used factor analysis using the SPSS Software by converting the collected data into functions to analyze their corresponding values. The Not Applicable or 'N/A' option in the survey was announced as '0' but declared as 'Missing' in the SPSS software. This is to consider that the questions may have "Not Applicable" instances to the respondents. For the initial result, 9 sub-criteria were created from the initial 45 questions: For Affordability, Pricing and Budgeting are the sub-criteria. Journey Satisfaction for Reliability, Ease of Access for Accessibility, Pollution Exposure for the Environment, Customer Service for Tangibility, Bus Stop Condition and Bus Condition for Comfortability, and lastly, Personal Safety and Security for the sub-criteria of Safety.

5.2 Proposed Improvements

The researchers provided several solutions for each sub-criterion.

Table 2. Possible Solution Alternatives

Alternative	Sub-Criteria	Solutions	Reason
A1	Pricing	Proper training for conductors in km-based standard payments	The rates vary per bus and conductor despite having the same route.
A2	Pricing	Automated payment system	
A3	Pricing	Optimal value for fixed fare price (VAM)	
A3	Budgeting		
A4	Budgeting	Incentive platform for e-payments; earn points for every peso spent	Through an incentive platform, passengers get a chance to earn points to use as cash as the EDSA Carousel is only free from 4 am to 11 pm.
A5	Budgeting	Strategic program for gradual implementation of price fare matrix and still fund a percentage of the program	Customers can still have time to adjust according to their budget when the fares increase partially.
R1	Journey Satisfaction	Annual maintenance checkups on bus conditions	Annual maintenance prevents unnecessary accidents and breakdowns as EDSA Carousel buses are reused and refurbished to be qualified as buses for the EDSA Carousel.
R2	Journey Satisfaction	Real-time estimated time of journey from station A to B	The implementation of an estimated journey time from station A to B could provide customers with great convenience as there is an inconsistent estimated time of arrival per bus per station.
AC1	Ease of Access	Proper lines for PWDs, Senior Citizens, and Pregnant Women	There are no priority lanes in any EDSA Carousel stations.

AC2	Ease of Access	Elevators and escalators that can accommodate PWDs and Senior Citizens	Some bus stations lack escalators and elevators. Most bus stations can only be accessed by a flight of stairs, some of which are steeper than others, making them inconvenient or inaccessible to PWDs, SCs, and pregnant women.
AC3	Ease of Access	Strategic locations to accommodate more passengers while ensuring their safety, security, and convenience	There are stations that are difficult to reach from one means of transportation to another, as well as stations with narrow pathways, very low ceilings, and steep staircases.
E1	Pollution Exposure	Proper ventilation and enforce safety standards	The EDSA Carousel bus stations are in the middle of EDSA, exposing the passengers to a variety of illnesses brought on by air pollution.
E2	Pollution Exposure	Zero Emission Buses and an emission tracker	This will lessen EDSA's existing emissions and cut carbon footprint release
T1	Customer Service	Improved routes and signages to easily be seen and understood (e.g.in-transit signboards)	Some bus way directions are only printed through bond papers and posted beside cashiers at MRT/LRT Stations making it not visible to everyone
T2	Customer Service	Rush hour system especially on stations with high-volume passengers	There are fewer buses after 11 PM up to 4 AM which causes inconsistency and inconvenience to the customers.
T3	Customer Service	Regular schedule for bus stations	There is an inconsistent estimated time of arrival per bus per station. Also, there are lesser bus after the free ride program/
C1	Bus Stop Condition	Proper pathways with standard dimensions and ensure safety during loading and unloading	There are narrow walkways that are not passable but considered as pathways.
C2	Bus Stop Condition	Standard maintenance schedule for cleaning and sanitizing of Edsa Carousel Stations	The passengers are exposed to different kinds of diseases that are caused by air pollution.
C3	Bus Stop Condition	Improve waiting shed roofing and provide seats with priority for PWDs and SCs	Some bus stations' roofs don't completely shield customers from the sun's harsh rays, the heat, and rainfall.
C4	Bus Condition	Provide automated speed tracker and anti-overloading system	Certain bus drivers drive too quickly and brake harshly. Also, some buses tend to overcrowd, endangering the passengers.
C5	Bus Condition	Provide KPIs for buses	Providing metrics to track the status of the buses in relation to safety, security, etc. can be used as data to find ways for improvement
S1	Personal Safety & Security	Implement a safer barricade for the bus	Some passengers have been known to climb the barricades and cross the EDSA Highway. Accidents result from this, which may result in traffic and risk.
S2	Personal Safety & Security	More lights, security personnel and CCTVs on different stations	Authorities are only located inside the station, which is difficult to access due to long lines. Some stations lack sufficient lighting, security, or CCTV, which increases their vulnerability to danger and criminal activity.
S3	Personal Safety & Security	Proper Queueing Lines	Customers who responded to the poll expressed that they felt obliged to wait in line outside the station, which is a walkway outside the highway.

5.3 Analytical Hierarchy Process

The proponents assessed the seven (7) criteria by deriving their priorities (in weights) through pairwise comparison. The judgments were then checked through the consistency index and consistency ratio of 8.96% and 6.79% respectively which means that there is no bias in the judgment of the proponents. Two to three (2-3) alternative solutions were generated per sub-criteria generated two to three (2-3) alternative solutions per sub-criteria which were

based on qualitative feedback and suggestions, research studies, and even journal articles. Each alternative was assessed by deriving its priorities (in weights) through another set of pairwise comparisons per sub-criteria. Afterward, the proponents derived local priorities (preferences) for the alternatives per sub-criteria by multiplying the weight of an alternative by their respective sub-criteria and criteria.

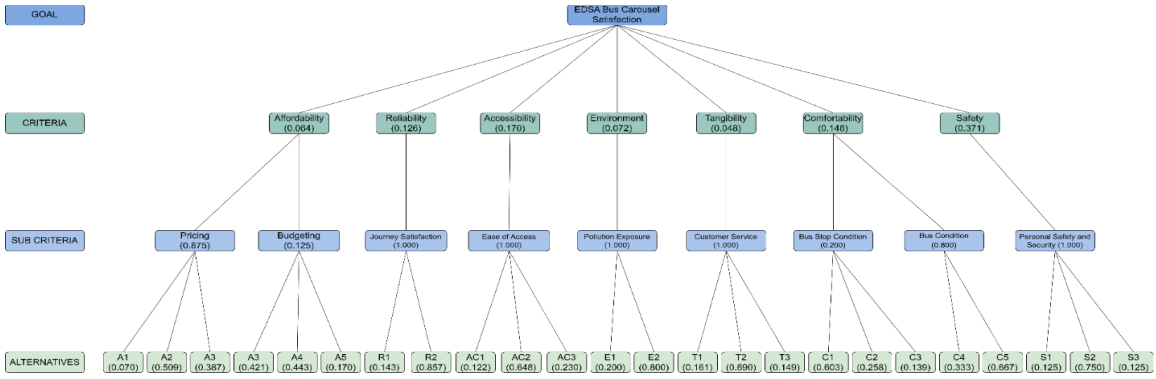

Figure 4. Decision Tree

The pairwise comparison matrix of the criteria and sub-criteria formulated by the researchers according to relative importance are shown below. The relative intensity of importance between each criterion and sub-criterion was determined through a focused group discussion involving 5 passengers of the EDSA Bus Carousel.

$$C = \begin{Bmatrix} 1 & 1/3 & 1 & 1/2 & 1 & 1/3 & 1/7 \\ 3 & 1 & 1/2 & 2 & 4 & 1 & 1/5 \\ 1 & 2 & 1 & 2 & 3 & 1 & 1 \\ 2 & 1/2 & 1/2 & 1 & 1 & 1/2 & 1/5 \\ 1 & 1/4 & 1/3 & 1 & 1 & 1/5 & 1/7 \\ 3 & 1 & 1 & 2 & 5 & 1 & 1/4 \\ 7 & 5 & 1 & 5 & 7 & 4 & 1 \end{Bmatrix}$$

Figure 5. Pairwise Comparison Matrix

Table 3. Pairwise Comparison Matrix for each Criteria with more than 1 Sub-Criterion

Criteria	Pairwise Comparison Matrix
Affordability	$SC_A = \begin{Bmatrix} 1 & 7 \\ 1/7 & 1 \end{Bmatrix}$
Comfortability	$SC_C = \begin{Bmatrix} 1 & 2 \\ 1/2 & 1 \end{Bmatrix}$

The relevance and importance of the proposed alternatives with respect to each criterion were also identified.

Table 4. Pairwise Comparison Matrix for each Sub-Criterion

Criteria	Sub-Criteria	Pairwise Comparison Matrix
Affordability	Pricing	$AF_P = \begin{Bmatrix} 1 & 1/9 & 1/5 \\ 9 & 1 & 1 \\ 5 & 1 & 1 \end{Bmatrix}$
	Budgeting	$AF_B = \begin{Bmatrix} 1 & 3 & 1 \\ 1/3 & 1 & 1/2 \\ 1 & 2 & 1 \end{Bmatrix}$

Reliability	Journey Satisfaction	$R_{JS} = \begin{Bmatrix} 1 & 1/6 \\ 6 & 1 \end{Bmatrix}$
Accessibility	Ease of Access	$AC_{EA} = \begin{Bmatrix} 1 & 1/5 & 1/2 \\ 5 & 1 & 3 \\ 2 & 1/3 & 1 \end{Bmatrix}$
Environment	Pollution Exposure	$E_{PE} = \begin{Bmatrix} 1 & 1/4 \\ 4 & 1 \end{Bmatrix}$
Tangibility	Customer Service	$T_{CS} = \begin{Bmatrix} 1 & 1/4 & 1 \\ 4 & 1 & 5 \\ 1 & 1/5 & 1 \end{Bmatrix}$
Comfortability	Bus Stop Condition	$CO_{BSC} = \begin{Bmatrix} 1 & 4 & 3 \\ 1/4 & 1 & 3 \\ 1/3 & 1/3 & 1 \end{Bmatrix}$
	Bus Condition	$CO_{BC} = \begin{Bmatrix} 1 & 1/2 \\ 2 & 1 \end{Bmatrix}$
Safety	Personal Safety & Security	$S_{PSS} = \begin{Bmatrix} 1 & 1/6 & 1 \\ 6 & 1 & 6 \\ 1 & 1/6 & 1 \end{Bmatrix}$

The overall priorities of each alternative for each criterion and sub-criterion are determined using AHP.

Table 5. Overall Priorities (Model Synthesis)

	AF		**R**	**AC**	**E**	**T**	**CO**		**S**	
	0.064		0.126	0.170	0.072	0.048	0.148		0.371	
	AF_P	**AF_B**	**R_{JS}**	**AC_{EA}**	**E_{PE}**	**T_{CS}**	**CO_{BSC}**	**CO_{BC}**	**S_{PSS}**	
Criteria Weights	0.875	0.125	1.000	1.000	1.000	1.000	0.200	0.800	1.000	
Combined	0.056	0.008	0.126	0.170	0.072	0.048	0.030	0.119	0.371	Overall
A1	0.070									0.004
A2	0.509									0.029
A3	0.421									0.024
A3		0.387								0.003
A4		0.443								0.004
A5		0.170								0.001
R1			0.143							0.018
R2			0.857							0.108
AC1				0.122						0.021
AC2				0.648						0.110
AC3				0.230						0.039
E1					0.200					0.014
E2					0.800					0.058
T1						0.161				0.008
T2						0.690				0.033
T3						0.149				0.007
C1							0.603			0.018
C2							0.258			0.008
C3							0.139			0.004
C4								0.333		0.040

C5	0.667	0.079
S1	0.125	0.046
S2	0.750	0.279
S3	0.125	0.046

Highlighted rows in table 5 show the solutions the best possible decision to make for each factor. For example, the solution A2 or the implementation of an automated payment system is the most desirable decision for affordability in terms of pricing with an overall priority of 0.029. For budgeting, the identification of the optimal value for a fixed price through the creation of an incentive platform for e-payments is the best possible decision with an overall priority of 0.004.

5.4 Validation

The study was presented and discussed to 2 panelists (both industry and academe practitioners). Focus group discussions with passengers of the service with regards to the solutions were done as well. No concerns or negating feedback were raised with regards to the model synthesis and overall results.

6. Conclusion

As efficient operation of mass public transportation is a key to improving the living and commuting conditions of citizens in Metro Manila, the Bus Carousel is one of the primary modes of transportation in EDSA. Starting operations in 2020, the service has offered transportation to passengers within the EDSA highway. This study fills the gap between customers' expectations and perceptions towards the EDSA Bus Carousel services.

The researchers based their criteria on several studies and other credible online resources regarding public transportation, especially on Bus Rapid Transit and Public transportation in order to identify and consider all the factors necessary to identify the customers' perception and satisfaction. From here, seven (7) criteria were made: Affordability, Reliability, Accessibility, Environment, Tangibility, Comfortability, and Safety. A total of forty-five (45) sub-criteria were created. The researchers utilized factor analysis through the SPSS software on the data that was obtained through an online survey where the forty-five (45) sub-criteria was reduced to nine (9) sub-criteria: Pricing, Budgeting, Journey Satisfaction, Ease of Access, Pollution Exposure, Customer Service, Bus Stop Condition, Bus Condition, and lastly, Personal Safety and Security. The proponents determined the importance of the criteria and their sub-criteria through relative weights using Analytical Hierarchy Process.

Several alternatives were identified and weighted according to their relevance and impact. The chosen alternatives have the greatest overall priority, serving as a guide that these alternatives can create a better impact compared to other suggested alternatives.

References

Arguja, A., DOTr's Libreng Sakay ridership reaches 1.4 million. PhilStar Wheels. https://wheels.ph/news/2020/07/29/19251/dotrs-libreng-sakay-ridership-reaches-1-4-million/, July 29, 2020.

Boquet, Y., BRT in the Philippines: A Solution to Manila and Cebu Traffic Problems? IOP Conference Series: Earth and Environmental Science, vol. 338, no. 1, pp. 012005, 2019.

Bucu, G., Salvador, A., Ngo, J., & Lugay, C., Service Quality Assessment of Local Government Units' COVID Pandemic Response using Factor Analysis, Proceedings of the International Conference on Industrial Engineering and Operations Management, pp. 3030-3041, Monterrey, Mexico, November 3-5, 2021.

Cao, J., and Cao, X., Comparing importance-performance analysis and three-factor theory in assessing rider satisfaction with transit. Journal of Transport and Land Use, vol. 10, no. 1, pp. 65-68, 2017.

Galvez, D., LTFRB: Less than 400 buses serve up to 182,000 Edsa Busway commuters daily, Available: https://newsinfo.inquirer.net/1447464/ltfrb-less-than-400-buses-serve-up-to-182000-edsa-busway-commuters-daily, June 17, 2021.

German, J. D. and Cabacungan, A. D. H., Customer Awareness and Satisfaction Analysis on the Use of Motorcycle Taxi Applications in the Philippines, 2021 IEEE 8th International Conference on Industrial Engineering and Applications (ICIEA), pp. 637-642, Chengdu, China, April 23-26, 2021.

Kyriazos, T., Applied Psychometrics: Sample Size and Sample Power Considerations in Factor Analysis (EFA, CFA) and SEM in General. Psychology, vol. 09, no. 08, pp. 2207–2230, 2018.

Lam, W., Lam, W., Yeoh, H., Fong, C., and Yeap, I., Evaluation on the Customer Satisfaction in Intercity Bus Transportation Using Analytic Hierarchy Process Model, Advances in Material Science and Engineering, pp.

Malang, A., Manlapas, L., Rivera, P., and Young, M., Application of Integer Programming in Maximizing of Public Utility Bus Passengers during COVID-19 Pandemic in Select Bus Stops in Epifanio Delos Santos Avenue (EDSA), 2020 7th International Conference on Frontiers of Industrial Engineering (ICFIE), pp. 135-141, Singapore, Singapore, September 27-29, 2020.

Marquez, C., Mandatory use of beep cards along Edsa busway halted — DOTr., Available: https://newsinfo.inquirer.net/1343510/mandatory-use-of-beep-cards-along-edsa-busway-halted-dotr, October 4, 2020.

Mayo, F., and Taboada, E., Ranking factors affecting public transport mode choice of commuters in an urban city of a developing country using analytic hierarchy process: The case of Metro Cebu, Philippines. Transportation Research Interdisciplinary Perspectives, vol. 4, pp. 100078, 2019.

Mijares, A., Suzuki, M., and Yai, T., Passenger Satisfaction and Mental Adaptation under Adverse Conditions: Case Study in Manila. Journal of Public Transportation, vol. 19, no. 4, pp. 144–160, 2016.

Mouwen, A., and Rietveld, P., Does competitive tendering improve customer satisfaction with public transport? A case study for the Netherlands. Transportation Research Part A: Policy and Practice, vol. 51, pp. 29–45, 2013.

Tugade, A., Omnibus Guidelines on the Planning and Identification of Public Road Transportation Services and Franchise Issuance, Available: https://ltfrb.gov.ph/wp-content/uploads/2017/11/DO-2017-011.pdf, 2017.

Zhang, X., Liu, H., Xu, M., Mao, C., Shi, J., Meng, G. and Wu, J., Evaluation of passenger satisfaction of urban multi-mode public transport. PLoS ONE, vol. 15, no. 10, e0241004, 2020.

Biography

Reina Stefanie H. Aguilar is an undergraduate student at the Department of Industrial Engineering of the University of Santo Tomas. She served the UST Industrial Engineering Circle (UST-IEC) as an Executive Associate to the Secretariat from 2021-2022 and currently, she is an Executive Associate for Academic Development. She has been a member of the Operations Research Society of the Philippines - UST Chapter since 2019. She recently garnered a certification in Lean Six Sigma Yellow Belt and is currently specializing in Quality Engineering.

Sofia Jeuel V. Alcoran is an undergraduate student at the Department of Industrial Engineering of the University of Santo Tomas. She served the UST Industrial Engineering Circle (UST-IEC) as the Vice President for External Affairs from 2021-2022 and the Philippine Institute of Industrial Engineers - National Student Chapter (PIIE-NSC) as the Head Ambassador from 2020-2021 and as an ambassador from 2019-2020. She previously served as the Executive Associate and Executive Coordinator for UST-IEC's External Affairs department from 2019-2021. She recently received her certification in Lean Six Sigma Yellow belt and is currently specializing in Quality Engineering

Alyzza Bianca G. Lopez is an undergraduate student at the Department of Industrial Engineering of the University of Santo Tomas. She served the Operations Research Society of the Philippines – UST Chapter (ORSP-UST) as the Vice President for Academics and Research from 2021-2022. Currently, she is the Vice President for Academic Development of the Industrial Engineering Circle (UST-IEC) after serving as an Executive Associate for 2 years starting in 2019. In 2022, she was part of the winning team of UPCIEM's IESHIKAWA Hackathon. She is currently specializing in Operations Research and Analytics.

Mardi Pauleann V. Taguines is an undergraduate student at the Department of Industrial Engineering of the University of Santo Tomas. Since 2019, she is a member of the Operations Research Society of the Philippines – UST Chapter and UST Industrial Engineering Department. She is currently an Executive Associate for Academic Development of the Industrial Engineering Circle. She recently earned her BOSH certification as a Safety Officer 2 and is currently specializing in Production Engineering. At present, she is specializing in Production Engineering.

Gabriel C. Bucu is a graduate of Bachelor of Science in Industrial Engineering at the University of Santo Tomas (UST) and a graduate of Master of Science in Industrial Engineering at De La Salle University-Manila. He served as the Department Head and Supervisor from 2019-2022 of the Industrial Engineering Program and currently, he is an Instructor at the UST Department of Industrial Engineering and is specializing in Service Engineering and Management. He is a Certified Industrial Engineer (CIE) awarded by the Philippine Institute of Industrial Engineers (PIIE) and an Associate Engineer (AAE) awarded by the ASEAN Federation of Engineering Organizations (AFEO). He has presented in several conferences both locally and overseas, in countries including Indonesia, Taiwan, Japan,

and South Korea. His research interests include Optimization and Simulation, Design Thinking, and Supply Chain Engineering and Management.