COMPREHENSIVE SUSTAINABLE URBAN MOBILITY PLAN FOR THE CURRENT MASS TRANSPORTATION SYSTEM FOR THE METROPOLITAN AREA OF PANAMA WITH METROTAXIS
PLAN INTEGRAL SUSTENTABLE DE MOVILIDAD URBANA AL SISTEMA ACTUAL DE TRANSPORTE MASIVO PARA EL ÁREA METROPOLITANA DE PANAMÁ CON LOS METROTAXIS

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	ABSTRACT
Keywords: metrotaxis, integrated, mobility, transport.	This research seeks to design a comprehensive urban mobility plan to address the problems caused by poor selective public transport service, considering factors of effectiveness, efficiency and social impact, with the aim of improving the quality of life of residents and guaranteeing a safe, efficient and sustainable public transport system in Panama City. It seeks to develop short-term strategies and action plans, considering various components of the current urban mobility system. The current system initially consisted of the first two subway lines. Immediately the feeders were attached to reach the places that geographically the subway could not access, which were called MetroBus. The way the city is structured makes it even more difficult for buses to access, so the need to add another system to the current mass transportation is appropriate due to: places that, due to the structure of the roads, it is not feasible for a MetroBus to access, for security reasons that current taxis are used as camouflage to commit robberies or that they are victims. This last one being integrated (compensated), and the single integrated system would use the same access card without the need to use cash and likewise, drivers with a fixed base salary. The goal of this research is to offer innovative solutions that improve the transportation network and provide reliable and safe tools to achieve an organized city recognized as a benchmark in urban mobility.

|	**RESUMEN**
Palabras clave:	La presente investigación tiene como objetivo diseñar un plan de movilidad urbana integral para abordar las problemáticas causadas por

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metrotaxis, integrado, movilidad, transporte.	el servicio deficiente de transporte público selectivo, considerando factores de eficacia, eficiencia e impacto social, con el propósito de mejorar la calidad de vida de los habitantes y garantizar un sistema de transporte público seguro, eficiente y sostenible en la ciudad de Panamá. Se busca desarrollar estrategias y planes de acción a corto plazo, considerando diversos componentes del sistema actual de movilidad urbana. El sistema actual consistió inicialmente en las dos primeras líneas de metro. Inmediatamente se le anexaron los alimentadores para llegar a los lugares que geográficamente no podía acceder el metro la cual se denominaron MetroBus. La manera como se encuentra estructurado la ciudad, dificulta aún más el acceso de los buses por lo que la necesidad de anexar otro sistema al actual de transporte masivo es lo adecuado debido a: lugares que, por la estructura de las vías, no es factible que acceda un MetroBus, por temas de seguridad que los taxis actuales sean utilizados como camuflaje para cometer robos o que los mismos sean víctimas. Este último al ser integrado (indemnizado), ya el sistema integrado único utilizaría la misma tarjeta de acceso sin la necesidad de utilizar dinero en efectivo y de igual modo, los conductores con un salario base fijo. La meta de esta investigación es ofrecer soluciones innovadoras que mejoren la red de transporte y aporten herramientas confiables y seguras para lograr una ciudad organizada y reconocida como referente en movilidad urbana.

Introduction

Within the structure of large cities, selective public transport plays an essential role. One of the greatest challenges facing public administrations in Panama City, which also includes the district of San Miguelito, is to achieve a system that meets the needs of the inhabitants. Efficient public transport will not only improve the quality of life of citizens, but will also facilitate sustainable and economic development adapted to the needs of the population (Arévalo, 2016).

Figure 1
Nomenclature Sectors for the Districts of Panama and San Miguelito
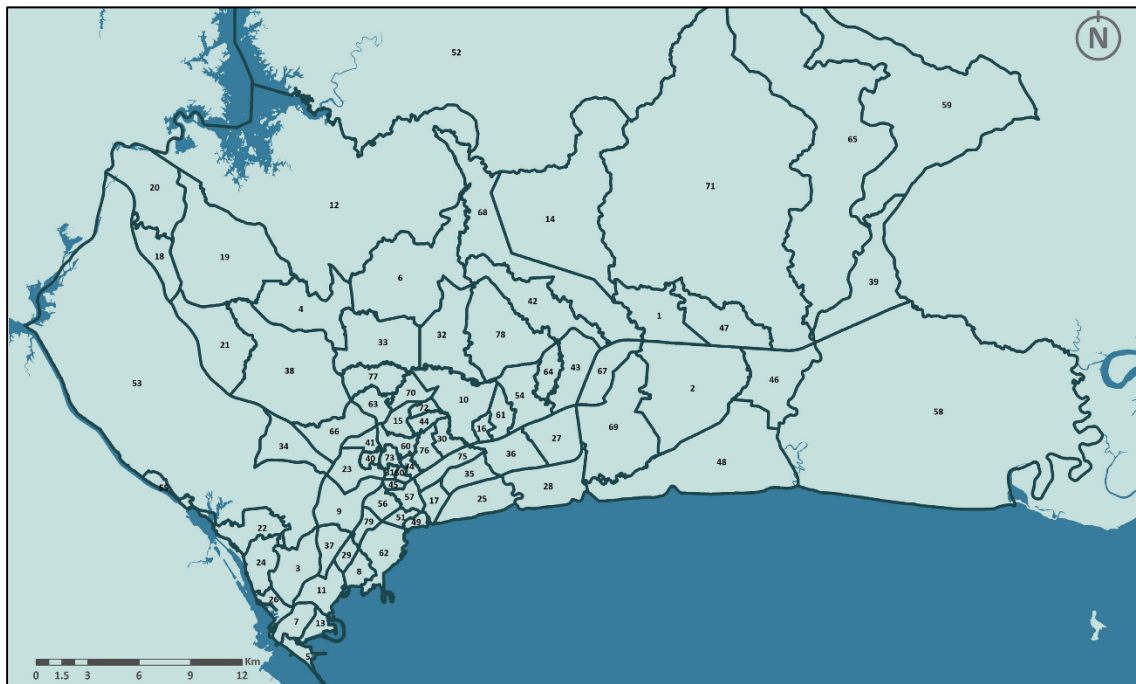
Note. Adapted from *Nomenclature System for the District of Panama* (p. 16), by Steer Davies, 2018, Manual of Graphic Standards.

Table 1

Sectors of the District of Panama and San Miguelito

ID	Name	ID	Name	ID	Name	ID	Name
1	December 24 North	21	Chilibre South	41	Los Andes 2	61	San Antonio
2	December 24 South	22	Clayton	42	Mañanitas North	62	San Francisco
3	Albrook	23	King's County	43	Mañanitas Sur	63	San Isidro
4	Mayor Diaz	24	Corozal	44	Hand of Stone	64	San Joaquin
5	Amador	25	East Coast	45	Monte Oscuro	65	St. Maarten
6	Bachelor	26	Diablo	46	Pacora Center	66	Bahai Temple
7	Balboa	27	Don Bosco	47	Pacora North	67	Tocumen Downtown
8	Bella Vista	28	Don Bosco South	48	Pacora South	68	Tocumen North
9	Betania	29	The Crab	49	Panama Viejo	69	Tocumen South
10	Brisas del Golf	30	The Crucible	50	Paradise	70	Torrijos Carter
11	Calidonia	31	The Hammer	51	Lefevre Park	71	Utivé
12	Long Causeway	32	Ernesto Cordoba Campos East	52	Chagres National Park	72	Urracá Valley
13	Historic Center	33	Ernesto Cordoba Campos West	53	Sovereignty Park	73	Veranillo
14	Cerro Azul	34	Rod Carew Stadium	54	Pedregal	74	Villa Guadalupe
15	Cerro Batea	35	Olympic Garden	55	Pedro Miguel - Paradise	75	Villa Lorena
16	Cerro Viento	36	Juan Diaz	56	Pueblo Nuevo	76	Villa Lucre
17	Chanis	37	The Locería	57	Rio Abajo	77	Villa Zaíta
18	Chilibre Center	38	Las Cumbres	58	Rio Chico	78	Villalobos
19	East Chilibre	39	Las Garzas	59	Indian River	79	Vista Hermosa
20	Chilibre North	40	Los Andes 1 - 9 de Enero	60	Samaria		

Note. Adapted from *Nomenclature System for the District of Panama* (p. 16), by Steer Davies, 2018, Manual of Graphic Standards.

The development of Panama's metropolitan area has experienced poorly planned growth, driven mainly by the real estate market and with deficient legislation in terms of planning, execution and control tools. During the last 60 years, development has been explosive and discontinuous, which has generated a linear structure in three different directions, with residential uses predominating in the periphery and labor activities concentrated in the center of the metropolitan area. This situation has resulted in complicated mobility for inhabitants, with long commutes to work and study centers, congestion on the few roads available, and high urban land costs (Metro de Panamá, 2016).

In recent years, specific projects have been carried out to improve mobility conditions in the metropolitan area, focusing in particular on Panama City, which also includes the district of San Miguelito. One of the main advances has been the implementation of the MetroBus system, along with the first two Metro lines, which are part of the city's current mass transit system (Metro de Panamá, 2016).

The way the city is structured makes bus access even more difficult, so the need to add another component to the current mass transportation system is appropriate due to: places where, due to the structure of the roads, it is not feasible for a MetroBus to access, also due to insecurity issues that the current cabs are used as camouflage to commit

robberies or that the cabs themselves are victims of robberies. The latter, when integrated (indemnified), would allow the use of the same multimodal access card for the current components of the mass transit system, both MetroBus and Metro de Panama, without the need to use cash. Similarly, that drivers have a fixed base salary (Metro de Panamá, 2016).

The difference of this project with respect to the various studies carried out on the cab system would be that apart from being part of an integrated system with the Metro and MetroBus, the fleet of Metrotaxis would first be well identified and labeled in accordance with the corporate image of the system.

In order to support the contribution of the research, we mention, among others, some previous studies where solutions to a similar need were presented in such a way that gaps in previous research can be raised to justify the objectives of the research.

Table 2
Previous investigations

Previous studies	*Disadvantages or peculiarities*
Economic Commission for Latin America and the Caribbean (ECLAC). Following successful examples in several cities around the world, a first effort to improve public transportation systems was undertaken in Latin America. This was achieved through the construction of rail systems in large cities, with the objective of counteracting the disadvantages and negative effects of conventional transportation that had prevailed in the region (Pardo, 2009).	These rail systems represented a significant improvement in the quality of transportation services in several Latin American cities. However, this improvement was limited to the specific routes where they were established, leaving the other traditional public transportation routes in the city untouched (Pardo, 2009).
The Andean Development Corporation (CAF) launched the Urban Mobility Observatory (OMU) in Latin America to address the lack of up-to-date and reliable information on transportation and mobility in the region. The project began with the analysis of 15 metropolitan areas in 9 countries in the region and showed that Panama City is not the only one facing these challenges (Fonseca, 2012).	The OMU found that the private transportation model predominates in the 15 cities studied, as a result of the irregular concession of services. The vehicles that use the road system most intensively are cars and individual cabs, accounting for 85% of total trips according to the CAF report (Fonseca, 2012).
To address the growing need for urban mobility in the city of Maracaibo municipality, Zulia state, the Presidential Transportation Commission in Maracaibo, Venezuela, implemented a policy aimed at introducing a collective transportation system that is in line with transportation and urban policies (Velásquez, 2015).	As a result of this initiative, the development of the Maracaibo Metro began, with the objective of offering an effective solution to the mobility challenges facing the city. The insertion of the subway in the city is currently positioned as a scenario that evidences a disarticulation between the policies of intervention of the desirable public space and the development models of the means of transportation that facilitate its mobility. The impact, as a good practice for transportation planning, was minimized by not considering diversity, accessibility

	and qualification of its public spaces, as indicators for mobility management (Velásquez, 2015).

Method

Design

The type of study carried out in the research was based on the construction of a theoretical and practical frame of reference. The main objective is to become familiar with a novel topic, so an exploratory or formulaic approach was used. This approach served as a starting point for further in-depth studies (FUNIBER, 2020).

The type of study proposed has little precedent in terms of its theoretical model or practical application, since no other studies have been conducted on the subject. Therefore, a theoretical compilation was sought due to the absence of a specific model related to the research problem. This work could serve as a basis for further research in the future (Vásquez, 2005).

To achieve the proposed objectives related to the variables to be measured, the collection of two types of information was considered: primary information and secondary information. The primary information was based on a series of field studies previously conducted by Metro Panama and financed by the Inter-American Development Bank. Secondary information included data from the latest Population Census (2023), the Economic Census prepared by the National Institute of Statistics and Census (INEC), and city databases with information related to population, household size, family income, among others. These data were combined with the surveys to estimate generation rates and trip matrices (Metro de Panamá, 2015 - 2016, p. 7).

It should be noted that initially secondary information was collected from textbooks, followed by field research with interviews that provided primary and updated information on the object of study.

The surveys were carried out with the support of the collaborators. The information obtained was then processed manually, starting with tabulation, graphs, analysis and interpretation of the results.

Once the information was collected, it was processed and analyzed to generate the necessary inputs to build the supply and demand models, as well as the transportation model.

Research Hypothesis

H_1: carrying two or even three different races or people on the same trip affected the time of the user boarding the vehicle in the first instance, as well as his or her safety.

H_2: the distribution of cab operation certificates indiscriminately by the competent authority exceeded the ratio between the number of inhabitants.

H_3: The fact that there are different cab owners from the same cab stand has caused vehicle races and accidents and congestion at the stops, in order to get to the passenger first.

Population and Sample

To determine the sample size, the formula for infinite population was used (Fernandez, 2010), since being a place where the greatest demand is concentrated, a survey was applied to the sample population, in this case, the metropolitan region of Panama City which also includes the district of San Miguelito, which according to

information from the National Institute of Statistics and Census (INEC) of the Comptroller General of the Republic of Panama, of the amount of 1,311,075 inhabitants it comprises, we will take 1.1%, which includes 14,461 inhabitants that are equivalent to a population of 10 years of age and older living in private households that, due to their activity, have a monthly household income of less than USD 1000.00 per month (US dollar), taking into account that the current average minimum wage is USD 769.00 per month (Hernández, 2023). To generate the sample, criteria such as the activities developed in the area, the potential for attracting and producing trips and the accessibility to the stations of the Metro Lines were used, seeking to generate the optimization of the users' way to the different transportation systems. Applying the formula, we obtain the following representative sample of 171 people, equivalent to 20% of the selected population (Office of the Comptroller General of the Republic of Panama, 2023).

The following formula was used to calculate the sample:

$$n = \frac{N * Z_\alpha^2 p * q}{d^2 * (N-1) + Z_\alpha^2 * p * q} \tag{1}$$

Where:

n = sample size = 171 persons
N = total population = 14,461

1. **Zα** = 1.645 squared (if safety is 90%)
2. **p** = expected proportion (in this case 20% = 0.20)
3. **q** = 1 - p (in this case 1-0.20) = 0.80
4. **d** = margin or precision (5% = 0.05)

$$n = \frac{14461 * (1.645)^2 * 0.20 * 0.80}{(0.05^2 * 14461 - 1) \quad + \quad (1.645^2 * 0.20 * 0.80)} \tag{1.1}$$

$$n = \frac{14461 * 2.7060 * 0.16}{(0.0025 * 14460) \quad + \quad (2.7060 * 0.16)} \tag{1.2}$$

$$n = \frac{6261.03456}{36.15 + 0.43296} \tag{1.3}$$

$$n = \frac{6261.03456}{36.58296} \tag{1.4}$$

$$n = 171 \tag{1.5}$$

Variables

The following were considered:
1. Historical research: establishment of background of previous studies similar to this research.

2. Satisfaction analysis: deepening in the impact factor that gave rise to the problem of dissatisfaction with the transportation service and showing recommendations that achieve safety, commitment, comfort and punctuality of the user and the efficiency of Metrotaxis in their integration to the current mass transportation system.
3. Investments and service adjustments: the external and internal thresholds with the greatest impact on the problem of dissatisfaction with the cab transportation service for users in Panama were determined.
4. Transportation alternative: an investigation was carried out on the positions of the carrier and the user regarding the selective public transportation service provided.
5. Adaptations and operating capacity: the current situation of the cab sheds, administration area, service operations and cab fleet were evaluated in detail.

Table 3
Data collection

Variables	Instruments
Historical research	Observation
Satisfaction analysis and transportation alternative	Survey
Service adequacy and operating capacity	Observation

Research Instrument

Having clear objectives in order to obtain better results, the computer and specialized programs were used as tools according to the particular variable of data collection that was required. In accordance with the nature of the data collected, both quantitative and qualitative research instruments were used.

In order to measure variables and analyze trends, the questionnaire was used to conduct surveys and subsequently evaluate the questions to ensure their reliability. Initially, in the case of the surveys, this was done by coding, and in the case of the quantitative results, by tabulation (Parra, 2023).

Similarly, regarding service adequacy and operating capacity as a proposal for operational planning, direct observation took place where the service will operate, which was a useful method for identifying inefficiencies or bottlenecks. The daily activities within the service were observed, which allowed the identification of operational problems such as delays, misused resources and redundant processes.

After submitting the collation instruments to consultation, in the opinion of the experts, it met two quality criteria, both in terms of validity and reliability. Content validity was frequently determined in two main contexts. One of them was related to the design of the test, while the other concerned the validation of an instrument that has undergone translation and standardization processes, with the purpose of adapting it to different cultural meanings (Robles, 2015). The validation of the instruments by the experts was based on the report of the Integral Plan for Sustainable Urban Mobility (PIMUS), specifically adjusted to this research, which at the time focused on selective public transport type cab however, the project was not implemented. Panel of experts composed of Metro de Panamá S.A., the Transit and Land Transportation Authority, the Municipality of Panama and the consulting group (Cal y Mayor Asociados - IBI Group).
1. Primary sources: in addition to the in-depth survey, techniques used included participant and non-participant observations. This allowed us to know the information provided by the users of the selective public transportation

system, obtaining valuable information with this data (Secretaría de Desarrollo Urbano y Ecología, 2022) as well as to observe directly how the service operates and is carried out. Observations on operational aspects, efficiency, interaction with users, and other relevant factors.

2. Secondary sources: secondary data were obtained through magazines, books, demographic databases, websites and articles related to the topic of urban mobility in the metropolitan area of Panama (Manrique, 2004).

Results

At present, the platform does not intend to compete directly with the already known commercial and private houses, but seeks to further integrate a system under the same common single payment umbrella. The choice of an appropriate transportation model required the evaluation of several aspects, such as: the scale of the policy-making environment, the problem being addressed, the degree of precision and level of detail, both spatial and analytical of the expected results, the availability of data and the resources that were available for its own development.

Satisfaction Survey and Data Analysis

With respect to the analysis of satisfaction and transportation alternative, the data were processed and analyzed in two ways:

1. Data processing: in the case of quantitative results, this was done by tabulation, followed by the use of statistical tables.
2. Data analysis: the research process on the integrated urban mobility plan for the current mass transit system was developed using a mixed approach. A qualitative approach was used to discover and refine the research questions, while the quantitative approach was used to collect and analyze data to answer the research questions and test previous hypotheses (Sampieri, 2003), relying on the extraction of conclusions and meanings from unstructured and heterogeneous data that are not extracted in a quantifiable or numerical form to accurately establish patterns of behavior in a population. The reproduction of a large number of data sources, of different origins and formats, makes it very often necessary in this research to analyze qualitative data using special techniques and tools such as observation and surveys. To facilitate statistical analysis, the questions were closed. We used software that facilitated the task of analyzing massive data from heterogeneous sources in digital format, such as the SurveyMonkey Internet tool. This tool allowed us to feasibly extract data patterns that could answer the questions of our analysis.

The data obtained were grouped, classified, and organized in tables and statistics showing the results in order to facilitate analysis, including brief notes on the finding. The surveys were used to analyze the attitudes of carriers and users regarding the selective public transportation service provided.

Question 1

How many different routes of public transport, either selective and/or collective, do you use per day to move around the city?

Table 4

Different public transportation routes, whether selective and/or collective, used daily to move around the city

Responses	Selection	Percentage
One	57	33%
Two	87	51%
Three	16	9%
More than three	11	6%
Total	**171**	

Findings and data analysis: the majority voted that they use approximately two routes per day, including transfers.

Question 2

Approximately how long does it take you to travel on selective public transportation units per day?

Table 5

Travel time on selective public transport units for daily commuting

Responses	Selection	Percentage
Less than one hour	44	26%
One hour	91	53%
Two hours	25	15%
Three hours	11	6%
More than three hours	0	0%
Total	**171**	

Findings and data analysis: we can observe that people can take hours on selective public transport and it is for this reason that improvements should be made to get people to their destinations faster.

Question 3

Have you used any mobile application for selective public transport use?

Table 6

Use of mobile application for selective public transport use

Responses	Selection	Percentage
Yes	13	8%
No	158	92%
Total	**171**	

Findings and data analysis: the question was very loose on whether or not they use applications for public transportation, but where NO with 92%, i.e., people do not download applications on the mobile because all those that are, are bad and / or deficient.

Question 4

How would you rate the city's selective public transportation system, where 1 represents the lowest score and 5 the highest.

Table 7

Rating you would assign to the city's selective public transportation system

Responses	Selection	Percentage
1	101	59%
2	23	13%
3	25	15%
4	13	8%
5	9	5%
Media	**1.9**	
Total	**171**	

Findings and data analysis: in the question we want to know how people who use selective public transport rate the system, which earns a 1.9 which means how deficient it is.

Question 5

What aspects do you consider to be the most important for the provision of a selective public transportation service in Panama City?

Table 8

Aspects considered to be the most important for the provision of selective public transportation services in the city

Responses	Selection	Percentage
Security	122	71%
Punctuality	43	25%
Cleaning	2	1%
Cost	4	2%
Total	**171**	

Findings and data analysis: what people would value most about transportation is security, either because of fewer robberies or because women would feel safer when riding selective public transportation. Secondly, it is punctuality, i.e., the time in which it arrives or the time in which we arrive at our destination. Thirdly and fourthly, cleanliness is extremely important now in times of pandemic, as well as the price we are paying is fair for the service provided by the transport.

Question 6

Would you be willing to install an application on your cell phone to help you make better use of selective public transportation in the city, where you can optimize time and money?

Table 9

Willingness to install an application on the cell phone that helps to better use selective public transportation in the city, where time and money can be optimized

Responses	Selection	Percentage
Yes	125	73%
No	46	27%
Total	**171**	

Findings and data analysis: people are willing to download an application on their cell phone as long as it is good and efficient, with 73% of the respondents saying YES.

Question 7

What do you consider to be the most important aspect that a mobile application should include, focused on selective public transportation in the city?

Table 10

Aspect to consider as the most relevant to be included in the mobile application aimed at selective public transport in the city

Responses	Selection	Percentage
Routes	35	20%
Schedules	112	65%
Location	7	4%
Passage	17	10%
Total	**171**	

Findings and data analysis: again we can see how timetables are so important for people e.g. the Metro tells us what time the next car will arrive, but for cabs it is non-existent. Routes and passage took into account also important. As all my respondents are Panamanians and live in the capital city or San Miguelito, location is not so important to them, but for a tourist it is and that is why it was not taken into account in this survey.

Question 8

From where you live, how efficient is selective public transportation?

Table 11

Efficiency of selective public transport

Responses	Selection	Percentage
Excellent	7	4%
Good	56	33%
Neutral	88	51%
Malo	15	9%
Lousy	5	3%
Total	**171**	

Findings and data analysis: in this question my concern is how good the transportation is and so neutral wins with 51% and with 9% bad which is good news, since not for many people the efficiency of transportation is lousy or inaccessible, and that for most it is quite good.

Question 9

For what reason do you use selective public transport?

Table 12
Reason for which selective public transportation is used

Responses	Selection	Percentage
Job	96	56%
Studies	57	33%
Leisure	14	8%
Another	4	2%
Total	**171**	

Findings and data analysis: the majority use transportation to commute to the workplace at 56%. The others are studies and recreation (leisure) among the most voted.

Question 10

Have you been satisfied with selective public transport?

Table 13
Level of satisfaction with the use of selective public transport

Responses	Selection	Percentage
Yes	20	12%
No	151	88%
Total	**171**	

Findings and data analysis: as a last question I wanted to know if they were satisfied with selective public transportation and by a wide margin they win that they are NOT satisfied with transportation.

Mobile Application

In terms of accessibility, Panama City is making a considerable effort to strengthen its public transportation system, achieving positive results compared to other areas in the Central American region. Although there is still much work to be done, the initiative to digitize the transportation network is an important step. This will allow users to have real-time access to the arrival of Metrotaxis, know the location of nearby stops and plan their trips with detailed route information, among other conveniences.

The implementation of the MetroTaxi application is a project integrated in the "open data" policy. In other words, it is a tool designed with reliable information obtained directly from the transportation system. Users can access this application directly or by easy registration through their email, Google account or Facebook social network profile (Alcalde, 2014).

The operation of the MetroTaxi application is similar to that of many other private service applications available on the market. The user enters the address, requests the cab and waits for the nearest cab driver to accept the ride, then meets and begins the journey.

The current application aims to address several of the key issues associated with taking a cab, safety being foremost among them. With this application, we are certain to know the identity of the driver who will transport us (Trujillo, 2013).

As in many countries, the application has an emergency button, located at the top right of the interface, with the main objective of improving safety conditions for occupants. This emergency button consists of an always visible siren. When pressed, either by the driver or the user, the position of the transport unit is notified to the corresponding authorities through the GPS system. In case it is proven that the button

was pressed intentionally and not by mistake, either by the user or the driver, penalties will be applied.

Given that the existing applications lack control and monitoring by the transit authority, and considering their potential usefulness for planning and control, the following is an analysis that addresses the application's weaknesses, opportunities, strengths and threats.

Table 14
SWOT analysis of the application

Weaknesses	Opportunities
• The applications do not monitor that cab drivers, in order to avoid traffic jams, do not accept rides, which does not improve the current situation of access to the service during rush hours. • The apps do not monitor that cab drivers comply with being "unavailable" while they are providing a service. • The use of apps while the cab driver is driving generates accident risk. • It depends a lot on the technology of the smart phone.	• Generation of information on trip generation and attraction points. • Real-time demand monitoring to optimize cab supply. • Decreased response time to service requests. • The special zones constitute an area of high demand during peak hours. • Integration of selective transport with other means of transport. • The applications have the possibility of compulsorily assigning races to the vehicle unit according to its availability status and geographic position. • Information is generated in the cloud that can be used for urban planning and development processes.
Strengths	**Threats**
• It is faster to order cabs by app than by radiotelephone. • Eliminates intermediaries in the cab supply and travel demand market. This may represent a reduction in some operating costs. These savings could be used to improve other aspects of the service. • Allows greater monitoring of the location of each unit. • It is safer to order a cab through an app than to take one on the street.	• Not having a radio phone (a cab driver who only works with apps) may imply greater insecurity for the cab driver since support networks are often triggered by this channel. • The handling of the information provided by the passenger can be used by cab drivers after the ride to threaten the person.

According to the latest reports of the National Institute of Statistics and Census of the Comptroller General of the Republic of Panama, the number of active cell phones in the country increased from 5,141,768 to 5,709,163 in the last five years (Instituto Nacional de Estadística y Censo, 2020).

As more people deal with various demands, they are turning to their smartphones to perform various tasks including secure mobility from one place to another. Based on this, we can conclude that the demand for using selective public transportation through a single digital medium would not be a limitation and could even increase due to the security it would represent for the user and the confidence of knowing the fare collection in advance.

While it is true that requesting a MetroTaxi unit requires no more than using the mobile application, the MetroTaxi charge would be coupled to the single card of the current integrated system that also includes both the Panama Metro and the MetroBus. The user would be required to register his or her integrated transportation system card under a unique identification number in the application.

Finally, the application will provide the route that the MetroTaxi unit will follow so that the user can see it on our smart phone. In addition, there will be no extra charges for cabs that want to take us on the longer route to charge us more.

It will be in operation for now in Panama City and the district of San Miguelito, although expansion plans consider other cities as access to both the Panama Metro and MetroBus is developed in the different areas.

Cards and Their Role in the MetroTaxi System

Like the Panama Metro and MetroBus, the MetroTaxi fare collection system will be operated by a company that, apart from integrating both systems, also has experience in the implementation of these types of systems, which in the case of the public transportation system includes, among others:

1. Areas designated as yards or piqueras will be equipped with Concentrators for automatic transaction downloading and balance validators. These elements will help streamline the process for users when recharging their MetroTaxi cards, as well as for accessing Metro de Panama and Metro Bus services.

2. A communications network will be established to facilitate the transfer of transactions from the concentrators or computers to the equipment installed with the central Clearing systems. This involves the creation of a system designed so that when transactions arrive at terminals equipped with a hub (computer), either via wireless or wired connection, the corresponding transactions are automatically downloaded. The main objective of this flow of operations is to ensure the efficient continuity of the collection process.

3. Daily transaction processing capacity for use and loading.

4. Secure antennas distributed in commercial networks will be implemented, thus facilitating the recharging of integrated public transportation system cards.

5. Transport system users will be provided with web access to consult movements and recharge their integrated public transport system card.

With the implementation of MetroTaxi, the aim is once again to integrate the system with a single card. The card will have the same special benefits and denomination for retirees, senior citizens, pensioners and disabled persons, and students.

Figure 2
Integrated public transportation system card proposal

Rates

The proposal recommends implementing fare and operational integration between the Metro, MetroBus and MetroTaxi systems. From the tariff point of view, the same card will continue to be used for payment of both systems, but users will pay a fraction of the individual tariffs if they combine services and/or systems. This fare integration starts operating simultaneously with Metrotaxis. For this purpose, the proper functioning of the collection system, including cards, recharge points, etc., must be guaranteed.

Current cab fares are managed according to the zonal and sectorial division that exists in Panama City and the District of San Miguelito. Taking into account that $1 U.S. Dollar is equivalent to B/.1 Panamanian Balboa.

Table 15
Rate between Zones

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7
Zone 1	B/. 1.20	B/. 1.60	B/. 2.00	B/. 2.40	B/. 2.80	B/. 3.20	B/. 3.60
Zone 2	B/. 1.60	B/. 1.20	B/. 1.60	B/. 2.00	B/. 2.40	B/. 2.80	B/. 3.20
Zone 3	B/. 2.00	B/. 1.60	B/. 1.20	B/. 1.60	B/. 2.00	B/. 2.40	B/. 2.80
Zone 4	B/. 2.40	B/. 2.00	B/. 1.60	B/. 1.20	B/. 1.60	B/. 2.00	B/. 2.40
Zone 5	B/. 2.80	B/. 2.40	B/. 2.00	B/. 1.60	B/. 1.20	B/. 1.60	B/. 2.00
Zone 6	B/. 3.20	B/. 2.80	B/. 2.40	B/. 2.00	B/. 1.60	B/. 1.20	B/. 1.60
Zone 7	B/. 3.60	B/. 3.20	B/. 2.80	B/. 2.40	B/. 2.00	B/. 1.60	B/. 1.20

Note. Adapted from *Autoridad del Tránsito y Transporte Terrestre de Panamá.* (https://www.transito.gob.pa).

Table 16
Tariff South sector

	Sector A	Sector B	Sector C	Sector E	Sector F	Sector G	Sector H	Sector I	Sector J	Sector K
Sector A	1.20 - 1.80	B/. 1.80	B/. 2.10	B/. 3.65	B/. 3.95	B/. 4.25	B/. 4.55	B/. 4.85	B/. 8.20	B/. 8.50
Sector B	B/. 1.80	1.20 - 1.80	B/. 1.80	B/. 3.35	B/. 3.65	B/. 3.95	B/. 4.25	B/. 4.25	B/. 7.90	B/. 8.30
Sector C	B/. 2.10	B/. 1.80	1.20 - 1.80	B/. 1.80	B/. 2.40	B/. 3.65	B/. 3.95	B/. 3.65	B/. 7.55	B/. 7.90
Sector E	B/. 3.65	B/. 3.35	B/. 1.80	1.20 - 1.80	B/. 1.80	B/. 2.10	B/. 3.65	B/. 3.65	B/. 6.05	B/. 6.35
Sector F	B/. 3.95	B/. 3.65	B/. 2.40	B/. 1.80	1.20 - 1.80	B/. 1.80	B/. 3.35	B/. 3.35	B/. 5.75	B/. 6.05
Sector G	B/. 4.25	B/. 3.95	B/. 3.65	B/. 2.10	B/. 1.80	1.20 - 1.80	B/. 2.40	B/. 3.65	B/. 5.45	B/. 5.75
Sector H	B/. 4.55	B/. 4.25	B/. 3.95	B/. 3.65	B/. 3.35	B/. 2.40	1.20 - 1.80	B/. 3.65	B/. 5.15	B/. 5.45
Sector I	B/. 4.85	B/. 4.25	B/. 3.65	B/. 3.65	B/. 3.35	B/. 3.65	B/. 3.65	1.20 - 1.80	B/. 6.05	B/. 6.35
Sector J	B/. 8.20	B/. 7.90	B/. 7.55	B/. 6.06	B/. 5.75	B/. 5.45	B/. 5.15	B/. 6.05	1.20 - 2.40	B/. 1.80
Sector K	B/. 8.50	B/. 8.20	B/. 7.90	B/. 6.35	B/. 6.05	B/. 5.75	B/. 5.45	B/. 6.35	B/. 1.80	1.20 - 2.40

Note. Adapted from *Autoridad del Tránsito y Transporte Terrestre de Panamá.* (https://www.transito.gob.pa).

Table 17

North sector tariff

	Sector A	Sector B	Sector C	Sector D	Sector E	Sector F	Sector H	Sector I	Sector J	Sector L
Sector A	1.20 - 1.80	B/. 1.80	B/. 2.10	B/. 3.65	B/. 3.95	B/. 4.25	B/. 5.75	B/. 7.85	B/. 8.45	B/. 12.40
Sector B	B/. 1.80	1.20 - 1.80	B/. 1.65	B/. 2.05	B/. 2.50	B/. 2.50	B/. 2.90	B/. 4.85	B/. 7.25	B/. 10.90
Sector C	B/. 2.10	B/. 1.65	1.20 - 1.80	B/. 2.40	B/. 2.70	B/. 2.70	B/. 3.15	B/. 4.55	B/. 6.05	B/. 9.70
Sector D	B/. 3.65	B/. 2.05	B/. 2.40	1.20 - 1.80	B/. 1.80	B/. 1.80	B/. 2.10	B/. 3.35	B/. 5.45	B/. 9.10
Sector E	B/. 3.95	B/. 2.50	B/. 2.70	B/. 1.80	1.20 - 1.80	B/. 2.10	B/. 1.65	B/. 2.40	B/. 4.85	B/. 8.45
Sector F	B/. 4.25	B/. 2.50	B/. 2.70	B/. 1.80	B/. 2.10	1.20 - 1.80	B/. 2.40	B/. 3.05	B/. 5.45	B/. 7.85
Sector H	B/. 5.75	B/. 2.90	B/. 3.15	B/. 2.10	B/. 1.65	B/. 2.40	1.20 - 2.40	B/. 2.40	B/. 4.25	B/. 7.25
Sector I	B/. 7.85	B/. 4.85	B/. 4.55	B/. 3.35	B/. 2.40	B/. 3.05	B/. 2.40	1.20 - 3.00	B/. 3.05	B/. 4.85
Sector J	B/. 8.45	B/. 7.25	B/. 6.05	B/. 5.45	B/. 4.85	B/. 5.45	B/. 4.25	B/. 3.05	1.20 - 3.00	B/. 3.65
Sector L	B/. 12.10	B/. 10.90	B/. 9.70	B/. 9.10	B/. 8.45	B/. 7.85	B/. 7.25	B/. 4.85	B/. 3.65	1.20 - 3.00

Note. Adapted from *Autoridad del Tránsito y Transporte Terrestre de Panamá.* (https://www.transito.gob.pa).

Table 18

Rate between Sectors and Zones

	Sector A	Sector B	Sector C	Sector D	Sector E	Sector F	Sector G	Sector H	Sector I	Sector J	Sector K	Sector L
Zone 1	B/. 4.60	B/. 4.90	B/. 5.20	B/. 5.80	B/. 6.70	B/. 7.00	B/. 7.30	B/. 7.60	B/. 9.15	B/. 11.25	B/. 13.65	B/. 16.40
Zone 2	B/. 4.20	B/. 4.50	B/. 4.80	B/. 5.40	B/. 6.30	B/. 6.60	B/. 6.90	B/. 7.20	B/. 8.70	B/. 10.85	B/. 13.25	B/. 16.00
Zone 3	B/. 3.75	B/. 4.05	B/. 4.35	B/. 4.95	B/. 5.85	B/. 6.15	B/. 6.45	B/. 6.80	B/. 8.30	B/. 10.40	B/. 12.85	B/. 15.55
Zone 4	B/. 3.35	B/. 3.65	B/. 6.95	B/. 4.55	B/. 5.45	B/. 5.75	B/. 6.05	B/. 6.35	B/. 7.85	B/. 10.00	B/. 12.40	B/. 15.10
Zone 5	B/. 2.90	B/. 3.20	B/. 3.50	B/. 4.10	B/. 5.00	B/. 5.30	B/. 5.65	B/. 5.95	B/. 7.45	B/. 9.55	B/. 12.00	B/. 14.70
Zone 6	B/. 2.50	B/. 2.80	B/. 3.10	B/. 3.70	B/. 4.60	B/. 4.90	B/. 5.20	B/. 5.50	B/. 7.00	B/. 9.15	B/. 11.55	B/. 14.30
Zone 7	B/. 2.05	B/. 2.35	B/. 2.65	B/. 3.30	B/. 4.15	B/. 4.50	B/. 4.80	B/. 5.10	B/. 6.60	B/. 8.70	B/. 11.10	B/. 13.85

Note. Adapted from *Autoridad del Tránsito y Transporte Terrestre de Panamá.* (https://www.transito.gob.pa).

In order to guarantee the profitability of the service, a management approach will be followed that is aligned with the zonal and sectorial division present in Panama City and the District of San Miguelito. Pricing will be based on traffic volume and time of day, which implies that the fare will be variable depending on the availability of Metrotaxis drivers at that time. As with the mobile application, users will also be able to check fares through the web in any sector where Metrotaxis operate. These tariffs will be strategically

adjusted to meet the needs of the population and compete effectively with existing platforms in the market.

Figure 3
*Areas of Panama City and the district of San Miguelito*
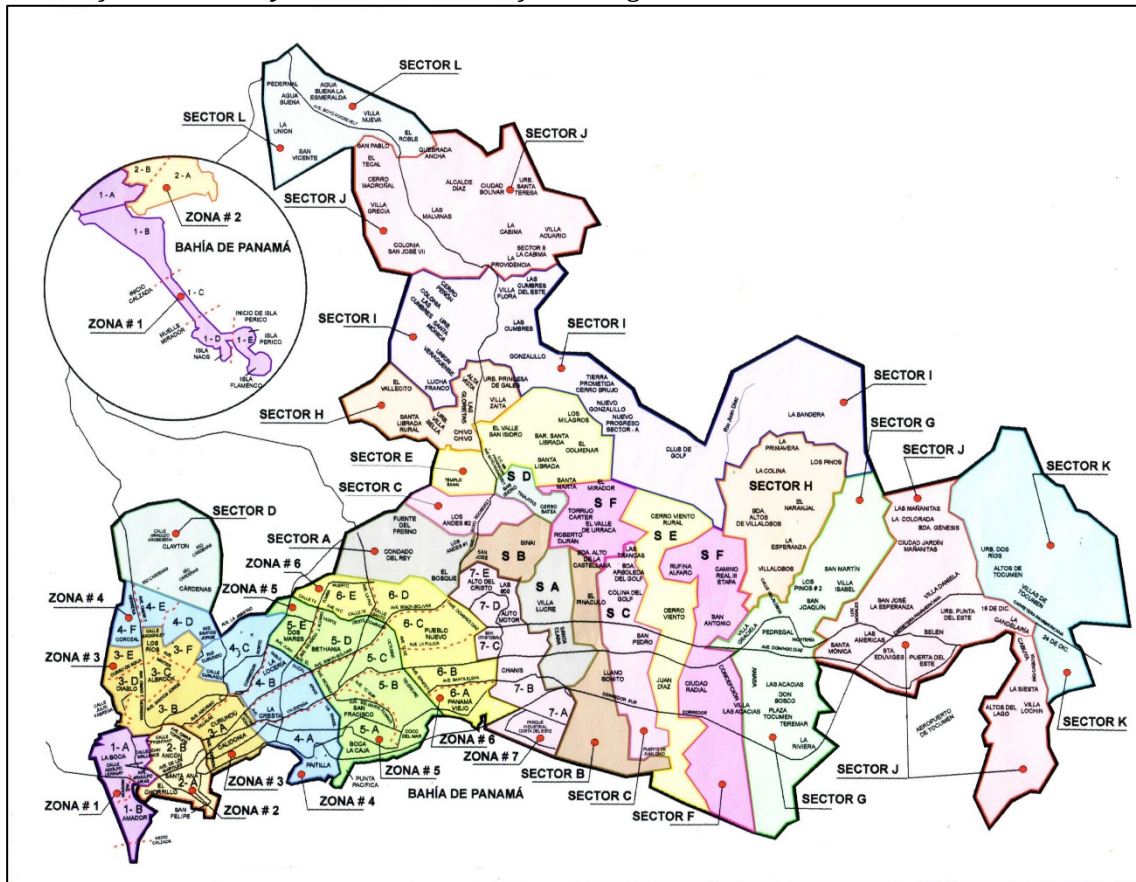
Note. Adapted from *Autoridad del Tránsito y Transporte Terrestre de Panamá.* (https://www.transito.gob.pa).

Yards for Operation: Paid Zones

For practical purposes, the same location of the current MetroBus Pay Zones within Panama City and the San Miguelito District will be used.

Figure 4
Current Paid Zones Locations
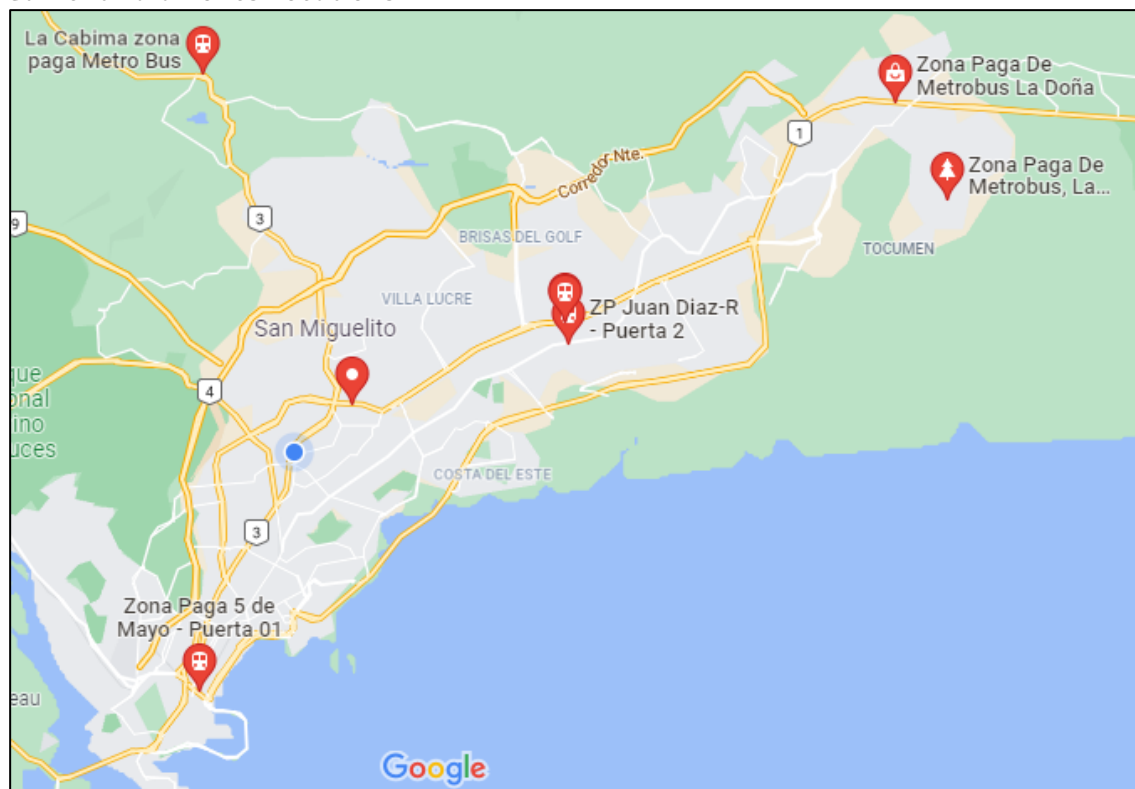
*Note.* Adapted from Current Pay Zone Locations, Google Maps.

The current Zonas Pagas of the MetroBus will be adapted for MetroTaxis where they will also be used as stops where passengers will form a dedicated line to board the MetroTaxi. They would maintain modern facilities for the operation and maintenance of the vehicles with state-of-the-art technology for efficient and safe operation of the fleet.

In addition to Paid Zones, Special Zones will also be designated areas on the public roadway, and may be located either on the vehicular roadway or in existing bays. These areas will be delimited with temporary parking spaces for individual passenger transportation vehicles, known as "cabs". In these zones, with prior authorization from the Panama Metropolitan Area Transit Authority, cabs may park temporarily while waiting to be requested, and the public may come to hire their services.

In the context of the special zones, the collection of vehicles is contemplated, which implies the physical presence of Metrotaxis waiting for the demand of the service, either on site or through reservations. It should be noted that the special zones will be exclusively reserved for the use of Metrotaxis.

For the purpose of establishing guidelines and detailing the functions of the special zone system, the following sections of this document present detailed information on the requirements, characteristics and conditions of the parking zone network for Metrotaxis.

Figure 5
Horizontal signaling special zone on the road
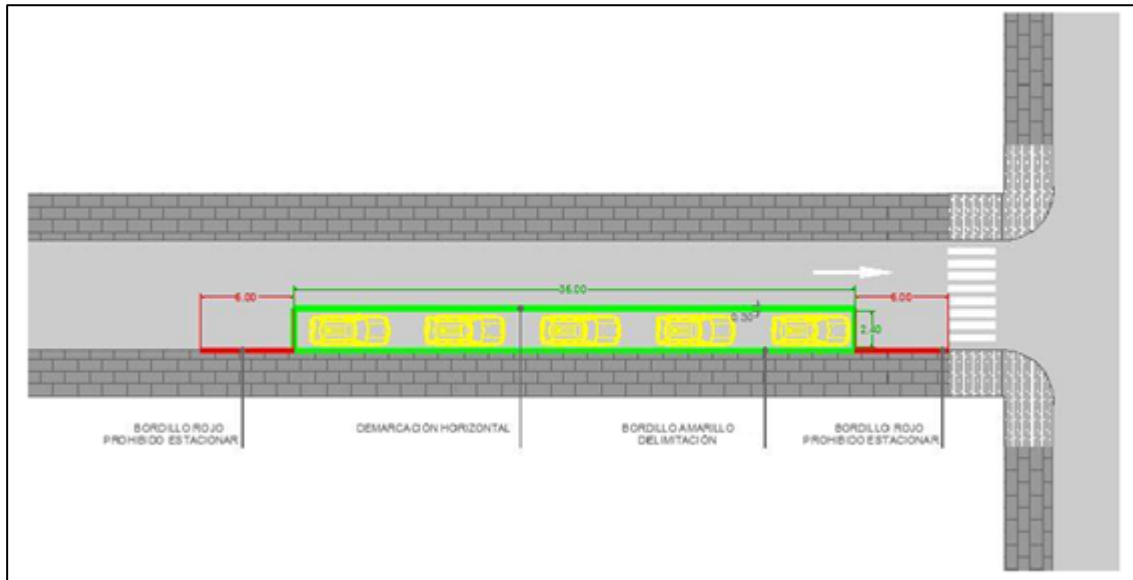
Note. Adapted from *Metro de Panamá*, by Cal y Mayor y Asociados, 2016, Plan Integral de Movilidad Urbana Sustentable - PIMUS.

Case study

The preliminary design of the special zones was based on the selection of a sector. A region was chosen based on the area of influence of the Metro Line 1 stations, where unauthorized piqueras were identified occupying a lane of the track to wait for users, affecting mobility in the area of the stations. The chosen sector includes the Iglesia del Carmen station and the Via Argentina station, both located in Panama City, as shown in the following figure:

Figure 6
Pilot zones

Note. Adapted from Current Pay Zone Locations, Google Maps.

At the end of the research, the following results were obtained:

1. A plan for the integration of Metrotaxis to the current mass transportation system, in order to reduce the participation of selective public transportation based on the understanding of different aspects such as the intelligent way to reduce the unnecessary consumption of hydrocarbons and the optimization of routes that achieve safety, punctuality and user comfort.

2. A platform that seeks to integrate even more, a system under the same umbrella of single payment in common and by different means.

3. A proposal for the development of special zones with proper signage, in demarcated areas of public roads with temporary parking spaces for taxi-type passenger transportation vehicles, where services can be requested through the mobile application and where the public can also go to hire them.

Discussion and Conclusions

It can be assumed that the authorities have not been able to approach the problems correctly and, therefore, adequate solutions to the problem of public transport, especially selective transport, have not been found.

The definition of the special zones seeks to address the problems of inefficiency in the provision of selective public service, inadequate use of road infrastructure, inefficient

operation of individual public transportation, increased operating costs and insecurity for drivers and passengers.

A main factor that could contribute to the efficient use of the integrated system by users is related to the transshipment item, triggered by several reasons: agility, fast mobility throughout the city and finally the economic factor. The current transportation system requires a feeder network, which can transport a large volume of users from their communities to the main roads and stations of the Panama Metro and the MetroBus and vice versa, becoming a branch of the latter.

According to the surveys, the system's problems are focused on three main points: route frequency, travel time and safety, causing distrust and fear among users.

Current development standards should encourage development around integrated transportation systems, including homes and businesses. This action will strengthen the components that make up the integrated transportation system and facilitate the establishment of urban centers away from the center to reduce the daily flow of people to urban centers. To curb the proliferation of single-function development projects, especially the so-called "dormitory cities" in remote areas, action must also be taken at the same time, because these projects are neither sustainable nor compatible with development.

References

Alcalde, I. (2014). *Open Data: datos, transparencia y conocimiento abierto.* https://ignasialcalde.es/open-data-datos-transparencia-y-conocimiento-abierto/

Contraloría General de la República de Panamá. Instituto Nacional de Estadística y Censo. (2013). *XII Censo Nacional de Población y VII de Vivienda.* https://www.inec.gob.pa/publicaciones/Default3.aspx?ID_PUBLICACION=1199&ID_CATEGORIA=19&ID_SUBCATEGORIA=71

Fonseca, Cecilia. La Prensa. (2012, septiembre 11*). CAF analiza los desafíos de la movilidad urbana en América Latina.* https://www.prensa.com/cecilia_fonseca_s-_-_elizabeth_garrido_a/CAF-desafios-movilidad-America-Latina_0_3477402226.html

Fundación Universitaria Iberoamericana. FUNIBER. (2020). *Introducción a la gestión de proyectos*

Instituto Nacional de Estadística y Censo. (2020). *Teléfonos celulares activos en la República de Panamá, por tipo de servicios: años 2016-20.* https://www.inec.gob.pa/publicaciones/Default3.aspx?ID_PUBLICACION=1077&ID_CATEGORIA=4&ID_SUBCATEGORIA=23

Hernández, Katiuska. La Prensa. (2023, diciembre 5). *Salario en Panamá aumentó apenas 1% en el último año.* https://www.prensa.com/economia/salario-promedio-en-panama-aumento-apenas-1-en-el-ultimo-ano/

Manrique, M. (2004). *Métodos de recolección de datos.* https://www.monografias.com/trabajos18/recoleccion-de-datos/recoleccion-de-datos.shtml

Metro de Panamá. Informe Final. (2015 – 2016). *Plan Integral de Movilidad Urbana Sustentable – PIMUS.* Cal y Mayor y Asociados

Pardo, Carlos. (2009, febrero). *Los cambios en los sistemas integrados de transporte masivo en las principales ciudades de América Latina.* Comisión Económica para América Latina y el Caribe (CEPAL). Santiago de Chile.

Parra, A. (2023) ¿Qué es la recolección de datos y cómo realizarla? *Question Pro.* https://www.questionpro.com/blog/es/recoleccion-de-datos-para-investigacion/

Robles Garrote, P. & Rojas, M. D. C. (2015). La validación por juicio de expertos: dos investigaciones cualitativas en Lingüística aplicada. *Revista Nebrija de Lingüística Aplicada, 18.*

Sampieri Hernández, R.; Collado Fernández, C., & Lucio Baptista, P. (2003). *Metodología de la Investigación*. McGraw-Hill Interamericana.

Secretaría de Desarrollo Urbano y Ecología. (2022,). *Programa Sectorial de Ordenamiento Territorial y Desarrollo Sustentable 2022-2027*. Gobierno del Estado Libre y Soberano de Chihuahua

Trujillo, Á.. (2013). Taxibeat, servicio de taxis desde tu Smartphone. *Xataka México* https://www.xataka.com.mx/aplicaciones/taxibeat-servicio-de-taxis-desde-tu-smartphone

Vásquez, H. I. (2005). *Tipos de estudio y métodos de investigación*. https://www.gestiopolis.com/tipos-estudio-metodos-investigacion/

Velásquez, Carmen. (2015). *Espacio público y movilidad urbana: Sistemas Integrados de Transporte Masivo (SITM).* Universitat de Barcelona.