

# Comparative Analysis of Public Transport between the Cities of São Luís and Madrid: Operational Characterization of the Collective Mode, Users Experiences and Solutions Proposals

Poliana Lima Rocha<sup>1</sup>, Carlos Alberto Araújo de Lima<sup>2</sup>, Rachid Santos Maluf<sup>3</sup>

<sup>1</sup>Federal University of Maranhão

<sup>2</sup>Estacio University Center

<sup>3</sup>Professor at the Federal University of Maranhão

(<sup>1</sup>polianalima38@gmail.com, <sup>2</sup>carlos7414eng@gmail.com, <sup>3</sup>rachid.maluf@ufma.br)

**Abstract-**The crisis in public transport, directly impacts urban mobility, a comparative study was proposed on these two themes with the capital of Maranhão and Madrid, Spanish capital. This work sought to obtain data from both cities regarding public transport - buses – analyzing their mobility plans, operability of modals and perception of users, then understanding the current Ludovicense situation, thus suggesting improvements. There are bibliographic analyses and data collection through questionnaires applied to the population of São Luís, totaling 307 interviewees, 258 daily users of public transport. User characteristics were evaluated, the public transport, dynamics of displacements, offer, the entry into the collectives, the waiting time, the frequency, situation of shelters, performance during the early hours, withdrawal of collectors and satisfaction public transport in the capital compared to Madrid. The results presented a percentage of 84.04% of daily users of public transport, 83.72% newcomers per electronic ticket, significant percentage. On the waiting time, 37.98% of passengers wait 20 to 40 minutes in shelters that 84.11% think is bad or bad, unlike Madrid that has a shorter waiting time, relying adapted and flagged shelters. The results point to the possible discussion of the implementation of lines during the early hours – a system used in the capital of Spain - with 57.36% in favor and the impact caused by the population with the withdrawal of collectors. Also punctuating the needs and designing solutions from the example of Madrid.

**Keywords-** *Urban Mobility, Public Transport, São Luís*

## I. INTRODUCTION

The theme involving urban mobility has been much discussed in current debates and being studied for several professionals. This is a theme that is being addressed as something beyond the simple reference to locomotion. Among the causes that are studied about urban mobility, a highlight is given to transport. This is due to the increase in the population on the outskirts of cities that require public transport [1], because they are means of precarious locomotion and by which the population pay ever greater portions of their earnings [2].

The rampant use of the car modified the modal distribution of urban transport, causing the deterioration of public transport [3]. Another obstacle identified in urban areas (common of many Brazilian cities) that affects mobility planning is the advance of spatial dispersion. The implementation of new housing and services in areas further away from central regions directly affects the mobility of cities. This generates a great dissociation between urban planning and transport in the urban soil planning factor [4].

## II. JUSTIFICATION

Public transport is an element that needs a lot of attention, analysis and discussion, due to the impacts and consequences that are generated in the urban environment influencing the city with a whole [5]. And as is notorious, especially in developing countries (such as Brazil, for example) the crisis that public transport has been going through. Among this narrated reality is the city of São Luís from the state of Maranhão, the capital that currently also presents major problems of urban mobility, a fact that drove the realization of this work.

The city chosen for comparative study was the capital of Spain, Madrid, identified by its large capacity public transport system - with recognized efficiency - and has a Sustainable Urban Mobility Plan active in application to improve the quality of life of its population [6].

Thus, this research aimed to obtain data from both cities related to public transport -bus- under analysis of their mobility plans, characterization of modals and perception of users of this system to understand the current situation of the capital Ludovicense, in order to suggest improvements.

## III. THEORETICAL REFERENCES

### A. *Urban Mobility and Urban Mobility Plans*

Urban mobility is an attribute of cities and refers to the ease of displacement of people and goods in urban space. Displacements that are carried out through vehicles, roads and

all infrastructure (roads, sidewalks, etc.) [7]. This theme is not limited simply to the mechanical operation of displacement of people and goods but is also a responsible for physical-functional organization of the territory. Thus, urban mobility behaves as a significant urban factor of intervention, directly associated with metropolitan, urban and local scales [8].

One of the tools of the National Urban Mobility Policy are mobility plans that aim (through short, medium and long-term planning) to translate the goals of progress of local urban mobility into goals, strategic actions and material and human resources, providing the means for real transformation, collaborating with the development of the city[9]. Among the components of urban mobility, there are non-motorized modes: pedestrians and bicycles.

In relation to motorized modes, these are divided into private (cars and motorcycles) and collective, the latter including buses, subways, trains and among others [9].

#### B. *Urban Mobility in São Luís*

The city of São Luís, capital of the State of Maranhão, is located on the island of São Luís, in the Golfão Maranhense, between the bays of São Marcos and São José, along with three more cities: Raposa, Paço do Lumiar and Sao Jose de Ribamar. It has an estimated population of 1.101.884 inhabitants and with an area of 831.7 km<sup>2</sup>, corresponding to a population density of 1,324.85 inhabitants/ km<sup>2</sup>[10].

The organization responsible for the administration of the public transport system is the Municipal Department of Traffic and Transport of São Luís - SMTT, in which it includes urban lines, that is, those that make travel only in the municipality. On public transport, São Luís has five passenger integration terminals, places where users can change lines without having to pay another fare, fees that comprise in the amount of R\$ 3.40 - for integrated lines - and R\$ 2.95, for non- are located in the most populous regions of the city [11].

When it comes to bike paths, in São Luís, there is a great demand for cyclists, however the existing roads are of small extensions and disconnected. There are only 18 km of routes intended for the use of bicycles, making the island, the second capital of the country with the lowest number of bike paths [12].

#### C. *Urban Mobility in Madrid*

The city of Madrid is the capital and largest city in Spain. It represents the third largest metropolis in Europe, with more than three million inhabitants occupying an area of 8,028 km<sup>2</sup>. The Spanish capital contains the second largest subway system in the European Union and the eighth in the world.

The Madrid Regional Transport Consortium was created by Law 5/1985 and is responsible for the regular public transport of travelers from the Community of Madrid and the associated municipalities. [14]

In relation to the public transport system of Madrid, this corresponds to a complex and intermodal system with the participation of a plurality of transport modes. It can be distinguished in two large systems that are articulated in the face of large sets of exchangers that are around the central area

of the city of Madrid and has an integrated and multimodal transport ticketing system of personal and unlimited use (monthly or annual), which provides the user with accessibility in the entire public transport system that is situated in the validity zone [14]. And in relation to universal accessibility, the region of Madrid has as one of the objectives, preferences from each means of transport.

### IV. METHODOLOGY

The research was carried out through the following steps:

Bibliographic research was conducted on the theme of urban mobility and among other related topics to support the study. In addition to the analysis of the mobility plans of the two cities referenced in this research, surveys of photographic archives and information were made with SMTT (Municipal Secretariat of Traffic and Transport of São Luís) and CRTM (Regional Consortium of Transport stain from Madrid).

The data acquired were two characters: primary (field research and practice of questionnaires) and secondary (data collection and collection) in order to study and present the aspects of the Public Transportation System of São Luís. Finally, the results obtained from the questionnaires were presented and discussed, together with the comparative analyses of the mobility plans of the chosen cities, and their conclusion.

#### A. *Database Construction*

The preparation of the questionnaire was performed in front of 7 questions, among this total, 4 of quantitative character and 3 of qualitative character. Regarding quantitative questions, the answers were around "yes" or "no", in addition to two other restricted options. Obtaining, therefore, percentages conformed. While qualitative questions were questions about some aspects of quality and service satisfaction, provided to the population using public transport.

The characteristics of the public transport of São Luís that were evaluated were: offer characteristics, opinions of users on the service offered, quality of bus shelters and changes currently implemented.

The data were obtained through the individual and face-to-face questionnaires were performed in the 5 integration terminals of the city of São Luís (Praia Grande, Cohama, Cohab, São Cristóvão and Distrito Industrial), during the days 3, 4, 5, 6 and 7 June 2019 in alternate shifts between morning and afternoon. The choice of integration terminals as a research site was given by the fact that the current Public Transport System of São Luís is integrated, housing daily a large flow of users from all points of the city. In each integration terminal, 20 people were interviewed, totaling 100 face-to-face interviews.

Online data was obtained through the Google Forms Platform. This tool was chosen to complement the face-to-face questionnaire, as it has some advantages, such as reaching a large number of people - from different locations - at a low cost, as well as the ease of accounting for answers.

The online questionnaire was available for 5 days and was released on June 10, 2019. In the end, 207 responses were counted. It is worth remembering that the questions that were asked in both questionnaires were the same. Totaling 307 interviewees, in which the answers were tabulated in spreadsheets in Excel and the graphs generated by the Power BI application for the analysis and discussions of the comparative study proposed by the theme of the research.

### B. Sample Size

The sample size of respondents using public transportation in São Luís was determined by calculating the sample size equation (n) based on the population's ratio estimate, as shown below [15]:

$$n = \frac{N \cdot \hat{p} \cdot \hat{q} \cdot \left(\frac{Z_{\alpha/2}}{2}\right)^2}{\hat{p} \cdot \hat{q} \cdot \left(\frac{Z_{\alpha/2}}{2}\right)^2 + (N-1) \cdot E^2} \quad (1)$$

Thus, the following values were chosen:

- n: Variable to be obtained, referring to the number of passengers using public transport in São Luís;
- N: 372,000 - According to SMTT (2019) is the amount corresponding to the number of passengers using public transport per day in São Luís;
- p: 0.5 - This value was adopted, as it is an unknown variable;
- q: 0.5 - This value was adopted, as it is an unknown variable;
- $Z_{\alpha/2}$ : 1.96 - Value obtained for a confidence degree of 95 %;
- E: Error of 6 %.

Replacing in (1), has up a sample of 258 people.

$$n = \frac{372000 \cdot 0.5 \cdot 0.5 \cdot (1.96)^2}{0.5 \cdot 0.5 \cdot (1.96)^2 + (372000 - 1) \cdot 0.06^2} \quad n = 258$$

## V. RESULTS AND DISCUSSIONS

### A. Boarding in the collective's buses.

Currently, in the capital of Maranhão, the form of entry into the collectives is done in two ways: through electronic ticket or cash composed by cards of gratuity and half pass, both of personal and non-transferable use, valid only in the collectives of the capital, benefiting elderly, retirees, disabled and students of the 307 people interviewed, 258 claimed to be daily users of public transport. Fig. 01 portrays the majority use of the e-ticket, referring to 83.72% of daily users of public transport:

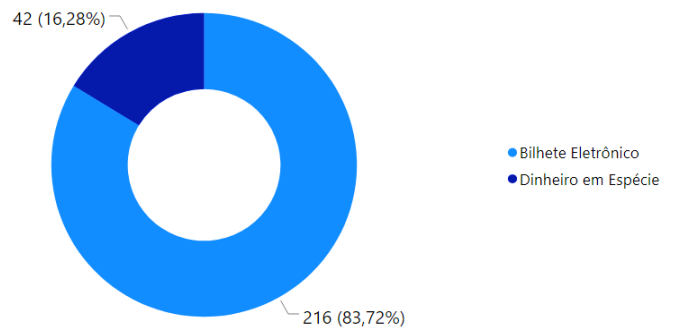


Figure 1. Form of collective boarding.

Even if there is a significant portion of e-ticket fans, 16.28% still utilize cash in kind, while Madrid presents various forms of admission such as the *Sencillo ticket*, purchased at €1.50 on buses and valid for a trip; *Metrthebus*, with 10 tickets and can be utilized both in buses and in subways; Transport allowance, multimodal and unlimited tickets for all age groups, plus tourist ticket, similar to allowance, but valid from 1 to 7 days. [16]

### B. Waiting time

Another major factor addressed in the research was the waiting time of users, characterized as: less than 5 minutes; from 5 to 10 min; from 10 to 15 min; from 20 to 40 min; and more than 40 min. According to users, the perceived waiting time was demonstrated in Fig. 02:

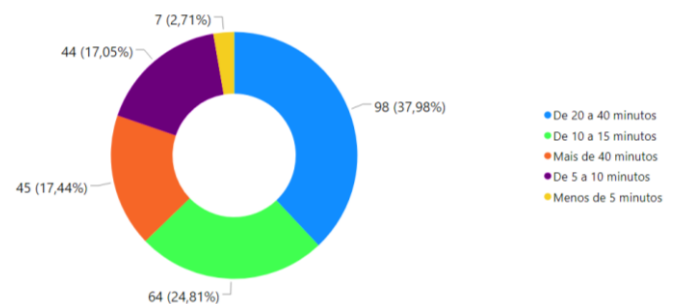


Figure 2. Waiting time perceived by the users of São Luís.

More than 55% of daily public transport users say they expect more than 20 minutes to expect collective bus, and only 2.71% wait less than 5 minutes, on average the waiting time, according to the survey conducted, corresponds to approximately 21.25 minutes. Compared to the Spanish capital, the maximum period of time in which users are expected is above 20 minutes, which corresponds to only 4%, according to the PMUS of Madrid (2014), with an average wait of 10.47 minutes, almost half the average time of the capital Ludovicense [17].

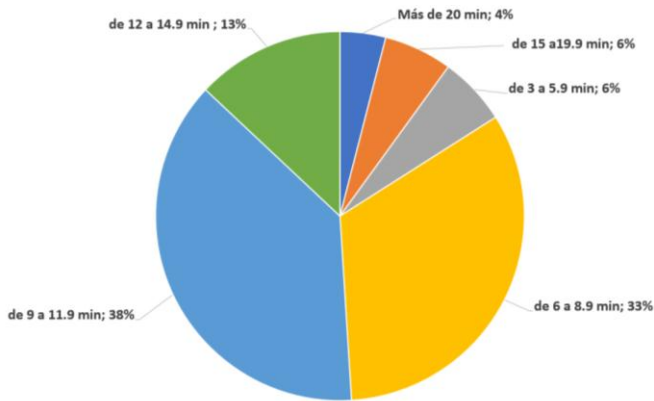


Figure 3. Waiting time perceived by users of Madrid.

### C. Shelter Situations

With a waiting time approaching a close twice as much as Madrid's, the situation of shelters (bus stops) is of extreme relevance when taken into account the more than 20 average minutes of waiting. According to the users interviewed in the survey, none of the shelters present satisfactory conditions, thus being validated by users as regular and with more than 80%, in the state of bad/very bad.

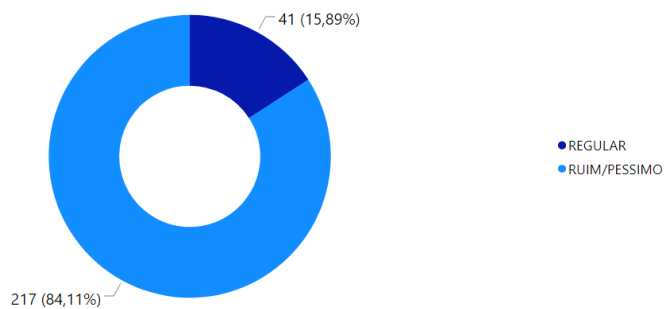


Figure 4. Situation of bus shelters in São Luís.

The basic features of the shelters of the capital maranhense, according to SMTT (2019), are concrete structures (older) and tubular (metal structure) [11]. Since 1987 the city of Madrid has been investing in the modernization of its bus and subway shelters, and in 2009 there has been renewal in the design of the "Marquesinas", and each shelters has information such as the lines that pass there, schedules and fares, also meeting the minimum accessibility requirements. The ludovicense capital has a certain aspect in this sense, having "stops" with ramps and tactile floors, meeting the requirements of the current standards (NBR 9050/2015) [18] as shown by Fig. 05:



Figure 5. Conditions of shelter in São Luís.

### D. Possibility of Performance in the Early Morning Period

The Spanish capital has a 24-hour bus running schedule. As soon as conventional bus times close, night buses, also known as "buhos" – owls, in Spanish – circulate. This time comprises from 23:20 to 23:45 hours until 5:30 to 6:00am. The city of São Luís does not have a public transport system during the dawn shift and there were no data that pointed to the future implementation of this service. Insecurity is one of the biggest obstacles, since this type of transport during this shift would be a major target of miscreants. On the other hand, during the research conducted, by assiduous users of public transport 57.36% were in favor and would use buses during the early hours, with a difference of almost 15% to those who were not favorable, a percentage in which in the future can be discussed for a possible implementation, because the population also has this need to move, being inhibited more by the absence of security. The data presented are shown in Fig. 06.

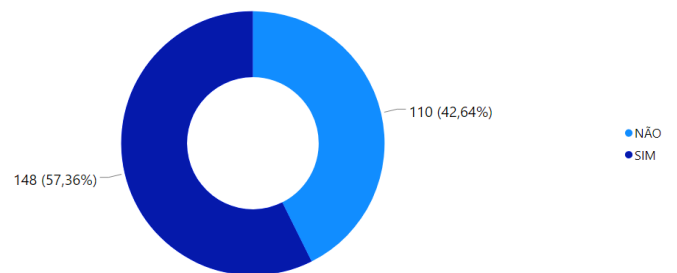


Figure 6. Use of public transport in the early hours of the morning in São Luís.

### E. Impact of Collector withdrawal

A change that is being implemented in some lines of public transport in São Luís, caused great dissatisfaction in the population and discussion by the authorities. This change is related to the withdrawal of employees who are responsible for the financial collection of collectives and among other functions in the vehicle, assisting the driver.

In Madrid, buses run with the absence of collectors and turnstiles, being the driver responsible for paying passengers, but it is important to highlight the distinct realities, since in this capital the payment electronically is much more significant and that there were a number of factors that helped this change and the incentive given the new technologies.

During the survey, 91.47% of the interviewees (Fig. 07) were against the withdrawal of collectors. The greatest justifications were in the face of overwork on the driver who in addition to driving the vehicle would also assume the functions of the collectors; delays in departures, due to the time elapsed to make the change pass to users who do not have electronic cards and the mass dismissal of the working class that was not being relocated in other posts.

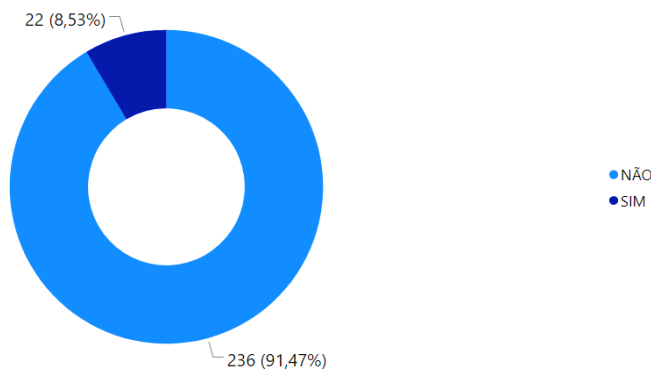


Figure 7. Opinion on the withdrawal of collectors.

#### F. Social Satisfaction with Public Transport

The quality of the service offered is linked to the point of view of those who use it, thus, there is a good quality when meeting the needs of individuals, seeking balance. The opinion of the public transport users of São Luís was collected through the last question of the questionnaire: "What suggestions do you think is important for the improvement of the bus system of São Luís?". The main problems encountered and the possible suggestions for improving this system used by several Ludovicenses were questioned.

This question, unlike the other questions asked, was subjective and included all interviewees, but repetition was noted in large points, thus reinforcing the collective dissatisfactions of users about the current service provided and the requirement by solutions. The most frequent answers were:

- Increased bus supply and improved logistics in order to avoid stockings and the long waiting time at the boarding points;
- Improvement of both road and vehicle infrastructure, because according to users, most buses are in poor condition and absent from accessibility, as well as some streets and avenues of the capital;
- Improvement of bus shelters;

- Measures to encourage the total use of electronic ticketing;
- Safety measures inside vehicles and at boarding points.

## VI. CONCLUSIONS

Concluded if Madrid offers better results due to urban mobility policies planned and implemented during their development. Still, São Luís presents some measures related to urban mobility. Another important point, which shows the results of the opinion polls, shows the current situation of the system.

Thus, some improvements in the public transport of the capital maranhense are necessary, based on the research carried out and the comparative analysis with the city of Madrid, highlighting some suggestions such as: increased bus supply - with better distribution of travel, especially in the regions furthest from the travel generating poles; infrastructure improvement - paying attention to bus shelters, which should be accessible and signposted by taking Madrid shelters as an example; better urban planning with public transport prioritization and awareness policies - measures already implemented in the Spanish capital, related to the fulfillment of its Sustainable Urban Mobility Plan; possible implementation of night lines, such as Madrid. In this way, the São Luís public transport system is in some ways moving, even slowly, to improve its distribution.

## REFERENCES

- [1] SILVA, A. d. Mobilidade Urbana e Equidade Social: possibilidades a partir das recentes políticas de transporte público na metrópole do rio de janeiro. GOT, Revista de Geografia e Ordenamento do Território, Universidade do Porto-Faculdade de Letras, n. 10, p. 293-317, 2016.
- [2] CARDOSO, C. E. de P. Análise do Transporte Coletivo Urbano sob a Ótica dos Riscos e Carências Sociais. 2008.
- [3] ARAÚJO, M. R. M. de et al. Transporte Público Coletivo: Discutindo Acessibilidade, Mobilidade e Qualidade de Vida. Psicologia & Sociedade, Associação Brasileira de Psicologia Social, v. 23, n. 3, p. 574-582, 2011.
- [4] LITMAN, T. Evaluating transportation land use impacts. 2008.
- [5] SOUSA, B. L. M. d. et al. Transporte Coletivo Público na Cidade de São Luís-Ma: Comparações Pré e Pós-Implantação do Sit Sistema Integrado de Transportes. Universidade Federal de São Carlos, 2012.
- [6] ELTIS. Devolver a Cidade de Madri às Pessoas (Espanha). 2018. Available in: <http://www.eltis.org/pt/content/devolver-cidade-de-madrid-pessoas-espanha>. Accessed in :07 /11/ 2018.
- [7] MINISTÉRIO DAS CIDADES. Programa Brasileiro de Acessibilidade Urbana: Construindo a Cidade Acessível. 2012a. Available in: <http://www.cidades.gov.br/images/stories/ArquivosSEMOB/Biblioteca/BrasilAcessivelCaderno02.pdf>. Accessed in: 15/12/2018.
- [8] GADENS, L. N. Sistemas de Mobilidade como Instrumento de Revitalização Urbana. 2017.
- [9] PLANMOB. Caderno de Referência para Elaboração de Plano de Mobilidade Urbana. 2015. Available in: <https://www.cidades.gov.br/images/stories/ArquivosSE/planmob.pdf>. Accessed in:28/08/18.
- [10] IBGE. IBGE divulga as estimativas da população dos municípios para 2019. 2019. Available in: <https://agenciadenoticias.ibge.gov.br/agencia-sala-de-imprensa/2013-agencia-de-noticias/releases/25278-ibge-divulga-as-estimativas-da-populacao-dos-municipios-para-2019>. Accessed in 13/11/2019.



- [11] SMTT. Dados referente ao Sistema de Transporte Coletivo de São Luís.2019. Secretaria Municipal de Trânsito e Transportes de São Luís.
- [12] G1. Malha cicloviária das capitais cresce 133% em 4 anos e já passa de 3 mil quilômetros. 2018. Available in:<https://g1.globo.com/economia/noticia/2018/08/28/malha-ciclovitaria-das-capitais-cresce-133-em-4-anos-e-ja-passa-de-3-mil-quilometros.ghtml>. Accessed in :18/12/2018.
- [13] COELHO, M. de C. Morfologia e Mobilidade Urbana, O caso de Madri. Faculdade de Arquitetura e Urbanismo, Universidade de Brasília, Brasília, 2015
- [14] CRTM. Madrid, referente mundial. Área de Estudios y Planificacfon.2013. Available in: [https://www.crtm.es/media/157715/madrid\\_referente\\_mundial.pdf](https://www.crtm.es/media/157715/madrid_referente_mundial.pdf). Accessed in :28/08/2018.
- [15] LEVINE, D.M; BERENSOM, M.L; STEPHAN, D. Estatística: Teoria e Aplicações usando Microsoft Excel em Português. Rio de Janeiro: LTC, 2000.
- [16] CRTM. Tu Transporte Público.2019. Available in: <https://www.crtm.es/tu-transporte-publico.aspx>. Accessed in:07/11/2019.
- [17] Plano de Mobilidade Urbana Sustentável de Madri. Plan de Movilidad Urbana Sostenible de la Ciudad de Madrid,2014.2014.
- [18] ABNT NBR 15570: 2011. Transporte — Especificações Técnicas para Fabricação de Veículos de Características Urbanas para Transporte Coletivo de Passageiros.



**Poliana Lima Rocha** Bachelor of Science and Technology and Civil Engineer from the Federal University of Maranhão (UFMA). Develops research in the area of improvements in Urban Mobility and Transports.



**Carlos Alberto Araújo de Lima** Civil Engineer at Estácio São Luís University Center. Postgraduate in Reinforced Concrete Structures and Foundations. Participation in research projects, writing in the areas of statistics and concrete structures. Taught lectures at Engineering Congresses. He is currently a designer of electrical structures and installations of the State Secretariat of Penitentiary Administration of Maranhão.



**Rachid Santos Maluf** Civil Engineer from UEMA (State University of Maranhão), specialist in Integrated Management and Occupational Safety, Master in Process Engineering. Lead Auditor ISO 9001/14001/45001, Quality and Occupational Health and Safety Consultant. Advisor teacher of this work. Develops research and extension projects, scientific project advisor, currently professor at the Federal University of Maranhão (UFMA).

How to Cite this Article:

Rocha, P. L., Lima, C. A. A. & Maluf, R. S. (2019) Comparative Analysis of Public Transport between the Cities of São Luís and Madrid: Operational Characterization of the Collective Mode, Users Experiences and Solutions Proposals. International Journal of Science and Engineering Investigations (IJSEI), 8(95), 107-112. <http://www.ijsei.com/papers/ijsei-89519-15.pdf>

