Study and design of a parking meter system

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Study and design of a parking meter system

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Abstract. The automobile is the main means of transportation in most cities of the world, however, its excessive use has generated several environmental and social problems, one of them is the lack of control over parking on public roads, affecting vehicle traffic, disturbing the image of the city, increasing the rate of accidents and causing negative effects on the mood of drivers and pedestrians. There are different alternatives to reduce these indicators, highlighting the effectiveness of the implementation of parking meter systems, which seek to regulate parking on public roads through a fee and a time limit. This article demonstrates the design, feasibility and impact (economic, social and environmental) of an implementation of the parking meter system in the center of the city of San José de Cúcuta, Colombia, with data from the Secretariat of Transit of the metropolitan area of the city of San José de Cúcuta, Colombia and the national institute of roads, achieving a solution to the problem of traffic congestion in the city and also contributing to create citizen culture among its inhabitants.

1. Introduction

In recent decades, transport and other related authorities have devoted a great deal of effort to reducing traffic emissions, and academics have also become increasingly interested in the science and engineering of traffic emission control [1]; these problems are not only the result of vehicles in circulation, they also come from parked vehicles and the enormous amounts of public space they occupy [2]. Parking is an important part of transportation planning because a typical vehicle spends 95% of its life sitting in a parking lot [3], so many cities have begun to implement various parking management strategies (*e.g.*, parking prices, reservations) to improve the efficiency of their parking systems [4].

Currently, the steady increase in the number of vehicles traveling the country's highways is causing problems in traffic management [5], for most areas with dense populations, the number of parking spaces, especially street parking spaces, are insufficient [6], so it is not surprising that cities plagued by parking shortages, congested streets, and limited financial resources are interested in parking policies that reduce cruise ships and improve the effective use of their existing parking infrastructure and highways [7]. Due to limited parking, it has been observed that 30% of traffic was navigating a parking space based on empirical data from several cities [8]. A survey conducted in 2011 showed that 60% of drivers had the experience of being so frustrated in the search for a parking space that they finally surrendered [9].

Traditional parking systems require a lot of space and lead to pollution and congestion, as drivers often continue to drive to find an empty parking space [10]. Parking meter systems aim to reduce parking cruises and their negative impacts on congestion and the environment, a reserve will eliminate the uncertainties that cause the need for a cruise, thus improving the efficiency of the private car [11], special attention should be paid to the wealth implications associated with such policies when presented near destinations of interest, such as: parks, city center, university campuses, etc. [12].

In the city of San José de Cúcuta, Colombia, there are mobility problems that tend to cause automobiles to spend most of their time stopped on the roads, diminishing the space available for other automobiles to travel freely; however, the city's road development projects tend to focus on the space they occupy when they are in motion, this represents a serious error due to the fact that vehicles that are stopped affect mobility more than those that are in circulation.

As a result, it is being studied and designed a parking meter system that can be controlled by a public company, service contract or concession, likewise must be governed by the ministry of transport of the city, in order to enforce law 769 of 2002 on prohibited parking, control of public space, increasing the rotation of vehicles, increased availability in parking areas and the economy of adjacent sites, safety for passers-by as well as for car owners, in turn helping the environment by reducing the fuel used to look for parking places in prohibited areas and reducing hearing pollution by excess noise.

2. Methodology

As a case study for the proposed system, the population was used as the vehicle fleet of private vehicles that are supplied by the transit secretary of the metropolitan area of the city of San Jose de Cucuta, Colombia, and because the city is located in the border area with Venezuela, was supplied by the national institute of roads in 2011 through a study of average daily weekly traffic, the number of vehicles that enter the country, in order to know the exact number that circulate on the city's public roads, thanks to a mobility agreement between these two countries [13], and thus use data collection tools such as the 382 surveys conducted to analyze sample satisfaction and acceptance by the community [14], the differences between the capacities of transport systems, their technical characteristics, requirements for their proper execution and, above all, the impact they can generate on the development of the city must be established [15].

2.1. Vehicles registered with the transit secretary

The following information was provided by the transit secretary of the city of San José de Cúcuta, Colombia [16]: In San José de Cúcuta there are 8220 vehicles registered, in Los Patios there are 3300 vehicles registered, and in Villa del Rosario there are 4000 vehicles registered.

2.2. Vehicles entering the city registered in the weekly average daily transit

The following information was provided by the national highway institute in 2011 through a study of weekly average daily traffic [13]. In the city of San José de Cúcuta, Colombia, by bridge “Francisco de Paula Santander”, that connect with Ureña, Venezuela, 16764 vehicles enter; by bridge “Simón Bolívar”, that connects with San Antonio, Venezuela, 19503 vehicles enter. Therefore, the study is performed with a total population of 51787 vehicles.

3. Results

3.1. Location of the parking meter model

The equipment must be in a visible place, with a great impact, clearly identifiable by the drivers and easy to access; therefore, the complementation of the parking meters in the main streets and avenues of the city center was evaluated due to its high level of traffic congestion. The intervention zone in which the project will be developed includes the following streets and avenues identified in Figure 1 (line orange corresponds to the limits of the area to be intervened, and lines green are the parking meter zones).

3.1.1. Characteristics of the area to be intervened. The perimeter to intervene concentrates the commerce of the city with 11 shopping centers, restaurants and chain stores, in addition to providing medical service by 13 public and private entities of the sector for its high demand, because this perimeter has located colleges, universities and banks around it, which are used throughout the city.

As the city increases its vehicles every day, the illegal parking lots in the streets and avenues of the

city expand, generating traffic and vehicular congestion, which are mostly in the center of the city's commerce, approximating a total of 13 illegal parking lots illustrated in Figure 2, which put the driver's vehicle at risk. There is a marked trend of illegal parking in the area covered between 3rd and 9th avenues with 5th and 9th streets, and on 8th avenue between 7th and 13th streets, sectors in which city commerce predominates, both formal and informal.

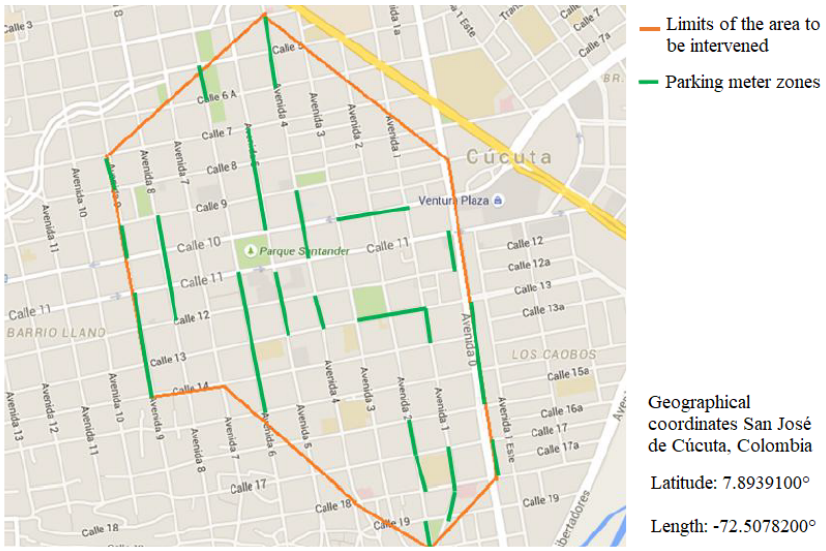

Figure 1. Parquet meter installation area.

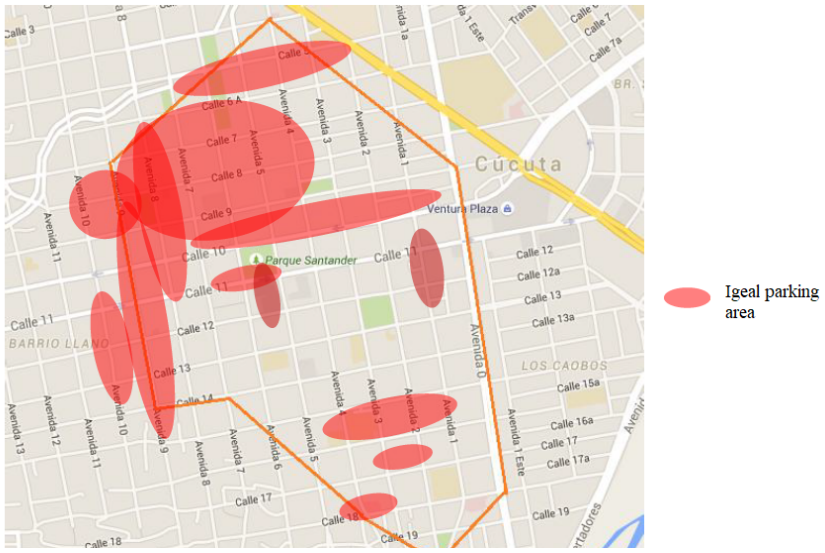

Figure 2. Illegal parking areas.

3.2. Selected parking meter model

The most suitable parking meter for this case was the multi-space parking meter, due to its payment facilities, operation of several parking cells, economy in the installation and maintenance. Currently there are different parking systems, this being one of the most traditional, which will work as follows: In which users must park in a marked area, where they must go to the nearest parking meter, which will give them a ticket as proof of registration to enter the plates of the vehicle, bearing in mind that it will not exceed the established time, as the system will generate a fine, at the end of their activities, must cancel the amount indicated, placing the ticket in the scanning area and may remove the vehicle from the parking area.

From a city perspective, multi-space meters are more reliable than those that need coins, which are often out of service due to vandalism or sabotage. The former has a higher rate of gain, usually between 20% - 30% due to ease of payment. Computerized revenue review reduces employee theft, improves revenue tracking and provides good information for policy analysis.

3.3. Characteristics of the service

The service will only be used by drivers of private vehicles, from which motorcycles must be excluded, and also excludes public transport, such as buses and taxis. It will have the following components: network of parking meters installed in different streets and avenues of the city center, fee for the use of the system, schedules defined for the use of the parking meter system, parking bays with their proper vertical and horizontal signaling, network of control of parking meter system in which statistics must be kept on the regularity of use of the system, maintenance, infractions and times of use. security for both the system and for users.

3.4. Parking meter system rates

The quickest and cheapest (and also the least precise) way to set the fare is to determine it on the basis of what is charged in similar places that already have meter systems, or for the various parking services in the area (public parking, valet parking service, flanneleros); once this fare is estimated, it is applied during an evaluation period. Between August 2011 and June 2014, the San Francisco municipal transportation agency adjusted parking rates 13 times based on demand by one-quarter of the city's total measured street parking spaces [17]. San Francisco parking prices for portions of its street and off-street public supply now vary by time of day and location. The goal of on-street parking is to charge the lowest possible prices [18].

Fees for the use of the meter will be charged in fractions of 15 minutes or one hour. The initial fare of the parking meter system will be $0.62 U.S. dollars, which is considered in balance with the values of public transport and parking type parking, also recommended an annual increase of $0.015 U.S. dollars.

3.5. System capacity

The location of parking cells shall not obstruct corners, pedestrian crossings or ramps for persons with disabilities. On the other hand, it must be taken into account that there are no elements in the adjoining platform that prevent the opening of doors or hinder access to cars, such as furniture, vegetation, posts, signs, etc. Taking into account the standard dimensions that the cells destined for automobiles will have is 5 m x 2.50 m parallel to the platform, 2.50 m x 5 m in perpendicular, and 5 m x 3.20 m when these are diagonally to the platform, a parking meter installation is established in the area of influence of 475 cells, which are divided into 38 parking bays in the center of the city.

3.5.1. Real capacity. The maximum duration of each vehicle parked in the cell will be 2 hours; the parking meter system will operate 12 hours a day (7:00 am – 7:00 pm) will cover most of the hours with greater presence of traffic flow in the center of the city, therefore, the actual capacity will be: 2850 vehicles parked daily, 74100 monthlies and 889200 annually, for an approximate population of 50000 vehicles circulating in the city.

3.6. Financial study

Table 1 defines the total investment that the project will have, with a fixed investment of 2,091,445,423.14 for: equipment, materials, construction of bays and office furniture. Deferred investment of 562,471,724.63, alluding to the set of goods that are property of the company and necessary for operation: Bays construction license, certificate of existence and legal representation of the company before the state, design of the company and publicity of the system; finally, the initial working capital, represented by salaries and office expenses with a total of 120,683,675.96. There are three operating models for project financing:

3.6.1. Public company. In this case, all costs and risks are assumed by the municipality, which buys or rents the equipment and operates it, receiving all the money collected by the parking meter system. It is typical of municipalities that already have a company with experience in managing urban mobility services, which find it relatively easy to create a department that operates the parking meter system.

3.6.2. Service contract. The municipality enters into a service contract with a private party who is paid a predetermined price for the operation of the system (which may include equipment rental). With this type of contract, the income received by the municipality is variable, since the same payment per operation is always deducted from these regardless of how much was collected. This model offers greater security to the concessionaire, since it has insured revenues to cover the system's relatively fixed operating costs.

3.6.3. Concession. With this model, a private concessionaire administers for a certain period of time and in exchange for a previously established payment the administration of the parking lot on the public highway. The economic risk of the operation is assumed entirely by the concessionaire, who in exchange retains a certain percentage of the resources collected by the parking meters. The equipment can be owned by the municipality, rented or by the concessionaire.

Table 1. Total investment

Components	Value
Fixed investment	2,091,445,423.14
Deferred investment	562,471,724.63
Initial working capital	120,683,675.96
Total	2,774,600,823.73

3.7. Impact of the project

3.7.1. Economic impact. The installation of this parking meter system will generate income from the parking of private vehicles on public roads, a percentage of that income will be given to the city of San José de Cúcuta, Colombia, which could mean an investment in public space and the improvement of public transport, representing an increase in the use of these. In addition to bringing benefits to the municipality and the company in charge of its operation, the system also provides benefits to drivers as it decreases the cost of fuel and of wear and tear on cars in search of parking, helps to decongest and reduce travel times due to vehicle congestion. It also represents an opportunity to generate employment since personnel are needed to implement the system, it also generates greater access to commercial establishments, markets and local products, due to the ease of finding parking available in front of them.

3.7.2. Social impact. Possible social benefits provided by the parking meter system include: Creation of jobs for the city's population, liberation of public space, hindered by poorly parked drivers, improvement of the image of the city center, thanks to the organization of parking in public space, safety and comfort for passers-by in pedestrian zones, facilitation of vehicular traffic, shorter journey time due to improved vehicular mobility.

3.7.3. Environmental impact. The parking meter system does not generate great environmental impacts, thanks to the fact that its technology is environmentally friendly, because it does not consume much battery and some even work with solar energy, despite being located on the platforms where there are commonly trees and different types of plants, these will be located so that they do not generate any damage to them. Its greatest impact is centered on the adequacy of the parking bays, since in some cases it will be necessary to make bollards or platforms generating debris and noise product in the construction process, the handling of tickets issued by the device can also mean an environmental impact, because for each vehicle is necessary to use two of them.

4. Conclusions

In order for parking meter systems to be successful, they need their price to be set appropriately to encourage rotation of places, being an influential factor in the decision of drivers to travel by car, because, if the price is very low, parking meters will not be effective and if the value is exceeded, there may be a very low occupancy of the system, which would affect its profitability. In this order, the city center of San José de Cúcuta, Colombia, was chosen as the implementation zone due to its high degree of illegal parking and invasion of public space, situations that are presented more than by the lack of parking (since in the area there are about 127 establishments of this type), it is the indiscipline and lack of education of citizens, factors that undoubtedly influence the accidently and deterioration of the image of the city.

The multi-space parking meter is considered the best for the city, since it covers several parking cells, frees space and minimizes installation costs, gives greater transparency to the collection process, is environmentally friendly and adaptable to different forms of payment and tariffs, an aspect that is undoubtedly of great importance for the acceptance of the system because it takes into account the different types of users who may use it and allows to define an amount that potentiates both the use and income of the parking meter system.

As for the financial study, it is evident that the factors that determine the size are acceptable, the capacity of the project is adequate taking into account that initially it is viable, in addition the location of the parking meter system is in a strategic point to be able to provide the service of regulation of the parking in the public thoroughfare, due to the strong presence of illegal parking and invasion of the public space, being this an important point since it will guarantee security to all the actors of the road, who will be able to accede to a safe, opportune and reliable service. Therefore, the feasibility study for the implementation of the parking meter system concludes that this is a profitable project, as well as being innovative and beneficial for the city.

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