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Vehicular flow analysis and diagnosis of the public transport

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Abstract Public transport is one of the major means of mobilization for the general population of a country, achieving great importance to its policies of mobilization and economic analysis because it creates controversy to have a poor quality of service, directly affecting the users and drivers of these means. Due to the above, an alternative is proposed for the decongestion of main public transport routes, presenting the degree of saturation and the performance index that can create different alternative routes by moving a percentage of the routes in the city of Cúcuta, Colombia. In order to evaluate the effectiveness of this solution, information was collected by means of surveys for users and drivers, analyzing the data with the SPSS version 21 software, manifesting that there is low quality in public transport. In this way, the final characteristics of this method are evaluated in the new alternatives and in the problem sector, satisfying the quality requirements of public transport worldwide.

1. Introduction

Public transport is generally considered as a relatively sustainable mode of transport [1,2], more than half of the population has a travel subscription for the public transport system and with regular use, this includes upper class and state representatives [3]. It is supported by governments to achieve social and environmental objectives through a series of public values established through the instrument of a subsidised transport service for its inhabitants and visitors [1], but in cities with low car ownership rates, public transport becomes the main mechanism for articulating urban structures and facilitating access to territory within sustainability objectives [4].

Lack of transport can result in difficulties in accessing social life, education, health services and economic opportunities [4], and with unbalanced distribution of public transport services among the population can have adverse effects for groups that are often relegated to the margins of society due to lower socio-economic status [5]. The quality of public transport is one of the greatest challenges of economic analysis and mobility policies, given the importance of such data both for companies providing these services and for the public administration [6], in reducing the traffic load, but disruptions due to congestion, as well as planned or unplanned events, such as maintenance work or accidents, can have strong effects on the journey times of public transport vehicles and their quality of service [7].

In Hanoi and Hochiminh City, despite improvements in service and continued increases in subsidies, bus actions increased modestly from 3% to 10% over the same period [8], while Madrid had the highest public transport use rate in 2010 compared to 21 other European cities, and the degree of satisfaction among public transport users reached a level of 78% [9]. Buehler (2011) carried out a comparative study between the USA and Germany, showing that the number of sustainable transport users in Germany was

higher; 40% of German travellers used sustainable modes (8% for TP), while only 11% of US travellers used sustainable modes (2% for TP) [10].

Based on the previous description, a previously analyzed improvement alternative is proposed for the most saturated corridor of commune 5, corresponding to Guaimaral Avenue, by means of a series of up and down surveys of passengers, calculation of the degree of saturation and the performance index, establishing if the corridor is in conditions to house the quantity of routes assigned by the municipal transit secretary of the city of Cúcuta, Colombia; to give a sustained proposal of improvement to the problems of the sector.

2. Methodology

Taking into account that the capacity of transport systems is directly proportional to the independent infrastructure necessary for their putting into service [11-13]; the study was carried out with the 56,569 residents of commune 5 of the city of San José de Cúcuta, Colombia and a floating population that used public transport on these routes for work, study or personal reasons. The research used the quantitative method and information collection instruments were applied both for the users of this transport and for the drivers of the system when using direct surveys; interviews were conducted with the Municipal Transit Secretariat and different companies providing this service, Fontur urban transport technical manuals were consulted, information in [14] and the SPSS software that allowed analysis of the information.

3. Results

The lack of quality of the roads is reflected in the lack of signage and the poor condition of the area, causing drivers to disregard restrictions and limitations on the roads, causing prohibited stops, speeding or dangerous maneuvers, so an inventory of traffic signs in the sector is presented in the Table 1.

Table 1. Inventory of traffic signs in the sector.

Regulatory Signals	Quantity
Maximum speed	3
Maximum permitted height	1
No parking	1
Forbidden left turn	1
Forbidden to turn in u	3
No heavy vehicles allowed.	1
Warning Signs	**Quantity**
Caution	1

Inefficient synchronization of traffic signals attributed to inability to adapt to prevailing traffic conditions leads to different small and congested areas which, in turn, can cause major traffic jams [15]. Consequently, many urban and transportation planners assume that better integration of land use and transportation will reduce congestion by promoting both compact development and alternatives to private vehicle travel [16], improving the quality of public transportation service for users and drivers themselves, thus proposing as an alternative to relocate 35% of the routes circulating on Guaimaral Avenue to an alternate route at Av. 3E Ceiba II in the city of Cúcuta, Colombia.

3.1. Evaluation of the current conditions of the relocation alternative

3.1.1. Degree of saturation (α) for the new transport channel. The degree of saturation of the road is the relationship between the volume of traffic in the survey and the capacity of the road, reflecting the relationship between demand and transport supply (Equation 1) [17,18].

$$\alpha = \frac{VB}{Ct} \quad (1)$$

where, α: degree of saturation of the corridor %. Vb: Volume of buses in circulation (bus/hour); (see Table 2). Ct: Theoretical capacity of Table 3 (bus/hours) [18].

Table 2. Traffic data in the Guaimaral Avenue with Calle 4N Corridor.

Hour	Bus total volume						
(AM)	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
7:00	12	10	15	13	14	10	6
7:10	11	12	14	15	10	9	8
7:15	12	9	15	14	16	11	12
7:20	15	14	10	12	9	13	8
7:25	12	13	9	10	12	10	9
7:30	10	12	11	13	9	8	10
7:35	13	11	14	11	13	10	11
7:40	8	12	9	10	10	12	9
7:45	10	8	12	9	12	9	12
7:50	9	16	12	10	8	12	10
7:55	13	9	10	8	13	11	8
8:00	10	10	8	11	12	13	9
	135	136	139	136	138	128	112

Table 3. Frequency of passengers route 5 off-peak hour TRANSRISARALDA S.A**.**

RUTA 5: Rodeo - Belisario - Doña Ceci - Américas – Nueva Sexta - Cenabastos - Zona Hospitalaria - Centre - Terminal and Return.
Off-peak hour 3:00 PM - 3:30 PM

Paths		Initial passengers	Unicentro-Transversal 18	Zulima-Av 11e	Guaimaral-Intersection Pinos	Total	
Monday	Go up	3	2	3	5	13	7
	Go out	-	1	1	3	6	
Tuesday	Go up	4	2	2	6	15	9
	Go out	-	1	1	4	6	
Wednesday	Go up	3	1	1	5	12	5
	Go out	-	1	1	4	7	
Thursday	Go up	5	2	2	7	18	10
	Go out	-	2	2	5	8	
Friday	Go up	4	3	3	4	13	7
	Go out	-	2	2	3	6	
Saturday	Go up	3	2	2	5	13	8
	Go out	-	1	1	3	5	
Sunday	Go up	2	1	1	4	10	5
	Go out	-	1	1	3	5	
Average frequency from monday To Saturday:			16 Minutes	Average frequency Sundays:		19 Minutes	

Guaimaral Avenue has a total of 55 routes by which they move, but it was proposed to move 35% of the routes to Avenida 3e de Ceiba II, will have 19 new routes and deduct the volume of buses in circulation (bus/hours) expected for the new system.

- Vb = 132 (Buses/Hours) → 55 routes that circulate through Guaimaral Avenue.
- Vb theoretical expected for 3E Avenue (Ceiba II). → 19 routes that would circulate through 3E Avenue (Ceiba II).
- Vb theoretical = 46 (buses/hours).
- Ct = 90 (Buses/Hours) in maximum operating conditions for shared transit.
- α= 46(Buses/Hours)/90 (buses/hours) = 0.511 → 51.1%

According to the result obtained for α= 51.1%, it is established that the new corridor of Avenida 3E (Ceiba II), has the optimal conditions for the mobilization of 35% of Guaimaral Avenue's routes, stating that it reduces impacts that increase its degree of saturation such as: congestion, risk, pollution, noise, segregation, intimidation, visual intrusion, inaccessibility to public transportation [19].

3.1.2. Performance index (β) for the new runner. The Equation (2) was used to find the performance index of a corridor (β), this being the relationship between the average values of operational speeds and commercial travel of the vehicles that use it in each total stretch. By commercial speed, reference was made to the average speed of buses in sections, including all operational stops (bus stops, terminals and traffic lights) [18,20].

$$\beta = \frac{Vp}{Vo} * 100 \quad (2)$$

where, β: Performance index, Vp: Commercial travel speed and average speed of vehicles on a given section [18].

If a corridor is not saturated, a commercial speed can be proposed, in this case $Vp = 25\ km/hrs$, according to Table 4 for ideal conditions.

Table 4. Ideal speed for the operation of urban buses [18].

Type of vehicle	Operating conditions	Ideal Speeds (Km/hour)		
		Commercial	Operational	Max Point
Minibus/By place	Shared Transit	25	40	60
	Exclusive Way	40	50	60
Conventional Bus	Shared Transit	15	25	40
	Exclusive Way	25	30	60
	Exclusive Way	30	40	60
	Reserved Routes	20	30	40

Operational speed will be for one minibus/per shared transit location. ($Vo = 40\ km/hour$). Then, using these values in Equation (2) is obtained a β=62.5%. It is deduced that the alternate corridor of 3E Avenue (ceiba II) would be in optimal conditions for the performance of the buses that would circulate for this route, since the speed of commercial buses is a key variable in the operation of public transportation systems because it is related to both the level of service provided to users and the cost of the system [20].

3.2. Evaluation of the conditions of the routes moved

3.2.1. Degree of saturation (α) for routes that have been moved. To transfer routes to another transport channel to reduce congestion in the main channel, Equation 1 is used to deduct the expected volume of buses in circulation (bus/hours) for the old corridor, after moving the new routes to the new corridor.

- Vb theoretical expected for Guiamaral Avenue = 86(buses/hours).
- Ct = 90 (buses/hours).
- α= 86(buses/hours)/90 (buses/hours) = 0,956 → 95.6%

For a α= 95.6% the alternative to move 35% of the routes (19 routes) to 3E Avenue (Ceiba II) is considerable viable, providing decongestion, improved operating speed of buses in circulation in the main corridor, relatively low operating costs, route flexibility and permeability in city centers and urban centers. Today, buses carry almost 70% of all public transport passengers [21].

4. Conclusions

Public transport with deficiencies in the quality of its service directly affects users, emphasizing that they need an improvement of current vehicles, the need to increase the vehicle fleet and the extension of service schedules. On the part of public transport drivers, they show the bad state of the road network, vehicle congestion and illegal Public Transport that carry out their work in a cheaper way but increasing the risk of accidents by not complying with the necessary safety measures for its users and not complying with traffic signs.

In Ghana, transport experts have attributed the depressing traffic congestion to an increase in the vehicle population on the city's already inadequate roads. There are an estimated 1.2 million vehicles in Ghana, 60 per cent in Accra alone, and with a total road network of 1632 kilometers, of which 1310 kilometers are tarred. Accra's roads seem sadly inadequate, as most roads in the national capital are heavily congested [22].

As a result, having a problem of vehicular congestion, different alternatives can be taken for its solution such as the transfer and increase of routes to other sectors, increase of road signaling, entities for the fulfillment of the traffic norms, awareness of the drivers and pedestrians or governmental policies of transit, for which it was opted for the transfer of 35% of the routes (19 routes) that circulate through Guaimaral Avenue, when evaluating the optimal conditions to house this vehicle quantity, since it was obtained a α= 51.1% and β=62.5%, in the new corridor of 3E Avenue Ceiba II, achieving a modification in Guaimaral Avenue with a α= 95.6% in its vehicular zone and thus improving the quality of the roads by decongesting them and decreasing the speed of public transport collectives to create a better satisfaction of its public service to users and visitors to the area.

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