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DETERMINATION OF THE TECHNICAL AND OPERATIONAL INDICES OF THE "XI FESTIVAL" BUS TERMINAL

DETERMINACIÓN DE LOS ÍNDICES TÉCNICO Y DE EXPLOTACIÓN DE LA TERMINAL DE ÓMNIBUS "XI FESTIVAL"

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Summary

This research was conducted at the "XI Festival" UEB with the aim of determining the technical and operational performance of YUTONG ZK-6120 buses. It was found that the coefficient of good technical condition of the fleet was 0.58, the coefficient of time utilization (between 0.996-0.999) and the coefficient of route travel (between 0.75 - 0.95) are high. The utilization of the load capacity is high, which affects the fuel consumption and the technical condition of the vehicles. The actual fuel consumption is higher than the standard of 380.14 L daily, which affects the number of trips committed by the UEB. The greatest difference is observed on route A10 where 86 L less than necessary are served daily. The specific expenditure per unit of work performed (Ce) varies between 0.577 and 0.705 L/Km per route, while the expenditure per hour of operating time (Ch) varies between 0.241 and 0.587 L/Km*h per route. The multiple linear regression model was established to predict the behavior of the consumption index from the values of movement speed, fuel consumption, number of stops and total distance traveled.

Keywords: Indices, consumption, utilization, Fuel

Resumen

La presente investigación se realizó en la UEB "XI Festival" con el objetivo de determinar el comportamiento de los índices técnicos y de explotación de los ómnibus YUTONG ZK-6120. Se obtuvo que el coeficiente de buen estado técnico del parque fue de 0.58, el de aprovechamiento del tiempo (entre 0.996-0.999) y del camino de recorrido (entre 0.75 - 0.95) son elevados. El aprovechamiento de la capacidad de carga es alto lo que afecta el consumo de combustible y el estado técnico de los vehículos. El consumo de combustible real es superior al normado en 380.14 L diariamente lo que afecta el número de viajes comprometidos por la UEB. La mayor diferencia se observa en la ruta A10 donde se servician diariamente 86 L menos de los que se necesitan. El gasto específico por unidad de trabajo realizado (Ce) varía entre 0.577 y 0.705 L/Km por ruta, mientras que el gasto por hora de tiempo de explotación (Ch) varía entre 0.241 y 0.587 L/Km*h por ruta. Se estableció el modelo de regresión lineal múltiple para predecir el comportamiento del índice de consumo a partir de los valores de velocidad de movimiento, consumo de combustible, número de paradas y distancia total recorrida.

Palabras Claves: Índices, consumo, aprovechamiento, Combustible

Introduction

It is known that economic growth generates greater demand for transport (Iglesias, 2010). Empirical evidence correlates the growth of the Gross Domestic Product (GDP) and the growth of demand for transport, although elasticities vary from one country to another. In industrialized countries, land transport elasticities between 0.7 and 1.5 have been obtained for goods, and between 0.6 and 1.4 for passengers (Stambrook, 2006). These elasticities tend to decrease with the level of development (Vickerman, 2002), due to the level of saturation of individual mobility and a greater weight of activities that require less movement of goods in developed economies.

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The transport sector, due to its complexity, requires a system of indicators that enables the comprehensive evaluation of the progress of the transportation process. Its correct selection, based on the characteristics of the transportation process, the analysis of its behavior and the corresponding decision-making, will determine the effectiveness of the process. Elements such as fuel consumption, timing of operating times, use of the distance traveled, the coefficient of good technical condition and availability of the fleet, economic costs per vehicle, are part of the technical-economic and operating indices of the means of transport and the fleet as such. The systematic study of consumption indices is essential to make a comparison and thus determine the efficiency under the working conditions of the means of transport existing in any company, allows to know the differences in the designed working conditions, to discover the causes of non-compliance with the traffic plan, to show the production reserves of the cars, in order to be able to adopt pertinent measures for the improvement of the work in general. (García, 2006).

Considering the problem that arises when analyzing the technical-economic and operational indices of the “XI Festival” bus terminal, the general objective of this work is:

To analyze the technical-economic and operational indices of the “XI Festival” bus terminal.

Materials and Methods

Methodology for determining fuel consumption

To determine and evaluate the fuel consumption of buses in the UEB

Cotorro Terminal “XI Festival” two measurement methods were used: tank calibration method and the full tank method. In the first one, a ruler or other calibrated instrument is additionally required to control the variation in volume, the tank must be in a horizontal position. The first step is the calibration of the tank, for which a container with a capacity of 20 liters was taken. It was filled to full capacity, poured into the tank (reservoir) and marked how many centimeters from the previously selected dipstick corresponded to that volume of fuel, this operation was repeated until the tank (reservoir) was full. After the tank calibration, the measurement is carried out in which the means of transport is served. Once the journey has been made, the amount of fuel in the tank is checked with the dipstick and is subtracted from the amount initially served. The second method is one of the easiest and most economical methods, therefore, it is the most used by most vehicle owners. This procedure consists of the following steps:

1. Fill the fuel tank.
2. Reset the trip meter (Odometer).
3. Take a tour.
4. Refill the tank.
5. Record the distance traveled.

Perform the same procedure above several times, trying to maintain the same route and conditions each time.

Methodology for determining technical and operating indices

The main indexes for performing the calculation are:

- Coefficient of good technical condition.
- Coefficient of park utilization.
- Coefficient of utilization of the route.
- Specific expense per unit of work performed.
- Expenditure per hour of operating time.
- Taking advantage of working time.
- Taking advantage of movement speed.
- Utilization of load capacity.

Coefficient of good technical condition

The coefficient of technical good condition, expression (1), is defined by the ratio of vehicles - days in good technical condition and vehicles - days in existence. A vehicle - days is considered to be in good technical condition when the vehicles have not spent the entire working day in repair or maintenance.

$$\alpha_t = ADt/ADex \quad (1)$$

where:
ADt vehicle- days in good technical condition.
ADex vehicle- existing days.

Coefficient of park utilization

The relationship between vehicles - working days and vehicles - existing days represents the coefficient of utilization of the fleet, expression (2). When vehicles work equally every day of the week, this coefficient coincides with the dispatch coefficient.

$$\alpha_a = ADtr/ADtr \quad (2)$$

where:
ADtr vehicles- days working.

Coefficient of route utilization (β)

The relationship between the useful distance and the total distance of the car defines this coefficient and is determined by the expression (3)

$$\beta = L/Lt \quad (3)$$

where:
L= useful distance of the vehicle with passengers, Km.

The distance between the total and useful distance is the zero distance (L0) which contains the vehicle movements from its base to the route headers, as well as the return to said base.

Specific expenditure per unit of work performed (Ce)

The specific expenditure per unit of work performed by expression (4) indicates the quotient between the fuel expenditure during work and the volume of work performed. In the case of transport, the volume of work is the distance traveled in a closed cycle.

$$Ce = gm/Q(L/Km) \quad (4)$$

where:

gm: fuel consumption during the performance of the work volume, L.

Q: volume of work performed, km.

Expenditure per hour of operating time.

The expenditure per hour of operating time, expression (5), is the relationship between the specific expenditure and the operating time.

$$C_h \equiv C/T_{07}\,(L/Km{*}h) \quad (5)$$

Where:

T 07 = operating time in hours.

Taking advantage of working time

The coefficient of utilization of working time represents the relationship between actual working time (Tr) and shift time (TT).

$$\tau = T_r/T_t \quad (6)$$

This coefficient indicates the portion represented by time spent on loading and unloading and on stops during the shift.

Taking advantage of movement speed

Technical speed: It is the coefficient of division between the length travelled in km (L) and the actual movement time in hours (Tmov). The technical speed does not take into account the time of stops during the turn except for those related to movement conditions.

$$V_t = L/T_{mov} \quad (7)$$

The speed of exploitation depends greatly on the organization of the transport process and the distances.

Utilization of load capacity

The utilization of the load capacity of a transport unit is assessed by the coefficient of load capacity utilization (Y), the comparative evaluation of the load capacity of the unit taking into account the transport distances is determined by the static load capacity coefficient Ye .

Static load capacity utilization coefficient: is the ratio between the amount of load actually transported and the amount of load that can be transported if the nominal load capacity of the means of transport is fully utilized.

$$Y_e = Q_r/Q_{nom} = Q_r/q{*}z \quad (8)$$

where:

q- nominal load capacity

Z- number of trajectories

Given the same coefficient of load capacity, the degree of utilization of the transport unit may be different depending on the transport distances (Gonzales, 1993).

Methodology for statistical analysis

Mathematical-statistical methods were used to process the information collected: to analyze the behavior of fuel consumption (diesel) (Peña, 2000). The processing was done using the STATGRAPHICS 5.1 software. Within this analysis, the following were used:

- Descriptive statistical analysis: This analysis summarizes the mass of data and describes it, it does not draw conclusions about the group, its essential objective is the characterization of the numerical data sets, said characterization reveals the quantitative properties of these sets for their analysis (it contains the measures of central tendency (mean, mode and median), the measures of dispersion (Variance, Standard Deviation, Coefficient of Variation) and the measures of asymmetry and pointing (coefficient of asymmetry and Kurtosis respectively)), the mean, the standard error and the coefficient of variation were taken as statisticians, the latter to know the dispersion of the criteria with respect to the mean. This analysis was used to describe the behavior of fuel consumption (diesel) in the UEB Terminal Cotorro "XI Festival".
- The Multiple Regression procedure is designed to build a statistical model describing the impact of two or more quantitative factors X on a dependent variable Y. The procedure includes an option to perform stepwise regression, in which one of the previously established variables X is selected. The model can then be used to make predictions, including confidence limits and prediction limits. The residuals can also be graphed to show how they influence each other.

The procedure contains additional options for transforming the data using a Box-Cox or Cochrane-Orcutt transformation. The first option is useful for establishing variability in the data, while the second is useful for handling time series data, in which the residuals exhibit serial correlation (Ostle, 1974).

Result and Discussion

Characterization of the experimental area

The Basic Business Unit (UEB) "XI Festival" is located at AVE 101 corner 34 in the Cotorro municipality in Havana. The vehicle fleet is made up of YUTONG buses dedicated to urban passenger transport, with 34 of these, 20 of which are in good technical condition and the rest paralyzed due to engine failures.

This UEB provides services inside and outside the municipality organized by routes. Table 1 lists the routes, destinations, number of stops (Np), distance traveled in each cycle (S), number of cycles performed (Nc), number of buses assigned to each route (No), as well as the time allowed to travel it (Trec).

As can be seen in Table 1, the bus stop covers 11 routes, of which 4 cover between 20 and 45 km, another 4 cover between 46 and 60 km and 3 between 61 and 80 km. The number of stops varies depending on the route, routes C1 and C2 are recognised as "social" routes, so called because due to their characteristics, stops are planned close to each other and routes such as the A47 and the A21 have stops with average distances of up to 1 km. The planned journey times depend on the characteristics of the route itself, taking into account road conditions, the established speed (whether it is an urban or rural area), the number of traffic lights and intersections, etc. Of the 11 routes offered by the UEB, 5 make 3 cycles with 1 assigned bus, 3 make 6 cycles using 2 buses for each route, one route makes 9 cycles for which it has 3 assigned buses, one makes 12 cycles (with 6 buses) and one makes 16 cycles for which it is assigned 4 vehicles.

Analysis of fuel consumption of buses by route

Fuel consumption is one of the main factors that affect the consumption of a vehicle, and knowing the demand for it and the damage it causes to the environment makes its study more important. There are several elements that influence fuel consumption, so even if two vehicles have similar technical characteristics and make similar journeys, their consumption can vary. The loaded weight of the vehicle, the number of stops, the road conditions, the technical condition, the work regime, the way of driving and even the driver's mood are components that directly affect whether the vehicle consumes more or less fuel. With this analysis, it can be inferred that fuel consumption is variable and that there is no constant consumption, on the contrary, it always depends on the performance of the technical conditions of the vehicle, the terrain and environmental conditions.

To determine fuel consumption in the UEB, fuel consumption per bus was measured during the months of January, March and June 2023 and a multivariate descriptive statistical analysis was carried out. Table 2 shows the results of the statistical analysis where Rto is the count of the number of data entered for each route, me is the mean, De is the standard deviation, ee is the statistical error and Cv the coefficient of variation.

By analyzing the values of standard deviation and coefficient of variation, it can be said that the deviations of the data with respect to the mean and between each other are low, which means that the fuel consumption behavior is stable and during the measurement period there were no factors that affected the fuel consumption behavior.

In Figures 1, 2 and 3 it can be observed that fuel consumption varies on each route, the bus stop covers 11 routes, which have different characteristics that directly influence fuel consumption,

From figures 1, 2 and 3 it can be summarized that:

- Route C1 actually consumes 183.46 L of diesel per day (66,961.44 L per year), when by technical standard it should consume 156 L (56,940 L per year), which results in a difference in fuel consumption equal to 27.46 L (being 10,021 L per year) of diesel per day, as mentioned above, making 12 cycles per day, makes 408 stops, for a total of 312 km traveled, with 2 buses working.

Table 1. Characterization of the routes.

Route	Destination	Np	S, km	Trec, h	Nc	No
A5	Parque Fraternidad	78	48	2.20	9	3
A6	Nazareno	68	51	2.00	6	2
A7	Villa Panamericana	62	42	2.20	6	2
A9	Santiago de las Vegas	78	56	2.20	6	2
A10	Ceguera	50	43	1.50	16	4
A19	Hospital Julio Trigo	68	52	2.30	3	1
A21	Túnel Bahía	76	80	2.20	3	1
A47	Hospital Almejeiras	70	74	2.20	3	1
A52	La Palma	72	45	2.00	3	1
C1	Circular Santa Amelia	68	26	1.00	12	6
C2	Comunidad 1ro de Mayo	82	64	2.50	3	1

Table 2. Statistical analysis by routes

	C1	C2	A5	A6	A7	A9	A10	A19	A21	A47	A52
Rto	5580	2790	8370	5490	5580	5580	11160	2790	2790	2790	2790
me	182.49	117.79	273.76	169.72	161.85	216.49	430	99.36	153.85	125.42	84.91
Of	0.026	0.021	0.050	0.075	0.106	0.024	0.069	0.021	0.025	0.021	0.022
ee	0.003	0.004	0.005	0.010	0.013	0.003	0.006	0.004	0.004	0.004	0.004
CV	0.015	0.012	0.031	0.043	0.064	0.015	0.043	0.013	0.016	0.012	0.014

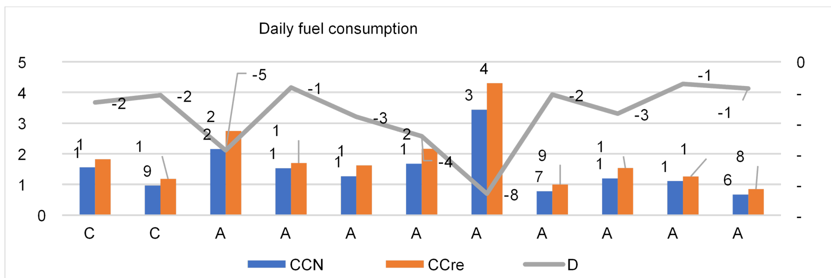

Figure 1. Daily fuel consumption

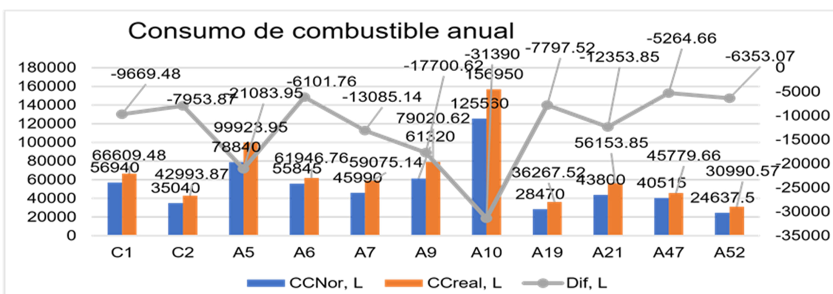

Figure 2. Annual fuel consumption

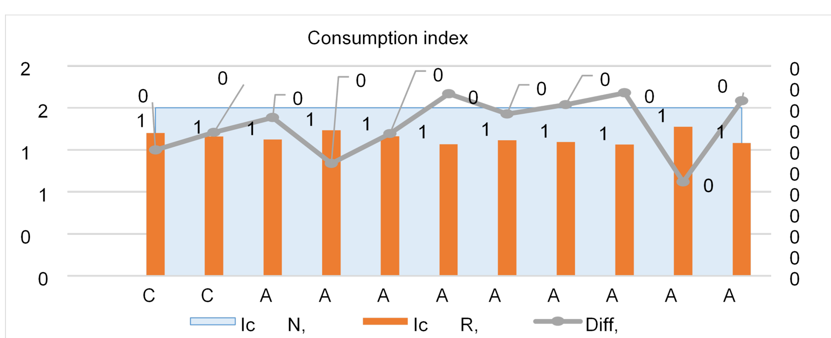

Figure 3. Consumption index by route of the “XI Festival” bus terminal

- Route C2 actually consumes 231.55 L per day (84,516.48 L per year) of diesel (it offers 6 cycles in which it makes 246 stops and travels 384 km), when by technical standard it should consume 192 L (70,080 L per year) of diesel, which results in a difference in fuel consumption equal to 39.55 L of diesel, adding up to a deficit of 14,436 L per year, with 1 bus working.
- Route A5 should consume 216 L (78,840 L per year) of diesel per day, while it actually consumes 266.11 L (97,130.88 L per year) of diesel, which results in a difference in fuel consumption equal to 50.11 L of diesel per day and 18,290 L per year. This route covers 432 km daily, in 9 cycles making 702 stops, with 3 buses working.

- The A6 route actually consumes 23.56 L more per day than its assigned amount (actual and regulated consumption 176.56 and 153 L of diesel respectively). When analysed annually, there would be a consumption of 8,600 L of fuel consumed above that established according to the consumption index by which the fuel allocation in the UEB is calculated. The total daily journey of 306 km is made in 6 cycles, accumulating 408 planned stops, with 2 buses working.
- The A7 route actually consumes 151.70 L per day (for an actual annual consumption of 55,371.96 L) of diesel, when by technical standard it should consume 126 L (per year would be 45,990 L) of diesel, which gives a difference in fuel consumption equal to 25.70 L of diesel per day and 9,381 L per year. It covers 252 km per day in 6 cycles and has 372 stops, with 2 buses working.
- The A9 route, travelling 336 km (in 6 cycles and with 468 planned stops), consumes 46.37 L of diesel above the consumption standard (214.37 and 168 L of actual and planned diesel fuel respectively). The annual consumption differs from the planned consumption by 16,924 L of diesel fuel, with 2 buses in operation.
- The A10 route actually consumes 851.74 L per day (for an annual consumption of 310,886.56 L) of diesel, when by technical standard it should consume 688 L (251,120 per year) of diesel, which results in a difference in fuel consumption of 163.74 L of diesel per day and 59,776 per year. In view of the 32 laps it provides in the day, and making 800 stops, for a total of 1,376 Km travelled, with 4 buses working.
- The A19 route actually consumes 195.94 L of diesel per day (71,516.64 L per year), when by technical standard it should consume 156 L of diesel (56,940 per year), which results in a difference in fuel consumption equal to 39.94 L of diesel per day and 14,576 L per year. For the 6 trips it provides per day, and making 204 stops, for a total of 312 km travelled, with 1 bus working.
- The A21 route actually consumes 306.72 L of diesel per day (for an annual consumption of 111,952.80 L), when by technical standard it should consume 240 L of diesel (87,600 L per year), which results in a difference in fuel consumption of 66.72 L of diesel per day and 24,352 L per year. In view of the 6 laps it makes per day, and making 228 stops, for a total of 480 Km travelled, with 1 bus working.
- The A47 route actually consumes 249.97 L of diesel per day (which would be 91,239.78 L per year), when by technical standard it should consume 222 L of diesel (81,030 L per year), which results in a difference in fuel consumption of 27.97 L of diesel per day and 10,209 L per year. This is due to the 6 laps it makes per day and 210 stops, for a total of 444 km travelled, with 1 bus working.
- The A52 route actually consumes 190.35 L of diesel per day (69,477.75 L per year), when by technical standard it should consume 135 L of diesel (49,275 L per year), which results in a difference in fuel consumption of 55.35 L of diesel per day and 20,202 L per year. This is due to the 6 laps it makes per day, making 216 stops, for a total of 270 km travelled, with 1 bus working.

Festival" which we compare with the UNAH vehicle fleet whose specific expenditure index per work unit has a value of 1.17L/Km, according to García, 2006, which we also attribute to the homogeneity of the vehicle fleet of the "XI Festival" terminal and its radical difference with the UNAH vehicle fleet, which makes both results incontestable.

In the analysis of the fuel consumption rates of buses by route

The "XI Festival" bus terminal came to understand that in all cases the actual consumption rate is below the standard, so the actual fuel consumption is above the planned. Every day, 380.14 L of fuel is needed above the allocated amount.

Analysis of the technical and operational indices of buses

The transportation sector, due to its complexity, requires a system of indicators that enables the comprehensive evaluation of the progress of the transportation process. Its correct selection, based on the characteristics of the transportation process, the analysis of its behavior and the corresponding decision-making, will determine the effectiveness of the process.

Knowledge of technical-economic and operating indices allows for maintaining order and organization of work and operations carried out in a given company or entity. Transport, as a branch of the economy, linked to production, service to the population and others, requires control and analysis so that its efficiency and use is the best and most appropriate. Planning activities and carrying out periodic reviews of the transport system is a factor that marks the quality and efficiency of any entity dedicated to this operation.

The determination of the value of the aforementioned indexes at the "XI Festival" bus terminal in the Cotorro municipality yielded the results analyzed below.

The coefficient of good technical condition (at) was 0.58 (table 3) which means that 58% of the entity's vehicles are in good technical condition, taking into account that it is considered in good technical condition when the vehicles have not spent the daily working day in repair or maintenance. This result, taking into account the age of the means that make up the park, is acceptable, most of the vehicles already have more than 8 years of exploitation since they were incorporated into the

Automotive Fleet, their technical and operating conditions are not optimal, therefore, it is necessary to carry out maintenance frequently, on the other hand, there is a lack of parts and supplies in the country, which causes that when parts that do not exist break, the bus is left without working capacity until it is decommissioned. The coefficient of utilization of the fleet (aa) and the coefficient of good technical condition (at) have the same value because there are no reserve vehicles, the technical condition of the fleet allows the planned routes to be covered as long as there are no breakdowns, in the event of a breakdown, the route served by the vehicle with difficulties is affected until it recovers its working capacity.

Table 3. Vehicle fleet exploitation rates

Index	αt	αa
Worth	0.58	0.58

The technical condition of vehicles affects the increase in maintenance and repair costs, which are part of total costs, and reduces the performance of transportation processes, and therefore, income, which doubly affects the Income/ Total Expenses ratio. On the other hand, breakdowns and workshop stays affect the coefficient of time utilization. Therefore, the coefficient of technical readiness (αt) is proposed as a support indicator, as a means to explain possible causes of increased expenses, reduced income and poor use of time, which also affects the fulfillment of plans, and, therefore, efficiency. All of the above shows its comprehensive nature. In the effective use of human and material resources, not only the technical condition affects, but also the good use made of what is technically available, in this sense, the coefficient of use of good technical condition acts as a valuable complement in the evaluation of the good use of resources. (Pérez Chaviano 2019)

Table 4 shows the technical and operational indices of the fleet by route, which relate the use of the distance travelled (β), the shift time (ţ) and the load capacity (Ye). The values of the specific expenditure per work unit (Ce), the expenditure per hour of operating time (Ch), the working speed (Vr), the latter being the daily and monthly values, are also related.

The coefficient of utilization of the route (β) establishes the relationship between the distance traveled with passengers and without passengers, with load and without load, therefore, the higher its value, the more the distance traveled by the vehicle is used for useful work, which in the entity is based on the transport of passengers. This index has a value between 0.996 and 0.999 (the optimal value in transport operations) (table 4), which indicates that there is a good use of the route traveled, the geographical position of the stop, as well as the location of the first stop, make the empty route minimal.

The coefficient of time utilization (τ) represents the relationship between the actual working time (Tr) and the shift time (TT), that is, the time that elapses from when the vehicle's work begins until it ends each day, taking into account the vehicle working hours and vehicle working days between the time that must be worked. In this study, the value for the shift time was taken as 8 h, which is the value used by the entity, since it must be taken into account that the shift time in transport operations is irregular. In table 3.3 it can be observed that the routes C1, A6 and A52 is 0.75, which means that the vehicle has more time without movement between one departure and another, in the routes A5, A7, A9, A19, A21 and A47 are in the range of 0.85 to 0.90 and that A10 and C2 in the range 0.91 to 0.95 which have the minimum time without movement between one departure and another, this is due to the relation of adjustment and organization to the demands of the population and the possibilities of the terminal within an 8-hour workday.

Table 4. Data on the technical and operational indices of the park by route.

Route	β	ţ	Ce, L/Km		Ch, L*h/Km		Vtec, km/h	Vr, km/h		Ye
			D	M	D	M		D	M	
C1	0.996	0.75	0.588	0.588	0.587	0.588	21.818	25.874	25.900	1.375
C2	0.998	0.93	0.603	0.603	0.241	0.241	25,500	25.550	25.560	1,450
A5	0.998	0.87	0.616	0.616	0.279	0.280	19.091	21,674	21,773	1.425
A6	0.998	0.75	0.577	0.577	0.287	0.288	25.455	25.323	25.450	1,450
A7	0.998	0.87	0.602	0.602	0.270	0.274	28.667	18.789	19.045	1.475
A9	0.998	0.87	0.638	0.638	0.291	0.290	22.609	25.525	25.409	1,500
A10	0.998	0.91	0.619	0.619	0.407	0.413	36.364	28.224	28,600	1,450
A19	0.998	0.87	0.628	0.628	0.275	0.273	33.636	22.763	22.565	1,400
A21	0.999	0.87	0.639	0.639	0.293	0.290	22,500	36.651	36.318	1.475
A47	0.999	0.87	0.563	0.563	0.255	0.256	26,000	33.439	33,591	1.425
A52	0.998	0.75	0.705	0.705	0.354	0.353	25,600	22.563	22.450	1.475

The utilization of the load capacity (Ye) has an average value of 1,375 and 1,500 (table 4). This coefficient reflects the relationship between the amount of cargo actually transported and the amount of cargo that must be transported. When observing the results, it shows that the capacity of the vehicles is used to the maximum. On each route it has been proven that the number of passengers exceeds the number of ordinated passengers, so the index will always be greater than 1 and this implies that the use of the load capacity is at the maximum of its capacity and in some cases even with excess between 1/3 and ½ of its capacity because the center does not have enough buses to cover the demand in the service, although it is socially good that the bus transports more passengers than what is established, from the technical point of view the repercussions are negative because it threatens the good technical condition of the vehicle, which implies that breakdowns may arise, not to mention that it directly affects the fuel consumption index, negatively varying the numbers

The technical speed (Vt) is the speed that the vehicle must reach and maintain taking into account its technical conditions, traffic regulations, road conditions, traffic and established stops; it is the relationship between the total distance traveled and the total time in motion, it has an average daily value between 21,674 km/h and 36,651 km/h per route and its values fluctuate during the course of the year between as can be seen in table 4 these values are so low due to the technical condition of the vehicles, road conditions (a high percentage of the trips made are on roads that are in poor condition and many are not even paved) such as embankments. The behavior between the average technical speed and the actual speed (Table 4) reveals that routes C1, A5, A9, A21 and A47 are above, which implies higher fuel consumption, in addition to the technical condition of the vehicle, a deterioration of its indicators during operation, and routes A7, A10, A19, A52, A6 and C2 show the same or even lower behavior of this indicator, which means that they are within the established working range, thus contributing to fuel savings and maintenance of the vehicle as established.

The specific expenditure per unit of work performed (Ce) indicates the fuel expenditure during the performance of the volume of work and the volume of work performed by the vehicle. This index is the economic performance factor of the set and is essential to measure the efficiency of the means of transport, it has an average daily value between 0.577 and 0.705 L/Km per route (table 4), with this analysis it can be inferred that fuel consumption is variable and that there is no constant consumption, on the contrary, it always depends on the behavior of the technical conditions of the vehicle, traffic regulations, road conditions, traffic, established stops, environmental conditions, driver experience, just to mention a few, which depends to a greater extent on the natural process of deterioration of the vehicle indicators which have 8 years of exploitation. The hourly expenditure of operating time (Ch) takes into account the fuel expenditure during the performance of the volume of work and the operating times in hours, that is, it indicates the liters consumed per kilometer - hours of work, in this case, as indicated in table 4 with an average daily value between 0.241 and 0.587 L/Km*h per route, this indicator depends to a greater extent on the specific expenditure per unit of work performed (Ce), which as mentioned above is variable and there is no constant consumption, in addition to any eventuality that may arise regarding the time regulated per route (detours, accidents, interceptions, environmental conditions), to name just a few.

A multiple regression statistical analysis was performed to determine the relationship between the consumption index (Ic) and elements such as: total distance traveled (S), travel time (T), fuel consumption (Cc), number of stops (Np) and speed of movement (Vr). Table 5 shows the result of the same where it can be verified that since the P-value in the ANOVA table is less than 0.05, there is a statistically significant relationship between the variables with a confidence level of 95.0%. The model that describes the behavior of Ic with respect to the rest of the elements mentioned is the one shown in expression 9, it is a multiple linear regression model.

$$\begin{aligned} \mathrm{Ic} = {} & 0.913 + 0.0141{*}\mathrm{S} + 0.259{*}\mathrm{T} \\ & - 0.042{*}\mathrm{Cc} + 0.002{*}\mathrm{Np} + 0.026{*}\mathrm{Vr} \end{aligned} \tag{9}$$

The high value of the coefficient of determination (R2) (98.26%) shows the strong relationship that exists between the consumption index and the rest of the elements analyzed, which makes the model obtained very reliable for predicting the behavior of the Ic.

Conclusions

The coefficient of technical condition of the fleet shows that the use of the fleet is limited and there are no spare buses. The coefficients of time utilization (between 0.996-0.999) and route utilization (between 0.75 - 0.95) are high. The utilization of the load capacity is high, which affects fuel consumption and the technical condition of the vehicles.

The actual fuel consumption is higher than the 380.14 L per day, which affects the number of trips committed by the UEB. The biggest difference is observed on the A10 route, where 86 L less than necessary are served daily.

The specific expenditure per unit of work performed (Ce) varies between 0.577 and 0.705 L/Km per route, while the expenditure per hour of operating time (Ch) varies between 0.241 and 0.587 L/Km*h per route.

Table 5. Result of the multiple regression statistical analysis taking into account the travel time.

Regresión Múltiple – Ic.

Variable dependiente: Ic
Variables independientes: S, T, Cc, Np y Vr.
Variable Ponderante: Ruta
Número de observaciones: 11

		Error	Estadístico	
Parámetro	Estimación	Estándar	T	Valor-P
CONSTANTE	0.912893	1.16889	0.780989	0.4702
S, km	0.0141759	0.0182094	0.778493	0.4715
T, h	0.259523	0.49293	0.52649	0.6211
Cc, L	-0.0415378	0.00371786	-11.1725	0.0001
Np	0.00172205	0.00197248	0.87304	0.4226
Vr, km/h	0.0256349	0.0419901	0.610499	0.5682

Análisis de Varianza

Fuente	Suma de Cuadrados	Gl	Cuadrado Medio	Razón-F	Valor-P
Modelo	0.0886226	5	0.0177245	56.33	0.0002
Residuo	0.00157323	5	0.000314647		
Total (Corr.)	0.0901958	10			

R-cuadrada = 98.26 %
R-cuadrado (ajustado para g.l.) = 96.516 %
Error estándar del est. = 0.018
Error absoluto medio = 0.007
Estadístico Durbin-Watson = 2.165
Autocorrelación de residuos en retraso 1 = -0.140

The multiple linear regression model was established to predict the behavior of the consumption index from the values of movement speed, fuel consumption, number of stops and total distance traveled.

Recommendations

Modify the fuel allocation according to the results obtained in this research.

Carry out maintenance according to planning with a shorter period with respect to the ranges to improve its technical condition and along with this fulfill the assigned tasks using the correct vehicle according to availability.

Manage the supplies that guarantee the recovery of the working capacity of buses that are out of service.

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