

Available online at [www.sciencedirect.com](http://www.sciencedirect.com)

ScienceDirect

Procedia - Social and Behavioral Sciences 160 (2014) 410 – 419

---

---

**Procedia**  
Social and Behavioral Sciences

---

---

XI Congreso de Ingeniería del Transporte (CIT 2014)

## Restructuring of public transport service of Alcoy

**Davinia San Nicolás<sup>a</sup>, Oscar Colomer<sup>a</sup>, Mauro Fiore<sup>b</sup>, José Vicente Colomer<sup>\*a</sup>**<sup>a</sup>*Polytechnic University of Valencia (UPV), Cami de Vera s/n, Valencia 46022, Spain*<sup>b</sup>*Movus, Paterna 46980, Spain*

---

### Abstract

Alcoy has a population of 60.000 inhabitants and is located in Valencia, on the north of the province of Alicante. Alcoy has been provided with an urban public bus transport service since 50 years ago. As a result of the current economic downturn, the Municipality of the city applied to the Polytechnic University of Valencia for a study to restructuring the public transport service to allow less municipal subsidies, ensuring quality from two points of view - coverage and frequency.

The aim of this study was to provide the government team of detailed information about public transport service of Alcoy from several points of view; functional, economic, social, spatial coverage and other aspects, making easier the decision-making of the municipal government team, to achieve a public transport service more functional and socially appropriate and economically viable.

The study consists of several phases. In the first phase, "Diagnosis of the current situation," the methodology used consisted, first of all, in assembling available information from recent years, on this basis, the UPV planning team made a study of the characteristics of the existing offer and demand, making more than 3.800 gauging and 700 surveys. The second phase consisted in meetings with neighborhood associations and the municipality to define objectives and make proposals to the government team. The third phase consisted in making a deep analysis of the proposals, according to the criteria considered and allowing an operation of the service approachable from a financial point of view.

The paper presented details the work carried out as well as the proposed solutions and its impact on demand and municipal subsidies. As evidenced by the restructuring proposed that it is possible to achieve savings greater than the 30 % in the municipal contribution with a demand damage lower than 10%.

© 2014 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/3.0/>).

Peer-review under responsibility of CIT 2014.

\* Corresponding author. Tel.: +34- 963-877-000 ; fax: +34-963-877-379

E-mail address: [jvcolomer@itrat.upv.es](mailto:jvcolomer@itrat.upv.es)

*Keywords:* Urban Public Transport; sustainable mobility; bus lines network; Polytechnic University of Valencia (UPV).

## 1. Antecedents. Project aim.

Alcoy has a population of 60.000 inhabitants and is located in Valencia, on the north of the province of Alicante. Alcoy has been provided with an urban public bus transport service since 50 years ago. As a result of the current economic downturn, the Municipality of the city applied to the Polytechnic University of Valencia for a study to restructuring the public transport service to allow less municipal subsidies, ensuring quality from two points of view - coverage and frequency.

The aim of this study was to provide the government team of detailed information about public transport service of Alcoy from several points of view; functional, economic, social, spatial coverage and other aspects, making easier the decision-making of the municipal government team, to achieve a public transport service more functional and socially appropriate and economically viable.

## 2. Offer and Demand

The urban public transport of Alcoy has wide territorial coverage. There are 5 lines - A, B, C, U and D - , and a special line, serving the cemetery and the sports complex. The line 5 drives, exclusively, on Saturday and Sunday mornings.

There are a total of 80 bus stops distributed homogeneously in the different neighborhoods. Almost all the stops are served by more than one line.

There are 14 vehicles in total (including one assistant) and the 80 % of them are over 10 years old. The operation is managed by an advanced System Operation Assistance (SAE).

The bus service operation is different depending on the period (winter, July or August) and the day of week (weekday, Saturday and Sunday). The study have been focused on winter weekdays.

On winter period buses run a total of 267 routes and near 2.380 km every day. Daily, line A runs 819 km, the line B 503.2 km, the line C 238.4 km, line D 248 km and line U 573.3 km. There are 12 buses driving in their itineraries with a frequency ranging between 12 and 15 minutes, except the line D which drives every 30 minutes.

### 2.1 Offer areas and micro - areas.

It is interesting to analyze the public transport according to different areas or neighborhoods because one of the objectives to be present, in the actions proposed, is that neighborhoods get an adequate offer of public transport. See table 2. Inhabitants by areas.

Table 1. Population

AREA	INHABITANTS
BATOI	1919
EIXAMPLE	13812
CENTRO	3877
ZONA NORTE	16936
VIADUCTO	1150
SANTA ROSA	14935
ZONA ALTA	7928

## 2.2 Demand

To analyze existing demand, first, it was carried out a reviewing of the existing information supplied by concessionaire responsible for operating bus lines, called TUA S.A. Following, it was analyzed an extensive data performed by the planning team. The data provided by the company TUA SA belonged to the week beginning the 5 November 2012, representative of an average working week of winter. The average demand of 2012 is 5413 on winter weekdays, the distribution is homogeneous from Monday to Friday. Demand on weekend has fallen to 65 % on Saturdays and 71% on Sundays. See Fig.1.

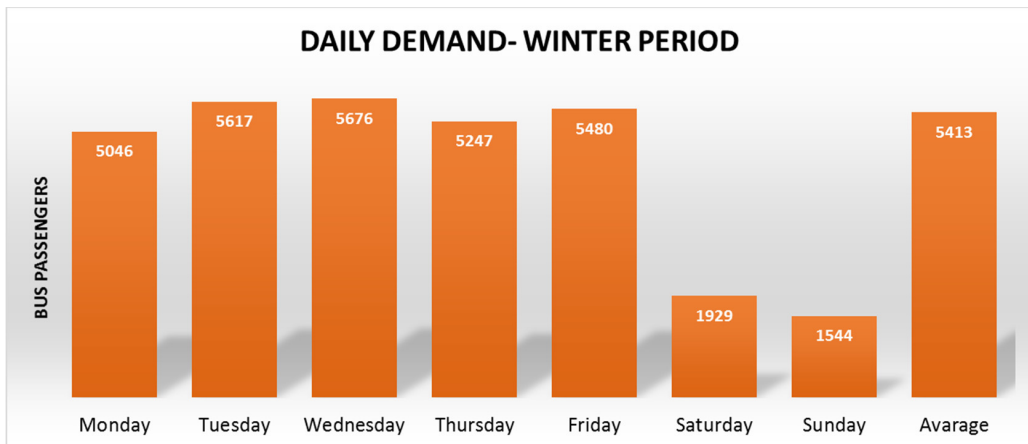


Fig 1 – Daily demand, 2012.

Line A, weekly, moves 11.013 passengers. At weekend, demand falls to 1.014 on Saturdays and 525 passengers on Sundays.

Line B weekly transports 7.105 passengers. Demand is similar from Tuesday to Thursday. Mondays and Fridays it falls to 32%, this important variation seems surprising although demand can be different on Mondays and Fridays.

Line C, is called the viaduct line. Its demand is very low, 1.414 passengers weekly, the 80% lower than line A and B.

Line D transports 325 passengers daily similar to line C (275 daily).

Line U transports 9.500 passengers weekly, 1669 daily. Its route is pretty similar to line A's route. The difference is the head stop.

And finally, line 5 has a social function, it only runs at weekend to go to the cemetery. Global demand is like line C and D, nevertheless, the passenger cost is like lines A, B and U.

## 2.3. Annual Demand 2012.

Global demand on 2012 was 1.500.481 passengers. The 84.5% of demand belongs to weekdays, while the 15.5% demand belongs to Saturdays (9.9%) and Sundays (5.6%).

## 2.4. Annual demand 2013, according to surveys.

### 2.4.1. Methodology to get dates: surveys.

Before making surveys, demand was defined by:

- Geographic location and city orographic characteristics.

- Neighborhood's inhabitants and location.
- Infrastructures and public services
- Characteristics of demand previous year. It was useful to compare the results obtained by surveys.

Planning team designed a data collection based on the surveys in all lines A, B, C, D and U from Tuesday to Thursday, and several polls at weekend, in winter period.

The sample was huge, planning team was able to know the origin and destination, reason for the trip and means of payment of 3.583 passengers in lines A, B, C, D and U, and of 393 passengers in line 5. Knowing that the average daily demand in 2012 were 5.413 passengers and 323 passengers in line 5, it is demonstrated the guarantee of the data collected.

Furthermore, 762 surveys were made - 424 polls in lines A, B, C, D and U, 41 in line 5, and 297 other surveys at weekend. The expansion of the data was based on 2012 data provided by TUA SA.

Multiplying each origin-destination matrix's line by its respective expansion coefficient it was obtained the expanded origin and destination matrix considered as the actual demand of 2013.

The daily demand obtained in 2013 was 5.522 passengers.

### 3. Operation supply transport system.

In the next section the use of data obtained from the viewpoint of the whole network is analyzed. This analysis allowed to obtain general data relating to the whole network (€ / km, Travelers / km, travelers / line, km / line, etc...) that contrasted with the detail of each line and each area helps to get a diagnosis more suitable.

#### 3.1 Economic analysis of cost per passenger and line.

Based on the economic study provided by municipality, it was possible to know the actual cost of the public transport service, summarized in three main concepts: operational costs directly linked to the number of kilometers run, overhead costs, not variable depending on the km and industrial benefit.

Table 2. Unit costs. General network.

SERVICE COSTS	COSTS PER KM	COSTS PER PASSENGER
OPERATIONAL COSTS	2,94€	1,48€
OVERHEAD COSTS	0,34€	0,17€
IND. PROFIT (6%)	0,20€	0,10€
TOTAL COSTS	3,48€	1,73€

Based on the passenger of each line and operational costs of them, it has been calculated the cost per passenger.

Table 3. Costs per passenger-line.

LINES	PASSENG./KM	€/PASSENGER
A	2,07€	1,42€
B	2,27€	1,30€
C	0,96€	3,06€
D	0,91€	3,23€
U	2,49€	1,18€
5	2,40€	1,22€

This analysis demonstrates the substantial difference exists between the lines C and D and the others. Passengers of lines A, B, U and 5 cost, on average, less than 1.30€, however lines C and D lines cost 2.5 times the other lines.

### *3.2 Joint analysis by areas (neighborhoods) and micro – areas.*

With this analysis we know how passengers move by public transport within the city of Alcoy. It were able to establish the main relationships or mobility flows. The demand was contrasted with the level of offer, and adjusted it.

Demand research carried out let us to know the flows demand between different bus stops. To facilitate the overview of the passenger movements, stops were grouped into areas and neighborhoods. The next step was to ungroup the biggest areas into small ones to know the offer and demand of them thoroughly.

## **4. Operation of surveys.**

The research phase of demand includes, as already mentioned above, two types of surveys: quantitative (origin, destination, purpose of travel and means of payment) and qualitative ones. This second type of survey is a personal survey and open-ended questions, to realize it was prepared a questionnaire with 13 questions to be answered in a few minutes. A total of 424 surveys were obtained on weekdays and 297 during weekends. From surveys data were obtained reasons, titles, socioeconomic characteristics, times etc. that allowed to characterize socio-demographically every line

## **5. Objectives of course of action.**

Following diagnosis phase about the current situation of urban public transport in Alcoy, the selection criteria to define the course of actions is:

- Main purpose of Alcoy's urban public transport is to contribute to sustainable mobility in the city, understanding sustainability in three key areas: social, environmental and economic.
- From social point of view, public transport must serve the diverse neighborhoods and micro - areas of the municipality keeping in mind the population, topography, use of the public transport, and other considerations of each area.
- From environmental point of view, urban public transport should be able to avoid shifting in private vehicles. As far as possible, taking into account the economic aspect, it will go to more efficient vehicles from the environmental point of view. In fleet renewals it will take into account the environmental aspect of the new vehicles.
- From economic point of view, it must be planned an urban public transport that supports economic present and future municipal budgets.

Given the criteria outlined, and the unavoidable need for the City for reducing the cost currently accounts for public funds, the aim of the proposals analyzed by the planning team can be defined as: proposals that decrease the monetary contributions from the city council in public transport and, as far as possible, offering the main demand movements between areas from both quantitatively (total number of trips) and qualitative points of view.

The next phase, considering the criteria and objectives above, it has been defined in two courses of action. They were evaluated from both effect on the demand and cost reduction points of view:

- To modify the currently lines and decrease the number of routes. Sometimes the captured demand is very low (almost zero) and the cost of providing these lines is very high. It deals with proposals which get a percentage reduction in costs higher than the decrease demand condition.
- To eliminate some lines and plan new ones keeping, as far as possible, the existing bus stops and introducing new ones and varying frequencies. It is to propose a new network of public transport, respecting the most important lines (A and U) which represent the 66% of total demand.

## 6. Course of action

### 6.1 Definition and evaluation of proposals for action.

#### 6.1.1 Proposals based on the existing network and modifying the routes.

##### 6.1.1.1. Alternative 1: Take away routes with low demand.

Definition:

LINE A: Take away the four routes between 5am and 7am, and the four after 9:22pm.

LINE B: Remove the first two routes, 6:51am and 7:15am. Remove six of the last eight ones from 8:25pm to 10:40pm

LINE C: Leave only three routes in the morning (from 10:15am to 11:45am) and three routes in the afternoon (5:00 pm to 6:30pm)

LINE D: Take away all routes, serving the school and the polygon in highest demand hours. The proposed routes are: 7:20am, 12:20pm, 12:50 pm, 1:20 pm, 3:20pm, 3:50pm, 5:50pm, and 6:20pm.

LINE U: Start service at 7:00am (three routes are removed in the morning), and finish at 9:36pm (removing three more routes)

LINE 5: Take away six routes, leaving transport service from 9:30am to 12:30pm.

Economic and demand impact: This alternative affects to the 6.5% of global demand and reduce the operational costs in 16.5%.

##### 6.1.1.2. Alternative 2: Leaving out the C and D lines without reducing routes in other lines.

Definition: Eliminate the lines C and D, the ones with the least demand. It would mean no connectivity by public transport to industrial estate and the viaduct areas but they could be served by other lines.

Economic and demand impact: 226 passengers (3.6%) will be affected by this action and the savings gotten is the 18% of operational costs.

##### 6.1.1.3. Alternative 3: Leaving out the C and D lines and reduced routes in the other lines.

Definition: Consists on leaving out the lines C and D and reducing routes on the other lines like alternative 1.

Economic and demand impact. Demand falls 7% and operational costs decrease 25%.

#### 6.1.2. Proposals based on remodeling the network.

This proposal needs a deep analysis and it would be part of a second study. The details contained in this proposal should be subject to a deep analysis - tracing new lines, routes, schedule, cost impact, incidence on demand, etc.-.

Definition: To optimize the offer of the lines A and U according to demand, eliminate the lines B, C and D and define two new lines - 2 and 3 - using the new bridge in the north in order to connect by public transport the downtown and uptown area with the hospital in the north.

Economic and demand impact: Based on the new parameters designed. The current costs would decrease about 26% and demand would fall around 7%. See table 4.

Table 4. Main parameters new transport service.

LINES	NUM. ROUTES	KM PER ROUTE	TOTAL KM DAYLY	NUM. VEHICLES	SPEED	HEADWAY (MINUTES)	
A	70	10,5	735,0	4	58,7	12,52	12,0
U	57	9,1	518,7	3	43,4	11,95	14,6
2A	25	8,6	215,3	1,3	19,1	11,28	22 / 45
2B	5	13,0	64,9	0,2	5,8	11,28	-
3	19	7,5	142,5	1,3	11,5	12,39	35,0
	<b>176</b>	<b>48,68</b>	<b>1.676,3</b>	<b>9,8</b>	<b>138,45</b>	<b>11,88</b>	<b>20,5</b>

### 6.2 Complementary actions common to all alternatives.

Regardless of whatever choice you want to implement, it is very advisable to perform different actions to improve urban public transport in Alcoy, among which includes:

- Activation the displays at bus stops. This project represents a considerable improvement in the quality of service.
- Restructuring bus stops: Study to eliminate some bus stops, the ones too much closer.
- Leaving out the fleet vehicles because of their age: new vehicles according to demand.
- Dissemination campaigns, population must be informed about the actions will be carried out..

## 7. Summary and conclusions.

Among the highlights, the following points should be mentioned:

### 7.1. Referred to the object of study.

The aim of this study was to provide the government team of detailed information about public transport service of Alcoy from several points of view; functional, economic, social, spatial coverage and other aspects, making easier the decision-making of the municipal government team, to achieve a public transport service more functional and socially appropriate and economically viable.

## 7.2. Diagnostic phase

### 7.2.1 Zoning

Alcoy has divided into districts (or areas). Some of these areas or neighborhoods have been subdivided into smaller spatial units that we are called micro - areas.

### 7.2.3 Offer

- The urban public transport is based on 5 lines (A, B, C, D, U). On Saturdays and Sundays the service is different with an additional line (replacing other) which is line 5.
- Public transport service in the months of July and August differs from the rest of the year. In summer there is less traffic of vehicles.
- The bus network has 80 stops. Their spatial coverage is all the city. The lines share part of their route in a significant percentage so there are relationships areas served by more than one line.
- The total number of daily routes in winter is 267, covering about 2.400 kilometers. Daily frequencies vary from 12 to 15 minutes.
- There are 12 vehicles running 185.6 hours of service. Average transportation speed is 13.6 km per hour. The timeliness of fleet in the data collection period has been almost total. This referred to winter period.
- The company has 13 vehicles (plus one assistant). Vehicles' capacity vary from 51 and 84 passengers. The age of these vehicles exceeds the 7 years in 11 of them and 4 vehicles are over 12 years old.
- The operation is managed by an advanced System Operation Assistance (SAE) that enables real-time tracking of each vehicle as well as possible act on them. The existence of SAE can provide information about waiting times. In this sense, there are installed information boards at some bus stops but they are not working.

### 7.2.4 Demand

- The annual global demand of urban public transport in Alcoy is around 1,500,000 passengers. The daily demand in the period type is distributed fairly constant (with slight variations) from Monday to Friday and decreases very markedly in Saturday and Sunday.
- The 87.8% of annual demand is distributed in the period winter (in every month except July and August), the 7.4% in July and the 4.8% in August.
- Both lines A and U represent the 66.2 % of the annual demand. The lines, A, B and U mean the 90 % of annual demand.
- From the data taken on buses and the data supplied by the company TUA SA it was obtained the origin-destination matrix between different bus stops that shows the movement of travelers. Proving statistically meaningful data of qualitative surveys have let a deep understanding of demand.
- The use of data by each of the lines enabled to know in detail the following parameters; - Bus stops with the mayor number of travelers uploaded / downloaded, areas with more input rating uploaded /downloaded,



the most important relationships between areas and filling ratio of vehicles in the most charged issue is 70% -.

- As common aspects to all lines include; - In the most charged issue the filling of the bus does not reach 70%. It means, there is residual capacity on buses. On one hand, there are not passengers in the first routes in the morning (before 8 am in general) and the last ones in the afternoon (after 8 pm in general), on the other hand, a very important part of the demand is concentrated heavily on a limited number of bus stops -.

#### *7.2.5. Operation of data for the whole bus public transport network.*

- The cost of each passenger is 1.73 euros in average.
- In the lines C and D, the cost per passenger is more than three euros, while in the other lines, including line 5, the cost varies from 1.2 € to 1.4 €. So there is a clear imbalance of cost per passenger in lines C and D.
- The distribution of offer and demand by areas shows that, relative to the population, there is a clear imbalance in the most populous areas regarding travels and routes.
- The distribution of travels per capita is a measure of "dependence" of the inhabitants to the neighborhood bus service, especially in outlying neighborhoods.
- The distribution of passenger for purposes, keeping in mind that the 47% of the travel purposes are back home, results that the 20% are "work + study" and the 24% leisure or other.
- The 74% of travelers are women and the 26% are men according to the data collected.
- The 52% of travelers do not have a driving license. The 36% of them have to travel their own car.
- The 40% of travelers are older than 50 years old. The 37% are between 25 and 50 years old.
- The distribution of occupancy shows that the 29.28% are workers, students the 22.55%, the 25.54% retired and the rest are unemployed or in another situation.
- The "average" bus travel is 22 minutes.
- It should be noted that over the 50% of travelers report that their access time (from the origin to bus stop) and dispersion (from the bus stop to the final destination) is less than 2 minutes, which is a clear indicator about the comprehensive coverage of the urban public transport service of Alcoy.

#### *7.3. Criteria and objectives. Proposals*

Based on the 2012 data and diagnostic phase, and taking into account that it would want to move towards more sustainable mobility, the desirable objective within the actions to take account is to formulate proposals designed to bring about cutting down on municipality budget and allowing connectivity between the different neighborhoods and micro - areas of the city of Alcoy. By the restructuring proposed could be generated savings exceeding 30% in the municipal budget against a demand damages lower than 10%.

#### **Acknowledgements**

The paper is part of the activities of the company professorship "ACAL - Sustainable City".

The company professorship is the result of an agreement between the UPV and the sponsoring company " ACAL– Abogados y Consultores de la Administraión Local, S.L. ".