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Innovative Techniques in Planning and Finance of Public Transportation Projects: Lessons Learned and its Applications

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Abstract
The International Transit Studies Program (ITSP) conducts two study missions each year to provide transit managers from across the United States the opportunity to examine public transportation practices in other countries and regions, with the goal of encouraging innovation domestically. The program is sponsored by the Transit Cooperative Research Program (TCRP), funded by the Federal Transit Administration, and managed by the Eno Transportation Foundation. The subject for the 2005 Fall Study Mission was *Innovative Techniques in Planning and Finance of Public Transportation Projects*. The mission studied systems in Barcelona, Spain; Copenhagen, Denmark; Shanghai, China; and Osaka, Japan. As a participant, the author had the opportunity to meet with the managers for the different systems and learn and document the experience. This paper presents a more detailed insight on the author's assigned studied systems in Barcelona, the way it has been integrated to become an effective transit system, its financial model, the lessons learned and its possible applications in Puerto Rico and elsewhere.

Keywords
integration, transit, planning, finance, public private partnership

1. Introduction

The International Transit Studies Program (ITSP) conducts two study missions each year to provide transit managers from across the United States the opportunity to examine public transportation practices in other countries and regions, with the goal of encouraging innovation domestically. The program is sponsored by the Transit Cooperative Research Program (TCRP), funded by the Federal Transit Administration, and managed by the Eno Transportation Foundation. The subject for the 2005 Fall Study Mission was *Innovative Techniques in Planning and Finance of Public Transportation Projects*. The mission studied systems in Barcelona, Spain; Copenhagen, Denmark; Shanghai, China; and Osaka, Japan on a 2-week time span.

As a participant, the author had the opportunity to meet with senior officials and managers of the different systems to learn and document their experience and practices. The author's assigned country was Spain, were the city of Barcelona was selected to be visited and studied by the mission. In Barcelona, we met for three days with the officials of the Metropolitan Transit Authority (ATM), the Metropolitan Transit Entity (EMT), the Barcelona Metropolitan Transport (TMB) and TRAM, a private operator, to discuss the system, and how is has been integrated to become an effective transit system.

2. Objectives

The objective of this paper is to show the lessons learned from the Barcelona's transit system through meetings held with their top executives and managers, and how it can be applied in Puerto Rico and elsewhere. The discussions will cover the characteristic of the city and its system, service design and integration, and the financial strategies followed.

3. Findings

3.1 Characteristics of Barcelona's City and Transit System

Barcelona is Spain's second largest city, and capital of the autonomous state of Catalunya. It is located in the northeast of Spain, only 168 km from southern France, on the Mediterranean seaboard. Catalunya is bounded on the east by the Mediterranean Sea, on the north by France and Andorra, and on the west and south by the autonomous communities of Aragon and Valencia. The Barcelona Metropolitan Region or RMB (short for *Region Metropolitana de Barcelona*, or Barcelona Metropolitan Region) is made up of seven counties, l'Alt Penedès, Baix Llobregat, Barcelonès, Garraf, Maresme, Vallès Occidental and Vallès Oriental, with a total of 164 municipalities occupying an area of 3,239 km², and has a population of 4.7 million, which represents over 60% of the Catalunya inhabitants.

Barcelona is a municipality of the Barcelonès County, and is one of the largest cities in the Mediterranean Sea, with a population of 1.58 million. The city occupies 99.1 km² and is bounded by the Mediterranean Sea (southeast), the mountains of Montjuïc (south) and Tibidabo (northwest) and is framed by the river Llobregat to the south and the river Besós to the north.

The RMB public transportation system is coordinated by Autoritat del Transport Metropolità (ATM), an inter-administrations voluntary consortium open to all authorities responsible for mass transport services in the region. ATM's main duties are: to plan the public transport infrastructure and services, to prepare and approve a common fare framework, to establish relations with transport operators, to prepare the proposals for funding agreements with the different public administrations, and to establish communication campaigns to enhance the corporate image of the metropolitan public transport system.

Currently, the consorted administrations are the Generalitat de Catalunya (the autonomous government, 51%), the Ajuntament de Barcelona (the Barcelona City Council, 25%) and the Entitat Metropolitana del Transport (EMT, the Metropolitan Transport Body, 24%). The EMT has the role of organizing, planning and coordinating public transport services through 18 municipalities in the Barcelona metropolitan area. The EMT region consists of 331.5 km^2 and a population of near 2.65 million. This region is the same as the First Crown or Zone used for the fare integration. Including the EMT, there are 4 main operators in the Metropolitan Region of Barcelona: Transports Metropolitans de Barcelona, Ferrocarrils de la Generalitat de Catalunya, Renfe Cercanias and Tramvia Metropolità.

Transports Metropolitans de Barcelona (TMB) is the common name for the join management of the public companies within the EMT, Ferrocarril Metropolità de Barcelona S.A. and Transports de Barcelona S.A., which provide metro and bus services. Those companies have their own legal identity.

With a total staff of 6,078 employees, TMB operates Barcelona's Metro and Bus network. The Metro fleet is made up of 118 trains, 115 five-car trains and 3 double car trains. This represents a total of 581 cars, 466 of which are engines and 115 trailers. The metro's average commercial speed is 27.65 km/h and the trains circulate every three or four minutes, or every 30 seconds in rush hour. This arrangement gives 343 million trips (2004). The TMB Bus fleet is made up of 1000 vehicles that travel at an average speed of 12.2 km/h. Air-conditioning is fitted to 100% of the fleet and 712 vehicles are single decker buses with

the service regulated via GPS. TMB also operates four additional leisure transport modes: the Montjuïc Funicular railway, the Montjuïc Cable Car, the historic Tramvia Blau and the Barcelona Bus Turístic.

In the year 2004, for a total of 465 lines and 9,186 km of network, 868 million trips were generated with an increase of 3.7% from 2003.

The Ferrocarrils de la Generalitat de Catalunya (FGC) runs two principal lines, the Barcelona-Vallès and Llobregat-Anoia. During 2004 FGC transported more than 75.8 million passengers on its two principal systems. The Barcelona-Vallès runs the Metro del Vallès (27.3 million) and an urban service (29.0 million). The Llobregat-Anoia runs the Metro del Baix-Llobregat (16.9 million) and a commuter service (2.6 million). This supposes a 3.9% increase compared to year 2003. Its staff consists of 1,237 employees in charge of operation, maintenance, Information Technology and security. FGC also runs three funicular and cable cars leisure systems: la Molina, Valls de Nuria and Explotacio Monserrat.

Tramvia Metropolità, S.A. is a new operator, created in 2001 with a Public Private Partnership (PPP) agreement. It has two different networks, the Diagonal-Baix Llogrebat and the Sant Martí-Besós. With its three lines, the Diagonal-Baix Llogrebat serves six municipalities and consists of 28 stations and 16 trams with a total length of 15.2 km. It corresponds with Renfe and Metro through 6 modal interchangers. The expected average demand for the Diagonal-Baix Llogrebat is 16.9 million travelers per year, varying from 7.6 to 18.8 at 2025. The Sant Martí-Besós serves three municipalities and consists of 27 stations and 15 trams with a total length of 14.1 km. It corresponds with Renfe, Metro and the Nord Bus station. The expected average demand of the Sant Martí-Besós is 8.4 million travelers per year, varying from 3.7 to 9.3 million at 2025.

Renfe Cercanias is the local trains section operated by the Spanish railway company. There are also many interurban lines that are run by private companies under concession and agreements with regional government. Tables 1 and 2 shows the details for the Barcelona Metropolitan Region transit systems.

Table 1: Train System Count

Train System	Lines	Km.	Stations	Trains
TMB Metro	6	86	123	118
FGC	3	144	71	68
Renfe	5	438	106	170
Tram Baix	3	14.5	28	19
Tram Besós	1	6.4	14	9
Total	**18**	**688.9**	**342**	**384**

Table 2: Bus System Count

Bus System	Lines	Km.	Stops	Buses
TMB Bus	103	887	2375	1000
Interurban	263	6000	7000	675
Other urban	72	521	nd	nd
Total	**438**	**7,408**	**9,375**	**1,675**

In the whole metropolitan region, 38.2% of journeys are carried out by foot, 36.5% by car and the public transport share is 25.4%. The number of transport validations in year 2004 was 837.2 millions, uplifting in 4.64% the figures for 2003. On a working day, residents in the RMB over 15 years of age make 12.4 million trips. Of those, 23.3% use Public transit; 33.9% are pedestrians and 42.8% rely on automobiles.

3.2 Financing Strategies

To embrace all public transport in the Barcelona Metropolitan Region, independent of the responsible administrations and operators, the RMB has implemented the *Infrastructure Master Plan 2001-2010* (PDI). The PDI is an infrastructure planning and programming plan to aim at a truly integrated transport system in the region. The total cost of the plan is 6,596M€, distributed in the three following programs: the Network Extension Program (5,665M€), the Interchange Program (347M€) and the Network Modernization and Improvement Program (583M€) for measures affecting the state railway network. The funds for this investment will be provided by the Generalitat of Catalunya (44.1%), the State General Administration (42.3%), the Local Authority (3.3%) and the European Union (10.3%). The PDI 2001-2010 involves the construction of 75 kilometers of metro lines, local railway and tram lines and 77 new stations, as well as 26 interchange stations.

The PDI defines the financing types for public mass transit system in the RMB depending on the type of action to be taken:

- Infrastructure funding agreements for the network extensions and improvement. For this 1/3 of the funds comes from the State General Administration and 2/3 from the Generalitat de Catalunya.
- Contract-Programs are short-term funding agreements that include the participation of all Administrations, for investing in the network modernization and improvement of the existing network for improvement of service.
- Specific funding of the tram, with deferred capital contribution by the Generalitat de Catalunya and compensation to the private franchisee, by a Technical Tariff of the operating deficit plus the investment royalty.
- Self-funding for line L9 to be defined by the Generalitat de Catalunya.

For the Contract-Program on the 2002-2004 triennium, the ATM received 1,175M€ distributed as follows: 380M€ from the State General Administration, 479M€ from the Generalitat de Catalunya, 153M€ from the EMT and 163M€ from the Ayuntamiento de Barcelona. Figure 2 shows a big increase on subsidies from year to year as the projects stated on the PDI goes to execution. For 2004 the amount of subsidy was 480M€, this amount is expected to rise up to 800M€ when the Metro Line 9 is finished and operating (expected in two to three years from now).

Figure 2: Income and Subsidies (M€)

3.2.1 Financing Issues

Contract-Programs are short-term funding agreements that are developed for two, three or four years to fund the transit infrastructure. Due to its short timeframe, it becomes dependent of administration and management changes. For example, the Contact-Program for the 2002-2004 was negotiated during 2004, almost at the end of the period. This action causes the need for the ATM and all its operators to start looking for outside, or private, financing for the transit projects. That was the case of the Barcelona's tramway, which became the first Public Private Partnership (PPP) for a rail transit project in Spain.

As defined by Grimsey and Lewis (2004), a PPP is "a risk sharing relationship based on a shared aspiration between the public sector and one or more partners from the private and/or voluntary sectors to deliver a publicly agreed outcome and/or public service". This practice has been in use for many years in Europe, Australia, Canada, Latin America and the US. One of the forms a PPP can take, and the one used by Barcelona for its tramway, is the Design Build Finance Operate Transfer (DBFOT) with the following awarding criteria:

- Minimize Construction Cost
- Technical Quality
- Minimize Technical Tariff to be paid by the Administration
- Minimize amount of public funds Granted to the project
- Minimize term of Operation

3.3 The Barcelona Tramway Project

The city of Barcelona needed an alternate surface transit system to alleviate the Bus lines network saturation and reduce the access time of the system. With this in mind, and after different studies on the options were made, they decide to go back to a system previously used in the city from 1872 to 1971 and abandoned, the tramway. As previously exposed, it consists of two separate networks, Diagonal-Baix Llobregat and Sant Martí-Besós, which will join in the near future with lengths of 15.8 km and 14.1 km, respectively, when completed. As can be observed in Figure 3, the design characteristics of these two systems included the reduction in roadway lanes, increase in sidewalks widths, and the integration between the urban, and traffic segregated environments. The platforms are nor intrusive, or dominant, to the urban environment, and the use of mast for the catenaries installation was minimized combining the required masts with the street lightings.

Figure 3: Barcelona New City Lansdscape

After discussion, the ATM Board approved to call for open tenders in October 16, 1998 for the Diagonal-Baix-Llobregat network. The bid was awarded to the successful bidder, *Tramvia Metropolità, S.A.* (TramMet), by May 2000. From May 2000 to November 2000 the parties arranged the financing structure, a Project Finance structure that enabled the Government to spread the necessary funds over the long term and optimize the investment cost. On November 2000 the concession contract was signed and the financial close was reach by July 2001. The first disbursement was made by September 2001. Figure 4 shows the present and future network of the Barcelona Tram.

The Diagonal/Baix-Llobregat (TramBaix) runs since April 3, 2004, and the San Martí-Besós (TramBesós) since May 8, 2004. The trams are the newest transit system in Barcelona and, as previously mentioned,

the first in Spain to utilize the Public Private Partnership approach. A traditional approach was used to structure the partnership agreement. In this approach, the sponsors (TramMet) created a Special Purpose Vehicle (SPV) to contract with the public sector procurer (ATM) and the principal subcontractors, these took equity stakes in it, as sign of their commitment to the project and its delivery. Financers are involved in the consortium, taking minor equity in the SPV and assuming a stronger role after the construction phase. The main responsibilities of the operating group are: to operate the network; to maintain the infrastructure and rolling stock; to control the fraud; to do marketing of the system; and to offer system improvements.

The organization of the TramBaix project includes a new privately owned operating company, *Tramvia Metropolità, S.A.* (TramMet). Within this company there are two consortiums, or UTEs (short for *Unión Temporal de Empresas*, or Enterprise Temporary Union), one in charge of the civil construction and vehicles, and the other in charge of the operation and maintenance. The Construction UTE (UTE TramMet) has 68% of the total asset share and is composed by Comsa, S.A. (12.4%), the Acciona Group (Acciona Concesiones, S.L. with 12.4%), the Alstom Group (Alstom Transporte, S.A. with 20.25%; Alstom Transport, S.A. with 5.1%) and the FCC-Veolia Group (FCC Construcción, S.A. with 19%). The Operation UTE (TramBaix UTE) has a share of 26% and is composed by the FCC-Veolia Group (CGEA Connex, S.A. with 1%; Detren, S.L. with 4.82%; CGT, S.A. with 1%) and Sarbús Group (Marfina, S.L. with 10%; Arande, S.L. with 8%).

The second project, the TramBesós, was also awarded to the same consortium under the new name *Tramvia Metropolità del Besós, S.A.* This SPV is similar to the first one, composed of two UTEs, one in charge of the civil construction and vehicles, and the other of the operation and maintenance. The UTE TramMet has 68% of the total asset share and is composed by Comsa, S.A. (11.9%), the Acciona Group (Necso Entrecanales Cubierta, S.A. with 1.165%; Acciona Concesiones, S.L. with 10.735%), the Alstom Group (Alstom Transporte, S.A. with 20.25%; Alstom Transport, S.A. with 5.1%) and the FCC-Veolia Group (FCC Construcción, S.A. with 19%). The TramBaix UTE has a share of 26% and is composed by the FCC-Veolia Group (CGEA Connex, S.A. with 1%; Detren, S.L. with 4.82%; CGT, S.A. with 1%) and Sarbús Group (Marfina, S.L. with 10%; Arande, S.L. with 9%).

There were also two local banks involved in the financing structure of both projects, the Bansabadell Inversió Desenvolupament, S.A. and Société Générale, with 5% and 1% of the share respectively. Figure 4 shows the traditional PPP structure used for the TramBaix and TramBesós networks.

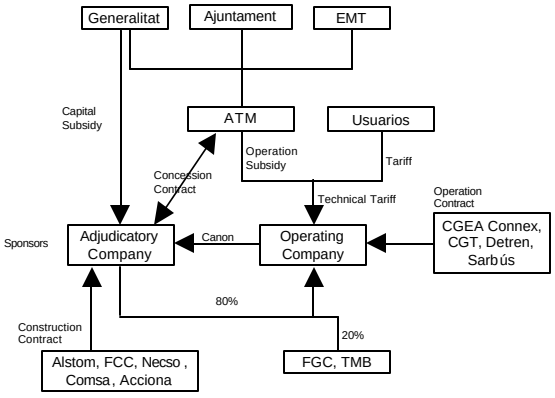

Figure 4: Structure of Partnership Agreement

A 231M€ multisource debt and equity financing package was arranged for the TramBaix. The package consisted of a 205.8M€ debt (103.4M€ from EIB debt, 67.6M€ from bank debt, 17.4M€ from the VAT

and 17.4M€ from other sources) and 25.7M€ in equity. For the TramBesos the package was 179.8M€ of total debt (105.1M€ from EIB debt and 74.7M€ from bank debt) and 25.2M€ in equity for a total debt and financing package of 205M€. The overall investment was 436M€, including infrastructure, systems, expropriations, city development and rolling stock (Alstom Citadis 302, length 32m). Table 3 summarizes the investment of the Trambaix and TramBesos networks.

Table 3. Barcelona's Tramways Investments

Financing	**TramBaix**	**TramBesos**	**Total**
Construction	202.7	183.65	386.35
Financial Costs	25.9	20.68	46.58
Others	2.4	0.67	3.07
Total Investment, M€	**231**	**205**	**436**

The risk from the infrastructure was separated from the traffic risk to reduce the risk of the interested banks. The infrastructure was financed through the European Investment Bank (EIB). The European Investment Bank (EIB) is one of the participants of transit investment through Spain. The EIB participates in the improvement of the European systems up to 50% of the total investment, where there is no major opposition against the projects. Security for the debt and equity financing rest largely on the 25-year TramBaix and the 27-year TramBesós franchises granted for both projects. Table 4 shows the responsible partner for the different project risks.

Table 4. Risk Allocation

Risk	**Responsible**
Construction Risks	
Design	Contractor
Cost and term	Contractor
Expropriations	ATM
Changes due to administration	ATM
Operation Risks	
O&M Cost	Operator
Traffic	Administration support/audited ratios
Availability	Operator
Termination	Spanish Law
Financial Risks	
Counterparty Administration	Regional Government
Interest rates	Fixed interest rates

As previously stated, the ATM contributes with 13 annual payments to the investment in project, infrastructure, expropriation, rolling stock and financial cost. The awarding company receives a levy from the operating company during 25 years, corresponding to the redemption, remaining investment, insurance and financial cost. As can be observed on Figure 4, the funds for the operation of the system come from a Technical Tariff.

3.4 Cost Recovery

Before 2001, in the Barcelona Metropolitan Region, there were 41 operators with 4 price modes: flat rates, kilometric rate for buses, kilometric rate for trains and a system of zones for Renfe. The criteria were not homogeneous when the systems were compared on the same basis. The creation of ATM allowed giving the Barcelona Metropolitan Region the opportunity to develop a new integrated fare

system. This system entered into service in the year 2001 extending the metropolitan region to the Renfe and FGC local train networks, covering 202 municipalities and serving 4.5 million inhabitants. This project is of vital importance for public transport in the metropolitan region, as it represents a substantial improvement to the features of the service provided and enables users to see all the different operators as forming part of a single, global system.

The main objective of the system is to help position the public transport as the most attractive system for users, with an easy-to-understand fare system based on principles accepted by users, and perceived as an integrated and unified network with a single image. At the same time this system helps in the cost recovery by increasing the transfer between modes (intermodality). ATM has automated the follow-up process of the earnings distribution. With this process they know the distribution and determine the intermodality index. The intermodality index of the transit system in Barcelona has increase from 8.3% before 2001 to 21% for the overall system. More than 30% of the journeys transfer between modes.

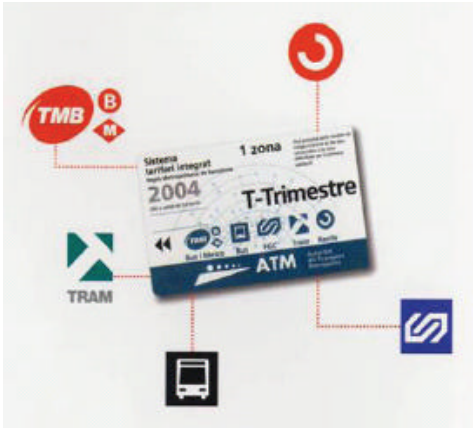

Figure 6. ATM Integrated Ticket

The Zoning for the integrated fare system is divided into 6 crowns, or rings, and 33 different sectors. The crowns have a concentric shape around zone 1 and are defined according to the distance. A "fare zone" consists of the intersection between crowns and sectors. There are 8 radial sectors based on the preferential mobility corridors of the RMB. The ATM ticket, similar to the one shown on Figure 6, allows the user to choose between 8 different options of fare (e.g. 10 days, 50 trips in 30 days, unlimited trips on a month, etc…). The prices are fixed according to the number of zones crossed on each journey with a maximum of 6 zones. The public operators are compensated monthly according to their contracts and the private operators based on their concession contracts.

4. Conclusions

Since ATM conception in March 1997, the Barcelona transit system has been improved and developed as an integrated system. To do this, the ATM works in the field of integrated infrastructure and service planning, in the framework of the, already implemented, Integrated Fare System. Since the beginning ATM has been given the function of mid-term mass transit infrastructure system planning and has been able to address more than 50% of the actions established on the PDI 2001-2010.

The main challenge faced by the Generalitat de Catalunya, specially the Barcelona Metropolitan Region, is to execute the PDI 2001-2010. The PDI is very ambitious with a big improvement on the transit system for the RMB. From now until 2010 there will be a need to have at least two more Contract-Programs. The ability to make it independent of administration and management changes will tell the success of the Plan and the development of an integrated transit system for the metropolitan region with an increase in the mobility and intermodality.

5. Recommendations

Based on the finding and conclusions, recommendations are made that can be applied in Puerto Rico and elsewhere. To become attractive to the users the mass transit systems shall be integrated between modes, and have the meanings to attract the user to utilize it. In the following sections we will review Barcelona's best practices and its possible implementation in Puerto Rico, and elsewhere:

5.1 Organization, Integration and Planning

Barcelona created a new Public Transport Authority (ATM) to coordinate the integration of available system components and the fare between them, and to improve the product quality. As previously mentioned, the functions of this authority include:

- To organize, plan and coordinate public transport services through the defined region in coordination with the Strategic Planning.
- To coordinate services between the different operators (public and private).
- To establish the financial arrangements with the public and private entities.
- To establish and maintain the operators contracts.
- To establish the fare policy.
- To develop and execute the new transit capital projects
- To manage the Public Relations, defining and promoting the corporate image of the system.

Having all the mass transit components under one governing body allows establishing a more uniform vision of the system to be developed, and permits a more transparent fare integration. These, together with a clearer urban integration policy, put all the system components to work in a synergistic manner, increasing the system utilization and intermodality.

With a common vision establish on the system, it becomes easier to work the medium and long-term plans to define the infrastructure to be developed. In Barcelona, those plans are established for ten year periods and reviewed every three, four or five years under the Contract Programs that allocates the funds to be used by the government on those periods.

5.2 Financial Strategies

Since the development of the Tramway project, all mass transit projects in Spain were funded through government funds. Barcelona has become the first city in Spain to use the Public Private Partnership as a way to build new mass transit projects, and so far has been a success. This, tied with the fare integration, has increased the transit options in the city of Barcelona.

The Public-Private ventures are well known around the world, and may be attractive when the proposing body can show how the new system benefits from the existing network, and where the subsidy money will come. They expect a financial commitment from the proposing body, which in this case is the Transit Authority.

Glossary

1. Ajuntament de Barcelona – Barcelona City Council
2. ATM - acronym for *Autoritat del Transport Metropolità* or Metropolitan Transit Authority. Barcelona Metropolitan Region transit agency.
3. EMT - acronym for *Entitat Metropolitana del Transport* or Metropolitan Transport Body serving 18 municipalities through the Barcelona Metropolitan Region through TMB and other systems.

4. Ferrocarril Metropolità de Barcelona S.A.– public company under TMB in charge of the trains served by the EMT region.
5. FGC - acronym for *Ferrocarrils de la Generalitat de Catalunya* or Catalunya regional trains
6. Generalitat de Catalunya – Spaniard state with autonomous government. Its capital is the city of Barcelona.
7. PPP – acronym for Public Private Partnership.
8. PDI – acronym for *Plan Director de Infraestructura* or Infrastructure Master Plan for the Barcelona Metropolitan Region.
9. Renfe – Spaniard Railway Company that operates passengers, freight, high speed, regional and metropolitan trains through Spain.
10. RMB – acronym for *Región Metropolitana de Barcelona* or Barcelona Metropolitan Region.
11. S.A. – acronym for *Sociedad Anónima* or Anonimous Society. A type of corporative arrangement defined under the Spaniard law.
12. TMB - acronym for *Transports Metropolitans de Barcelona* or Barcelona Metropolitan Transport. Common name for the public companies within the EMT which provides metro and bus systems.
13. Transports de Barcelona S.A.– public company under TMB in charge of the buses served by the EMT region.
14. UTE – acronym for *Unión Temporal de Empresas* or Enterprise Temporary Union. This are joint ventures between companies to build infrastructure projects.

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