1. INTRODUCTION

The municipalities of the metropolitan area in Barcelona, which are closer to the central city, have a functional dependence with Barcelona, which has been stressed due to the continuous urban development that these cities have had in the second half of the XXth century.

The area surrounding the river Llobregat in its final stretch has been one of the most populated zones in Barcelona metropolitan area. The municipalities of Esplugues de Llobregat, Cornellà de Llobregat, Sant Joan Despí and Sant Just Desvern, where the tramway is implemented have a population of more than 175.000 inhabitants.

In 1987 first feasibility studies were carried out, to analyse the introduction of a railway system on surface connecting the area in Baix Llobregat with Barcelona central city, using the main axis of Avenida Diagonal as the basic way to penetrate in Barcelona.

Since that year up to 1998, the EMT (Entitat Metropolitana del Transport, Metropolitan Transport Authority), organisation with responsibilities in planning and coordination of transport in municipalities of the first metropolitan ring in Barcelona, commissioned several studies and initiatives, including the construction and operation of a test stretch of single way in Avinguda Diagonal, which served to try different tramway manufacturers.

In 1998, ATM (Autoritat del Transport Metropolità) was created, taking the responsibilities of the EMT and Generalitat de Catalunya (Regional Government) on administration and financial obligations for the planning, coordination and tendering of the tramway system in Diagonal - Baix Llobregat. That same year there was a restricted international public call for tenders to prepare the engineering project, construction and the operation of the tramway under a BOT scheme. After several discussions during 2000, it was awarded to the consortium Trammet. Works started in July 2002, with an estimation to start the operation in the first quarter of 2004.

Simultaneously in 1999, the ATM Board agreed within the framework of the National Plan for Infrastructure Development 2001-2010, the introduction of a comprehensive tramway system in Barcelona from Baix Llobregat to El Besos, so that Avenida Diagonal becomes in practically its whole length the basic axis for this system. The initial stretch from Baix Llobregat up to Francesc Macià was the already studied and foreseen, while the rest of the system is divided in two other stretches. The first one goes from Francesc Macià up to Glories square, and the tendering and implementation processes are subject to a subsequent analysis of the different alternatives (it is the most
urban stretch and therefore the area with more difficulties to place a tramway on surface), and the second stretch from Glories square up to Sant Adria del Besòs, with access to the Forum 2004 and the new urban developments in the area of Poble Nou and Diagonal Mar.

This last stretch is the one that was tendered later, and it was awarded in 2002 to the group Trammet, the same consortium than in Baix Llobregat.

The Baix Llobregat section opened to the public in April 2004, while Trambesos was officially opened 2 months afterwards.

The tramways in Barcelona are the first example of modern tramways private operated in Spain (Valencia was previous, but under a classical public financing and operation framework). It has been a first example of concession contract under a BOT scheme applied to public transport.

2. FUNCTIONAL CHARACTERISTICS OF BARCELONA TRAMWAYS

2.1 Trambaix (Diagonal - Baix Llobregat)

The total length of this stretch is 15.8 kilometres, with a total of 31 stops when completed, of which three stops are connecting directly with the metro network and one of them with the suburban railway of RENFE.

The service is organised in three lines (T1, T2 and T3), with a common stretch in most of its length. Headways in each line vary between 15 and 20 minutes,
but in the common section and during peak tour (which represents most of the day) this headway is only 5 minutes. Service extends from 5 to 24 hours, which are extended 2 hours more on Friday and Saturday nights. The maximum number of trains on service is 16.

Functionally, Trambaix connects 7 municipalities in the area of Baix Llobregat with the south section of Avenida Diagonal in Barcelona, with several attracting points like the University of Barcelona, commercial centres in Cornellà and L’Illa, Stadium of FC Barcelona, etc.

Total investment is of 266,8 M€, including infrastructure, rolling stock and urbanisation, as well as expropriations.

The expected annual demand is 16,9 M passengers/year varying from 7,6 on the first year to 18,8 on the last year.

The concession period is 5 months to prepare the engineering projects, 27 months of construction and 25 years of operation.

2.2 Trambesos (Diagonal – San Adria del Besos)

The total length of this stretch is 14,1 kilometres and has 27 stops, with connections to metro, suburban railways of RENFE and a bus station in Nord.

In this case, the system will be operated with 2 lines (T4 and T5), with several overlapping along the stretches. The headway during peak hour will be of 9 minutes with the same time coverage than in the case of Trambaix. The maximum number of trains in the final image of the system will be of 15 trains in service.

Trambesòs had as a short-term objective to provide access to the Forum 2004 (a major event in Barcelona in 2004), but it will be used as a way to develop the urban transformation in the northern area in Barcelona, an old industrial area that has been planned as a future extension area of the city.

Total investment is of 205 M€, including infrastructure, rolling stock and urbanisation, as well as expropriations.
The expected annual demand is 8.5 M passengers/year varying from 3.7 on the first year to 9.3 on the last year.

The concession period is similar to Trambaix, and both systems have their fares integrated in the whole fare system of the metropolitan area of Barcelona.

2.3 General characteristics and rolling stock

Rolling stock is the CITADIS model TM 302, with a theoretical commercial speed of 20 km/h and a maximum speed of 70 km/h. The length of the vehicles is 32.5 metres, with a width of 2.65 m and a height of 3.27 m.

Each unit is made of 5 modules, and in its total length is 100% low floor.

Regarding infrastructure and superstructure, the system has UIC track gauge, with some stretches in single track. The minimum radius is 20 m. (18 m. in depot) and a maximum slope of 7.5%.
The platform length is 70 m. with a height of 28 cm. The catenary’s voltage is 750 dc.

The system has reserved right of way in all its length, except in crossings, where a priority system has been implemented. This system is working properly, but it has to be further improved in those crossing in Diagonal, where transverse traffic flows are high.

The payment system is “open”, with cancelling machines inside the trains and no controls at platforms. This has meant to improve and push fraud-controlling systems.

2.4 Urban integration

The development of the new tramways in Barcelona has been an opportunity to improve the quality of urban life in certain areas by means of urban regeneration of the streets. These improvements have been in several cases pavement extension, new bicycle lanes, renewal of street furniture and fixtures, plantation of trees and general improvement of aesthetic impacts, with the plantation of grass between tracks. On the next table there are some figures on the extension of this program of urban integration.

<table>
<thead>
<tr>
<th></th>
<th>DIAGONAL-BAIX LLOBREGAT</th>
<th>SANT MARTÍ-BESÒS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renewal of roadways surface</td>
<td>102.500 m²</td>
<td>155.000 m²</td>
</tr>
<tr>
<td>Renewal of pavement surface</td>
<td>162.500 m²</td>
<td>89.000 m²</td>
</tr>
<tr>
<td>Surface of garden zones</td>
<td>135.000 m²</td>
<td>110.000 m²</td>
</tr>
<tr>
<td>Total surface of action</td>
<td>400.000 m²</td>
<td>354.000 m²</td>
</tr>
<tr>
<td>Number of trees planted or moved</td>
<td>2200</td>
<td>207</td>
</tr>
</tbody>
</table>

Furthermore, the introduction of the tramway has led to overcome two important urban barriers: the motorway AP2 and the rail tracks of RENFE in Cornellà, generating new connections, which improve access and relation within the municipalities. The urban renewal in the University area is a good example of recovering urban spaces for urban life. The tramway passes through a new pedestrian square which links different schools, library and other common buildings.

The design of platforms and stops has been particularly oriented to this integration with a maximum accessibility to platforms as well as the access from platform to trains.

3. CHARACTERISTCS OF THE CONTRACT

The two tramway systems in Barcelona have been made under a BOT scheme, in which a consortium constructs and operates the system during a period of 25 years.
The two awarding consortiums (Tramvia Metropolità and Tramvia Metropolità del Besòs) are made in different proportions by constructors and manufacturers (FCC, Acciona, Alstom, Comsa), financing groups (Banco de Sabadell, Société Générale) and operators (Detren – Connex, Sarbús).

The project is financed through a structure, which allows the administration to provide the necessary funds in the framework of a technical fare, and introducing several commercial and quality risks to the consortium.

The structure of the consortium is:

**Construction companies**

- FCC 19%
- COMSA 12%
- ACCIONA 11%
- NECSO 1%

**Manufacturers**

- ALSTOM 25%

**Operators**

- CONNEX 1.5%
- DETREN 5.5%
- SARBUS 19%
Banks

- Banco de Sabadell 5%
- Société General 1%

It is important to stress the predominant role of the rolling stock manufacturer, as well as the more spread shares of the construction companies, which in any case, are also important.

There is also an operator which owns a high percentage of the shares. This is not a common case in other BOTs in Spain, where operators intend not to participate significantly in capital.

Investments and major capital costs are, as in most BOT contracts, incurred initially by the awarding contract.

Revenues and other payments to the consortium are coming from three different ways:

- Initial payment, as a consequence of the national infrastructure financing agreement.
- Technical fare by passenger or price paid by the administration to the concessionaire, and calculated as the addition of operating costs plus benefits divided by number of passengers
- Bonus/malus depending on the performance of the system (quality, level of fraud, number of passengers, etc.)

In the case of Trambaix, the total investment costs are of 266,8 M euros. The total costs were:

- Construction 266,8 Me
- Financing costs 34,1 Me
- Others 3,1 Me
- TOTAL 304,0 Me

Financing resources were the following:

- Equity 33,8 Me
- BEI credits 136,1 Me
- Long term debt 89,0 Me
- IVA 22,9 Me
- Others 22,9 Me
- TOTAL 304,0 Me

The periods for the credits are of 15 years for the BEI one, 22 years for long-term debts, and 35 years for the IVA credit.
This financing structure is basically supported by the BEI credit and holds a percentage of equity between 10-15% of total capital costs, which is roughly the common and recommended case for this type of projects.

4. CHARACTERISTICS OF THE CONTRACTS

The foreseen structure and relationships of the different members of the consortium, the administration and the contracts that are deducted from the Terms of reference and those of private nature can be divided in two depending on the situation: contracts during the construction phase, and during the operation phase.

The next figure shows the contracts and relations existing during the construction phase:

The administrative entity in charge of the contract is the ATM (Autoritat de Transporte Metropolítà), which is the PT authority in the metropolitan area of Barcelona. It is important to differentiate it from the EMT, which was originally created longer ago than the ATM.

EMT had historically similar responsibilities, but its area of influence was the municipalities closer to the city of Barcelona. The settlement of population commuting with the central city to a wider hinterland, led to the creation of a new PT authority, with the participation of all the different administrative entities involved, which could overcome the historical problems of EMT.
ATM was created in 1998, and since then the main issues in its activity have been oriented to the fare and functional integration of public transport in the metropolitan area of Barcelona.

ATM made the call for tenders for the tramways, and the awarding consortium is the one that signed the administrative contract of concession.

During the construction phase, a construction company is created, which signs a contract with the awarding consortium. Partners of the awarding consortium make up this company, but not every partner participates in the construction company (i.e. operators are not present), and therefore, the percentage of shares is different than in the original awarding consortium.

In the case of Trambaix the construction company is only constituted by the five construction and system providers (FCC, NECSO, COMSA, ACCIONA and ALSTOM).

The relations during this phase are very clear. The administration initial funds and the loans that are necessary for the construction are provided to the awarding consortium, which hands them to the construction company. This scheme is the same in both contracts, Trambaix and Trambesos.

The construction company is planned to disappear after the construction, although the different phases of the system development make that this company still performs its activity several years after the concession awarding.

During the operation phase, relations change drastically, as shown in the following figure for the case of Trambaix.
In this case an operating company is created, in which the administration retains 20% of the shares. The other 80% is owned by the awarding company, but only through several partners, the operators. In the case of Trambaix, Detren/Connex holds a 66% of the total private participation, while the other 33% is owned by Sarbus, a local bus operator.

The awarding company signs the administrative contract with the Public Authority, but relations between parties vary according to the following lines:

- Technical fare is paid directly by ATM to the operating company. This technical fare is made up by direct fare box revenues plus the operation and compensation subsidies that complement them.
- With all these revenues, the operating company has to pay all its operation and maintenance costs, and still pays a canon to the awarding company.
- This canon is used by the awarding company to pay its own operating costs and interests and loan costs to the banks and financing entities.

The contract signed between the awarding company and the operating company states the main principles underlying, one of the most important is the "back to back" coverage, which means that any penalty or responsibility which ATM can put on the awarding company, must be passed to the company which is responsible of. This is particularly important in the case of the availability, punctuality and other operation related penalties.

This scheme results very comfortable to the operating companies, because revenues are directly derived to them, and still the direct contract responsibilities lay on the awarding consortium side. In the case of Trambaix there is not even passenger risks.

Nevertheless, in the case of Trambesos, the operation relations were changed as shown in the following figure.

In this case, the awarding consortium holds the contract relations with the administration and also receives all the revenues and payments, being the operating company subject directly and through the operation contract to the obligations and the control of the awarding consortium, and receiving the payment for the operation and maintenance costs directly from them. This means that for the operator’s point of view, the consortium is its client.

This scheme for Trambesos is fairer for each party involved in the concession, and it was added a commercial risk on patronage under band system. That definitely clears the non-imputation of debt according to the principles stated in SEC-95 European accounting system, which basically recognises two ways to differentiate a concession:

- Availability risks (as existing in the Trambaix contract)
- Patronage risk (added to the previous one in the case of Trambesos)

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There are still many problems both in Trambaix and Trambesos derived on the BOT system as itself, and the particular contracting system as described.

5. EXISTING PROBLEMS IN BARCELONA TRAMWAY CONTRACTS

Risks and problems of a BOT system and obligations are placed in every phase and in every party. During the construction and operation phases, risks for the awarding company are basically the following, much of them derived form the risk transfer from the administration and the accounting of public debt:

- Extra costs in construction (costs are committed in the proposal, where the engineering project is also developed)
- Delay in the operation, due to non controlled factors
- Reduction in revenues
- Non foreseen increment of operation and maintenance costs
- Non fulfilment of obligations by the administration
- Macroeconomic risks

On the other hand there are benefits or incentives for the private company such as:

- Distribution and correct assignment of responsibilities between different parties.
- Financing optimisation in a competitive environment
- Long term financing
- Financing management, due diligence, etc.

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• Time to obtain financing, costs of the contract, etc.

The role of the administration is essential in a BOT, in order to keep an adequate equilibrium between all the factors that can influence on deviations of the foreseen magnitudes.

Therefore, the Administration must:

• Keep a stable environment, trough agreements with municipalities, other public bodies, etc.
• Restructure of public transport, adapting other PT systems to the new conditions
• Design of an equilibrate project (risk/profitability), commercial speed, crossings
• Take charge of administrative issues like expropriations, licences, affected services

These are more or less the typical problems and benefits from a BOT scheme. In the particular case of the Barcelona contracts there are other complementary lessons that can be taken.

One of the main issues that appeared as a problem, and which can be also common in other BOT projects is the different objectives, point of view, interests etc, from the parties constituting the consortium. Construction companies are particular interested in short term benefits, and reduction of construction costs, that can affect later the operation.

This is a major problem, since, due to the volume of investment in the construction, the construction companies lead the awarding consortium. Operators have during the construction phase a minor role, which can bring future problems while operating the system.

The differentiation between awarding company and operating company has had consequences on the correct functioning of the concession. Once the system is in operation, the physical presence of the awarding company is not so necessary (maybe a manager, a financing director and some administrative). This has not been the case in Barcelona tramways, where the awarding company still has a large staff. On one hand it is logical, since there is still some work in progress, but there is to some extent some duplication of functions (particularly in marketing and representation activities), which can cause problems and lack of efficiency.

This also leads to an increment of bureaucratic stages (public transport authority - awarding company - operating company). In Barcelona, maintenance is also subcontracted to a group of partners led by Alstom, which is an additional step to the before mentioned chain.

Distribution of responsibilities in an environment like this can be in some cases difficult.

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One example of this latter issue is the fraud control. There is a penalty on the fraud level that the system have. This penalty is supported by the awarding company, as signatory of the contract with the ATM.

At the same time, one of the functions of the operating company is to provide human and material resources to avoid fare evasion. The principle of "back to back" in the contracts, means that penalties on fraud level can be transferred to the operators if there is a direct responsibility that there are not enough resources to maintain a reasonable level of fraud.

And here start the discussions between the three parties: administration, consortium and operating company, to define which is an acceptable fraud level, and what are the minimum resources needed to reach that level.

6. BOT PROJECTS IN SPAIN

After the Barcelona tramways BOTs were launched, there have been a number of similar projects in Spain, focussed in tramway or metro systems.

In Andalusia the metros in Seville and Malaga were tendered also under a BOT scheme. The tramway in Parla is very similar to the case in Barcelona.

Tenerife tramway was launched under a different system in which a public company was created, with participation of private partners, but in which the public share is more than a half. This prevents the payments to be considered out of public debt, but on the other hand offers a more stable situation for the private companies with less risk (and therefore less benefits).

The recent case of Madrid LRT systems in Pozuelo and Boadilla is a very particular case. Initially it was intended to split construction, operation and rolling stock provision, so that MINTRA, a public company from the Regional Government was supposed to make the construction of the system and to order the trains. Operation was going to be tendered as a more or less conventional operation.

Once the process was launched, there was a notice from the EU that MINTRA expenditure was to be considered as public expenditure (which in previous years never happened). That forced to change the operation tender including the funding of the nearly already finished construction and the already ordered trains by the awarding consortium. It is therefore a BOT, in which the awarding consortium has very scarce control on construction and rolling stock, having to finance the whole system.

This is the present situation. Even the two metros in Andalusia tendered as BOTs have problems, due to the importance of construction (more than 80% of the whole length is underground in both cases), which brought problems on project modifications, construction problems, and the lack of participation of an operator since the beginning. That can cause in the future problems on the operation (both systems are still under construction).
The regional government of Andalusia is not completely satisfied with this BOTs schemes and it seems that for future developments another system will be used.

7. CONCLUSIONS

BOTs applied to concessions in transport infrastructure, and more precisely in public transport system are well known and extended ways to develop projects in environments with no public money to spend or in which there are strict limits on public expenditure.

The experience in the tramways of Barcelona shows a comprehensive BOT scheme, in which a call for tenders is made for the engineering project, the construction and the operation of the whole system during a large period.

The awarding consortium was set up with the usual members (constructors, manufacturers, financial entities and operators), and the system is already in service since more than 2 years.

Nevertheless there have been and are some problems during the project which are worth to take into account. Although some of this problems or difficulties can be found in the literature on BOTs and are related more or less to the concept of the concession, there are some internal problems, which not always have been stated:

- Lack of a significant role of the operator in these contracts, in some cases due to the predominant role of constructors and manufacturers comings from the Terms of Reference, in other cases due to the participation of each party in the capital.
- Participation of operators in the engineering projects and during the construction. This can lead to build good and cheap infrastructure, but with operating difficulties.
- Duplication of functions between the awarding company and the operation and/or construction company (if any).
- Assignment of responsibilities between parties during the different phases of the concession. This should be set up very clearly by the Terms of Reference.

These are the most important problems particular to the case of Barcelona. There are no other projects in Spain in operation right now, but it seems that there are other difficulties related to the ones before mentioned, even during the construction phase.

Although BOT concession tenders offer an excellent opportunity to public bodies to develop PT infrastructure system without incurring in high public expenditure, problems stated in existing systems make necessary to think on changes in the following directions:
• Terms of reference of BOT tenders must be changed and adapted to the complexity of these systems. Traditionally the existing TR in Spanish tenders are much more developed on the construction side, while there is more "holes" on the operational side, maintenance and even in the financing issues.

• Operators must have a more important role during the previous phases (project and construction) to be sure that built systems are "operable".

• The penalty systems and other operation issues must be much more developed. In nearly every BOT case in Spain, penalty schemes are copied from the Barcelona one, which has some practical difficulties to be applied, which has led to some changes during the operation period.

There must be also a thinking on BOTs and their application, and maybe in some cases it can be better a separation of construction and operation in two different contracts, which can be linked in some ways:

• Operators can act as advisers or technical supporters to the administration during the engineering and construction phases, in order to control that the infrastructure won't have future operational problems.

• Operators should be subject to a complete risk scheme (patronage, penalties on punctuality, quality issues, etc.). That can make the payments not attributed to public debt.

• In the case of construction that can be more difficult, but if there is a type of risk attached to infrastructure maintenance (availability of infrastructures), and there is also a relation between the operation contract (payment of a canon), this also could be considered not a public expenditure.

Fare system and user participation in the whole financing of the system is another issue to discuss, but this is more linked to other external factors like the cost of living, the historical consideration of fares and its level in PT, all of this very country-based.