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PPP in Light Rail Transit Systems in Spain

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***Abstract*—**Light rail systems have proliferated in Spain in the last decade, following a tendency that is common not only in other European countries but also in other parts of the world. This paper reviews the benefits of light rail systems, both related to environmental issues and mobility issues. It analyses the evolution of light rail projects in Spain and shows that light rail systems in this country have evolved towards an extensive use of public-private partnerships. The analysis of the Spanish projects, however, does not contribute any conclusive evidence about whether public-private partnerships have been more efficient than publicly owned enterprises in building and operating light rail systems.

***Keywords*—**light rail systems; public-private partnerships; BOT.

I. Introduction

IN the late 1980s there was a resurgence of tramways under the new denomination of 'light rail'. The mode's reemergence as an alternative means of transport to cars or buses was due to its potential to mitigate congestion and support mobility around urban centers [1]. Light rail transit (LRT) has developed as form of rail-based transport particularly suited for distances between 10 and 40 km. Common light rail train systems use two-car rolling-stock configurations with articulated joins between cars. This arrangement provides for greater passenger capacity while still allowing for tight radius-cornering capabilities [2,3]. In some cases, the differences between LRT systems and other urban rail systems are not clear in practice. To provide a clear picture of this, Table 1 shows the main technical features of light rail, subway and commuter trains, highlighting the operational similarities and differences. Light rail systems have proliferated in both developed and developing countries in the last decades [4,5]. Among European countries, LRT construction has been particularly evident in the United Kingdom, France, Spain, Portugal and Italy. This paper reviews the environmental and mobility benefits of LRT systems and analyses the evolution of LRT projects in Spain. Based on a survey of Spanish projects, the authors identify an evolution towards greater use of public-private partnerships in LRT construction and operation. The Spanish experience, however, does not contribute any conclusive evidence concerning the efficiency of the public-private partnerships relative to publicly owned enterprises. The paper draws on a review of the relevant literature, to which the authors add an analysis of data gathered from Spanish light rail companies. Further context was provided through interviews with representatives of the majority of light rail projects in Spain.

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TABLE I
TECHNICAL FEATURES OF URBAN RAIL SYSTEMS

	Light rail	*Subway*	*Commuter train*
Length of vehicle (m)	14-20	15-20	15-30
N. of vehicles per unit	1-2	2-10	2-10
Comm. speed (km/h)	18-23	25-40	25-50
Distance bet. stops	450-800	1,000-2,000	2,000-4,000
Passengers per vehicle	125	180	375
Capac. seated (pass/h)	6,000-20,000	10,000-40,000	n.a.

Source: Elaborated by the authors

II. Benefits of Light Rail Systems

Concern over the environmental effects of urban transport occupies a prominent place in the global environmental agenda. Ever greater emphasis is placed on the effort to achieve efficient transport networks that offer sustainable mobility and are compatible with broader social and community aims. The main benefits of light rail systems may be divided into two categories: those related to environmental issues and those derived from its relationship to the urban environment.

LRT systems offer significant environmental benefits. The past decades have produced continuous growth in the number of vehicles circulating on the highways and roads of developed countries. This has in turn instigated numerous studies on the environmental consequences of transport, with particular focus on the increasing carbon emissions and other gases and pollutants, and their noxious effect on human health. Until recently, the principal policy instrument for regulating the environmental impacts of transport has been the imposition of vehicle emissions standards achieved through technological improvement. Nonetheless, it has become clear that this is no longer sufficient if the environmental goals of the international community, such as the targets set by the Kyoto Protocol, are to be achieved.

LRT systems have several important positive features from the environmental point of view:

1) A more efficient use of natural resources. Unlike other modes of transport such as the automobile or the bus, LRT is driven by electric power. Therefore consumption of limited resources and emissions of pollutants can be reduced by use of renewable sources for electricity generation.
2) The absence of polluting emissions since light rail vehicles do not employ fossil-fuelled combustion engines. In addition to this, LRT may lead to overall reduction in the overall emission of greenhouse gases by diverting traffic from other modes of transit (one light rail train is equivalent to three or four buses).
3) Energy savings deriving from the generation of electric power by the braking system that can be reused within the system.

4) The reduction of noise pollution. LRT systems operating at maximum speed generate noise at around 60 decibels, far below the daytime noise levels in congested high-density urban areas. Furthermore, the design and materials used in the rails, along with the anti-vibration systems fitted in the rail cars, contribute significantly to the reduction in noise generated by system operations

Beyond strictly environmental benefits, LRT systems further contribute to a higher quality of urban life.

The following features of LRT systems are relevant in this respect:

1) Light rail vehicles are often pleasant, comfortable and versatile, and employ the latest technology, with low floors that considerably facilitate accessibility for all passengers.
2) Light rail as a mode extends the right to transport to all citizens and allows an equitable division of public space, which has often been strongly dominated by the automobile.
3) Transit along dedicated tracks allows light rail to circulate at commercially attractive speeds, meeting scheduled timetables and thus providing a reliable service to riders.
4) Road occupancy is reduced, allowing more driving and parking space for remaining vehicles. As a result, there is a potential for the urban space to become more comfortable and more accessible for pedestrian mobility.
5) Light rail contributes to consolidation of the urban pattern, limiting the distance of transit trips and favouring the creation of a compact, mixed-use city, with integration of residential, professional, academic, commercial and leisure areas.

III. Utilization of PPP in Light Rail Systems in Spain

In the last decade, LRT systems have proliferated in Spain. From 1994 to 2011, sixteen light rail projects have been built or commissioned in this country—almost all of them between 2002 and 2011. Out of them, eleven are already in operation as shown in Table 3. The other five projects are under construction. The first project was delivered into service in Valencia in 1994.

Out of the sixteen (16) light rails commissioned from 1994 to 2011, only four (4) have been procured through traditional procurement routes, while the rest have been procured through different formulas of collaboration between the private and public sectors. The most common formula has been the Concession, which is granted in most cases for Build-Operate-Transfer (BOT) schemes, but can also be granted for the operation of an existing infrastructure. In one of the cases (Tenerife) the project has been implemented through a mixed Special Purpose Company with private and public shareholders.

As shown in Table 3, the analysis of the LRT projects implemented in Spain shows an evolution over the years towards the utilization of public-private partnerships and more specifically BOT formulas. The three first projects (Valencia, Bilbao and Alicante) were built and are managed by public companies. However, starting in 2004 most of the projects have been built and managed by private companies under a BOT scheme. In BOT projects the public authority contracts with an outside organization (developer) to provide services at a specified quality of service standards. The developer must, consequently, provide the required inventory of fixed and movable assets backed by its own resources or through external financing. The developer also retains all revenues and commits to absorb either all or a contractually agreed portion of traffic and revenue risks, as well as the risks associated with construction. Risk sharing may also extend into the areas of regulatory risk. A BOT is often the most appropriate type of contract for situations with no previous services and with a requirement to provide depots or other infrastructure. New light rail schemes are often covered by long-term contracts of this nature. To ensure sufficient time for recouping investment costs, these arrangements are generally long-term, with contract periods of 20 to 30 years [5].

The LRT projects built in Spain under a BOT scheme have followed the traditional risk allocation where the private sector bears construction risk and demand risk. However, almost all projects have some kind of mitigation mechanism for demand risk, usually through a minimum income guarantee. With this kind of guarantee, the concessionaire's revenues are capped between +/- 30% of anticipated demand.

The awarding criteria for the LRT projects built in Spain under a BOT scheme have followed similar patterns, as shown in Table II. There are some differences in the various projects regarding the allocation of points in the awarding process, which varies across the projects analysed.

But all of them take into account four aspects:

i) Technical aspects related to building the infrastructure; *ii)* Technical aspects related to operation; *iii)* Economic-financial aspects related to the proposal; *iv)* Economic-financial aspects related to the sponsors' solvency.

TABLE II
Awarding criteria for LRT projects built in Spain under a BOT scheme (% of points)

	Technical aspects infrastructure	Technical aspects operation	Economic proposal	Sponsors' solvency
Tenerife		40%	55%	5%
Boadilla-Pozuelo (Madrid)	7%	43%	37%	13%
Las Tablas (Madrid)	7%	43%	37%	13%
Parla (Madrid)	7%	43%	37%	13%
Metro Sevilla	26%	34%	35%	5%
Metro Málaga	25%	35%	34%	6%

Source: Elaborated by the authors with data taken from [6]

TABLE III
LIGHT RAIL SYSTEMS IN SPAIN, 2002-2012

City (urban/metropolitan area)	*Year delivery into service*	*Procurement model*	*Length (km)*	*Capital expenditure (Eur2007)*	*Average annual pass. (million)*
Valencia	1994	Public enterprise	12.8	-	6.3
Bilbao	2002	Public enterprise	5.2	21.3	2.2
Alicante	2003	Public enterprise	93.2	-	2.4
TramBaix (Barcelona)	2004	Concession (BOT)	15.8	238	10.2
TramBessos (Barcelona)	2004	Concession (BOT)	13.5	213.6	2.8
Vélez-Málaga	2006	Management contract	4.7	19.3	1.2
Tenerife	2007	Mixed enterprise	12.3	227	12.2
Boadilla-Pozuelo (Madrid)	2007	Concession (BOT)	22.4	362.2	17.7
Las Tablas (Madrid)	2007	Concession (BOT)	5.4	262.3	3.4
Parla (Madrid)	2007	Concession (BOT)	9.5	93.5	6.8
Metro Sevilla	2009	Concession (BOT)	19	430	14.0
Metro Málaga (*)		Concession (BOT)	14.7	456.2	17.1
Metro Murcia (*)		Concession (BOT)	17	264 (2009)	10.8
Palma de Mallorca (*)		Public enterprise	7.2	110	2.8
Chiclana-Cádiz (*)		Concession (OT)	23.6	116.4	2.9
Arganda (Madrid) (*)		Concession (BOT)	19.1	116.6	6.0

(*) Under construction
Source: Elaborated by the authors

IV. DOES THE SPANISH EXPERIENCE SHOW THAT PPP ARE MORE EFFICIENT THAN PUBLICLY OWNED LRT SYSTEMS?

The analysis of advantages and disadvantages of public-private partnerships versus publicly owned enterprises for building and operating light rail systems has been addressed in the last few years by a number of authors, including Clements and O'Mahony [7], Phang [8] and Mandri-Perrot [5]. The main reason for turning to the private sector is arguably that the private sector can provide more cost-effective and efficient solutions to problems, due to both its profit motive and its tendency to avoid over-engineering, a common fault of the public sector. Relying on the private sector for building and managing LRT systems, however, also involves higher borrowing costs, higher transaction costs and frequently an optimism bias—the tendency to leave unquantifiable risks out of the account. In this section we analyze whether the Spanish experience with LRT systems can contribute any evidence in this debate—whether the analysis of the Spanish projects shows that public-private partnerships are more efficient than public companies. We have been able to gather data related to operational expenditures, investment, and some aspects related to the operation of LRT. However, these data were available for only six projects. Of these six, four are BOT concessions (Trambaix, Trambessos, Seville and Pozuelo), one is managed by a publicly owned company (Valencia) and another one is managed by a enterprise with both public and private shareholders (Tenerife). As shown in Table IV, data on operational expenses show that there is no significant difference between the projects except for Valencia (a publicly owned LRT). However, the information provided for Valencia includes not only the operation of LRT but also of commuter train lines.

Therefore, no relevant conclusions can be confidently drawn from the analysis of operational expense data, apart from the broad similarity across the projects analysed. Data on operational characteristics of the LRT systems show no relevant difference when it comes to commercial speed. The high speed of Sevilla's LRT presents an anomaly, but it has not been possible for the authors to confirm that information or discover the reasons for the difference between this project and the others. The punctuality is very high for all the projects analysed and the number of accidents, where available, is also similar. Data related to number of complaints must be regarded as irrelevant since each project has dealt with complaints differently. Moving on to data covering investment in civil engineering works, significant variation can be observed. These differences, however, depend mainly on the percentage of the infrastructure built underground. The cost of installation has been significantly higher in the cases of Pozuelo (Madrid) and Sevilla, although the authors have again been unable to discover the causes. In the case of rolling stock, the costs have mostly clustered around 3 million euro per kilometre of rail, with the exception of the Tenerife project.

The comparison between LRT systems under a BOT scheme and a publicly owned enterprise should ideally include an analysis of the projects' financial performance. However, the information available did not allow such an analysis. In some cases, the information provided by the companies was vague and general, while in other cases (Valencia) the company does not distinguish between LRT lines and commuter trains, and finally in other cases the companies did not provide any financial information at all.

TABLE IV
VARIOUS DATA RELATED TO LRT PROJECTS IN SPAIN

	Trambaix (Barcelona)	Trambessos (Barcelona)	Tenerife	Pozuelo (Madrid)	Sevilla	Valencia
Operational expenses (OPEX)						
Operation (€/km)	4.21	4.46	n.a.	3,51	n.a.	12.4
Maintenance (€/km)	4.26	4.40	n.a.	3,87	n.a.	2.4
Total OPEX (€/km)	8.47	8.86	8.92	7,38	9.67	14.8
Operation						
Commercial speed (km/h)	17.8	18.8	21.0	23-26	30.0	17.5
Punctuality (%)	96.4	93.0	99.0	99,0	n.a.	99.1
N. accidents (2009)	40	29	35	n.a.	n.a.	n.a.
N. complaints	703	352	1,528	n.a.	n.a.	n.a.
Investment (mill €/km rail)						
Civil engineering works	8.6	6.7	15.82	15,7	24.8	n.a.
Installations	3	4.8	2.66	6,46	7.6	n.a.
Rolling stock	2.98	3.35	4.73	3,09	3.0	n.a.

Source: Elaborated by the authors with data provided by the LRT companies

V. CONCLUSIONS

The analysis of the Spanish experience with LRT systems shows that in this country there has been a shift from publicly owned enterprises in the early projects to BOT schemes. In most cases, the main reason for this shift appears to be lack of public resources. In some projects, particularly in the case of Madrid, this has been reinforced by the regional government's need to reduce its public debt.

The analysis of the available data did not allow us to conclude which one has been more efficient in building and managing LRT systems: publicly owned companies or BOT schemes. In most cases in Spain, it is too early to obtain data with sufficient track record. In addition, the data gathered by the authors for some of the projects were provided in a form that made comparison with other projects impossible.

Thus, the research conducted for this paper constitutes a first step in the endeavour of using the Spanish experience with LRT systems to determine whether BOT schemes are more efficient than those managed by publicly owned enterprises. The analysis done in this paper should be continued in the near future as more data becomes available.

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