Benefits of the introduction of a light rail system using the old rail infrastructure

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Abstract

This paper describes the advantages and the expected benefits of the implementation of a light rail system using the infrastructure of the conventional rail system in urban areas, increasing the comfort, and constituting a means to improve the quality of life according to important vectors. As a case study, we focus on the expected results for the Porto Light Rail System that will use a part of the old rail network in the urban and suburban area.

1 Introduction

The uncontrolled increase in the circulation of private cars in the cities, jointly with the problems linked to the preservation of environmental and social interests and to the quality of life, have required a rethinking of the existing options of transportation.

The desertification of the urban centres and the degradation of the real estate in old cities leads to a new approach of the transportation system as a basic condition for the revitalisation of those areas – light rail systems.

In the opinion of the population, those systems are fast, easy to use and bring animation and security to the transportation mode and to the streets where they run.

Among other modes of public urban transport, light rail is a very good tool to respond to the increasing problems of congestion, pollution and noise. At the
same time this approach is easily inserted in the urban mesh allowing flexible solutions.

On the other side, the free access of other companies to the infrastructure of the national railways (in some cases not very well adapted to the quality of transport needed and requested) is in agreement with the development of the Common Transportation Policy. The important commercial success of this kind of approach allied to the environmental benefits is a new source of interest for governments and local authorities.

2 The choice of the right system

First of all, we will try to give in a concise way some definitions of mass transit systems necessary for a better understanding of what are the light rail systems.

In general, rail traffic can be classified in three groups: urban, suburban and long distance. To make the discussion easier, the urban group can be split into five categories: people mover, tramway, light rail, metro low capacity and metro high capacity.

From this point of view, long distance traffic is characterised by a high average station spacing of 100 to 1000 km and a relatively low capacity of roughly 5000 p/h.d (passengers/hour.direction) [1]. Suburban traffic shows a station spacing of 1.5 to 7 km and a capacity up to 10000 p/h.d. On the other hand, urban traffic has a wide capacity range of roughly 5000 to 60000 p/h.d, or in special cases, even more, and a narrow band of station spacing from 500 m to 1500 m. Included in this group, tramways have a limited capacity of 5000 p/h.d, and people movers only add up to 16000 p/h.d.

Light rail systems are characterised by a high flexibility and can fill the gap between bus, tramways and metro systems. They reach capacities of roughly 25000 p/h.d, varying from around 15000 p/h.d up to 30000 p/h.d depending on the number of vehicles. Metro systems can be divided into two groups: low capacity of around 30000 p/h.d and high capacity of 60000 p/h.d, or more.

As a result of the characteristics indicated above, each system has specific application ranges, that must be taken into account when implementing a new mass transit system. Light rail systems, the subject of the present study, in comparison with a system of buses, are more expensive to construct, but may be cheaper to operate for a given capacity. They will have lower whole-life cost, a higher commercial speed and will contribute to reduce pollution. In a comparison with a metro or urban railway, light rail will be cheaper to build and operate, but with a lower commercial speed. However, it has a remarkable visible presence on surface public transport, offers a better penetration in urban areas, enables better security and generates less noise.
Light rail is more adequate, economically and effectively, for passenger flows between 2000 and 20000 p/h.d, which usually are found in cities with populations between 200000 and one million inhabitants [2]. They can be mixed with road traffic when necessary and, unlike the tramway, the on-street track is only used under certain circumstances like attracting passengers to the system in city centre areas.

The steel rails can be grooved, that is, they can be laid flush with the street surface, or set up like normal rail track using ballast. In this way, light rail is the only system which can operate both on city streets or jointly with conventional rail services (like in the Karlsruhe system). Tracks can be laid in tarmac, mass concrete, ballast or grass according to operational and environmental needs. Light rail can be built on former railway lines, or even share tracks with railways, whether in little used lines dedicated either to freight or to passenger service.

If the traffic volume is variable during day-time, the system can be adapted easily to these requirements by varying the number of vehicles. If there is a mix with road traffic, 2.65 m wide vehicles should be used, with a maximum train length of 75 m. The vehicles are normally articulated. With a typical headway of 2.5 minutes, these systems normally carry up to 25000 p/h.d. The average operating speed depends on the route characteristics and varies from 25 to 35 km/h. Under emergency conditions these systems have to be able to decelerate with an average deceleration rate of 2.7 m/s^2.

3 Advantages and expected benefits of the implementation of a light rail system

The term "Light Rail" embraces tramways but goes further than traditional tramways. It can move large numbers of people quickly and efficiently.

It allows to travel in a town smoothly, comfortably, quietly, doesn't spew out noxious fumes over pedestrians, reaches right into city centre pedestrian areas, doesn't need parking, is economical to use, runs frequently, and generally makes city life a bit more civilised.

In some situations there is substantial free capacity available on heavy rail lines and light rail systems may potentially be provided using the heavy rail lines but deviating from them to serve suburban areas and, in towns, to allow penetration to the heart of the town. The utilisation of existing heavy rail lines means that infrastructure costs can be a small fraction of the costs of an entirely new rail line.
In a brief way, the main benefits are:

- Clean and green - enhances the environment - no emissions at street level;
- Safe - many times safer than car travel;
- Speed - short journey times;
- Avoids traffic congestion - through segregation and priority;
- Smooth and comfortable - no violent movements vertically, laterally, or backwards/forwards;
- Compatible with pedestrians in dedicated areas;
- Civilising - a city transported by light rail is a more human and more livable place;
- Acceptable and accepted - only rail borne modes can in practice get people out of cars;
- Reassuring – light rail lines give confidence that service operates;
- High capacity - only heavy metros or heavy rail have higher carrying capacity;
- Versatile - can run at high speeds on segregated way and can penetrate narrow historic centres;
- Adaptable - can cope with steep gradients and tight curves;
- Inspiring - modern light rail can be aesthetically breath-taking;
- Capable of running on the surface, underground or elevated, whichever is more adequate.

A crucial fact sometimes forgotten by light rail systems enthusiasts but rarely by passengers is the high “cost” of having to interchange between modes. A new system, which eliminates interchanges, may, therefore, be preferable to one that increases vehicle speed. It is the end-to-end time and cost which a passenger perceives, not just that spent within a vehicle. As a conclusion, a transport system which requires feeder services and substantially increases interchanges is less likely to be successful than one which can provide direct links between origins and destinations of passengers.

The system has particular qualities in meeting two groups of objectives: transport and environmental and social[3].

The transport objectives are: to reduce travel time and improve access for public transport passengers, especially to central areas and out-of-town shopping centres, office complexes, colleges and hospitals; reduce the number of car journeys, congestion and dependency on car and car ownership; reduce car-parking in central areas; and contribute to the improvement of pedestrian facilities in town centres and transport for disabled persons.

The environmental and social objectives include: reduction of noise and air pollution; strengthening city centre commercial and leisure activities; developing
an improved image for an area; contributing to regenerate an area, increasing job supply and reducing unemployment.

4 Why use the old rail network?

As the solutions must be adapted to specific local conditions, in the national case, it is necessary to explain why the old rail infrastructure will be used by the light rail system.

Some lines situated near urban centres where a significant daily commuting trips exists, reveal that the traditional railway mode is not the best adapted and efficient in order to meet the needs of the populations in terms of transport quality.

The main social benefits of rail, when comparing with road, are that it unifies cities because the stations are in the city centre. Rail does not disrupt community life, on the contrary usually improves it.

The publication of national legislation (Despacho Normativo n. 115/93) [4] was the first step for the creation of the conditions for the use of some sections of line referred above by another mode of transportation - light rail - by means of the transfer of those lines for carrying out this type of local transportation. In this way, a large regional rail network could be established with some capital savings and it should reduce initial construction costs.

In Porto physical and administrative barriers have been crossed, in order that a new concept of service (light rail) can be built to serve towns far outside the city.

5 Case study - the Porto Light Rail System

Porto and its suburban area have grown substantially in recent years with inner city areas, experiencing increased employment and higher density residential living. This growth has led to a substantial increase of commuting trips, as well as an increase in the number of short trips across the city. Porto is an important regional and industrial centre, with a growing car-owning population, but with serious space restrictions, which means that Porto cannot have new roads. So a light rail system was considered to be the most viable solution to meeting demand.

So far, the present transport system taken as a whole and also within transport modes is inefficient, only a few new jobs have arisen in the suburbs and the traffic conditions are intolerable.
Presently, the sole destination reached through public transport system is the city centre (virtually no effective suburban to suburban service is available) and the trips take a lot of time, so sooner or later it will be necessary to choose a new solution.

On the other hand, passengers on CP routes who wish to reach the city centre are obliged to change to another mode, which is often a time-wasting and annoying process. Market share in such cases is considerably smaller than with the predictable future services, which in some areas use tunnels, right under the city centres and can distribute and collect passengers at several convenient locations.

To improve the quality of service available, a modern integrated transport system was proposed, to alleviate congestion while enhancing the overall image and accessibility of the Porto’s radial transport system. The proposed trains will have a 3 minute frequency that corresponds to a hourly capacity of 18000 passengers in both directions.

The driving force behind suburban development was the aim of linking urban and suburban areas, serving at the same time the centre of Porto, enabling passengers to travel into and out of the city centre without having to change vehicles and with lower cost per passenger.

For light rail systems there is a set of circumstances, which can be found in Porto, which would favour its implementation, such as:

- high levels of existing transport users in the corridor;
- high levels of congestion along the city streets, roads and slow competing bus services;
- an existing corridor for most of the potential light rail route;
- major residential/commercial areas clustered along the route, within walking distance, to ensure good levels of ridership over much of the day and during evenings and weekends;
- available depot site close to the line.

The so-called "Metro do Porto" will serve an area of 1 500 000 inhabitants. The city’s population is only around 350000. The construction of the light metro network in Porto, with a total length of 70 kilometres, began in January 1999 and is scheduled to be built in five years’ time (Figure 1). The light metro system is structured in four electrified lines connecting the centre of Porto with the suburbs of Matosinhos (north-west of the city), Póvoa do Varzim (north), Trofa (north) and Gaia (south).
The first one is completely new and links Santo Ovidio (south of Douro river) to Hospital de S. João. The second will have two new sections Campanhã-Trindade (in tunnel) and Senhora da Hora-Matosinhos (on surface) and a third one Trindade-Senhora da Hora that will use the existing line. The third line links Senhora da Hora-Póvoa and will take over the alignment of metre-gauge, presently operated by the Portuguese Railways. The fourth line Senhora da Hora-Trofa will also use the existing line. In this line a variant will be developed in the city of Maia in the form of a surface line [5].

Nowadays, Póvoa do Varzim, Trofa and Gaia are served by trains operated by CP. About 50 km of the network will make use of existing rail lines belonging to the national railway network which will be upgraded and converted to standard gauge. The remaining 20 km require newly built track with 13 km at surface and 7 km in tunnel. This will include the century-old Dom Luis I bridge that crosses the Douro river.
The development of the system consists of two main components:

- Building new stops on existing heavy rail lines which can be served without extending journey time, thanks to the improved acceleration of light rail vehicles;

- Connecting the heavy rail lines to a light rail system, as the future system will pass in the railway stations serving the railway lines of suburbs and intercity network. This also makes for more frequent service eliminating longer waiting times.

There will be an interchange with rail services at Campanhã and S.Bento and at other stops with suburban buses.

In a total of 66 stations, 56 are surface stations (19 of them modernised and refurbished) and 10 are underground stations in the urban and central areas which will be built.

Major civil works will include the construction of a 5.9 km underground section. Besides the eventual influence, during scooping of tunnels, in building structure, other problems can be indicated. As some of the interventions will take place near important rivers (Douro, Ave and Leça), it is possible that unstable land, formed by clays and mud or even underground torrents may be found. When the interventions are located in areas presently occupied by the old infrastructures they will be less demanding.

In the sections Santo Ovidio - Trindade and Trindade - Campanhã the civil works will be very delicate and time consuming. For this reason those lines will be the last ones to be open [6].

With the intention of minimise the negative impacts over the public places and citizens a new bridge will be constructed to transfer traffic during the upgrade of the Luís I bridge. In the future, with the installation of the light rail in this bridge, to connect both sides of the river, the private car users will only use the lower platform, leaving the upper platform for the light rail. On the other hand, the necessary disabling of rail services during infrastructure execution, requires an alternative transport system.

Some other important interventions will occur in the city centre due to the installation of the underground section and related stations, like the deviation of electric cables and water pipelines [7].
As different gauges exist, gauge conversion will be considered. The use of standard gauge, that is larger than narrow gauge, allows the adequate application of the most recent concepts of low floor vehicles. In this kind of vehicles, the space available inside is directly dependent on the distance between wheels, and consequently between seats, which has influence in the vehicle capacity.

The existing rail lines used for a large part of the route will be converted to overhead line electrification powered by a current of 750 V DC.

The most important technical difficulties in converting the old infrastructure, besides the gauge conversion and the electrification already referred, reside in the adaptation of architectural civil works like the Trindade tunnel (located in the city centre) which has a total length of 488m. Adding to this, the old lines to be used by the light rail system are located in rugged lands with winding routes. Therefore, more than 30 upper passages in the Senhora da Hora - Póvoa link and more than 25 upper passages in the Senhora da Hora - Trofa link must be the target of special care.

The Environmental Impact Study points to the following benefits (positive impacts) that are expected from the operation of the light metro system [8]:

- increasing the offer of the public transportation system;
- decrease of road traffic;
- decrease of urban pressure and parking problems;
- decrease of fuel consuming in the urban centres due the expected decrease of road traffic;
- decrease of air pollution and noise in the main urban centres;
- better conviviality and urban quality of life;
- valorisation of leisure and commercial activities, mainly in the zone classified as world heritage site;
- decrease of the barrier effect created by the Douro river;
- global decrease of medium trip time specially for the commuting trips, using the public transport.

6 Conclusion

Since some years ago, an implementation of a heavy mass transit system to serve the city of Porto has been under study. Recent installations of light rail systems in Europe and their success in terms of public opinion and as a tool to meet other requirements, such as environmental and financial costs, have led to a new approach of the urban and suburban transport system.
This paper shows that a given solution is not easy to set-up or to adequate to a specific reality, specially in transportation, where the changes in demand and in citizens’ requirements are difficult to predict in long term.

The presented application is an example of a solution that has suffered some evolutions. Initially, a metro system was proposed, but due to traffic demand, economical and political conditions, an integrated light rail system will be implemented. The possibility of sharing the old rail infrastructure with heavy rail services was not considered, since the requirements of the initial solution - a metro system - wouldn't allow this kind of application.

The success of this system will be an important step for the installation of identical systems in other Portuguese cities, served by railway lines, but considering the importance of sharing the same infrastructure, safeguarding that there aren't optimal solutions and each application must have a special treatment.

The new modern light rail is expected to be built in the predicted time, with little disruption for civil engineering works and with the desired success.

7 References

[1] Getting the right system right from the start, CRI, 12/97, pp. 29-32, 1997
Section 2: Land Use