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RAIL URBAN PROJECTS: A WAY FOR IMPROVING PUBLIC TRANSPORT PATRONAGE

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ABSTRACT

Motorised mobility has increased in a significant way in last years in European cities, and this has brought too much congestion in urban areas, which has deteriorated city centres' liveable conditions. For that reason, there is a need of effective and flexible transport systems in order to improve this situation in favour of public transport.

The investment on design and innovation of competitive public transport is necessary in order to improve its modal share. Nevertheless, there exists other aspects, also very important, which make public transport more attractive. In the last years, many cities have implemented rail urban projects (tram, metros and light rail systems) as they have been considered the optimal option to foster public transport patronage and also for getting a sustainable mobility for the growing urban population.

These kind of projects provide fast, regular, safe and comfortable services with medium-high capacity. At the same time, they provide a modern image of the city. Those characteristics are essential for a competitive public transport in contemporary cities, although they require large investments for its construction.

This paper will present a comparison between different rail urban projects running in European cities since, at least, ten years ago. There will be described how they have increased modal share of public transport in different cities contexts..

1. INTRODUCTION

In the last years, motorised mobility has increased in a significant way, and this has brought too much congestion in urban areas (EC, 2001). This situation has deteriorated city centres' liveable conditions and it will be worst if nothing is done.

Current situation in most urban areas could be described by the cycle of urban decline, and they trend to unsustainable transport schemes. In those areas, the choice of travelling by car produces more traffic jams, thus reducing the efficiency of public transport and the quality of live in urban districts by increasing pollution and accidents levels. This reduction on liveable conditions makes both residents and firms to move out to suburban areas, where the provision of public transport is very low, and therefore the use of car increase again producing the vicious circle (Iris Plan, 1998).

The idea is go towards a sustainable urban transport in order to get a balance between the economic, social and environmental issues linked to the transport, thus minimising road accidents, air pollution, noise, etc. produced by this sector. Public transport has an important role in this process, since modal shift from private to public transport would reduce those negative effects mentioned before. Moreover, public transport is a catalyst for economic and social opportunities that contribute to efficiency and productivity in urban areas where most of the wealth is created (UITP, 2004).

The main benefits of public transport are (Tyson, 1999):

- relief of traffic congestion arising from the greater efficiency of public transport in using road space;
- reduction in accident costs and damage;
- improvement in the quality of the environment including less noise, atmospheric pollution, visual intrusion, severance of communities and ecological damage;
- a more efficient economy with benefits of lower expenditure on road construction and maintenance;
- benefits from more efficient public facilities (for example, hospitals);
- improved economic efficiency of city and regional centres;
- improved energy efficiency.

Public transport is the key solution to urban problems in the European Community (UITP, 2004). It is the safest means of land transport, consumes less energy, uses less road space and is less damaging to the urban environment. The modal shift from private to public transport has to be made: it does not mean a reduction in car ownership, but more use of public transport in urban areas by a combination of push an pull strategies.

The White Paper (EC, 2001) deal with this `problem´ by encouraging the promotion of good practice. It states the need of making the alternatives to the private vehicle more attractive in terms of both infrastructure and service. The achievement of high levels of comfort, quality and speed by public transport is one of the points to consider in order to fulfil people's expectations, thus improving public transport patronage.

It is essential for public transport to adapt to societal changes and to develop alternatives that are of sufficiently high quality to attract drivers out of their cars (Mackett & Babalik, 2003). Since 1970, 141 new urban rail systems have been opened worldwide (Taplin, 2002), 61 metros and 80 light rail systems. This quality option has been the choice of many European cities which have decided to innovate by putting into service new metro or tram lines. Light rail vehicles, running on segregated track, are an economic form of transport that is also popular among passengers, as the designers have revitalised the trams with a particularly innovative look. Many European cities have made tangible progress in shifting the balance between their transport modes by opting for this mode. They have invested in non-road transport modes and the proportion of car use has been reduced by 1% per year (EC, 2001).

In spite of this growth in the interest of those urban rail systems, there appear many criticisms against them regarding that they do not achieve the levels of patronage predicted (Pickrell, 1992), or meet the objectives set for them (Kain, 1988; Mackett & Edwards, 1998).

The other way for improving public transport patronage could be the search for more revenue, thus avoiding the problem of large investments, and at the same time keeping its cost base at an acceptable level.

The overall objective of this paper is to present the benefits produced by the urban rail systems, and afterwards make a comparison between different rail urban projects running in European cities since, at least, ten years ago. The benefits assessment procedure was developed in the framework of a V FP European project called TranSEcon (Urban Transport and Socio-economic Development). The methodology is based on a multicriteria analysis which considers a number of criteria to achieve the global objective of sustainability.

Later on, it was also the basis of the main author's PhD thesis with improvement on the seven case studies analysed.

2. RAIL URBAN PROJECTS CHARACTERISTICS

In all countries, the fight against pollution and congestion has been tackled in urban areas through the promotion of efficient mass rail transport. Some European countries have drastically expanded their rail systems (ERRAC, 2004) in order to reverse the growing dependence on the private car and deal with the growing congestion due to the increase in car traffic.

Among those urban rail systems, this paper deals with projects of both, light rail systems and metros in urban areas.

The modern tram, or light rail system, was born in Nantes, France, in 1984 (Wansbeek, 2001). Since then, many European cities have incorporated those systems to their urban transport networks, so nowadays there exists around 10.000 Km. of tram network within more than 100 European cities. Light rail systems are flexible and expandable. They can be developed from traditional tramway systems or planned and built as entirely new systems.

The metro, by which we mean an electrically powered train operating on reserved tracks in urban areas, was born in 1890, with the official opening of the first underground line in London. Since then, some 120 conurbations in Europe, Asia and America have joined the ranks of cities with their own metro system. In 2002, metro networks carried some 150 million passengers per day (UITP, 2003), or 34 times the average daily number of air passengers. On its own, this comparison demonstrates the economic and social importance of developing, organising and operating metro systems. The metro is the most efficient transport mode in terms of energy consumption and space occupancy, thanks to its combination of electrical traction and high capacity. Some calculations made by the RATP (Paris) show that, in order to transport 50,000 passengers per hour and direction, metro needs a right-of-way measuring 9 metres in width whereas a bus would require 35 metres, and cars 175 metres. Moreover, the metro does not produce any local pollutant emissions or greenhouse gases, and as an underground transport mode, it frees surface space for developments thus allowing improvements in the quality of urban life. However, metro systems require heavier investment than light rail, and can be implemented only in large cities where demand justifies the capital cost (ERRAC, 2004).

The following tables show some general figures of the existing light rail and metro systems within Europe:

Table 1: Tram and light rail systems in Europe

	Systems	Lines	Track length (Km.)
EU-15	107	448	4.793 (59%)
New Member States[1]	30	349	2.240 (28%)
Beyond EU-25[2]	33	144	1.027 (13%)
Total	170	941	8.060

Source: ERRAC, 2004

Table 2: Metro systems in Europe

	Systems	Lines	Track length (Km.)
EU-15	27	117	2.072 (88%)
New Member States	3	7	93 (4%)
Beyond EU-25	6	14	181 (8%)
Total	36	138	2.346

Source: ERRAC, 2004

3. DESCRIPTION OF THE CASE STUDIES

In this chapter, there will be described a number of rail urban projects which effects will be analysed afterwards. There has been chosen seven case studies out to 13, and they represent an interesting range of different rail urban projects, in particular metro, light rail and S-Bahn systems. Most cases are at least ten years old, however there are some more recent.

The public transport systems distinguish themselves primarily by the *range and type of service*. There is one proper *S-Bahn systems* (Stuttgart), three proper *metro systems* (Lyon, Madrid and Vienna), t*wo types in between* (Tyne & Wear and Manchester) as well as one *surface transport system* (Valencia). Within this paper, Tyne & Wear will be considered as suburban rail system, and Manchester as a tram system.

Table 3 summarises the main characteristics of the case studies.

Table 3: Summary of case study characteristics.

City	LYON	MAD	MAN	STU	T&W	VAL	VI
Project	Metro	Metro	Metro /	S-Bahn	Metro /	Tram	Metro

[1] New Member States joining the EU in May 2004.
[2] The countries beyond EU-25 include Norway, Switzerland, Bulgaria, Romania, Turkey, and Western Balkan countries.

			tram		S-Bahn		
Areas concerned	City	city	city and suburbs	city and suburbs	city and suburbs	city and suburbs	city
Length (Km.)	15.0	7.0	31.0	16.0	55.5	9.7	8.2
% new project/ total network	54.5%	4.1%	84.7%	14.5%	94.1%	7.3%	13.3%
Total investment (M€ of 2002)	524.4	283.0	270.0	352.0	1233.0	124.2	2487.0
Investment/km. (M€/km.)	35.0	40.4	8.7	1.88	22.2	12.8	303.3
Operation since	1992	1995	1992	1992	1984	1994	1991

Source: TRANSECON, 2003

Lyon

Lyon has a population of 450,000 and the metropolitan area 1.2 million. Car ownership is relatively high with rather high congestion and moderate public transport modal split.

The case study is based on the development of a fourth line in the Lyon metro system, Line D. It was opened in 1992 and is driverless. It provides a very frequent service into the city centre and the extension also included a multi-modal interchange. The amount of the investment was evaluated to 1,100 million Euro (2002).

The accompanying measures which took place were:

- urban bus and metro network fully integrated
- city centre parking policy
- the metropolitan authority subsides transport by funding the metropolitan transport executive, which in turn contracts the operator to run services to the required specifications

Madrid

Madrid city has a population of 3 million inhabitants (in 2001), but the population of the Madrid region is 5.4 million inhabitants.

Madrid region has 2 million employment, which are mainly concentrated in the city centre, with 1.4 million employment. It has a relatively high car ownership, high public transport modal split and rather high traffic congestion.

The Madrid case study is the extension of a metro line, line6, and its conversion to an orbital metro line. The investment represents 282.83 million Euro (2002). The circle metro line has 24 Km. long with 27 stations, but the extension has 7 Km. and 6 stations. This last link was opened in May 1995, and it provides connection with other 4 metro lines, 2 suburban rail lines and 2 metropolitan bus terminals.

Fig. 1: Madrid metro line 6 scheme.

Manchester

The city of Manchester has a population of more than one million inhabitants, while the whole conurbation –Great Manchester- has a population of 2.6 million. It presents high car ownership levels and considerable traffic congestion during peak hours. The city has a comprehensive urban rail network running along the main radial corridors from the city to the sub-regional centres.

The case study of Manchester is the phase 1 of the construction of Metrolink. This light rail system was conceived to overcome the accessibility problems the area had by linking the suburban rail lines through on-street running in the city centre.

Metrolink phase 1 linked major suburbs to the regional centre, and it was opened in 1992, with an investment of 270 million Euro (2002).

It is the central element of the Transport Strategy of the region, which is built around the expansion and improvement in public transport through new infrastructure, bus priority measures, quality bus partnerships, and Park&Ride initiatives. The authorities are also pursuing policies of restraint through either work place parking constraints or road pricing.

Stuttgart

The overall population of the Stuttgart Region is about 2.6 million inhabitants (2000), and it is one of the most densely populated region of Germany. The city of Stuttgart concentrates 570,000 inhabitants (22% of the population in the region).
An enormous growth in industrial and business zones took place in the peripheral zones, which besides its traffic-generating impact on commuting and passenger transport in general, surely affects freight transport as well and has led to a dramatic increase in population and workplace redistribution.

The Stuttgart case study consists in the extension of the light rail system (S-Bahn) S1, that runs parallel to the A81 motorway, from the city centre to the southwest of the region. The new section started to operate in 1992, it is about 16 Km. long, and it has 6 new stations.

The main accompanying measures carried out in parallel were the creation of Park&Ride facilities, the restriction of parking in the city centre and the interconnectivity and interoperability of interurban transport scheme.

Tyne and Wear

Newcastle is the centre of the metropolitan county of Tyne and Wear. The city itself has 300,000 inhabitants but the whole area of Tyne and wear has about a million. Car ownership is relatively low with an average of 295 cars per 1,000 persons.

In Newcastle, the modal split characteristics for journeys to work are: 56% by car, 21% by bus/coach, 5% by metro/train, 11% walking and 7% by other modes.

The case study is the construction of the first 55.5 Km. of the Tyne and Wear metro network, which was opened in 1980. Nowadays, metro network has 76.5 Km. long.

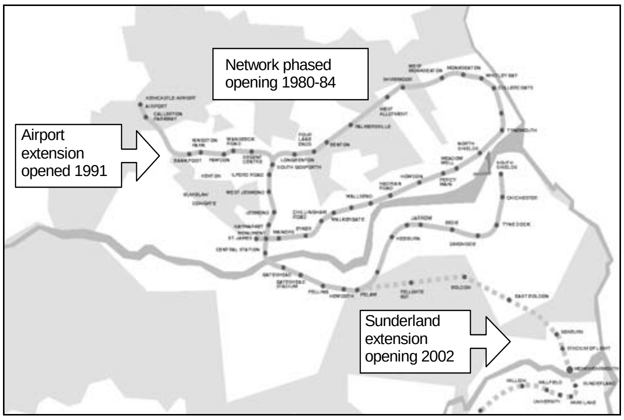

Fig. 2. Tyne and Wear metro network.

Valencia

The city of Valencia has a population of 782,000 inhabitants in its urban area, and the wider region 1.4 million inhabitants. It has moderate car ownership and congestion level, although the trend is to growth within the next years.

Valencia case study is the construction of the first tram section, line 4 of the tram and light rail system. Line 4 is a tram line which has replaced and enlarged an old railway line. The first section (9.7 Km.) has been put in service in 1994. It collects and distributes users in the north city, and it has 2 stations connecting metro lines 1 and 3.

The main accompanying measures carried out were the improvement and recovery of urban spaces, and the development of the integrated ticketing in the metropolitan area.

Vienna

Vienna has a population of 1.6 million inhabitants (2001), a relatively high car ownership and moderate traffic congestion. A Master Plan exists aiming to increase the public transport modal split, reducing private car modal split at the same time.

The case study is the construction of the centre part of the undergroung line U3, between Erdberg and Johnstrasse stations, connecting the south-east of the city with its western part, passing through the city centre. This section was built in several phases: the first stretch was opened in 1991 with 9 stations and 4.9 Km., in 1993 a second stretch of 1.9 Km. was put in service, and the final stretch was opened in 1994 with 1.4 Km. long and 2 stations. The total length of the case study is 8.2 Km. and it has 14 stations.

Unlike some other line in Vienna, the track of the U3 metro line is completely under the surface, except one terminal station at the end of the line. The total construction cost was about 2,380 million Euro (2000), including rolling stock depot.

There were established some accompanying measures to the construction of the metro line. Among those measures there were implemented short term parking restrictions in the inner city districts. Also, Park&Ride facilities were set up at the terminal station "*Erdberg*". And finally, various urban regeneration measures were implemented along the line: markets, and recreation and shopping centres were built or renovated, and housing projects as well as offices were developed surrounding the metro stations.

4. IMPROVEMENTS OF PUBLIC TRANSPORT PATRONAGE IN THE CASE STUDIES

In this chapter there will be presented the main benefits produced in the case studies, regarding their influence in order to promote public transport patronage.

4.1. Impact assessment

The calculation of the impact of different public transport investments has been defined by the methodology adopted in TranSEcon, as mentioned in the Introduction. For each assessment indicator, the impact of the project corresponds to the difference between the value of this indicator for scenario with project (WS) and the value of the same indicator for the reference scenario[3] (RS). With this calculation we define the absolute variation:

$$\text{Absolute variation} = \text{Data in WS} - \text{Data in RS}$$

From this absolute variation , it is possible to calculate the relative variation of the indicator in the scenarios with the following formula:

$$\text{Relative variation} = \frac{\text{Data in WS} - \text{Data in RS}}{\text{Data in RS}}$$

The proposed assessment method uses relative variations in order to compare the impact of the projects more accurately. So each benefit will be the percentage of an indicator variation between the reference and "with" scenarios.

4.2. Indicators defined for measuring the benefits

The assessment of the impacts of urban transport infrastructures leads to quantify the role of the new transport supply on the urban transport system. It is needed to define some indicators which contribute to characterise the urban transport. These indicators should characterise the transport system, so they have to consider both public and private transport.

The indicators are organised in two groups:

i) mobility and trip behaviour

ii) time savings

The first group of indicators aims to quantify the effect of the project on transport demand; they should quantify the evolution of transport demand and trip behaviour, so they allow a quantification of the role of the new project on modal split. This group is made up of the following indicators:

[3] The reference scenario (RS) is the situation without the project and its definition corresponds to the *do-minimum* scenario definition, whereas the scenario with the project (WS) is the situation which considers the implementation of the project. Both scenarios are referred to the same year.

- Number of public transport trips per day and O-D
- Number of private transport trips per day and O-D
- Public transport passenger-Km. per day and origin-destination
- Private transport passenger-Km. per day and origin-destination

The second group of indicators deals with the impact of the new project on time savings, thus aiming to assess the extent to which the investment modifies the time spent on transport. This group is made up of the following indicators:

- Average trip travel time on the public transport network, in minutes
- Average trip travel time on the road network, in minutes

4.3. Results

The following tables and graphics show the relative variation of the two groups of indicators. Positive variations mean an increase in the indicator between the two scenarios, and negative variations mean decreases of the indicator between scenarios.

Table 4: Relative variation of the mobility and trip behaviour indicators between scenarios

Mobility and trip behaviour indicators	LYON	MAD	MAN	STU	T&W	VAL	VI
PT trips	5,52%	0,09%	8,06%	25,48%	41,37%	3,03%	7,20%
Car trips	-4,71%	-3,00%	-0,84%	-6,22%	-4,17%	-1,00%	-7,05%
Passenger-Km. in PT	5,32%	1,08%	4,08%	35,99%	30,24%	41,51%	46,82%
Passenger-Km. in cars	-4,73%	0,00%	-0,56%	-10,36%	-4,15%	-1,00%	-7,28%

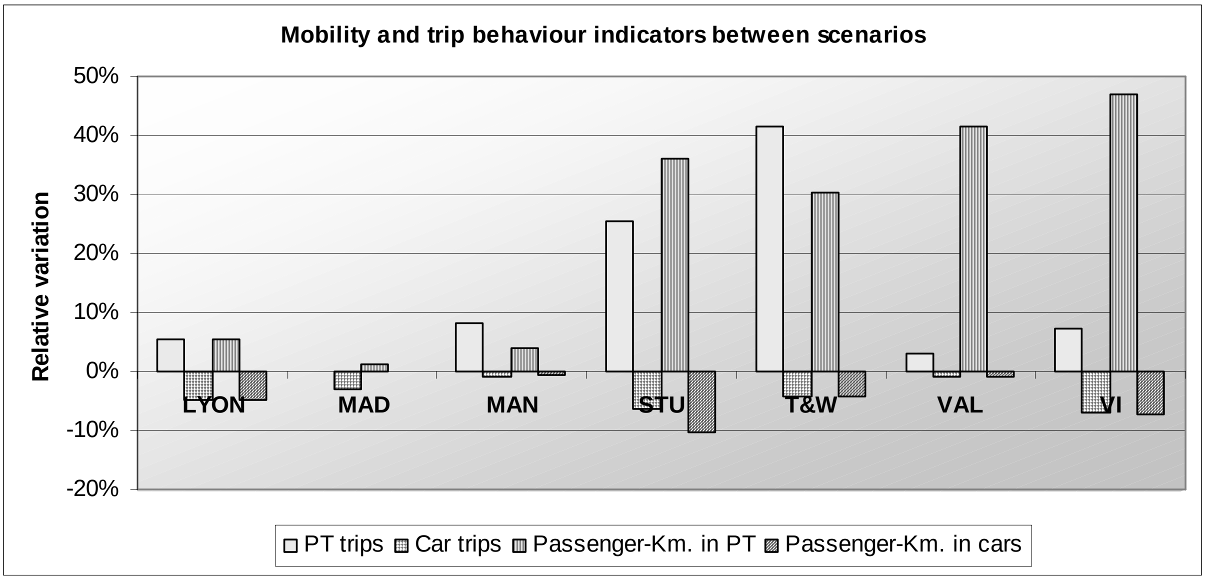

Fig. 3: Graphic representation of the relative variation of mobility and trip behaviour indicators

The results of Table 4 and Fig. 3 highlight the following aspects:

- In Lyon, the implementation of the metro line D, together with some other transport policies as the integration of bus and metro networks and parking restrictions in city centre, has led to a uniform improvement of the mobility and trip behaviour indicators, around a 5% between scenarios. Trips in public transport and the number of passenger-Km. in the public transport network increase, whereas trips in private vehicle and the number of vehicle-Km. decrease.

- In Madrid, the extension of the metro line 6 was included in the transport policy of the city and its metropolitan area, which included the promotion of intermodality and the public transport network integration. All these measures together have increased trips and passenger-Km. in public transport, but less than in Lyon, and the number of trips in private vehicle has been reduced by 3%.

- In Manchester, the more evident improvements in mobility and trip behaviour produced by *metrolink,* as central element of the Transport Strategy of the region, correspond to the increase in the use of public transport: 4% growth in public transport trips and 8% increase in passenger-Km. in public transport. However, the reduction in the use of private vehicle is almost insignificant (less than 1%).

- In Stuttgart, the extension of the S-Bahn S1 has dynamised the effects of all the measures carried out in the city. They have produced a big variation of mobility and trip behaviour indicators, particularly it is remarkable the improvements on public transport patronage in the new line corridor.

- In Tyne and Wear, as in Stuttgart, the new transport infrastructure has been extremely important in order to foster public transport use. It produces the highest increase public transport trips (around 40%). At the same time there is a clear reduction in the use of private vehicle.

- In Valencia, the implementation of the tram, in the context of a set of urban and transport policy measures, has implied an important increase in the number of passenger-Km. in public transport. The link between tram line 4 and other two metro lines makes that the trips in the network are much longer, and consequently the indicator grows. In spite of this improvements in public transport mobility, the reduction in the use of car is not so important, but at least there is a little fall.

- Finally, Vienna presents the highest increase in the passenger-Km. in public transport and also the highest reduction in the number of trips in private vehicle. So, compared with the other case studies, the construction of the metro line U3 and its accompanying measures have produced the most important enhancements in terms of mobility and trip behaviour, thus improving the public transport patronage.

Table 5: Relative variation of the time savings indicators between scenarios

Time savings indicators	LYON	MAD	MAN	STU	T&W	VAL	VI
Average travel time on PT network	-4,55%	-1,95%	-0,33%	-28,25%	-24,10%	-14,81%	-22,29%
Average travel time on road network	0,00%	-2,78%	-0,34%	-1,86%	0,00%	-3,33%	-15,65%

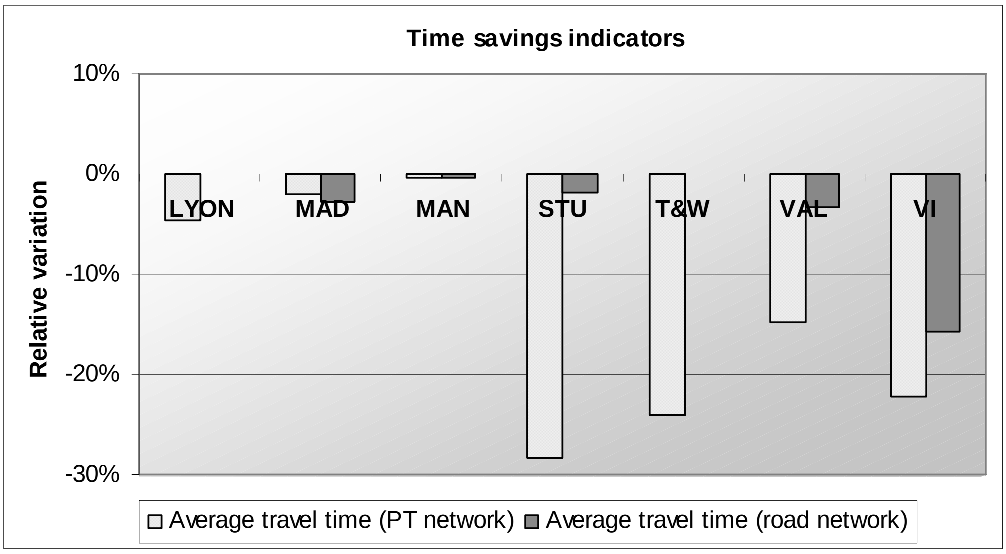

Fig. 4: Graphic representation of the relative variation of time savings indicators

The “time savings” indicator shows that there is a global reduction of travel time thanks to the implementation of the urban rail projects. The highest time savings in public transports services correspond to Stuttgart, whereas Vienna presents the maximum time savings in the road network. It means that the improvement in public transport patronage is also beneficial for car users.

4.4. Success of the urban rail systems

Mackett & Babalik (Mackett & Babalik, 2003) identified some factors and policies which might influence the success of a rail system: physical and socio-economic characteristics of the area, route location, cost factors, operating policies, and transport and urban planning policies.

The main findings arose from the analysis of the case studies can be summarised as follows:

- The introduction of an integrated ticketing in the public transport system has been found as an important accompanying measure to the implementation of a new urban rail project. This initiative promotes public transport use with non-penalised access to the whole network. The White Paper (EC, 2001) states that to facilitate transfers from one mode to another, encouragements needs to be given to the introduction of integrated ticketing systems. This has been the case of Lyon, where urban bus and metro network was fully integrated, Madrid, which its multi-modal travel pass was established in 1985, and Valencia, developing the integrated ticketing in 2000.

- In radial rail transport infrastructures, which link the city centre with the suburbs, the construction of Park and Ride facilities seems to help the patronage in this transport mode. This transport policy has been implemented in Manchester, Tyne and Wear, and Vienna.

- Another transport policy related to the previous one, and that is of relevant importance in order to help the success of public transport, particularly of an urban rail project, is the restriction of car parking in city centres. This policy has been implemented in most of the case studies: Lyon, Madrid, Stuttgart, Tyne & Wear and Vienna.

- The modern image offered by the new generation of light rail systems contribute to an urban regeneration of the zone in which it has been built, and sometimes also of the city as a whole. In Valencia, the construction of the tram line was conceived together with a series of operations of improvement and recovery of urban spaces; moreover, its construction was associated to an important urbanisation project with a cost of nearly 50% of the budget of the total intervention. In Vienna, various urban regeneration measures were implemented along the new metro line: markets, recreation and shopping centres were built or renovated.

- There are also other benefit related to the urban regeneration mentioned before, as the reduction of the level of crime, the attraction of new enterprises, the increase in quality of life, etc. This is the case of Stuttgart, where the extension of the S-Bahn line S1 has attracted new business and also new residential areas have been developed in the area. Similar is the case of Tyne & Wear, where the north-east of Newcastle has reorganized its land uses, changing from industrial to residential use. In Vienna, housing projects as well as offices were developed surrounding the new metro stations.
- Along the lines of urban planning policies, there also exist the possibility of pedestrianizing streets. This is the case of Vienna, in which due to the construction to the metro line (underground), several tramlines with the same route were closed, and this gave the opportunity to reconstruct the surface in many parts along the line in a pedestrian friendly way.

All these examples give an overview of the possible measures and policies which can be implemented in urban areas in order to encourage the use of urban rail systems, thus contributing to increase its patronage and their contribution to sustainable mobility.

5. CONCLUSIONS

- Some management policies, such as frequent services, integrated ticketing, and security on board and at stations, and some transport policies, such as public transport integration, provision of Park & Ride facilities and car parking restrictions are very important in order to increase the patronage of public transport.
- Tram and metro systems have great potential to improve modal split in urban areas.
- Although they are expensive projects, they produce long term effects on mobility patterns improving sustainability standards.
- Tram and metro projects should be integrated in urban transport policy packages which produces synergy effects on the whole city. It has been demonstrated that the success of urban rail systems are influenced by many factors and policy measures. So the integration of the transport policies with urban, socio-economic and environmental policies seem to benefit more than isolated policies.
- In some cases, the new tram has induced an urban regeneration process which has mobilised a lot of economic resources improving commercial activities and the quality of life in the area.

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