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METROPOLITAN MOBILITY IN SPAIN-ARE WE TENDING TOWARDS SUSTAINABILITY?

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ABSTRACT

There is a growing concern in the urban transport field about the development of a data set of indicators that would allow to undertake ongoing monitoring and evaluation of current transportation policies, compare data from territories facing the same kind of challenges, identify good practices and strategies to be followed, and strengthen the information, participation and decision-making process. These data set of indicators, known as observatories, are aimed to fulfil stakeholders needs, so that they achieve the precise knowledge to adopt pertinent policies.

The Spanish Metropolitan Mobility Observatory, sponsored by the Spanish Ministry of Environment, was launched in 2003 by the Metropolitan Transport Authorities of the major metropolitan areas in Spain, and TRANSyT. Its scope is to identify those elements within urban transport policy packages which have had a more significant impact on mobility (i.e. global transport demand, travel time, modal split,…), and on land use patterns. And its main goal is to serve as basis for Metropolitan Transport Authorities to improve operation of their public transport system, and thus increasing their contribution to sustainable mobility.

For its second edition, based on the year 2003, a set of data from the different Metropolitan Transport Authorities has been collected, in order to:

- Highlight public transport contribution to improve urban areas and sustainable development
- Describe the role of Metropolitan Transport Authorities in achieving an attractive and quality public transport
- Monitoring transport supply and demand characteristics, focusing on public transport
- Analyse resources dedicated to the public transport system
- Describe the financial models used for the public transport system
- Highlight the main initiatives and innovations developed by Metropolitan areas

This information will be compared to that one from the previous edition, and a statistical analysis will be conducted in order to identify those variables, which are likely to explain results in most cities.

Keywords: Mobility observatory, performance indicators, Spain, sustainability

1. INTRODUCTION

Most cities in Europe, many world wide, have a great concern regarding the transportation system within their metropolitan areas: achieving a sustainable mobility. Nowadays the concept of sustainability characterises a typically way to approach urban transport policies in metropolitan areas. This approach does not only consist in adopting particular measures but also should comprise the consolidation of trends and sensibilities among stakeholders, seeking consensus and expert participation. Therefore, it is important to adopt long-term strategies, while improving the information and decision-making process.

The first step to achieve this goal is the development of a data set of indicators allowing to:

- Undertake ongoing monitoring and evaluation of current transportation policies
- Compare data from municipalities facing the same challenges
- Identify good practises and strategies to be followed
- Strength the information, participation and decision-making process

These data set of indicators, observatories, are aimed to fulfil stakeholders need, so that they achieve the knowledge to adopt pertinent policies.

This study summarizes the results of a second year research conducted in the 11 major metropolitan areas in Spain, in the context of a Metropolitan Mobility Observatory, aiming to serve as permanent monitoring mechanism of sustainable urban mobility in major Spanish cities.

2. METROPOLITAN MOBILITY OBSERVATORY

The Spanish Metropolitan Mobility Observatory, sponsored by the Spanish Ministry of Environment, was launched in 2003 by the Metropolitan Transport Authorities (MTAs) and the Transport Research Institute (TRANSyT). The observatory aims to identify the elements, within urban transport policy packages, which have had a more significant impact on mobility and on land use patterns. In this paper we describe some of these elements like global transport demand, travel time, modal split, urban environment, financial aspects and investments. Moreover, the Observatory wants to compare mobility within the biggest metropolitan areas in Spain. The metropolitan areas have multimodal transport networks operated by several operators.

Approximately, we studied 11 metropolitan areas, bigger than 200.000 persons, where the different MTAs delivered data over an eleven year period (1993 to 2003); in these areas, the public transport means a complex task in terms of operation and financial aspects and the MTAs are the responsible coordinators. This paper compares and analyses the information, identifying those key transport policy choices taken by decision-makers within this period.

The MTAs are very young compare with other European authorities. The eldest is the corresponding to Madrid (Consorcio de Transportes de Madrid) founded in 1986, followed by Barcelona (1997), Bilbao (1997), Pamplona (1999), Valencia (2000) and Seville (2001). Currently new transport authorities have been created.

The objectives of the study are:

- To set the basis for the MTAs to improve operation of their public transport system, and thus increasing their contribution towards sustainable mobility
- To describe the role of MTAs in achieving and attractive and quality transport system highlighting the main initiatives developed by the metropolitan areas
- To monitor public transport supply and demand
- To analyze the resources devoted to public transport system describing the financial models used

3. RESULTS

We presented main results on key indicators, collected and compared for each metropolitan area, analyzing trends on their respective mobility. These indicators included all transport modes: public transport, private cars, bicycle and walk.

3.1 Basic data of Metropolitan Areas

The definition of each metropolitan area's boundary was marked by administrative divisions or by the operating zone of certain public transport operators not by person's own mobility. The following table shows some basic characteristics of the metropolitan areas considered:

Table 1: Metropolitan areas characteristics

Metropolitan area	Population	Surface (km^2)	Density ($Inhab/km^2$)	Nº Municipalities	Comparison with the whole region		Province GDP (€ per capita)
					Población	Superficie	
Asturias	935.254	5.107,36	183,12	42	87,0%	48,2%	15.502,00
Barcelona	4.953.459	4.086,90	1.212,03	164	98,0%	52,9%	21.523,00
Cádiz	623.528	1.877,00	332,19	7	54,0%	25,2%	13.538,00
Granada	448.762	861,00	521,21	32	54,2%	6,8%	12.936,00
Madrid	5.718.942	8.028,00	712,37	179	100,0%	100,0%	24.366,00
Málaga	744.288	1.228,00	606,10	12	54,1%	16,8%	13.890,00
Pamplona	295.432	81,94	3.605,47	17	51,1%	0,8%	23.004,00
Sevilla	1.141.092	1.393,00	819,16	22	64,0%	9,9%	19.714,00

Source: INE and MTAs

At this point, we appointed the growth change of main Spanish cities. Since last years, there is a trend for population to move from the city center to the periphery (urban sprawling). This circumstance had changed guidelines of mobility within regions; for instance, passengers from the Madrid inner municipality had lost weight contrary to metropolitan ring passengers.

Nearly half of the Spanish population lives in the metropolitan areas considered (44 %), while the territory considered represents less than a 5% of the total surface of Spain. The metropolitan areas are a very heterogeneous group in terms of population and surface. This will lead to drawbacks in terms of clarity from some of the analyses undertaken below.

In regards of the public transport system performing in each metropolitan area, table 2 shows the operators for the different means of transport present in each metropolitan area.

Table 2 Public transport operators

	Rail (National competence)	Rail (Regional competence)	Metro	Tram	Suburban Bus	Urban Bus
Alicante	-	FGV	-	FGV	Private companies	Private companies
Asturias	RENFE, FEVE	-	-	-	Private companies	TUA (Oviedo)
Barcelona	RENFE	FGC	FMB; FGC	-	Private companies	TB
Bilbao	RENFE, FEVE	EuskoTren	MetroBilbao	EuskoTran	Private companies	TCSA
Cadiz	RENFE				Private companies	Private companies
Granada	-	-	-	-	Private companies	ROBAR
Madrid	RENFE	-	Metro de Madrid, TFM		Private companies	EMT
Malaga	RENFE	-	-	-	Private companies	EMT
Seville	RENFE	-	-	-	Private companies	TUSSAM
Valencia	RENFE	FGV	FGV	FGV	Private companies	EMT

Source: MTAs

Rail services are mainly provided by the national rail operator (RENFE – FEVE), but there are several metropolitan areas where this service is also provided by regional operators. Larger metropolitan areas incorporate metro network to their public transport system, while tram network is only present in 3 metropolitan areas. Regarding bus transport, urban services are mainly supplied by a single municipal company, while suburban services are operated by a large number of private companies.

3.2 Motorization Index

There is no significant correlation between the number of vehicles per thousand inhabitants and the income per capita within the metropolitan areas under study. Factors such urban density, existence of efficient public transport systems, or utilization costs of private cars and parking could lead to low motorization indexes in those metropolitan areas with higher incomes.

Table 3 Number of vehicles per thousand inhabitants

	Cars	Motorcycles	Mopeds
Asturias	398	20	
Barcelona	453	174	
Cadiz	379	n.d.	n.d.
Granada	459	63	97
Madrid	500	28	
Malaga	482	43	84
Pamplona	453	27	
Seville	431	36	62

3.3 Modal Split: the role of Public Transport

3.3.1 Work trips

Data collected revealed that the private car is the most usual mode for work trips in the metropolitan areas considered:

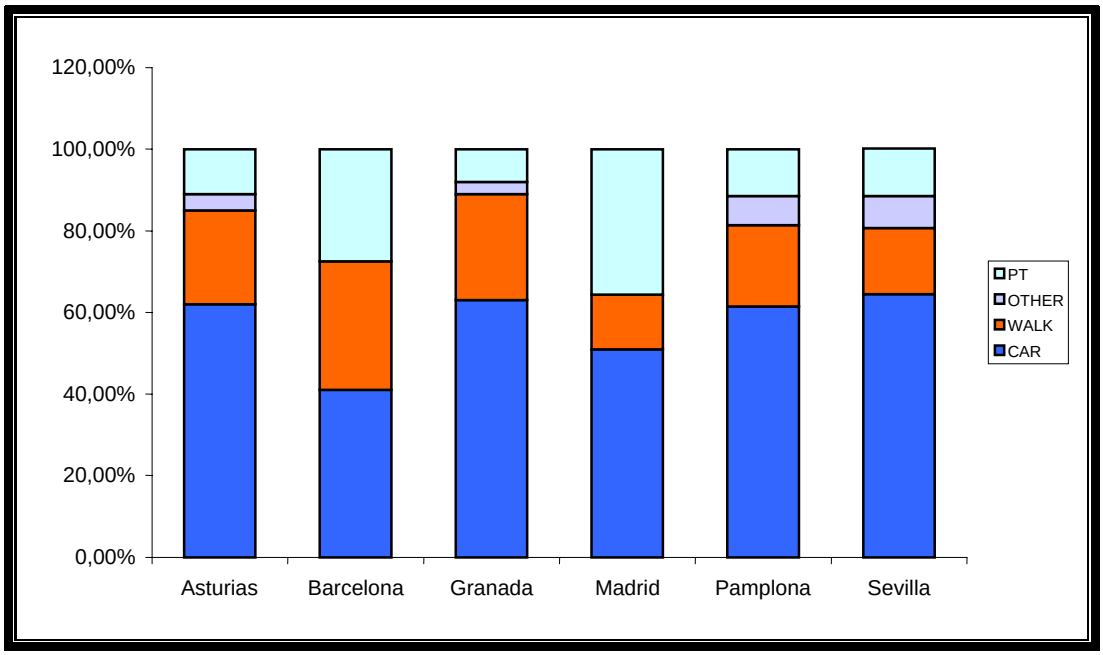

Figure 1 Modal split: work trips

Results from the study revealed that the traditional dense and compact morphology of the Spanish cities have not yet disappear, and walking trips maintain a significant share on the modal split for work trips. Nevertheless, the trend of this share indicates a decrease in the use of this mode over time. To highlight that the use of the bicycle in Spain is quite low compared to other European cities. Currently there is a trend towards promoting the utilization of bicycles by measures like the construction or rail tracks and the possibility of bringing them in metro.

From this analyses we can infer that Spanish metropolitan areas provide a favourable framework to make promotion of the non-motorised modes of transport. For that purpose, decision makers should develop supporting policies focusing on these modes. But MTA should get involved in the development of this kind of policies too, since non-motorised trips are usually one step in the public transport chain (specially if we consider walking, which is always one step in the public transport chain), and many times determines the public transport mode chosen.

3.3.2 Non-work trips

Considering non-work trips, modal split data collected revealed a significant decrease in the share of private car, and an important increase in the proportion of journeys made by walking. Results from this analysis suggests that leisure trips, shopping trips, etc. are usually made within a more reduced area from home. Nevertheless, as in the work trips, the trend of this share indicates an increase of the use of the motorises modes over time.

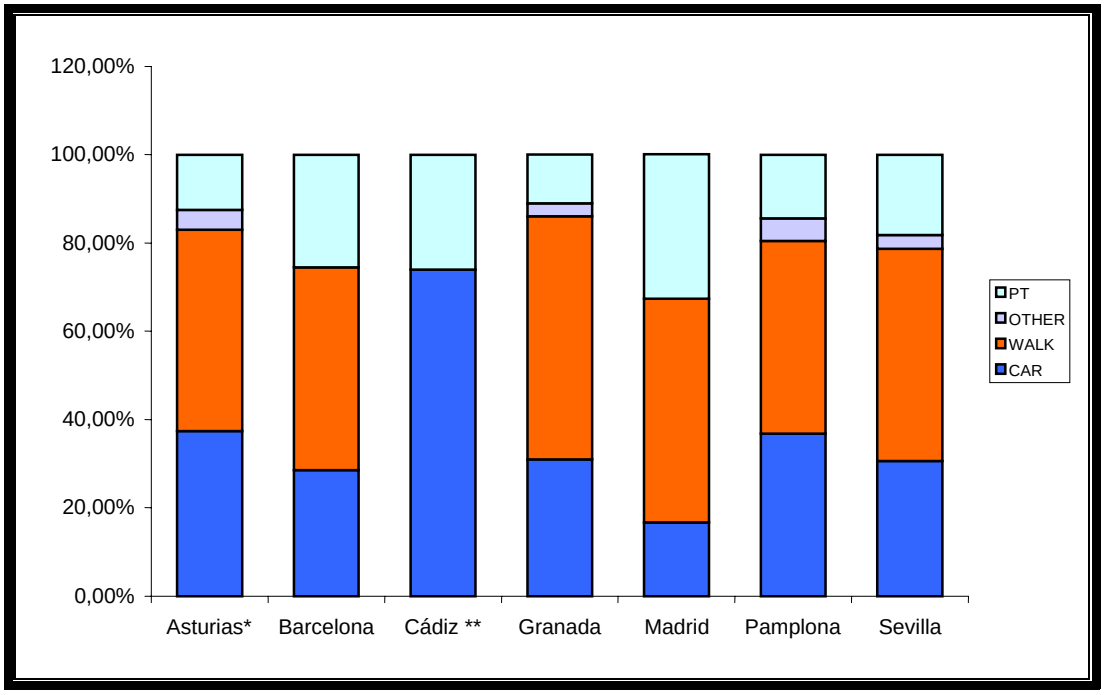

Figure 2 Modal split: non-work trips

***All passenger travel purposes. Only mechanized trips.*

3.3.3 The role of public transport

The overall role of the public transport system is directly influenced by the size of the metropolitan area considered. To highlight, the increasing importance of the public transport in big cities like Madrid, Barcelona and Malaga, particularly on regards commute trips and due to the development of new transport networks. The annual number of trips per habitant made by public transport modes show a big variation, ranging from 279 in Madrid to 64 in Malaga. Commute railroad services have a significant weight in big cities such as Madrid and Barcelona (13 % and 18 % respectively). The metro has a very important share in those metropolitan areas where it is present (with 45 % of the total public transport trips in Barcelona made by this mode). But is the high use of the bus system (either urban and suburban) what characterizes most Spanish metropolitan areas, even in those ones featuring commuting railroad services too.

The share of the transport system varies also between the main city and its periphery, being one of the most important aims to be considered by the MTAs and operators in the next years. In the future, the development of the public transport in the periphery of the big cites and not heavily populated areas should be promoted.

3.4 Mobility and urban environment

3.4.1 Pollutant emissions

Motorized mobility is the main source of pollutant emissions causing a severe damage to the air quality in our cities. The European Directive 1999/39/CE establish the threshold limit values for the number of times that the hourly or daily concentration of the main pollutants related to traffic (NO_2 and PM_{10}) can be exceeded:

- NO_2 – 1 hour concentration: no more than 18 times exceeded (by January 1st, 2010)
- PM_{10} – 24 hours concentration: no more than 35 times exceeded (by January 1st, 2005)

Data collected revealed that there is a big challenge to be faced regarding pollutant emissions in most Spanish metropolitan areas, in order to comply with the mentioned Directive (table 4). Almost every metropolitan area considered presents at least one pollutant emission measurement station which recorded higher excess values than the threshold limit value defined by the Directive for PM_{10} emissions (with the only exception of Alicante). In addition Madrid is having the same problem with NO_2 emissions.

Table 4 NO_2 (hourly) and PM_{10} (daily) concentration excesses (2003)

Province	Number of stations NO_2	Number of times excess (>200 µg/m3)	Number of stations exceeding more than 18 times	Number of stations PM10	Number of times excess (>50 µg/m3)	Number of stations exceeding more than 35 times
Alicante	6	3	0	3	22	0
Asturias	21	23	1	21	331	17
Barcelona	25	14	0	29	150	15
Bilbao	15	0	0	9	67	3
Granada	5	3	0	5	55	2
Madrid	40	63	10	40	195	38
Málaga	3	0	0	3	58	2
Sevilla	11	9	0	10	93	6
Valencia	13	3	0	4	43	2

Source: Ministry of Environment, 2003

3.4.2 Energy consumption and green-house gasses

Attempting to approximate energy consumption values, as well as green-house gasses (CO_2) emission levels, trends in fuel sales evolution were evaluated. Trends revealed by the analyses (5 % average growth) point to a significant increase in motorized mobility by private vehicle, mostly due to increasing urban sprawl and motorization rates, as well as population growth

Results regarding emissions and energy consumption evidence the need to develop more determined policies aimed to achieve a sustainable mobility, and more particularly to promote public transport and non-motorised modes.

3.4.3 Accidentality

Accidentality is another important aspect related to mobility and the urban environment. Accidents in the whole region area for the metropolitan areas considered have been evaluated, differentiating those who took place in the urban context (2003). Existing data revealed that 71 % of the accidents in urban areas takes place within the 11 metropolitan areas considered, and 51 % of the deaths caused by these accidents takes place within this metropolitan areas too. This data is similar to the previous year. To highlight that the private vehicle is involved in the vast majority of these accidents and accidentality in the public transportation system is comparatively insignificant.

Table 5 Number of road accident fatalities for the studied areas (2003)

Provinces	All zones			Urban zone		
	Total	Dead	Injured	Total	Dead	Injured
ALICANTE	2.405	170	3.835	497	11	636
ASTURIAS	2.662	148	4.134	1.055	25	1.448
BARCELONA	16.470	380	22.459	14.596	139	19.336
BILBAO	3.347	105	5.070	1.332	24	1.877
CADIZ	3.228	118	4.832	1.953	23	2.686
GRANADA	1.606	107	2.660	413	4	543
MADRID	13.806	358	19.674	9.928	122	13.448
MALAGA	2.545	149	3.858	1.282	31	1.705
NAVARRA	457	83	654	51	8	63
SEVILLE	3.989	182	6.898	2.445	31	4.230
VALENCIA	5.286	245	7.794	3.398	64	4.639

Source: Traffic General Directorate (TGD), 2003

3.5 Financial aspects

3.5.1 Coverage of operational costs

The average rate of coverage of operational costs by fare revenues, ranges from 40 % to 90 % of the total operational expenses of the public transport system (figure 3). The rest of the costs are mainly covered by public subsidies, and to less extend by publicity revenues in major metropolitan areas, reaching up to 350 M€ and 221 M€ for Madrid and Barcelona's urban transport systems respectively (table 6).

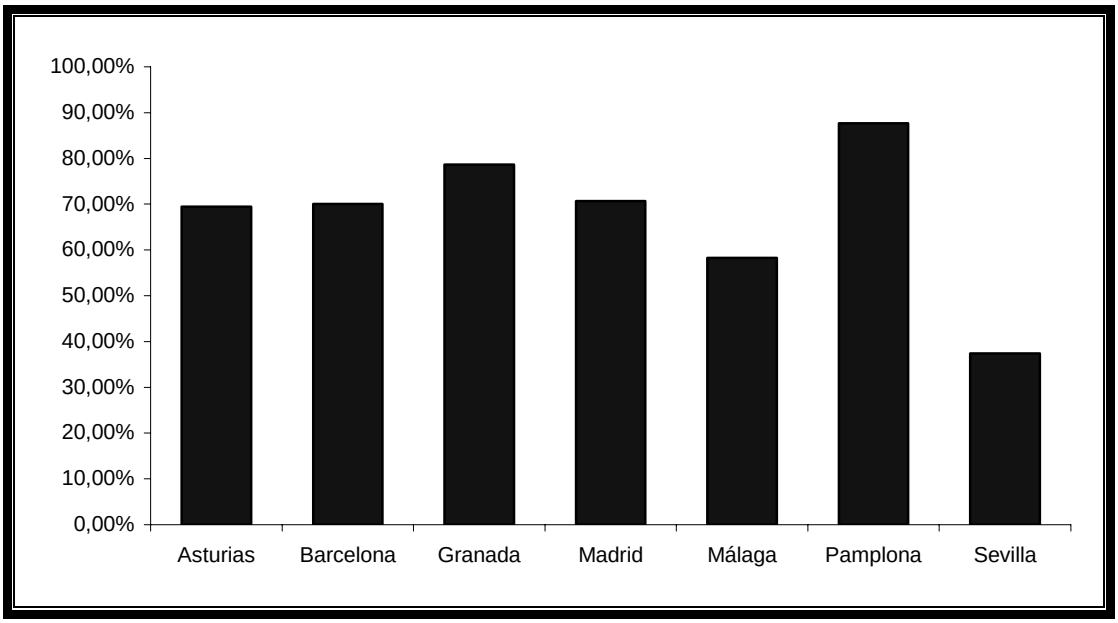

Figure 3 Coverage of operational expenses

Table 6 Percentage of operational costs covered by subsidies and publicity

	Transport mode	Subsidy (Millions €)	Publicity and others (Millions €)	Total	% Subsidy over operational costs
Asturias	Urban transport	0,83	1,82	2,65	4,10%
Barcelona	Metro and urban buses	143,42	19,54	162,96	36,51%
	Rail	49,99	8,55	58,54	48,87%
Granada	Urban transport	5,80	-	5,80	27,70%
Madrid	Urban bus	152,92	9,71	162,63	57,64%
	Metro	183,45		183,45	37,06%
	Interurban bus	3,40	0,94	4,34	1,42%
Malaga	Urban bus	15,98	0,34	16,32	40,91%
Pamplona	Urban transport	2,68	-	2,68	17,23%
Sevilla	Urban bus	-	2,60	2,60	-

Source: MTAs

3.5.2 Fares

Most metropolitan areas surveyed have a wide range of tickets available, including discount tickets for youngsters and students (the age limits ranges from 21 to 26 years old, depending

on the metropolitan area considered), and elderly people. These discount tickets represent a very important amount of resources that are being subsidized to favor these collectives (it is estimated that discounts sum up to 133 M€ in Madrid).

Public transport fares evolution reveals that they are growing faster than petrol prices and parking rates do, which mean that current pricing policies are more attractive for private vehicle users than for public transport users (table 7). In some of the metropolitan areas considered, public transport fares evolution also revealed that monthly tickets fares are growing faster that single ticket fares do, which means that current pricing policies in those metropolitan areas are not favoring the use of the public transport system with a regular basis.

This year, some of the MTAs have launched a fare integration, a successful policy within the public transport planning that has followed the Madrid's initiative of two years ago.

Table 7 Public and private transport prices (2002) and their evolution (1995-2002)

	Urban		Metropolitan	1hour parking fare	1l petrol price
	Single ticket	Monthly ticket	Monthly ticket		95 I.O.
Alicante	0,75 (-)	- (-)	- (-)	1,00 (-)	0,79 (23,0%)
Barcelona	1,00 (33,3%)	36,30 (34,9%)	52,30 (-)	1,60 (18,5%)	0,78 (21,5%)
Bilbao	0,81 (42,0%)	23,00 (27,6%)	27,50 (27,2%)	1,95 (68,1%)	0,82 (27,3%)
Granada	0,49 (26,9%)	- (-)	- (-)	1,00 (3,6%)	- (-)
Madrid	0,95 (26,7%)	32,30 (37,8%)	42,80 (39,0%)	1,70 (28,8%)	0,82 (27,3%)
Málaga	0,80 (-)	27,05 (-)	- (-)	1,20 (-)	0,80 (24,6%)
Sevilla	0,90 (29,0%)	26,00 (29,0%)	30,00 (-)	1,00 (-)	
Valencia	0,85 (77,1%)	29,50 (33,5%)	43,25 (2,8%)	1,50 (-)	0,79 (23,0%)

Source: MTAs; values in brackets (-) : prizes variation between 1995 and 2002

3.6 Investments and projects

The annual average investment in the public transport system along the last few years (1995-2003) show significant values for all metropolitan areas considered (158 € per inhabitant in Madrid, 67 € in Barcelona, 56 € in Valencia or 46 € in Alicante), following a positive trend. In Madrid and Barcelona the Metro is reaching new areas. Therefore, the construction of new tunnels in Madrid have made possible the rail to reach the city centre. In Barcelona, new tram lines are being opened.

But major investments in new public transport facilities do not seem to be translated into significant changes in modal split, in terms of transferring private car users to public transport, due to the fact that most of the investments are devoted to improvements in the existing network. In fact, these investments merely transfer public transport users from one mode to another. This general conclusion is, however, contested in some particular cases, where a number of conditions converge: corridors or links with previous poor quality services, lines where new public transport services have exclusively rights-of-way, key interchanges making transfer much easier… The many particularities in the case identified suggest that transport investments should be much more planned and designed on a case-by-case basis.

3.7 Public transport supply

Within the studied metropolitan areas, there are some more densely populated. In all of them there is a dense network of buses regulated by the local administration and operated by private companies through administrative concessions. Most metropolitan areas have rail network, more dense in heavily populated areas. Moreover, only in the big areas like Madrid, Barcelona and Bilbao, metro and urban rail are available in a frequency lesser than 15 minutes.

3.7.1 Public transport system density

Data collected revealed that the most populated metropolitan areas present denser railroad network, while the bus network density show more homogeneous figures (with the only exception of Madrid and Biscay, where the total region area was considered for this analyses). Service provision indicators revealed that, in terms of vehicle-km, railroad supply is significantly higher than bus supply, due to the higher capacity of this mode (table 8).

Table 8 Public transport density (2003)

	vehicle-km/inhabitant		vehicle-km/km^2	
	rail	bus	rail	bus
Asturias	-	8,5	-	1.559
Barcelona	31,2	19,9	37.828	24.150
Granada	-	24,1	-	12.558
Madrid	44,1	42,8	31.444	30.511
Malaga	1,4	20,8	845	12.585
Pamplona	-	22,1	-	79.564
Sevilla	0,0	20,0	0	16.368

3.7.2 Other public transport supply characteristics

Achieving an attractive and efficient public transport system requires the development of public transport priority schemes, allowing a bypass congestion and decreasing delays due to traffic flow inefficiencies. Most of the Spanish metropolitan areas surveyed have large BUS-ONLY lanes networks, but just a very small proportion of them are separate BUS-ONLY lanes (table 9).

However, except in Barcelona, there are no intersections that are giving priority to the public transport system. These intersections are generally linked to tram services.

Table 9 BUS-ONLY lanes network

	BUS-ONLY lanes (km)	
	Separate	Non-separate
Asturias	–	1,90
Barcelona	2,88	94,29
Cádiz	–	n.d.
Granada	n.d.	n.d.
Madrid	8,64	87,21
Málaga	6,10	
Pamplona	3,36	-
Sevilla	3,10	11,20

Public transport interchange stations are a very effective measure in promoting the use of public transport that is widely introduced in the public transport system in major Spanish metropolitan areas (table 10). The interchange stations influences the quality of the service, decreasing travel times.

Table 10 Basic characteristics of the interchange stations in Madrid (MTA)

Interchange stations	Connectivity (number of lines per mode)	Connectivity (All lines)
Aluche	Rail (1); Metro (1)	2
Legazpi	Metro (2)	2
Embajadores	Rail (1); Metro (2)	3
Palos de la Frontera	Rail (2); Metro (1)	3
Conde Casal	Rail (1); Interurban Bus	1
Ciudad Lineal	Metro (1)	1
Avenida América	Metro (4); Interurban Bus	4
Moncloa	Metro (2) + Urban Bus + Interurban Bus	2
Atocha	Rail (8); Metro (1)	9
Méndez Álvaro	Rail (3); Metro (1); Interurban Bus	4
Príncipe Pío	Rail (2); Metro (2); Interurban Bus	5
Plaza Castilla	Metro (3) + autobús urbano + autobús interurbano	3
Oporto	Metro (2)	2
Chamartín	RENFE (5); Metro (1)	6

Source: Madrid MTA

3.7.3 Quality of the transport system

An improvement of the quality of services provided has been regarded by public transport authorities and operators, as one decisive way to improve the attractiveness of public transport systems against private vehicles over the past years.

The accessibility to People with Reduced Mobility (PRM), as well as the emission rates of public transport fleet, are directly linked to the quality and sustainability of the system. The following table shows data collected regarding these two concepts for bus fleet:

Table 11 Bus fleet quality

	Accessible for PRM buses (%)		Low emission buses (%)	
	Urban	Interurban	Urban	Interurban
Asturias	100,00%		86% en Oviedo	
Barcelona	70,00%	50,00%	7,00%	-
Granada	60,00%	n.d.	60,00%	n.d.
Madrid	68,03%	50,60%	6,60%	-
Málaga	50,00%	1,00%	0,50%	1,00%
Pamplona	47,80%	n.d.	0,00%	n.d.
Sevilla	-	-	0,52%	0,00%

Table 9 reveals that urban fleet (mostly operated by municipal companies) reach higher quality levels than suburban services do. But there is still a big challenge for Spanish metropolitan areas to be faced. For instance, the MTA in Bilbao is acting to offer cheaper fares to PMR.

Regarding to the commercial speed, the data provided by the transport authorities confirm the hierarchy of the different transport modes: 45 km/h in average for rail services, 27 km/h for metro systems, 13 km/h for urban bus services and almost 27 km/h for inter-urban bus routes.

The amplitude of service is similar in all metropolitan areas. In Madrid and Barcelona, bus services have a shorter amplitude than Metro and some specific night bus routes, different from daily bus routes, are operated during closure of the metro.

4. CONCLUSIONS

The research conducted under the Spanish Metropolitan Mobility Observatory in its second edition, revealed the great effort that MTAs are making to improve the infrastructure and operation of their public transport systems. Results suggest that coordination of all public transport modes within one integrated system is a key element for the progress or maintenance of public transport share. Therefore, reshaping existing transport services, avoiding competition among modes and encouraging convenient transfers, have proved to give clear results in terms of public transport patronage.

Foundations have been settled, but there is still a lot of work to be done. From the point of view of sustainability, existing strategies seem clearly insufficient to cope with major urban challenges, particularly in the field of the environment (air quality and pollutant emission trends in most metropolitan areas seem to challenge existing objectives), and car traffic (although curved in many city centres, continues exploding in the suburbs). New policies should be adopted to promote public transport and non-motorised modes; in which the key elements for action move from infrastructure investment to soft measures and travel demand management schemes; integrating environmental and sustainability objectives, and development prizing policies coherent with this goals.

To sum up, we can say that mobility keeps some distinctive features in the different metropolitan areas. The importance of public transport is more important in the largest cities. However, car ownership rates are similar in all metropolitan areas having no correlation with GDP per capita. The figures in this study show that the public transport systems are more efficient in Madrid or Barcelona. Bus services are the large part of provision of public transport in most metropolitan areas and, only in the biggest metropolitan areas do rail modes account for the major share of supply.

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