ASSESSMENT OF THE EFFECTS OF IMPROVING THE MADRID INNER RING ROAD TO A MORE BALANCED AND SUSTAINABLE METROPOLITAN MOBILITY

Prof. Andres Monzon
Transport Research Centre. Universidad Politecnica de Madrid
Luis A. Vega, researcher
Universidad Pedagogica y Tecnologica de Colombia
and Transport Research Centre. Universidad Politecnica de Madrid
Ana M. Pardeiro, PhD. student
Transport Research Centre. Universidad Politecnica de Madrid

1. SUBURBANISATION PROCESS OF MADRID REGION: MOBILITY AND ECONOMIC EFFECTS

Madrid is one among 17 Autonomous Regions within Spain. It has 8,000 km^2 (1,6% of Spain Area) and 5 million inhabitants (12,7% of Spanish population), therefore it has high density (626 inhab/km2), which favours its high rate of PT patronage (EMTA, 2002). To analyse mobility patterns the region is divided into 4 zones: CBD, city periphery, metropolitan ring and the surrounding rural municipalities. These zones are shown in Figure 1 and their main characteristics in table 1.

Figure 1. Madrid mobility zones

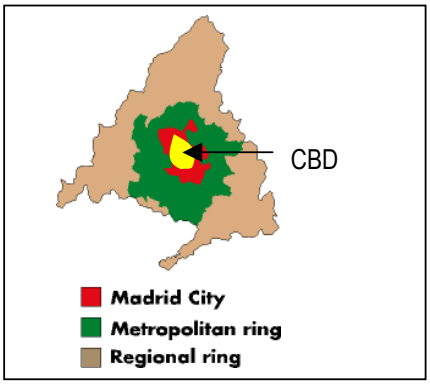


Table 1. General characteristics of Madrid Region, 1996.

		Population		Area Km^2	Density Inhab./Km^2	Household Size
		Inhabitants	(%)			
Madrid City	**CBD**	915,318	18.2%	42.0	21,793.3	2.6
	periphery	1,951,532	38.9%	564.0	3,457.7	3.0
Metropolitan Ring		1,913,804	38.1%	2,280.7	839.1	3.4
Regional Ring		241,635	4.8%	5,141.4	47.1	3.0
TOTAL		**5,022,289**	**100.0%**	**8,028.5**	**625.6**	**3.1**

Mobility patterns in Madrid Region are provided by the General Mobility Survey carried out in 1996 (CRTM, 1998) and some complementary information from PT

operators. Main results are shown in table 2, which highlight the dominance of PT over car trips.

Madrid is moving towards a poli-nuclei Metropolitan Area with the core in the central city, which is counterbalanced by the metropolitan ring. Mobility rates by crowns indicated what serves as dormitory and business/mix areas.

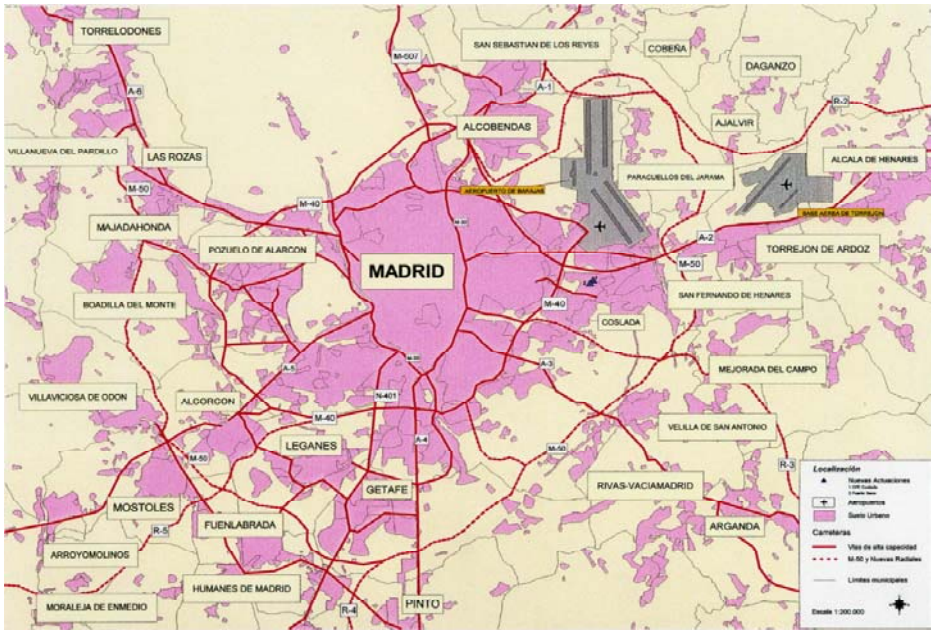


Figure 2. Poli-nuclei development patterns in Madrid Metropolitan Area

Table 2 indicates the dominance of PT means (bus and metro) in Madrid municipality while car is more popular in the exterior rings. Walking is very popular and it is growing while PT is declining in the smaller nuclei. Commuter rail is used homogeneously along the Region, but specially in the metropolitan ring.

Table 2. Daily trips distribution by mode in Madrid Region (%), 1996

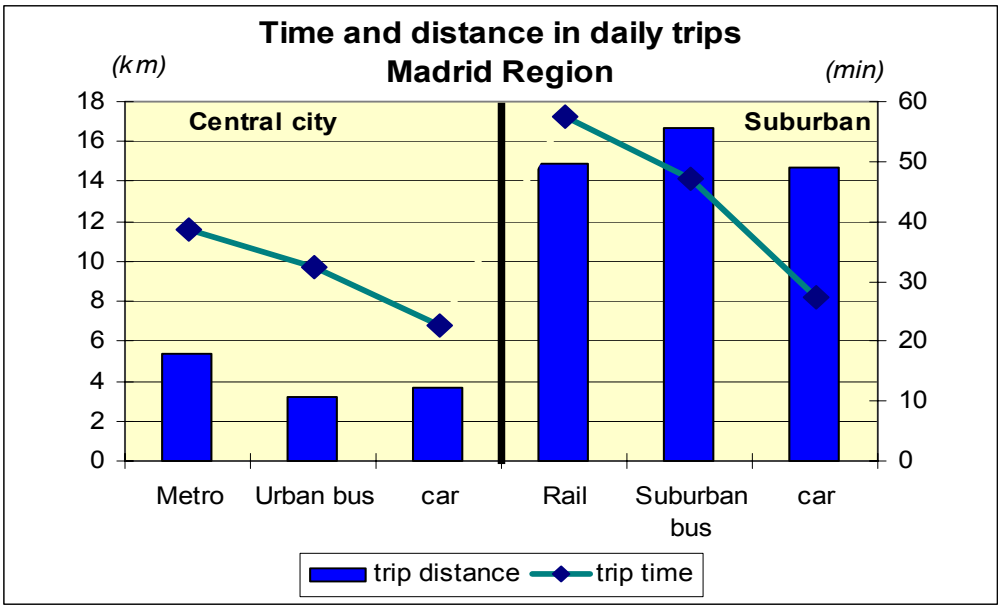
Modes	Madrid municipality		Metropolitan Ring	Rural Ring	Total
	CBD	City periphery			
Walking	25.4	32.6	48.3	46.9	37.3
Car	23.6	27.5	31.5	38.6	28.5
Urban bus	20.3	16.9	0.2	-	10.8
Metro	19.7	12.9	0.3	-	9.3
Suburban bus	4.0	3.7	10.6	6.9	6.5
Suburban rail	5.1	4.5	6.1	2.4	5.1
Others[1]	1.7	2.0	3.1	5.2	2.5
Total	100	100	100	100	100
Generation rate (trips/inhabitant)	**2.69**	**1.87**	**2.04**	**1.70**	**2.08**

[1] Others includes the discretionary buses, bicycles and motorcycles.

The brief analysis done reveals that mobility is not homogeneous in the Region of Madrid. Its complexity is related to many factors such as population densities, land uses, and the supply of the different means of transport. Buses and metro have a good supply in Madrid City; interurban buses and rail have their higher share in the metropolitan ring. All these performance patterns induce very different transport costs, both by trip and by passenger-km, for each mean of transport and for its geographical environment. They also produce different environmental and social effects associated to different trip length between the denser central city (Madrid municipality) and its suburbs.

Figure 3 shows that car trips are competitive with public transport both in central areas and in suburban ones. This is surprising because central area in rather congested and average speed is about 14 km/hour. The consequence is that, although Madrid has a good offer of public transport, car is still an attractive option even in central areas. Following the Zahavi principle (1980), users choose their transport option according to time spent.

Figure 3. Time and distance differences in urban/suburban trips in Madrid Region

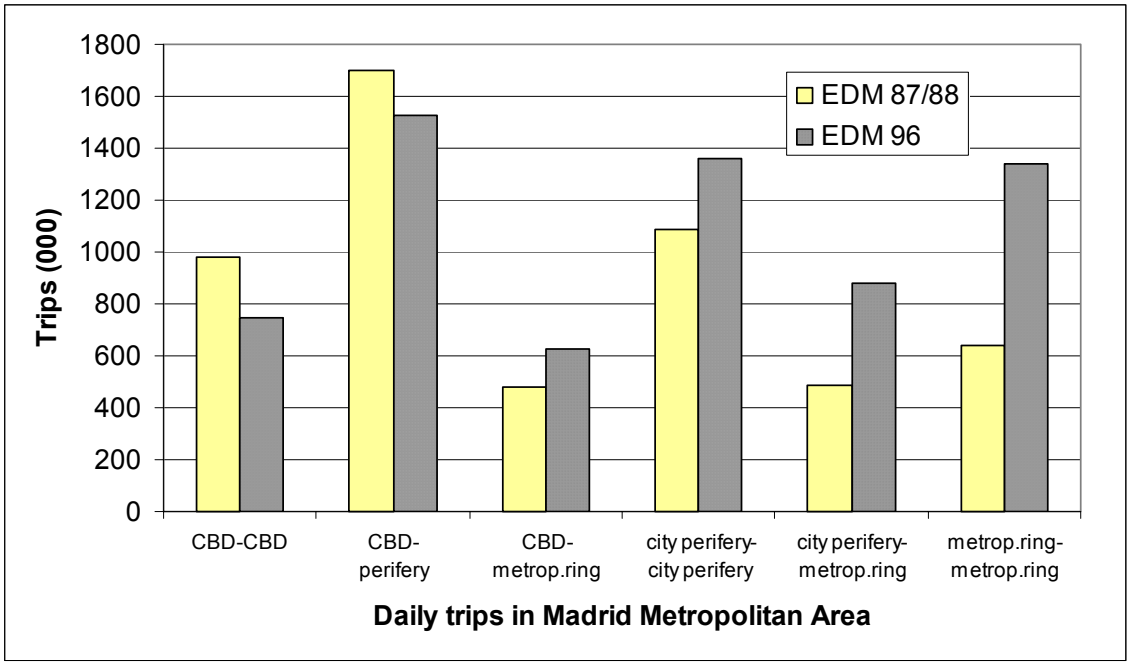


Economic activities of Madrid City have their biggest competitor in the cities in its metropolitan belt. Many companies and commercial activities are moving toward the periphery looking cheaper and bigger space for their business. Therefore, Madrid city is loosing part of its competitiveness due to congestion and other disutility of agglomeration. Figure 4 shows the comparison in mechanized trips between zones in the Madrid Region. It is clear that Madrid CBD and periphery are loosing trips in favour of outer Areas in the Metropolitan Ring.

Cairncross (1997) predicts the *death of distance* of cities like Madrid where new activities location patterns could change their functionality and competitiveness.

The new concept of *meta-town planning* (Hall, 1998; Verroen et al, 2004) indicates a way forward: a collaborative approach among means of transport and development policies to achieve a better mobility patterns and to improve quality of life in residential areas. A systematic approach of this vision is formulated in TRB (2002). Monzon (2005) analyse the relationships among local and arterial roads in the metropolitan planning process.

Figure 4. Evolution in mechanized mobility in Madrid Region



In fact, Madrid city is already experiencing disadvantages against alternative locations in its metropolitan ring. It is necessary to design a comprehensive policy to re-organize mobility to preserve liveable streets in central areas and, at the same time, to attract new business and keep alive old ones: to increase its attractiveness and economic vitality.

2. MADRID CITY MOBILITY STRATEGY

In this regard a number of activities are in place to recover city vitality through a number of initiatives in various sectors, including transport. The main principles to get a better mobility distribution are:

- To reduce car pressure in CBD
- To increase pedestrian and PT trips in CBD
- To foster PT in radial trips travelling in-out CBD
- To alleviate car pressure on local streets by conveying traffic trough orbital rings, mainly M-30 that surrounds CBD

To achieve those goals a number of policy actions has been started:

- Pedestrianisation of historical zones

In 1994 a number of projects oriented to give priority to pedestrians, improve accessibility, to built wider pavements with trees, etc. started. Up to now some 25,000 m2 have already improved in this way and a second wave is underway.

Some of those projects are designed to complete -when finished- several itineraries of pedestrians' priority in the city centre.

- Parking restrictions

An Area wide parking pricing scheme, called SER, has been implemented since 2001. More than 110.000 parking spaces are now under control, which cover most of the Madrid CBD.

- Improve PT patronage

Several cooperative actions are also in process of implementation, oriented to improve PT offer and the seamless mobility targets. Some of the projects are the Metro Extension Plan 2003-07; a new urban railway line of 8.3 km long to connect the north and south rail stations with connection with 4 metro stations; 5 new intermodal interchanges; 22 km of separated bus lanes, etc.

- Re-design of the M-30 inner orbital motorway

To attract car traffic out of CBD, the M-30 motorway is going to be totally reconstructed. The main goal is to get common standards and service lanes to improve level of service and to reduce accidents. The number of lanes would be about the same, but the more homogeneous design and better integration with urban arteries is intended to provide a bit more real capacity and less congestion. Three tunnels will also be built to avoid traffic nuisances and environmental quality in some stretches: the river banks, and the parks of Arganzuela and North.

3. CHOSING THE RATIONALE OPTION: A PARADOX?

The first three actions are "traditional" ones in any transport policy package designed to foster PT patronage and improve walking and cycling. However, the forth one is quite controversial: to improve an urban motorway seems to be an action in the opposite direction. Many planners and media have protested for such project that eventually will attract more cars towards the city centre and will, in principle, produce bigger environmental impacts.

Some project opponents proposed to convert the whole M-30 motorway in a new multi-lane avenue with traffic lights and moderate urban speed, well integrated in the areas where it pass through. Of course, its capacity would be much lower and then car would be less attracted to central districts in Madrid. This could be a risk for the CBD, but on the other hand, city centre would improve its environmental

and liveable conditions and, therefore, would attract clean activities and more services.

The rationale approach is to model the impacts of the three possible alternatives: to do-nothing; to replace the existing motorway by a boulevard; or to re-built the M-30, reducing its pressure on the urban grid and improving its safety conditions (the proposed project).

The Figure 5 shows the conditions of the present motorway that produces a big pressure on city conditions in central areas, particularly in the SW part where its alignment is closer to city centre (Puerta del Sol).

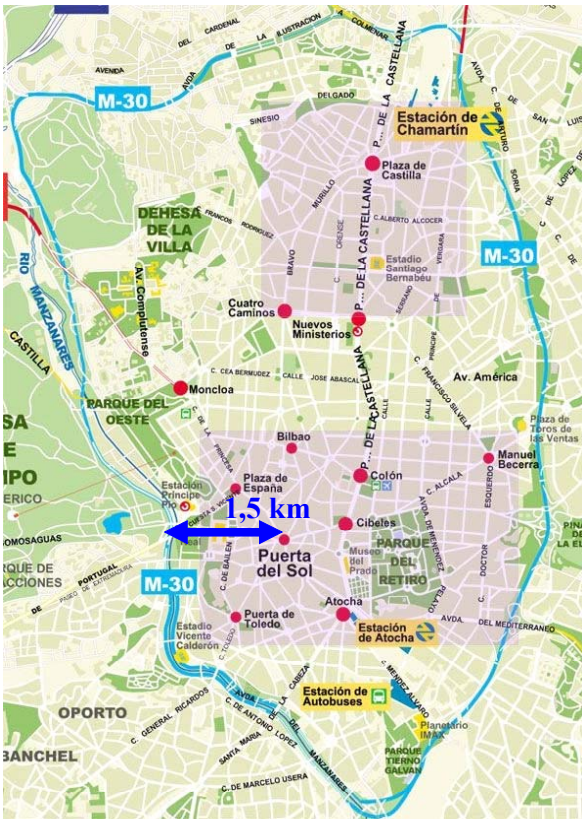


Figure 5. Existing M-30 motorway alignment

We have developed a model to test the medium term impacts of the alternative options and to compare the proposed actions: impacts of the boulevard or the re-building project decided by the City Council, in relation with the do-nothing scenario.

The results show which could be the different impacts of the two alternative options modelled against the “do-nothing” one. Two different time horizons has been tested: just after finishing the works (2007) and the medium term evolution (2012). Although absolute figures are different, the tendency and location of effects are about the same. Results are the following.

Table 3: Rebuilding option- average daily impacts in traffic and time

Rebuilding M-30 Project - do-noting					
2007	Traffic flow variation (veh-km)	Trip time variation (veh.-hour)	**2012**	Traffic flow variation (veh-km)	Trip time variation (veh.-hour)
CBD	-91,581	-6,057	CBD	-118,843	-8,699
M-30	909,465	2,559	M-30	1.053,843	1,478
City periphery	-129,065	-4,228	City periphery	-154,861	-5,492
M-40	-577,650	-9,884	M-40	-613,402	-11,716
Metropolitan ring	-292,912	-1,000	Metropolitan ring	-303,871	-3,364

Table 4: Boulevard option- average daily impacts in traffic and time

Boulevard – do-nothing					
2007	Traffic flow variation (veh-km)	Trip time variation (veh.-hour)	**2012**	Traffic flow variation (veh-km)	Trip time variation (veh.-hour)
CBD	333,616	17,455	CBD	366,402	22,743
M-30	-2,677,054	6,606	M-30	-2,809,276	9,888
City periphery	145,170	3,038	City periphery	238,336	6,001
M-40	1,500,813	28,318	M-40	1,510,646	33,372
Metropolitan ring	864,019	10,568	Metropolitan ring	1,037,409	14,944

The expected impacts of the two alternative options are quite opposite. The proposed project to rebuilt M-30 will reduce car pressure on the urban streets, both in the CBD and in the city periphery. On the contrary, it will attract a lot more car along the renovated M-30. The outer ring –M-40– will reduce its traffic load. In summary the M-30 will concentrate a lot of trips that nowadays are trying to get their shortest itinerary both crossing the city or surrounding it by the exterior. The change in the behaviour of the first group will reduce car pressure on CBD and its environmental impacts. The present M-40 users that will move to M-30, will produce less CO_2 and pollutant emissions, but in more central areas, which means also less dispersion effect.

The other option was to convert M-30 ring in a wide boulevard with intersections and traffic lights. According to the model results (see Table 4) this possibility would put away from the city of Madrid a lot of traffic, mainly using the outer ring road M-40, but, at the same time, the extra length of this option would send more traffic again to CBD and other streets in the city. Then, the number of cars in Madrid municipality would be less in absolute numbers, but they would use more normal streets in the city centre with the corresponding negative consequences, both for their liveable standards and the environmental effects.

Therefore, we could conclude that the new project will produce better quality standards and environmental effects in the streets, due to the concentration of heavy traffic in only one artery: the M-30.

4. ECONOMIC ASSESMENT

The project passed by the Municipality to re-built the M-30 motorway is rather expensive: it comprises 3 urban tunnels, a new design of 20 complicated intersections and their continuity in the urban local networks, and service lanes to reduce exit and entries. All together it sums up to some 4,000 M€. The key question is if such a big investment is economically and socially justified.

We carried out a CBA to answer that question, including the consideration of several externalities that could be measured with the available data following several valuation methodologies used at European level ECMT, 2001; EVA, 1991; Guerrero and Monzón, 2003; Powell, 2001; Maibach, 2000 ; Schreyer, 2004). The effects whose costs have been considered into the monetary evaluation process (Monzon et al, 2005) are: travel time, vehicle operation, climate change, noise, and severance. Other effects has been evaluated in a qualitative way: pollutants emissions, improvement of accessibility to PT and new green areas.

The assessment study was developed after a number of assumptions on new developments in Madrid Metropolitan Area and their expected induced traffic in the long term horizon. The evaluation period was from 2007 (year when the work is expected to be finished) and the 2037, therefore the economic life of the project is of 30 years.

The overall results validate the project. The following table includes the summary of results for each cost category.

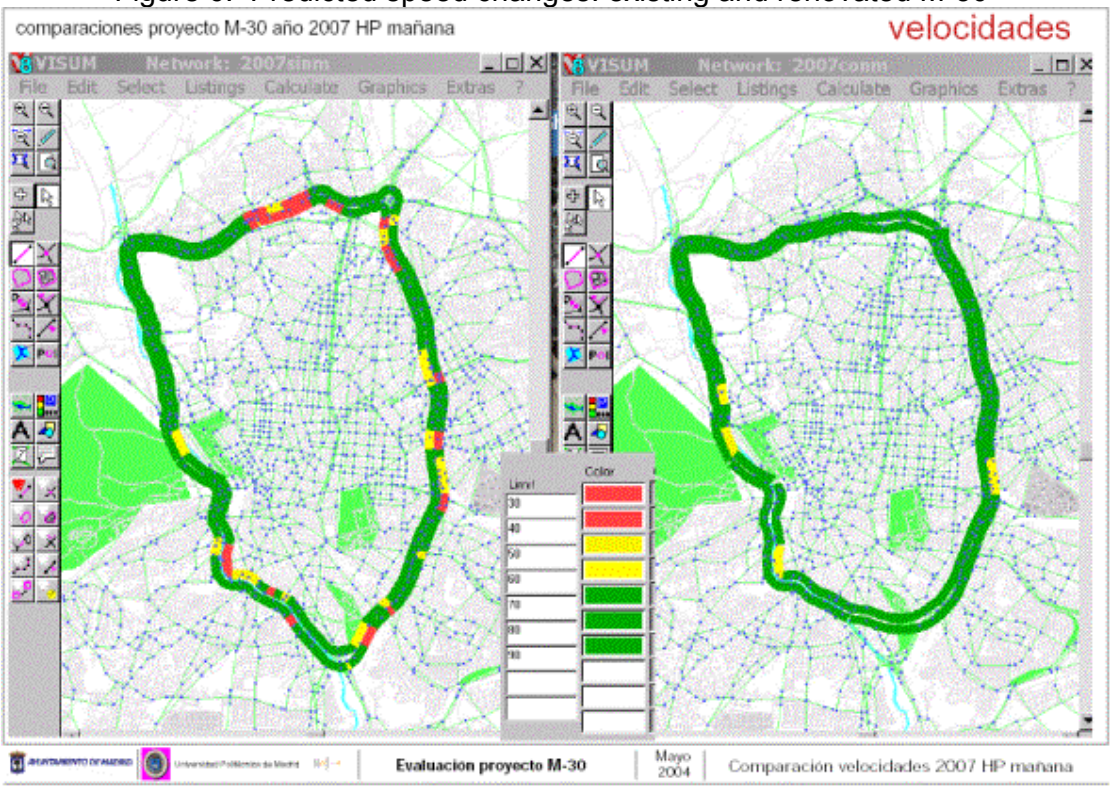
Table 5. Economic Assessment of M-30 renovation project (values year 2004)

Effects	**NPV benefits (M€)**	**NPV costs (M€)**
Project costs (without taxes)		3,663
Travel time savings	3,915	
Accident reductions	770	
Operating costs	117	
Noise reduction (tunnels)	197	
Severance	259	
Climate change (CO_2 emissions)	152	
NET PRESENT VALUE (2004)	**1,748**	
INTERNAL RATE OF RETURN	**5.24%**	

These figures give two clear messages: although the budget of the project is big, it is profitable considering the main socio-economic effects of the infrastructure.

Secondly, we could say that time savings is the main positive effect (72% of benefits), which could by itself justify the investment project. This is surprising because the new lay out of the motorway does not change very much its capacity (number of lanes) from the existing one. The benefits come from the more homogeneous alignment with less black spots, and the better nodes design. Figure 6 shows some results for year 2007, where it can be checked that most of the congested stretches disappear.

Figure 6. Predicted speed changes: existing and renovated M-30



It is also noticeable that the improvement of this “urban” motorway will reduce some environmental effects and, above all, the number of accidents. This is also a paradox because although more traffic will be attracted to central areas the global nuisances are less important. The explanation is related to the results shown in the previous section and the effects of the 3 tunnels, that will avoid noise and direct pollutant emissions in some densely populated central areas.

5. CONCLUSIONS

As result of the modelling exercise and the evaluation process, we could forecast that improvement of the M-30 inner orbital is consistent with other sustainable transport policies in the Madrid municipality. The concentration of traffic flow in this road could alleviate traffic pressure in the streets and reduce environmental effects.

The project will also allow to increase the competitiveness between Madrid City and its counterpart cities in the metropolitan belt, which are growing very fast and providing good facilities for new developments of housing, commercial centres, and offices.

6. REFERENCES

Cairncross, F. (1997) The Death of Distance: How the Communications Revolution will Change our Lives. London: Orion.

ECMT (2001). Assessing the Benefits of Transport. European Conference of Ministers of Transport, OECD, Paris.

CRTM (1998). *Encuesta Domiciliaria de Movilidad en Día Laborable de 1996 en la Comunidad de Madrid*. *Análisis y síntesis de la movilidad*, Consorcio Regional de Transportes de Madrid.

EMTA (2002). *Eurobarometer*, European Metropolitan Transport Authorities, Paris.

EVA Manual (1991). Evaluation Process for Road Transport Informatics. UE, DG XIII. Technische Universitaet Muenchen, Munich

Guerrero, M.J. and Monzón, A. (2003). Cuenta Económica y Socioambiental del Transporte Terrestre de Viajeros en la CAM, en 1996. CTM, Madrid..

Hall, P. (1998) Cities in Civilization: Culture, Technology and Urban Order. London: Weidenfeld and Nicolson.

Maibach, M. et al. (2000). External Cost of Transport: Accident, Environmental and Congestion Costs in Western Europe. INFRAS-IWW. UIC, France.

Monzón, A. (2005). Integración de Redes Locales con las Redes de Gran Capacidad. XVIII VYODEAL. AEC, Madrid.

Monzón, A., Pardillo, J.M., Vega, L., Bustinduy, J., Vicente, A., Pérez, M. (2005). El programa de mejoras de la M-30 en el contexto de una estrategia de movilidad sostenible para Madrid. Revista de Obras Públicas. CICCP, Madrid.

Powell, T. (2001). The principles of Transport Economics. PTRC, London.

Schreyer, C. (2004). External Cost of Transport. Update study. INFRAS-IWW. UIC, Zurich/Karlsruhe.

Transportation Research Board (2002). A Guide to Best Practices for Achieving Context Sensitive Solutions. NCHRP report 480. Washington DC.

Verroen, E., Le Clercq, F. and Stoelhorst, H. (2004). *Route 26, a pilot application of a new approach for interactive decision-making in Transport Planning.* WCTR 2004 (10th WCTR) Istambul (Turkey).

Zahavi, Y. & Talvitie, A. (1980). Regularities in Travel Time and Money Expenditure, 750, 13-19.