CHOSING RATIONALE: THE PARADOX OF ACHIEVING ECONOMIC AND ENVIRONMENTAL BENEFITS BY IMPROVING AN URBAN MOTORWAY

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ABSTRACT

Madrid started the renovation of its inner ring road (M-30) to alleviate car pressure on local streets by conveying traffic trough this orbital that surrounds CBD. The project will improve ring capacity and connections with the neighbourhoods. Some sections will be tunnels to avoid pollution and noise.

The project costs 4 billion€ and has big impacts on traffic. Therefore, some proposed to build a boulevard instead of improving the motorway. A new assessment methodology was applied to evaluate the two options; it includes CBA, environmental&social assessment. It shows that the project will produce positive impacts: investment costs are counterbalanced by time savings, reduction of accidents and other benefits. The rebuilt M-30 will reduce car pressure on urban streets, both in the CBD and in the city periphery. On the contrary, it will attract more cars along the M-30. The environmental assessment is also globally positive, although pollution problems will be more concentrated in the M-30 area.

The results indicate that the project should be managed in coordination with other sustainable urban transport strategies: parking control, public transport facilities, pedestrianisation, etc. By implementing this policy package, the expected results mean more balanced traffic patterns with less pressure on CBD.

1. MOBILITY PATTERNS AND ENVIRONMENTAL PROBLEMS

The Madrid Region, with its 5.4 million inhabitants, is moving towards a polinuclei Metropolitan Area (figure 1) where the denser core is offset by a metropolitan ring. Mobility rates by crowns indicate that this serves as dormitory and business/mix areas. However, its high population density and the quality of the public transport provided place Madrid at the top of Public Transport patronage within Europe [1].

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. It is clear that Madrid CBD and periphery are loosing trips in favour of outer Areas in the Metropolitan Ring.

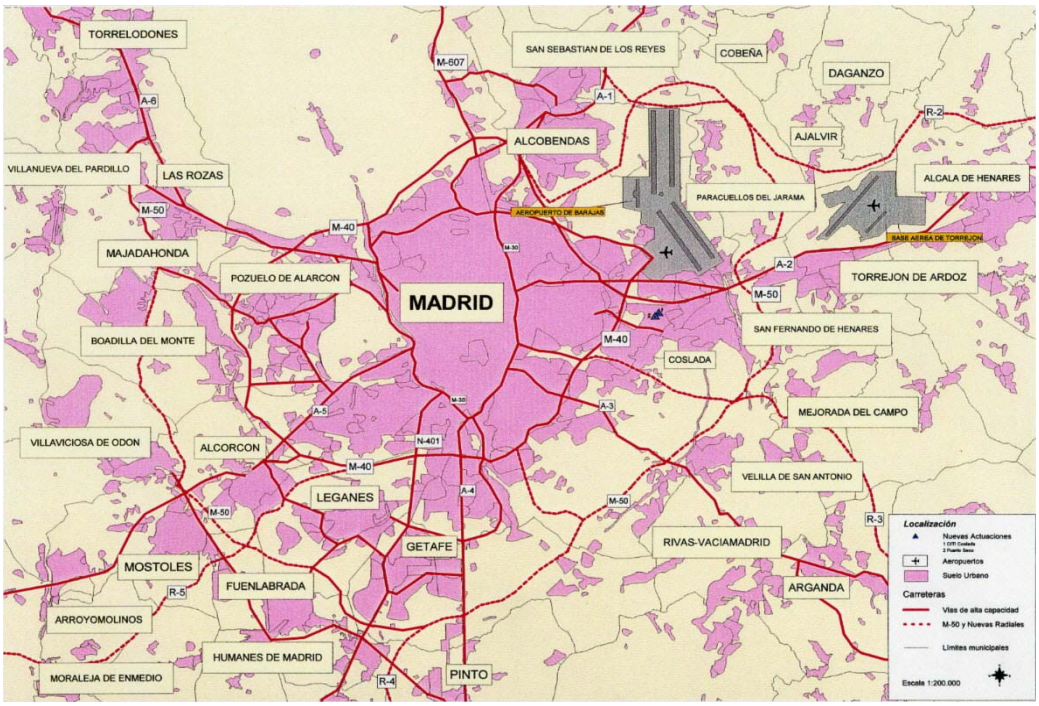

Figure 1. Poli-nuclei development patterns in Madrid Metropolitan Area

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. Figure 2 shows how Madrid City is loosing population in favour of its metropolitan ring.

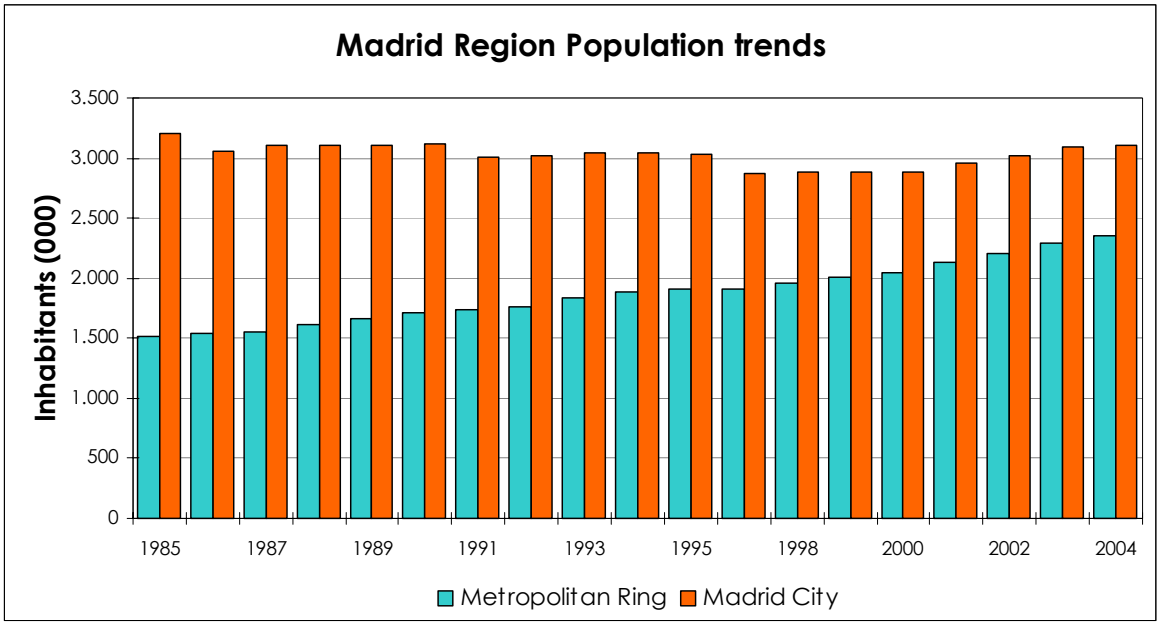

Figure 2. Population Trends in Madrid Metropolitan Area

Sustainable development however has to cope with three aspects, namely economic, environmental and mobility-related [2]. This whole process is producing substantial environmental problems. Longer trips and greater car dependency are steadily increasing the emission of pollutants and global warming gases [3].

Table 1. Annual Traffic-related Emissions

	NO_x (t)	**PM_{10} (t)**	**CO_2 (kt)**	**COVNM (t)**
Year 2002	22,585	1,591	4,268	18,908

Table 2. Contribution of Traffic to Total Emissions in Madrid

	NO_x	**PM_{10}**	**CO_2**	**COVNM**
% of total	77.03%	74.79%	51.15%	33.60%

Tables 1 and 2 show the level of emissions in Madrid City in 2002 caused by traffic. These values are too high and Madrid City Council has launched an Environmental Strategy to reduce emissions over the 2006-2010 period [4]. It includes a reduction of NO_x emissions by as much as 16,500 tons, implying 27% less than current values. There is no specific target for PM_{10} emissions but there are many measures designed to reduce the emission of these particles in line with European legislation. Spain has to reduce its CO_2 emissions by 14,500 tons in the near future. Madrid has taken on board the challenge of reducing a quantity equivalent to 4.8% of Spain's total emissions. The Environmental Strategy includes several measures to reduce traffic rates, comprising one of the key problems, particularly in the CBD.

2. A NEW STRATEGY

A number of activities are in place to recover city vitality and environmental quality through a series of initiatives in various sectors, including transport. The main principles for achieving a better mobility distribution are to reduce car pressure and increase pedestrian and PT trips in the CBD, to foster PT in radial trips travelling in and out of the CBD and to alleviate car pressure on local streets by conveying traffic through the orbital road surrounding the CBD.

To achieve these goals a number of policy actions have been started:

- Pedestrianisation of historical zones: pedestrian priority, improved accessibility, greener streets and squares, etc.
- Parking restrictions: a parking pricing scheme, called SER, has been implemented in a wide area since 2001. More than 110,000 parking spaces are now under control, covering most of the Madrid CBD.
- Improving PT provision and the seamless mobility targets: reserved bus lanes, extensions to the metro network, intermodal interchanges; etc.
- Redesign of the M-30 inner orbital motorway: this road is undergoing total redesign to attract car traffic out of the CBD. The main goal is to improve the level of service and to reduce accidents. The number of lanes will remain approximately the same, but the more uniform design and better integration

with urban arteries is intended to reduce congestion. Three tunnels will also be built to avoid traffic nuisance and to improve environmental quality in some stretches such as the river banks and two parks. Its estimated cost is over 4 billion €.

The first three actions are "traditional" ones in any transport policy package designed to foster PT patronage and improve walking and cycling [5,6]. The fourth one however is quite controversial. The concept of improving an urban motorway seems to be an action going in the opposite direction. Many planners and media have protested over this scheme that will eventually 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).

3. MOBILITY IMPACTS

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.

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

Rebuilding M-30 Project - do-noting					
2007	Traffic flow variation	Trip time variation	**2012**	Traffic flow variation	Trip time variation
	(veh-km)	(veh.-hour)		(veh-km)	(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

The results show which could be the different impacts of the two alternative options modelled against the "do-nothing" one. Two different time horizons have 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 4: Boulevard option- average daily impacts in traffic and time

Boulevard – do-nothing					
2007	Traffic flow variation	Trip time variation	**2012**	Traffic flow variation	Trip time variation
	(veh-km)	(veh.-hour)		(veh-km)	(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 and 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 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.

4. ENVIRONMENTAL EFFECTS

The results of the assignment model feed the emissions model based in COPERT [7]. The calculations take into account the road type, the distance and the vehicle type. Overall, emissions will be reduced as illustrated in figure 3. Higher CO_2 and NOx emissions will however appear in the M-30 orbital, but far less important than the reductions in other zones. Emissions inside the tunnels will be filtered and treated to eliminate PM and other pollutants.

Driving conditions in the CBD will be better, even in the areas surrounding the M-30, owing to less congestion. This implies lower pollutant emissions [8,9]. Current M-40 users moving to the M-30 will produce less CO_2 and pollutant emissions, but in more central areas, also meaning less dispersion effect.

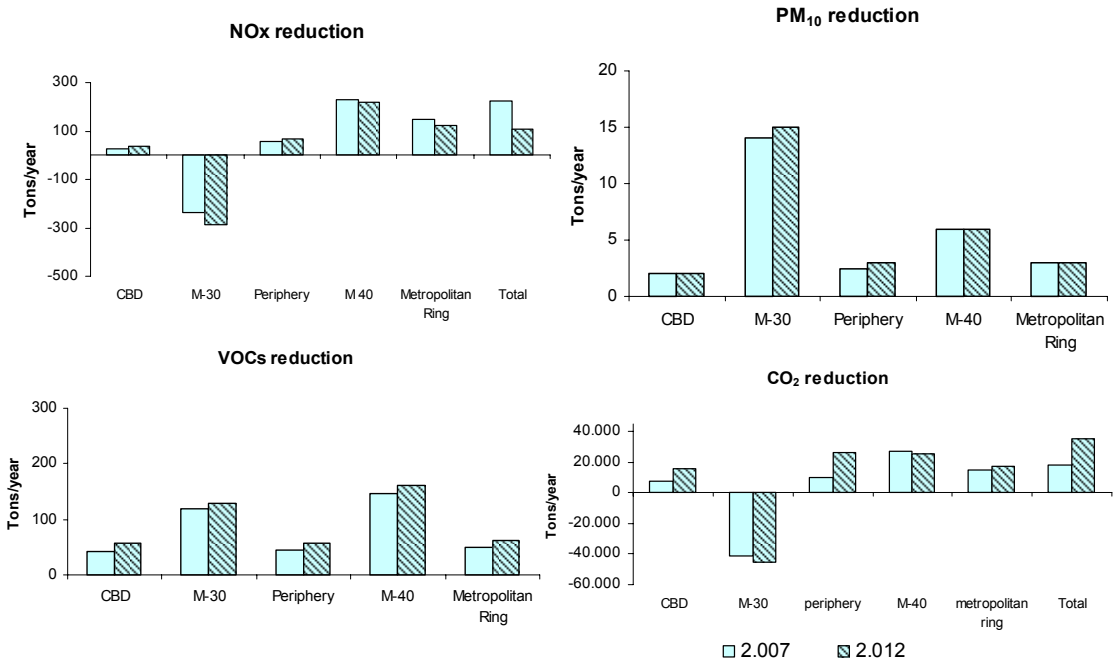

Figure 3. Reduction of emissions associated with the Madrid strategy

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.

A further noticeable advantage of improving this “urban” motorway will be a reduction of certain environmental impacts and, above all, in the number of accidents. This is also paradoxical as although more traffic will be attracted to central areas, the overall nuisance will be less significant. The explanation is related to the results shown in the previous section and the effects of the three tunnels that will avoid noise and direct pollutant emissions in some densely populated central districts.

Pollutant emissions are mainly due to traffic in the city. The characteristics of the construction lower the impacts on the environment and the number of traffic accidents. The new M-30 route will be more uniform and this will alleviate congestion. Additionally, almost 8 km of tunnels among the total 32.6 km will reduce environmental problems precisely where the population exposed is greatest.

We could therefore conclude that the new scheme will produce better quality standards and environmental impact in the streets as a result of the concentration of heavy traffic on only one artery - the M-30.

5. ECONOMIC ASSESMENT

The project passed by the Municipality to re-build 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 [2,10,11,12,13]. The effects whose costs have been considered into the monetary evaluation process [14] are: travel time, vehicle operation, climate change, noise, and severance. Other effects have 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 (star operation) 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. Costs are accounted without taxes.

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 fewer black spots, and the better nodes design. Figure 4 shows some results for year 2007, where it can be checked that most of the congested stretches disappear.

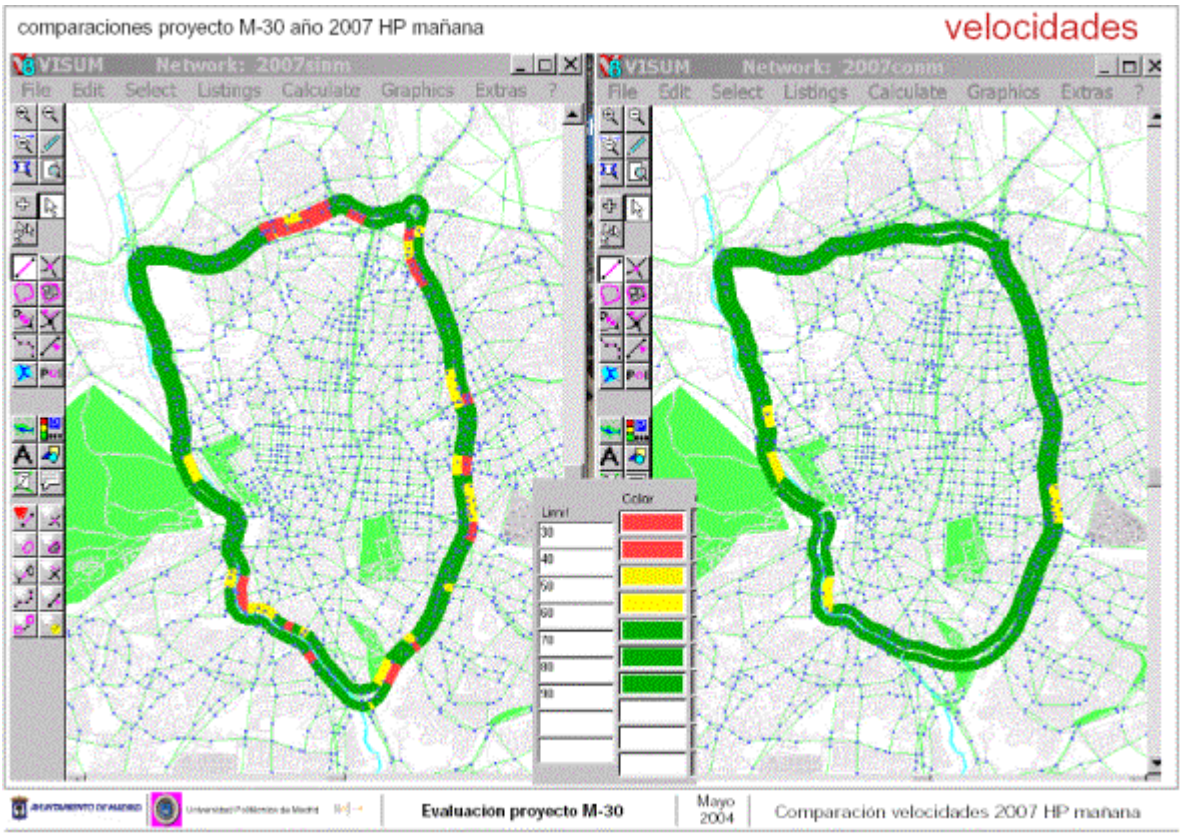

Figure 4. Predicted speed changes: existing and renovated M-30

6. CONCLUSIONS

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

The environmental benefits are important as the scheme will reduce CO_2 and pollutant emissions throughout the metropolitan area by concentrating them on the M-30, but with a clearly positive overall balance.

Madrid will also be recuperating economic vitality with mixed developments of housing and commercial areas that benefit from the better quality of the central districts.

The key elements of the positive strategy are the combination of push and pull measures in the design of complementary policy measures to control traffic in Madrid. The three central points of the strategy are reducing traffic in the CBD, attracting more passengers to PT and improving traffic conditions in the M-30 urban orbital as an alternative to crossing the city and avoiding longer trips in the periphery.

The M-30 urban orbital will have more capacity as a result of the lower traffic congestion. In addition, traffic will be reduced in the CBD because the M-30 takes it up. In both cases, the M-30 and the CBD, traffic conditions will improve and the emission of pollutants drop off.

Further actions are envisaged, such as reducing the average driving speed along the M-30 to obtain further reduction of emissions and accidents.

7. REFERENCES

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