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WIN-WIN TRANSPORT STRATEGIES: SEARCHING FOR SINERGIES

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RESUMEN

The need of an urban transport strategy on urban areas which solves the environmental problems derived from traffic without decreasing the trip attraction of these urban areas is taken for granted. Besides there is also a clear consensus among researchers and institutions in the need for integrated transport strategies (May et al., 2006; Zhang et al., 2006). But there is still a lack of knowledge on the policy measures to be implemented.

This research aims to deepen in the understanding of how do different measures interact when implemented together: synergies and complementarities between them.

The methodological approach to achieve this objective has been the double analysis – quantitative and comprehensive – of the different impacts produced, first of all by each of the measures by itself, and later on combining these measures.

For this analysis, we have first defined the objectives to achieve within the transport strategy – emissions and noise decrease without losing trip attraction - , and then selecting the measures to test the effects these objectives generate. This selection has been based on a literature review, searching for measures with have proven to be successful in achieving at least one of the objectives.

The different policies and policy combinations have been tested in a multimodal transport model, considering the city of Madrid as case study.

The final aim of the research is to find a transport strategy which produces positive impact in all the objectives established, this is a win-win strategy.

1. THE COMPLEX CONCEPT OF URBAN SUSTAINABLE TRANSPORT. A NEED FOR SINERGIES

European cities are essential in the development of Europe, as they constitute the living environment of more than 60% of the population in the European Union and are drivers of the European economy – just less than 85% of the EU's gross domestic product is produced in urban areas (EC, 2007a).

The car has been one of the main factors of development during the 20th century, but it is at the same time the origin of the main problems cities have to face: traffic increase. This has resulted in chronic congestion (Monzón and Guerrero, 2004), producing a loss of 1% of the EU's GDP, with many adverse consequences such as air pollution - urban traffic is responsible for 40% of CO2 emissions and 70% of emissions of other pollutants- and noise -about 40% of the population is exposed to road traffic noise exceeding 55 dB. (WHO, 2000; EC, 2007a).

Moreover, during the last few decades, cities have experienced a process of urban sprawl, evolving from the traditional compact model to more disperse urban areas. This new metropolitan model has produced an increase in motorized trips, and a higher dependency on the car (Gutiérrez and García-Palomares, 2007; Monzón and de la Hoz, 2009). As a result, car use has increased, and, consequently, all their associated problems: congestion, emissions and noise among others.

In response to this urban sprawl, the concept of Smart Growth was introduced as a reaction to the undesirable features of continuing growth through "urban sprawl" (Burchell et al., 2000; Downs, 2001; Burchell et al., 2002). Among these theories, it is worth noting the recovery of the Compact City (Schwanen et al., 2004), which promotes an urban model with high densities, land use mix, public transport promotion, concentration of urban development around major transport nodes, regeneration and revitalization of urban centers and growth restrictions in the peripheral areas.

Sustainable urban transport has concerned city officials, institutions and researchers since the 1980's. Among all the different communications and initiatives launched by the EC, we can highlight the Thematic Strategy on the Urban Environment, adopted in 2006 (EC, 2005), which strongly recommends the development and implementation of Sustainable Urban Transport Plans (SUTP) for cities above 100,000 inhabitants.

However, despite all the concerns and efforts aimed at achieving sustainable urban mobility patterns, and the reliance on Sustainable Urban Transport Plans, the complexity of city and transport dynamics makes it difficult to find a practical solution. Some authors have even claimed it is impossible to find an effective sustainable mobility (Banister, 2008). In practice sustainable mobility remains an entelechy. There is no single reason for this disparity between theory and practice but a mixture of political will, absence of public awareness, coordination, and lack of knowledge. There is a clear consensus among researchers and institutions in the need for integrated transport strategies (May et al., 2006; Zhang et al., 2006), but there is still a lack of knowledge on the policy measures to be implemented, as well as regarding compatibility and complementarity among them (Rupprecht Consult, 2005). And is in this lack of knowledge regarding synergies between measures where this research aims to contribute.

2. OBJECTIVES AND METHODOLOGY

2.1 OBJECTIVES

As previously said, the aim of this research is to contribute to gain knowledge in the possible synergies and complementarities among measures aiming to solve the problem of urban transport.

Despite the urban sprawl experienced in recent decades, European cities, especially city centers, still retain the main characteristics of a compact city, acting as important attractors and generator poles. Moreover, this fact is at the same time positive, with high densities helping public transport competitiveness, and negative, as car use increase has worsened congestion, emissions and noise, thus deteriorating urban conditions.

The EC states we must return to the dense city (EC, 2007a), but clean and competitive, and this implies reducing car use yet providing quality transport alternatives sufficient to recover and maintain the competitiveness of cities.

Consequently, European cities need an urban transport strategy which helps reducing their environmental problems –mainly emissions and noise – but without decreasing their trip attraction. This issue is very important because a loss of trip attraction would result in an increase of people moving to more disperse areas, contributing to worsen the current situation.

Therefore, the objective is to analyze possible synergies and complementarities between several measures aiming to reduce environmental problems in cities but without decreasing trip attraction.

2.2 METHODOLOGY

To achieve the objective defined in section 2.1, the steps followed have been:

- first of all, analyzing a selection of the measures to consider;
- second, selecting a case study to simulate and analyze the different measures;
- third, developing a tool to simulate the different measures;
- fourth, defining the range of scenarios to be analyzed;

- and fifth, defining a set of indicators to measure the goals to achieve.

Selection of measures

As already stated in section 2.1, this research is focused on compact urban areas, where the main problem from the transport perspective is urban congestion.

Among these measures, urban road pricing policy has been proposed as one of the most effective policies to curb down traffic congestion in the metropolitan areas (Ministry of Transport, 1964). But by their own, pricing policies are strongly rejected by people (Schade and Schlag, 2003), particularly when an existing infrastructure has been used for free for long time and a regulation is approved to pay for it (Palma et al., 2006).

The recent urban toll experiences of London and Stockholm have proved that, when public transport is improved at the same time as the new toll is implemented, rejection tends to decrease, since people perceive a direct benefit for it , not just an extra toll (Armelius and Hultkrantz, 2006).

From the plurality of measures aiming to improve public transport, we have chosen dedicated bus lanes due to two main reasons; the first one based on the fact that the EC (EC, 2007b) defines reserved corridors as the best solutions to ensure not only speed but regularity, which are crucial for public transport competitiveness. And the second one based on Banister and Marshall’s (2000) defense that measures to encourage modal shift, such as pricing, must be combined with strategies to make the best use of the “released space”.

Both cordon pricing schemes – London and Stockholm – have proved to produce positive impacts in terms of traffic and emissions reduction, but there is no evidence on noise decrease, which is one of the goals to achieve within the transport strategy sought.

The SMILE project (2010) – Guidelines for road traffic noise abatement - concludes that traffic calming is one of the most efficient measures for reducing traffic noise. And the EC (2007b) states that reserved corridors for buses support and are supported by traffic calming schemes, but does not give any evidence for this assertion.

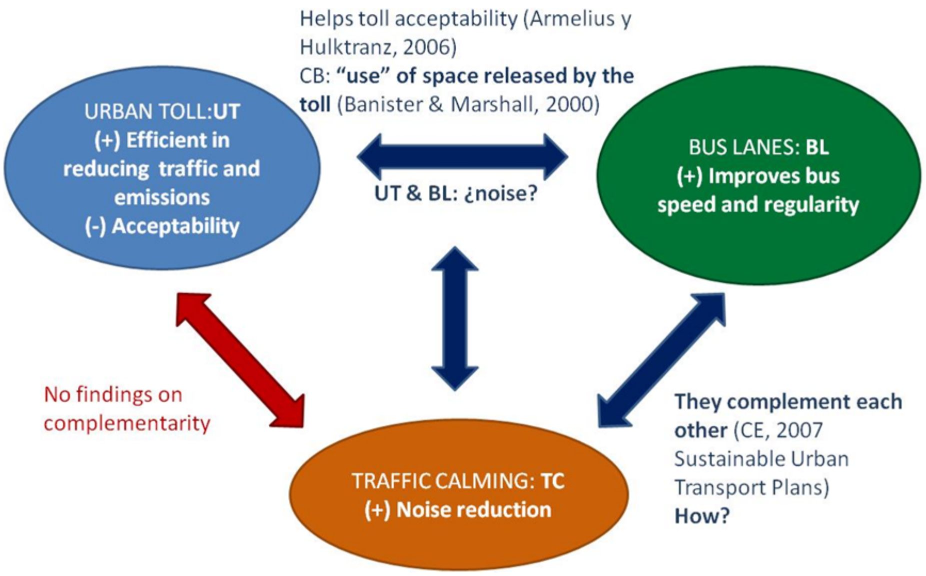

Figure 1 – Links between measures

These three measures – urban toll, dedicated bus lanes and traffic calming - seem to address the three goals to achieve: emissions reduction and noise decrease with no loss of trip attraction.

Positive effects of combining these measures have been proven when applying road pricing and public transport simultaneously, but not conclusive improvements have been observed with traffic calming.

The case study

The case study considered in this research is the Central Area of the city of Madrid. This Central Area is delimited by the M-30 inner ring road surrounding the city.

This area, of more than 61 km2, contains all the main characteristics of the "compact city":

- It locates more than 1.000.000 inhabitants and 35% of the jobs of the metropolitan area.
- It is the origin and/or destination for 43% of the mechanized trips done daily within the Metropolitan Area of Madrid.
- It has a high share of public transit - 60% to 75%. -, due partly to the high competitiveness of public transport in terms of travel time: public transit travel time is below 50% higher than car's.

The transport model

The three measures selected have been tested in a multimodal transport model developed in VISUM. This model includes all the metropolitan area of Madrid, though the analysis has focused on the Central Area of the city.

Figures 2 to 4 represent the road and public transit network characterized in the model.

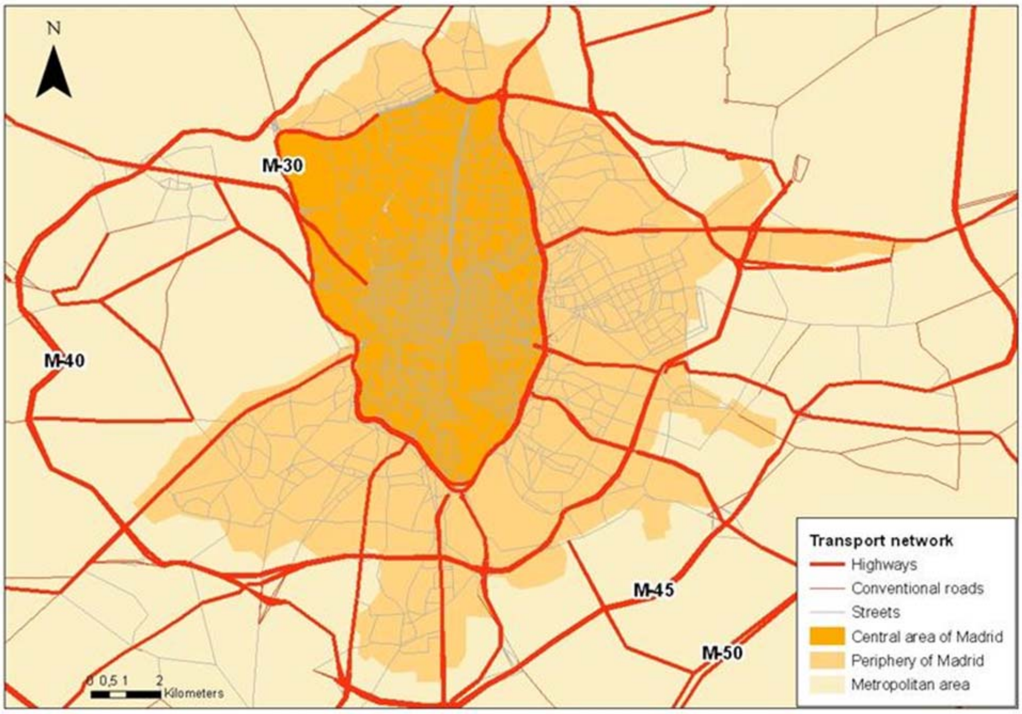

Figure 2 – Road network

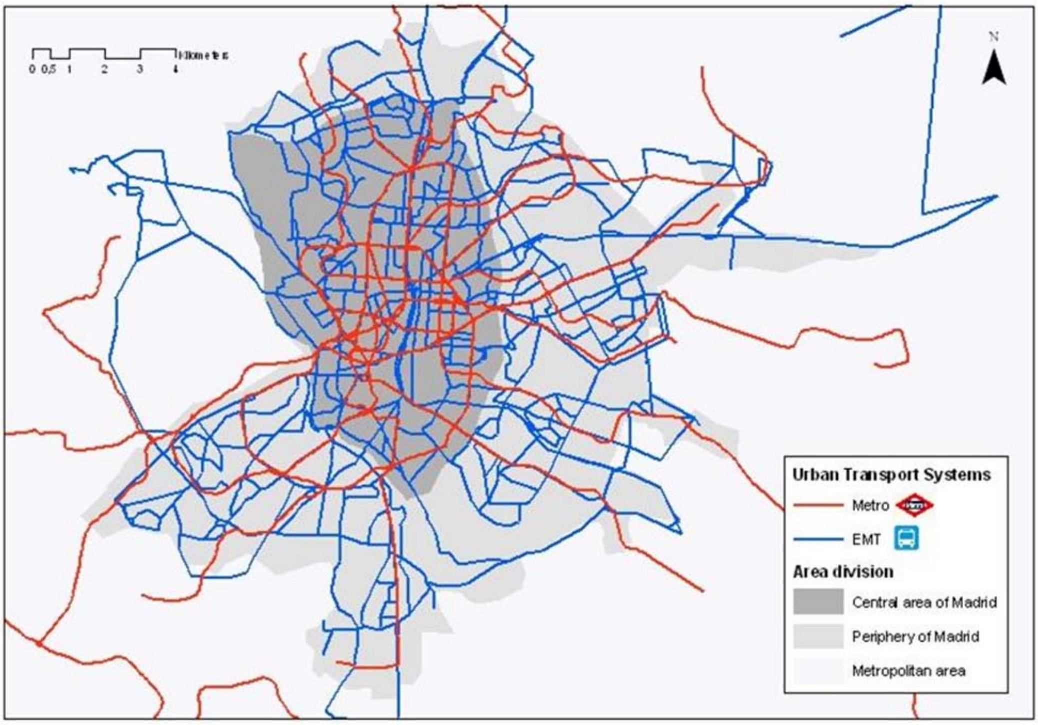

Figure 3 – Urban public transit network

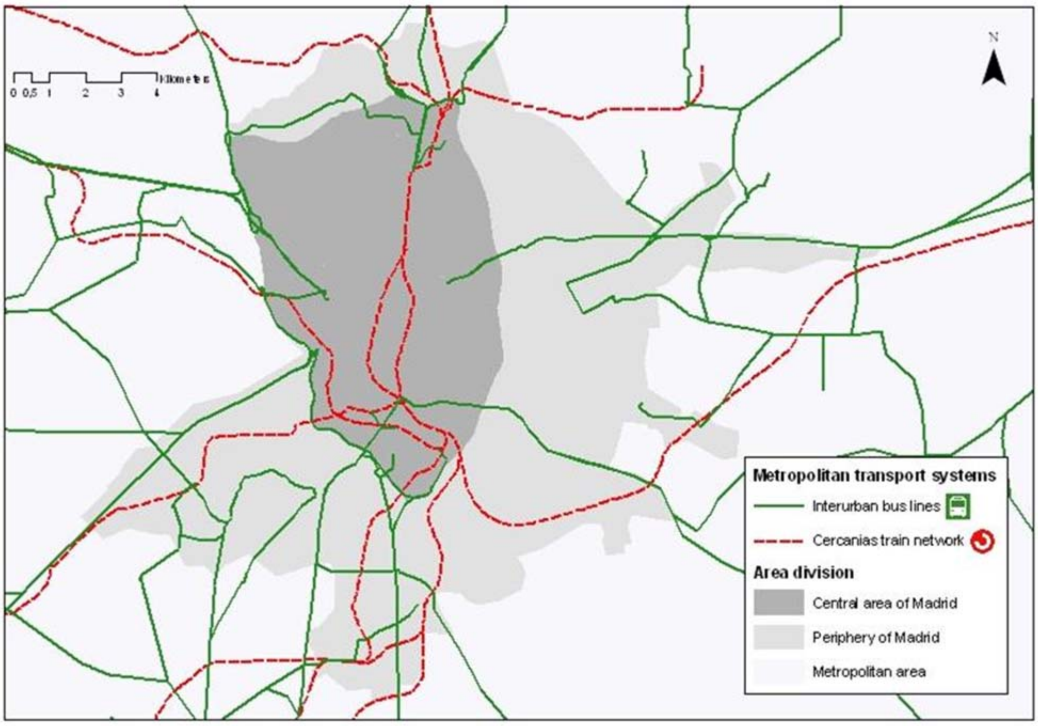

Figure 4 – Metropolitan public transit network

The urban toll defined is a toll ring, where vehicles have to pay for entering the tolled area. This toll has been implemented as an extra cost in all links entering the tolled area.

Efficiency of dedicated bus lanes increases with the number of bus services running in each road section (Sanz, 2008), reason why this measure has been simulated in the vertebral axes of the city -avenues and wide streets. Bus dedicated lanes are simulated by reducing car capacity on the links affected from n lanes to n-1 and re-calculating bus speed, as: $V_{cur_{bus}} = V_{o_{bus}}$

Traffic calming also pursues a gain of livability in neighborhoods, reason why it has been considered only in local streets - no more than 3 lanes in the whole road section - by reducing the maximum speed to 30 km/h.

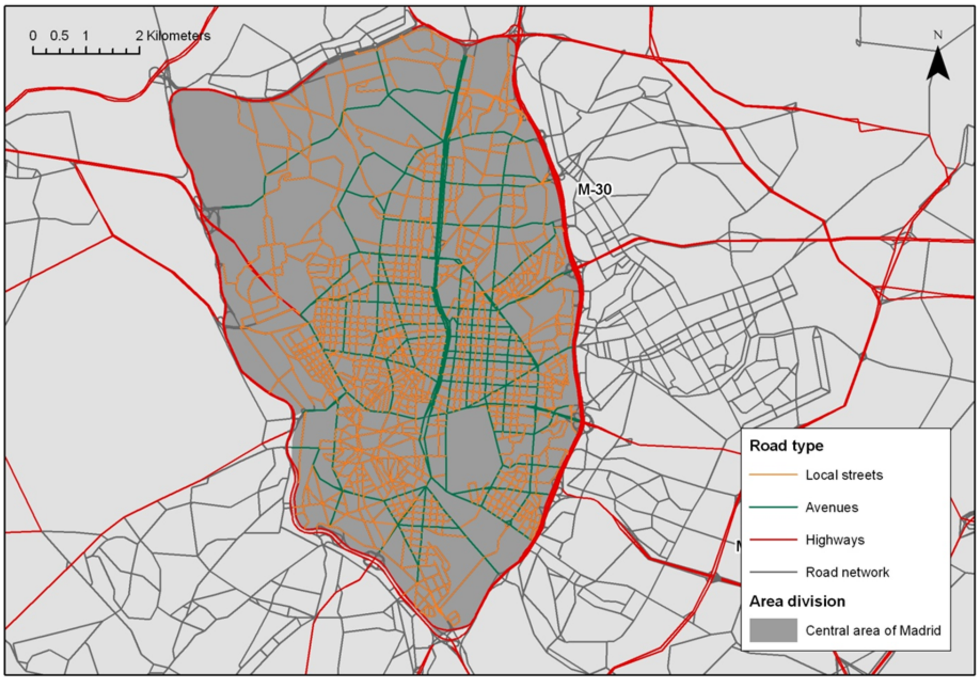

Figure 5 – Road network and hierarchy

Scenarios

In order to measure and understand possible synergies, several measures have been simulated firstly isolated, secondly combined two by two, and finally the three of them together.

This provides a wide range of seven different groups of scenarios, as shown in Table 1:

Measure	Scenario name
Urban toll (UT)	UT
Traffic calming (TC)	TC
Dedicated bus lanes (BL)	BL
Urban toll (UT) & Traffic calming (TC)	UT&TC
Urban toll (UT) & Dedicated bus lanes (BL)	UT&BL
Traffic calming (TC) & Dedicated bus lanes (BL)	TC&BL
Urban toll (UT) & Traffic calming (TC) & Dedicated bus lanes (BL)	UT&TC&BL

Table 1 – Scenarios

Each of the individual measures and a combination of them were simulated on three areas of different size, each area included the previous one and a new ring-road around it:

- Area 1 includes the Central district
- Area 3 includes the whole Central Area
- Area 2 is an intermediate level, delimited by consecutive big avenues which work as a main traffic-distributor axis inside Central Area.

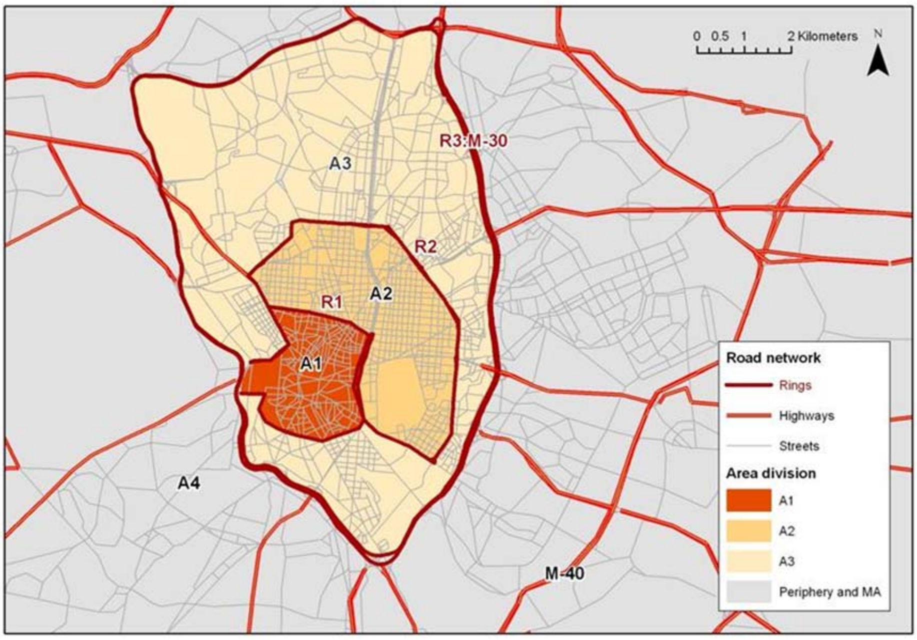

Figure 6 – Study area division

For the policy packages including just two measures, the scenarios considered are all the possible combinations of areas of implementations for each of the measures. When combining three measures, we only considered those which, from the values obtained in single measure scenarios, could generate the best results.

Indicators

Each of the objectives established in section 2.1 needs to be quantified, and this requires the definition of indicators. The indicators defined are:

- Emissions decrease

Considering the existence of several pollutants, an index of pollutants emissions (PEI) was defined. According to May and Marsden (2010), the main pollutants concerning air quality in urban areas are particulate matter (PM) and oxides of nitrogen (NOx), being the toxicity factor of nitrogen oxides a 0.5 of the toxicity of PM (NEEDS, 2010). Therefore, the resulting index is shown in equation 1:

$$PEI = \frac{0.5\times NO_X + 1\times PM}{1.5} \tag{1}$$

- Noise reduction

According to the modeling results, more than 98% of the road network inside the Central Area of Madrid, holds during the morning peak hour a noise level higher than 55 db, value set by the World Health Organization (WHO, 2000) as the annoyance level.

Noise has been measured as the sum of the noise level of each of the road sections weighted by their length.

- No loss of trip attraction

Measuring this attraction in terms of travel time, one could consider trip attraction will increase with travel time saving. But, according to several authors (Zahavi, 1974; Zahavi, 1980; Metz, 2004; Knoflacher, 2007), travel time budget is a universal constant. This means that a speed increase will not produce a time saving but an increase in distances travelled or number of daily trips.

If time dedicated to travel is constant, then modal distribution will be determined by the possibility of reaching different destinations within these temporal limits; so that, if the time difference between car and public transport increases in favor of the car, public transport will not be an acceptable choice (Monzón and de la Hoz, 2009). Therefore, the third target to achieve is to increase public transport competitiveness but without varying substantially the total travel time; this means by reducing public transport travel time.

All these indicators, summarized in Table 2, are compared to the base case, which is referred to the case where no measure is applied.

Indicator		Geographic scope
Emissions	PEI (NOx, PM)	Central Area
Noise	Noise	Central Area
Trip attraction	Travel time	Trips with origin and/or destination in Central Area
	Ratio $\frac{\text{Average travel time PT}}{\text{Average travel time Car}}$	
	Public transport speed	

Table 2 – Indicators

3. RESULTS

Quantitative results of all the scenarios considered on the different indicators considered are shown in Figures 7 to 11:

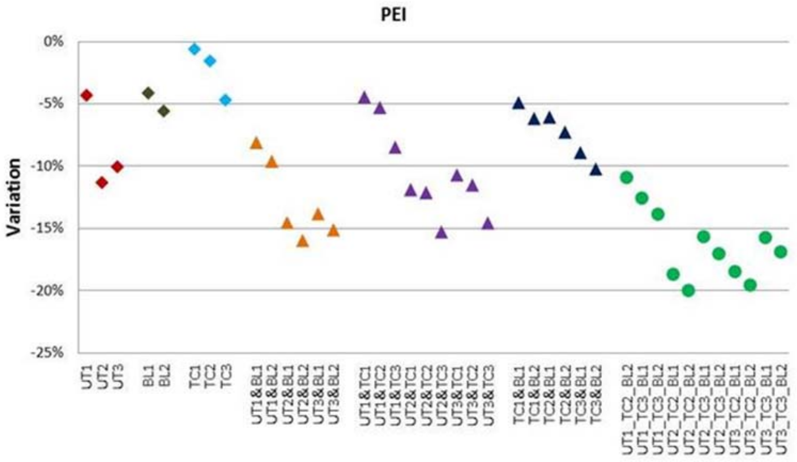

Figure 7 – Emissions variation

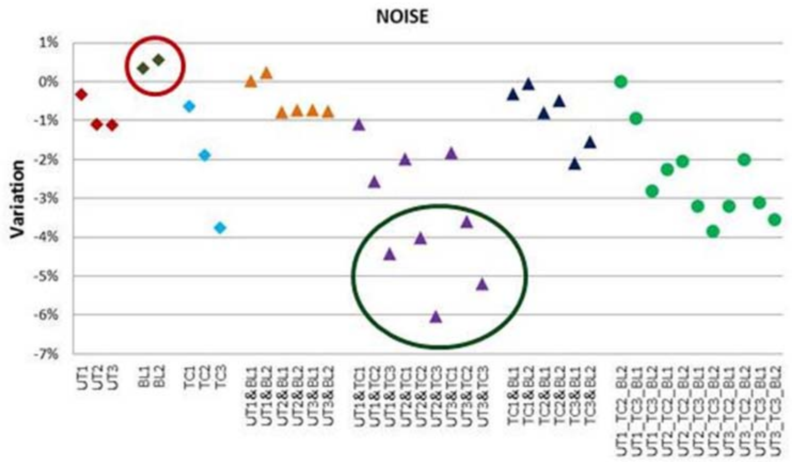

Figure 8 – Noise variation

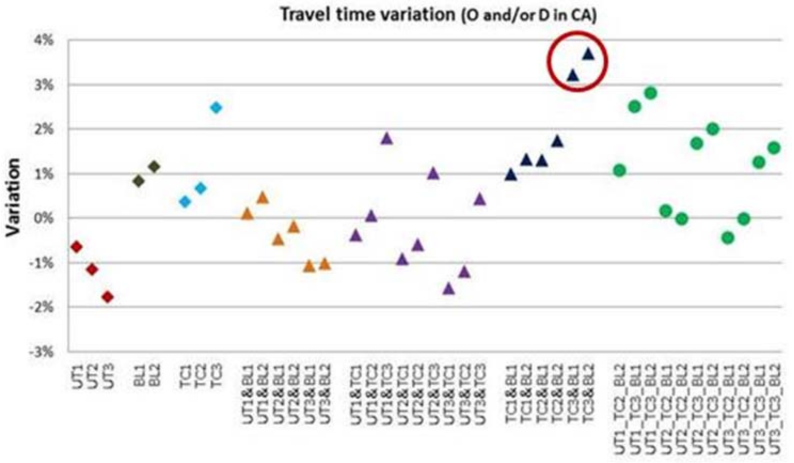

Figure 9 – Travel time variation

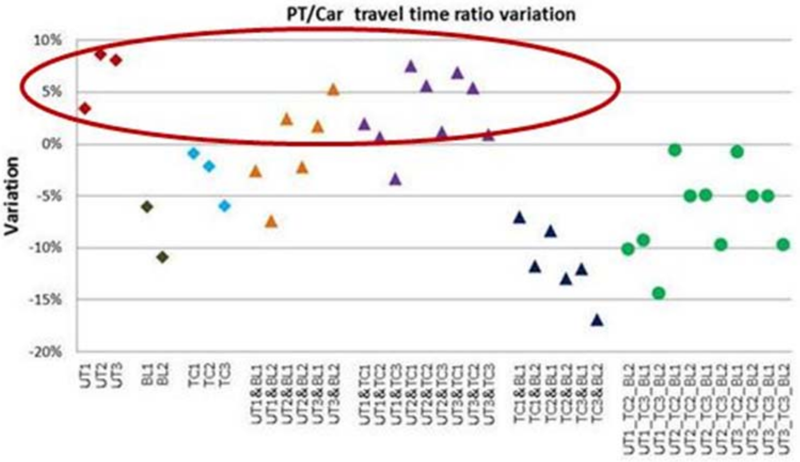

Figure 10 – PT/Car time variation

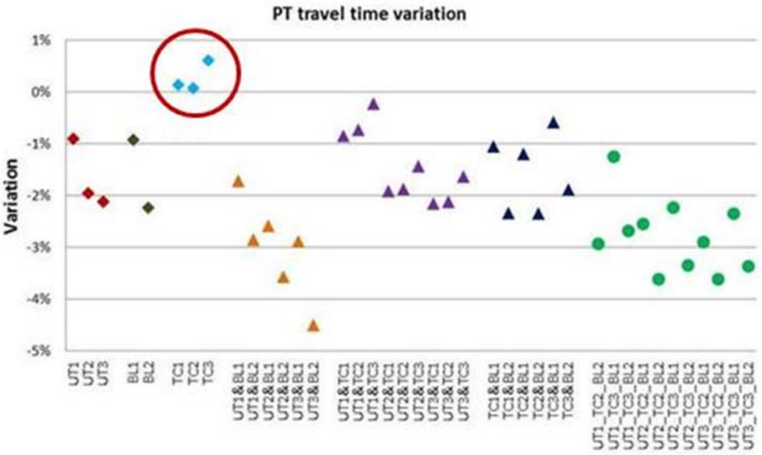

Figure 11 – Public transit time variation

Table 3 summarizes in a qualitative way - positive (+), negative (-) or neutral (~0) - the impacts of the different measures / combination of measures for each of the indicators previously defined.

Scenario	PEI	Noise	Trip attraction		
			Total trip time	Average PT time	PT time / Car time
UT	++	++	++	+	-
BL	+	-	-	+	+
TC	+	+	-	-	+
UT&BL	+	~0	+	+	-/+
UT&TC	+	+	+	+	-
BL&TC	+	~0	-	+	+
UT&BL&TC	+	+	~0	+	+

Table 2 – Qualitative representation of impact observed

All the three measures produce a positive impact in terms of veh-km inferring the three of them a modal split to public transit. Although distinct quantitative figures on the specific objectives achieved do vary with each of them.

The first of the measures considered – an urban toll - has a very positive impact for both emissions and noise. Regarding trip attraction, the total travelling time spent decreases, as well as the average time for public transit trips. But when comparing public transit time with car time, this ratio increases; this means car time decreases more than public transit time. As evidenced by Monzón and de la Hoz (2009), this ratio is strongly correlated with modal split. Therefore, we can expect an increase in car use in the medium term, especially for those origin-destination trips avoiding the toll but benefiting from traffic release.

Dedicated bus lanes do produce a positive impact on emissions, but not on noise. Traffic decreases on streets where a bus lane is implemented, decreasing noise at the same time, but part of this traffic does not disappear but spills over to nearest streets with no capacity constraint. This traffic increase produces a higher noise level. An the “re-distribution” of this traffic produces a negative impact on car’s time while positive in public transit, resulting in an increase of public transit competitiveness compared to car’s in terms of time. However, the total travel time increases.

Traffic calming produces a positive impact especially on noise, and also on emissions. This is because noise benefits from speed reduction whilst emissions do not. Besides, impact on trip attraction is negative; speed decrement is an obvious consequence of this measure, and therefore time increase. Moreover, as traffic calming also entails a traffic re-distribution from streets with traffic calming to streets without this measure, travel time also increases in this second group.

When combining an urban toll with dedicated bus lanes, emissions diminish more than in the case of having active just only one measure, as positive isolated impacts complement each other. The positive impact on noise of an urban toll is neutralized when including dedicated bus lanes. And in terms of public transit competitiveness, the addition of bus lanes to the urban toll benefits public transit time while neutralizes the gain of time by car produced with the urban toll, maintaining the ratio between time by public transit and by car in a similar way to the reference scenario. This is because the space released by traffic decrease is mostly dedicated to bus lanes, instead of benefiting both modes, as happened when considering only an urban toll.

When combining the measures related to dedicated bus lanes with traffic calming, the first aspect to highlight is the neutralization of traffic spill overs.

The combination of dedicated bus lanes with traffic calming generates a double positive impact on emissions, as positive isolated effects complement each other. The negative impact on noise produced by dedicated bus lanes is mitigated with the positive impact produced by traffic calming, and the negative impact of public transit time increase produced due to the traffic spillover observed by traffic calming is mitigated with the dedicated bus lanes in main avenues. These bus lanes reduce partially the total travel increase due to traffic calming, but still travel time increases.

If we now consider the three measures are simultaneously applied (UT+BL+TC) then there is a positive impact on the three aspects considered – emissions decrease, noise reduction and no loss of trip attraction. The following effects are noticed:

- Regarding emissions, the three measures produce a positive impact.
- As for noise, the negative impact of the bus lanes is offset by the positive synergies

that occur when implementing together an urban toll and traffic calming.

- Regarding not to lose trip attraction:
  - An urban toll produces a global time saving, but public transport loses competitiveness compared to car,
  - Bus dedicated lanes partially offset this loss of competitiveness, but not substantially.
  - The joint implementation of traffic calming and dedicated bus lanes makes the restriction higher for cars than for public transport: the speed restriction of the traffic calming measure entails a speed decrement. Implemented by itself, traffic calming affects both modes, partially due to the speed restriction and partially due to the congestion increase in the adjacent main roads produced by the spillovers. But when bus dedicated lanes are considered together with traffic calming, buses are practically not affected by the speed restriction, as they run mostly along dedicated bus lanes along the main roads.
  - The car speed imposed by traffic calming schemes produces a negative impact on global time saving when implemented by itself, but in combination with an urban toll this negative impact is annulled by the positive impact of the toll.

4. CONCLUSIONS AND DISCUSIONS

The results previously presented show how the combination of measures is fundamental in achieving sustainable mobility. As already mentioned, sustainable mobility encompasses a host of different goals to achieve, whilst no single measure has a positive effect on all.

However, when combined, sometimes they reinforce each other to a greater or lesser extent, and sometimes annul the negative effects of another measure for a specific target.

Thus, in a complementary manner, achieving an impact that is not necessarily higher in each one of the targets considered, it does produce a positive effect when considering all of them in a simultaneous manner – a WIN-WIN strategy.

To achieve this balance is essential to select the measures based on the objectives to be achieved, as stated by May et al (2000a). This may seem obvious; however, it is one of the main problems that SUTP has to face. As seen previously, the policy package combining the three measures produces a benefit in the three targets considered, whilst the policy packages considering only two do not. In practice this means that despite how well the SUTP is defined, the results do not produce a positive impact on all the targets when only part of the measures is implemented.

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