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Speed and car used regulation in urban areas Paris and Lyon case studies

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Abstract

Improvements in individual mobility conditions for drivers in the Paris conurbation (higher speed and lower cost of individual mobility) have contributed to the reduction of urban areas density and have led to dominant use of the car and a dramatic reduction in walking and cycling, while the use of public transport has remained roughly constant. The car now highly dominates the other transport modes in many places including the Paris metropolitan area.

As a consequence of the car domination, a great part of the public opinion claims a reduction of the car use and the development of alternative forms of transport. The aim of this study is to determine whether those claims are consistent with the actual present car traffic speeds. More precisely, our aim was to try to answer some questions: have car drivers a good appreciation of the car speed performance? How many are car's drivers who could save time by using other modes of transport? What can be expected from a drastic growth of the public transport supply and/or from a reduction of the car speed in order to reduce the car usage and consequently the car traffic flows.

This paper presents our methodology and the major results obtained through numerical simulations based on Paris and Lyon conurbations figures.

Keywords

Individual daily mobility; modal transfer; transport modelling; traffic management, traffic simulation

Topic area : E7 Assessment, Appraisal and Scenarios; Case Studies

1. Introduction

Over the last thirty years, transport policy, especially in France, has been oriented towards the development of radial and suburban motorways and new rail services (metro, Express Regional Railways and light rail). Achieving higher speed has been at the core of transport policy. It is recognised today that this policy has contributed to urban populations and employments sprawl.

As a matter of fact, the enhanced individual mobility in conditions of higher speed and lower cost has contributed to the spread of population of centres and dramatic changes in individual modes of transport. One observes significant reductions in walking and cycling, considerable growth in car use while there has been a little change in the use of public transport. The car now dominates the other modes of transport in the Paris metropolitan area (see table 1). This increase of the car's share combined with urban expansion and "peripheralisation" of traffic flow has resulted in 35% increase in average speed of trips in urban areas in France between 1982 and 1994 (Orfeuill, 2000).

Table 1: Percentage of all trips made by car in French urban areas in 1994

Car's share/ all transport modes	French urban areas of more than 300 000 inhabitants (except Paris)	Urban region of Paris
Trips	62%	47%
Kilometres	83%	62%
Evolution 1982-1994 (trips)	+ 10 %	+ 8 %

Source: National Transport Surveys– 1982 and 1994 (INSEE-INRETS)

As a consequence of those important changes, a dominant part of the public opinion demands a reduction in car dependence and the development of walking, cycling, and public transport. The aim of this study directed by INRETS is to analyse whether those claims are consistent with the current speed levels achieved in the current transport network of two major French conurbations: Paris and Lyon. More precisely, our objective was to find answers for two groups of questions:

- How many car drivers could save travel time by using other modes of transport each day? What reduction of car traffic could be expected from a modal transfer to other modes than car of those car drivers?
- What could be expected from a drastic growth in Public Transport supply and /or from a car speed reduction that could result from a general "traffic calming approach" for example? Would those changes and subsequent transfers result in longer travel times each day?

Due to the method used, it is supposed that people do not change their activity pattern in terms of daily activities and destinations.

This paper presents our methodology based on a cyclic simulation model that combined the assignment of car tours (defined below) to a set of alternative transport modes.

These simulations are based on:

- the most recent household travel survey of each conurbation (the 1991-1992 Paris Region comprehensive travel survey, and the 1994-1995 Lyon Region household travel survey, Cf. map 1) which recorded all trips made in a *typical day* by all the individuals over 5 years of age from surveyed households living in these regions. The surveys are based on face-to-face interviews conducted to collect details about the previous day's trips (for each trip: modes, origin-destination, purpose, depart and arrival time...), as well as the socio-economic characteristics of the household and the individuals in it;
- public transport assignment model which assigns trips on public transport network on the base of the shortest time path for each car trip. We used IMPACT model developed by the RATP (main Paris Public Transport Operator) in case of Paris Region and TERESE model developed by SEMALY consulting group based in Lyon, in case of Lyon Region;
- the speed of walk and bicycle that provides potential alternative to private car tours (or car round trips);
- the present individual cost of mobility. The impacts of modal transfer on daily monetary travel budgets are evaluated for each car' driver by comparison of the marginal cost of their daily car use with the cost of transport public use at present price for the same mobility. For car use, only marginal cost was considered, i.e. gazole and parking costs.

Several numerical simulations have been carried out according to several scenarios in which public transport characteristics were improved. The method allows us also to perform ex post a sort of appraisal measurement of the car usage in relation with the car performance (speed). We report the principal results obtained through the analysis of simulations based on figures and models of the Paris conurbation travels.

One aim of our research was to initiate a debate by determining the possible reduction extent of the car usage, on the basis of observed driver behaviours within the framework of stated transport policy. In other terms, we try to figure out who would benefit and who would suffer if speed reducing' policies were to be introduced on a large scale.

2. Methodology

We developed a method based on repeated iterations of a simulation model that assigned « car tours » to alternative transport modes according to current public transport supply (called HP-HC 90 for Paris and HP 95 for Lyon, see below) and several scenarios in which public transport was improved.

A car tour was defined as the sequence of several trips made between leaving home and returning home; an individual can make several car tours in the same day. Demand was channelled towards personal modes (walking, cycling), public transport routes and a combination of personal and public modes of transport on the basis of the shortest time path for each trip. *More precisely each car tour of which first trip is travelled by car* is assigned to other mode on the basis of rules and constraints. This system of rules and constraints constitutes the core of the modal transfer procedure, which examines the possibilities of car tours substitution in the context of current and future public transport scenarios. This method allows us *to identify realistic individual degrees of freedom with regard to personal travel and*

current daily travel speed and to evaluate the potential for changing modes of transport (to other than the private car) in relation to a transport speed policy.

In our approach, the following items are invariant: the population and activities in the study area, both with regard to the number of jobs and their locations, the major components of individual activity patterns. The effects that result from any change in supply, in particular trips that are generated by increased speed or improved reliability on transport networks, have not been considered either.

Our intention was not to develop a behavioural approach to study the choice of the travel mode. We intended to define individual potential changes in the choice of mode with regard to the speed performance of the different transport modes.

The following section develops first the basic principles of the transfer procedure (2.1) and then the description of the transfer procedure (2.2); (2.3) gives an overview of the current situation in the Paris and Lyon areas.

2.1. Principles of the transfer procedure

This section sets out the main principles and rules used by the algorithm that deals with the allocation or potential transfer of « private car tours » to other mode.

The four main principles of the algorithm were laid down as early as 1997 at INRETS (Gallez, Orfeuil, 1997). They are successively described below (more details on methods is provided in Massot et alli –2002b).

Car Tours

The modal transfer procedure is based on transfer rules that apply to car tours as we previously defined it (This procedure differs from usual modal transfer methods that consider individual trips, (Mackett, Robertson, 2000; Kaufmann, 2002; Cullimane, Cullimane, 2003)). The method uses the confirmed hypothesis that an individual's modal choice depends on the activities which one wishes to conduct thanks to travelling (Jones, 1990). Then activities (trip attribute) are used in the procedure. We also use that an individual's range of modal choices depends on his/her desired activity pattern. The procedure takes into account the close link between an individual's ability to use a given transport mode and the organisation and geography of the trips made.

Compliance with specific dependence on the car

The second principle takes into account the fact that some activities are deeply dependent on car usage. Thus, all car tours, which include activities for which the car is the most suitable mode, have been excluded from the procedure: the car tours, which include one or more trips for the purpose of “exceptional and weekly purchases”, have been excluded. The car has also been considered as essential for any car tour that includes more than one escorting trip. Lastly, any car tour that includes trips made at night has been excluded from the procedure, for reasons of security and because of the lack of public transport supply.

Compliance with daily travel-time budgets

The third principle states that the individual's existing daily travel-time budget (i.e. the individual daily time devoted to transport) should be respected. Then, any increase in travel time that could result from a transfer from the car to a slower mode is analysed and accepted

only if there is consistency between the time required for activities and the time required for travel (Schäfer, 2000).

The potential increase in the individuals' daily travel-time budget was therefore controlled, by applying a travel time-budget growth margin for the car tours. The maximum value of the budget time increase was fixed *a priori as a function of* the individual's initial travel-time budget and the average travel-time budget of the group to which the traveller and the trip belong (12 groups were defined on the basis of combinations of occupation, gender and activity). The constraints and rules that applied to the travel-time budget were specified on the basis of a detailed analysis of the travel of residents in the area (Massot et alii, 2002a; Bonnel et alii, 2002).

- Any individual whose initial travel-time budget was higher than 300 minutes was excluded from the transfer procedure for obvious reasons of duration of travel time budget.
- When an individual's initial travel-time budget was twice as high as the average travel-time budget of the group to which he/she belonged, the transfer was only possible if the travel-time remained the same or diminished. In this case, it was considered that the travel-time budget had reached its maximum value and therefore that the individual's travel-time budget could not increase;

This rule locates the travel time parameter at the centre of the methodology, thereby making speed a key part of the system. Those variables constitute a way to measure how acts a scenario and how it affects individuals especially regarding a strategy of car usage reduction.

Modal segmentation of the car tour' market

The employed procedure includes the capability to reflect the competition of modes with respect to travelled distances and speeds. Transferring a car tour to one of the three alternative modes (walking, cycling, public transport) depended on the total distance travelled. Several distance classes were specified based on an analysis of all the tours whose principal mode was walking or the bicycle.

- Transfer to walking was tested for a car tour whose distance was equal or less than 2 km. The walking speed used was 3,5 km/h.
- Transfer to a cycle was tested for car tour less than 11 km (depending on the traveller age and trip purpose); The associated speeds were fixed between 5 and 11 km/h.
- Transfer to public transport was tested for other distances: the transfer to PT (public transport) was tested on time basis. So the public transport time for all trips within car tour was computed using an assignment model (IMPACT and TERESE). The model gave the shortest time path assignment. The calculation was performed for the reference network and for the different network designs, which were defined in the improved public transport scenario.

2.2. The procedure

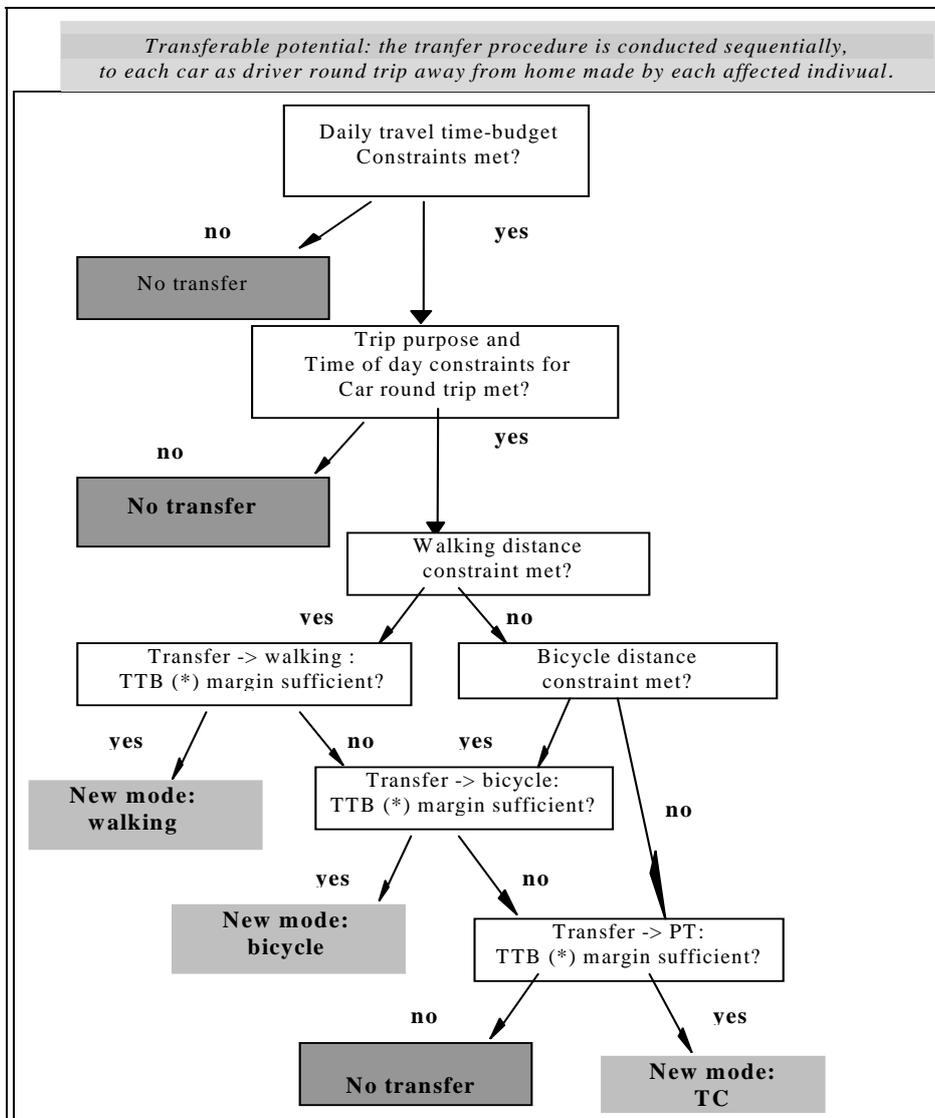
On the basis of the above set of rules, the transfer procedure was applied sequentially to all the car tours of each individual (Figure 1). Priority had been given to individual travel-time budget' constraints; the transfer of an individual's round trip or tour was realized under the following conditions:

- **IF** the travel-time budget constraints or if one of the trip’s purpose and time of day constraints for the car tour were not satisfied, **THEN** the individual’s car tour was not transferred;
- **OTHERWISE**, the car tour was transferred according to the following procedure:

The first transfer mode that was tested (walking, cycling or public transport in this order) depended on the total distance covered in the car tour:

- **IF** the growth of the travel-time budget after transfer was below the threshold that was set *a priori* **THEN** the procedure was successful, the transfer was possible and the travel-time budget was changed accordingly;
- **IF** the growth of the travel-time budget exceeded the threshold, transfer to a faster mode was tested (cycling in the case where transfer to walking was tested first, public transport, if transfer to the bicycle was tested first);
- **IF** no mode was able to comply with the travel-time budget conditions **THEN** the transfer failed for all trips of the car tour.

Figure 1: Simplified modal transfer procedure of individual car tour or round trip



Source: INRETS (Massot et alii, 2002a, 2002 b)

2.3. Application to the more densely populated areas

The transfer procedure has been applied to the most recent household travel surveys in the two studied conurbations.

Our analysis was only based on trips and tours realised in the more densely populated area of the Paris and Lyon conurbations where the competition between modes of transport is effective. For example, the total daily trips in this area not far from the core of Paris accounted for 66% of all sample trips (i.e. 21 million among the 33 million daily trips) and for 75% of total daily traffic (in kilometres) (table 2). In this densely populated area, the modal share of « soft » transport modes (walking, cycling and public transport) was dominant, and public transport is the most used travel mode in terms of daily traffic (51%).

So in the Paris conurbation, only one car tour in six is eligible for evaluation by the transfer procedure. However, the proportion is twice as high in the Lyon conurbation because the car has a much larger share of the market (table 2 and 3). Again a little more than one person in six has made car tours included in the transferable potential in the Paris region, while the proportion is twice as high in the Lyon conurbation. Lastly, the average distance covered in the car tours is more than 30 km in the Paris conurbation and a little over 10 km in the Lyon conurbation. The size of the conurbation seems to play a particularly important role.

Table 3 figures out the size of the different stakes of the private car usage regulation. The survey perimeter is given on Map 1 for each conurbation.

Table 2: Modal share in the two more densely populated areas
(Reference's state)

Transport Mode	More densely populated of Paris conurbation		Greater Lyon	
	Trips	Traffic (km)	Trips	Traffic (km)
Walking	35,5%	3,6%	31,1%	8,6%
Cycling	0,4%	0,2%	0,6%	0,4%
Motorcycling	1,0%	1,1%	0,6%	0,8%
Passenger Private Car	7,8%	7,5%	12,1%	14,4%
Driver Private Car	28,3%	35,8%	42,0%	58,2%
Taxi	0,4%	0,4%		
Public transport	26,3%	50,7%	13,3%	17,0%
NR	0,4%	0,7%	0,4%	0,5%
Total	100%	100%	100%	100%

Source: INRETS, based on EGT (DREIF) 91-92;

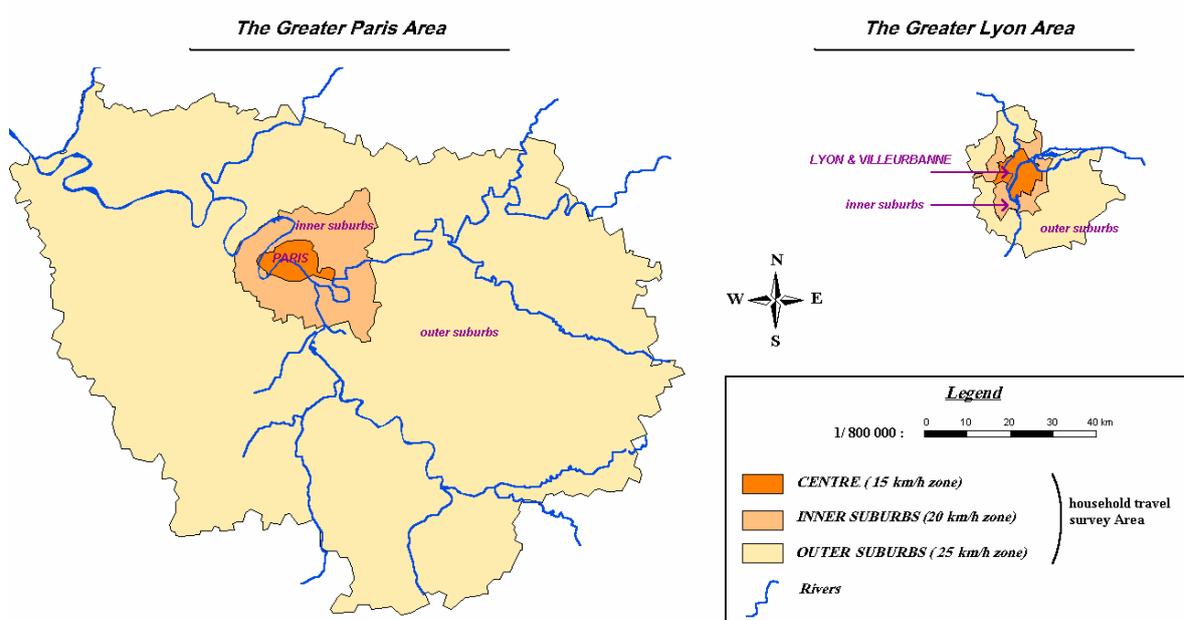
LET, based on EM Lyon (SYTRAL) 1994-1995

Table 3: The stakes of the private car’ regulation in the densely populated areas

	Number of tours (In thousand)	Number of car tours eligible for evaluation by the transfer procedure (In thousand)	Number of trips contained in tours eligible for evaluation by the transfer procedure (In thousand)	Number of persons making car tours eligible for evaluation by the transfer procedure (In thousand)	Number of driver car-kilometres in tours eligible for evaluation by the transfer procedure (In thousand)
Greater Paris	12 983	2 173	6 402	1 701	65 896
Greater Lyon	1 802	672	1 866	436	7 160

Source: INRETS, based on EGT (DREIF) 91-92;
LET, based on EM Lyon (SYTRAL) 1994-1995

Map 1: Study zones



3. Speed and car traffic regulation

3.1. The challenge of car speed for car use regulation

In the more densely of Paris area’s reference situation and while respecting the hypotheses of the transfer procedure, 9% of car drivers were in a potential position to conduct their daily mobility with another modes than car without an increase in their daily travel-time budget. So those car drivers were deemed to be “irrational” with respect to the modal performance in terms of speed. On the contrary 91% of drivers, representing 93% of car trips and 95% of daily car traffic (car kilometres) were not deemed acceptable for a modal transfer

without a decrease in their daily travel-time budget. Therefore the choice for the faster travel mode of the great majority of car travellers is confirmed by the method used.

If the same activity patterns are retained (our hypothesis), we can conclude here that reducing “irrational” car usage can only marginally assist a large-scale reduction in car usage.

If we analyse the social profile and the mobility practices of the car users not deemed suitable for modal transfer, we can observe a great proportion of working people with a high level of mobility: 87% are working people who realize 4.5 trips a day at a daily average speed of 19 km/h. Those car’s users spend two hours in their car each day for a mean daily travel distance of 37 kilometres. Those figures are higher than those for the total population in this area (51% of working people, 22 kilometres a day at 16km/h for a daily transport time budget of 82 minutes and a level of mobility of 3.5 trips a day). In Paris conurbation, *we can conclude that the great majority of car users have constructed their daily activity patterns on car speed performance.*

The challenge of car speed performance for car use regulation can be considered as very high. In fact, our simulations based on “car speed reductions” show it is higher.

In those simulations it is assumed that car drivers were prepared to accept a growth of their travel-time budget (~ a reduction of their general travel speed over the day) with no change in the current level of public transport supply (HP-HC 90). Simulations were performed by step of 10% over their current travel-time budget, from a 10% growth to a 100% growth (which is highly speculative indeed).

Results show that doubling the individual travel-time budget, leads to a **37%** reduction in car tours. This implies that **63% of car tours remain attached to car speed performance** (they accounted for 74% of the previous car traffic, see last line, table 4). A more realistic 25% growth in travel-time budget leads to a transfer of 16% of car tours to alternative modes, which means that **84% of car tours and 91% of car traffic remain attached to the car speed performance criterion** (see, line number 3, table 4).

Table 4: Potential car’s speed dependence based on a hypothesis of a step-by-step increase in individual daily travel-time budget.

% Growth in daily travel-time Budget	More densely populated area of Paris		Greater Lyon	
	% Car tours remaining dependent on car speed performance	% Car-km remaining dependent on car speed performance	% Car tours remaining dependent on car speed performance	% Car-km remaining dependent on car speed performance
0%	93%	95%	86%	94%
10%	90%	94%	82%	91%
25%	84%	91%	77%	88%
30%	82%	90%	76%	87%
40%	78%	88%	73%	85%
50%	75%	85%	72%	85%
75%	72%	79%	72%	84%
100%	63%	74%	71%	84%

Source: INRETS, based on EGT (DREIF) 91-92;
LET, based on EM Lyon (SYTRAL) 1994-1995

What generalisations can be drawn from those simulations?

We have made a comparison with another French city, Lyon (Massot, Armoogum, Bonnel, Caubel, 2002b). In this conurbation, the percentage of drivers who could not have performed their daily activity pattern otherwise than by car without altering their travel-time-budget is lower than that in the densely populated part of the Greater Paris Area (82%). It is thus apparent that greater the broad constraints that operate against car use (congestion, trip time irregularities, parking problems... are more important in Paris than in Lyon.), the higher the extent to which car use behaviours are “rational” in terms of time spent. In more relaxed constraints on car use such as in Lyon, we observe, as Kaufmann (2002), that “competitive travel times are a necessary but not a sufficient condition for public transport use” even if this travel mode is the fastest. But we can also observe that 94% of car traffic remain attached to the car speed: the car speed challenge for traffic car regulation is as high in Lyon as Paris (table 4).

Therefore the percentage of “irrational drivers” was greater in Lyon than in the densely populated part of the Paris’ Area (16% versus 9%). But the traffic involved in such “irrational” car use is comparable to what we obtained for the Paris conurbation (6% of car kilometres in greater Lyon). The level of mobility of those car drivers of Lyon is not less intensive than the car drivers of Paris but their car trips are shorter and slower. Because of that, our simulations show that the modal split of the trips, which could be transferred is structured in different manner.

In the more densely populated area of Paris, public transport would take 66% of potentially transferable car tours and 95% of the vehicle-kilometres travelled while making them. Walking, whose market has been assumed to involve car tours of less than 2 kilometres, only takes 8% of potentially transferable trips and the bicycle, whose market involves round trips of less than 8 kilometres, 26%. These two personal modes are only responsible for 5% of the reduction in automobile traffic (in vehicle-kilometres terms). Apparently, in the densely populated Greater Paris Area, although the problem of modal transfers can involve the familiar attempt to transfer short trips to walking or cycling, which are effective modes for them, the result is relatively marginal reductions in automobile traffic.

In the more densely populated area of Lyon, although walking is no more prevalent than in Paris, the bicycle is potentially the most important mode involved, taking 64% of the potentially transferable car tours and 41% of car traffic. Public transport represented only 28% of the potentially transferable car tours but 57% of the traffic. Even if public transport was the first mode in traffic terms, this result shows that in the Lyon region the modal transfers involved strategies at a different scale than in the more densely populated area of Paris.

If it is assumed, as for Paris case study, that car drivers were prepared to accept a growth of their travel-time budget, the challenge of car speed seems to be not so high in Lyon case-study as in Paris. In Lyon, we observe a greater impact of the increase in the travel time-budget on reduction of the car speed dependence while the simulated increase of the daily time-budget of car users remains smaller than 25%. Above that figure of increase, the level of car traffic dependence on car speed is quite constant, and this level is higher than for the Paris case-study (table 4). When all the shorter and slower car trips are re-assigned to an other modal alternative, that are more numerous in Lyon than in Paris, the potential transfer of car tours depends on the public transport network performance (in potential origins -destinations and speed). The performance of Parisian PT network is better than the network of Lyon: that

could explain that the car traffic dependence steadily increase with travel budget-time growth in Paris and not in Lyon.

3.2. Potential car use reduction assuming public transport development

The transfer procedure was first applied to public transport supply as it stood at the dates when the surveys of the Paris and Lyon conurbations were each conducted. On the basis of an examination of the features of the transferred round trips and the non-transferred round trips, we have proposed several public transport supply improvement scenarios. The procedure used to construct these scenarios involved successive improvements to supply.

As the levels of public transport supply are very different in the reference situation in the two conurbations (Table 5), different scenarios had to be provided for each context. The more detailed nature of the data on the Paris region enabled us to construct 7 supply scenarios (Massot et al., 2000). Only 5 scenarios were specified for Lyon (Bonnell et al., 2002). In this paper, we shall discuss only the most contrasting scenarios:

- For the Paris conurbation:

- HP-HC 90 which corresponds to the network as it stood in 1990 shortly before the Comprehensive Transport Survey was conducted in the Paris region. This is therefore the reference network;
- HP99 which corresponds to the network as it stood in 1999, with an extension of peak hour frequencies to off-peak periods and the implementation of the Mobilien plan (creation of 60 exclusive bus lane routes in Paris and in the suburbs, RATP 2000);
- HP2010 + 15,20,25 which is the same as the previous network but with an increase in supply in the outer suburbs with the creation of intersuburban routes and an increase in rail supply on the basis of the Masterplan that is based on the 12th and 13th State-Region plan contract. It is also accompanied by a restructuring of the bus network to match rail supply. Finally, this network includes the creation of exclusive bus lanes everywhere leading to speeds of 15 km/h in the centre, 20 km/h in the inner suburbs and 25 km/h in the outer suburbs becoming generalised.

- For the Lyon conurbation:

- HP95 which corresponds to the network as it stood in 1995, the date at which the Household Travel Survey for the Lyon conurbation was conducted. This is therefore the reference network. However, as the network has only been coded during the peak period, this scenario implicitly features an application of peak hour frequencies to off-peak periods. It therefore already represents a considerable improvement on the real situation in 1995;
- HP2010 PDU which corresponds to the scenario described in the Plan de Déplacements Urbains (Urban Travel Plan) for the conurbation in the year 2010 (SYTRAL, 1997). In particular, this plan envisaged the creation of 10 high capacity routes in addition to the 4 existing metro lines;
- HP2010+ rail +15,20,25. This is the previous scenario with a general development of rail services (using the existing network which is little used at the present time). As in the case of the Paris conurbation, we have also included the creation of exclusive bus lanes which leads to a speed of 15 km/h in the centre, 20 km/h in the inner suburbs and 25 km/h in the outer suburbs.

Table 5 shows the scale of the increase in the public transport supply: in comparison with the reference scenarios, simulations with the most ambitious scenarios result in an increase of 44% in seat kilometres for Paris and of 92% for Lyon. The second figure represents a doubling of supply and is more than two times the increase in capacity obtained for the Paris conurbation. So the simulated changes in the public transport supply are not marginal, even if in the most ambitious network in Lyon, supply in terms of seat kilometres per resident is at the same level as it was in Paris in 1990.

Table 5: Supply indicators for the public transport scenarios

	Greater Paris area			Greater Lyon area		
	HP-HC 90	HP99	HP2010 + 15,20,25	HP95	HP2010 PDU	HP2010+ rail + 15,20,25
Seat kilometres per year (billion)	106.7	143.4	154.2	7.2	12.6	13.9
Population of survey zone (thousand)	10 464 (Paris region, 1990)			1 195 (in 1995)		
Seat kilometres per person per year	10 023	13 704	14 736	6 085	10 554	11 653

Sources: INRETS, based on IMPACT models (RATP)
LET, based on TERESE models (SEMALY)

We can observe (table 6) the potential effect of these public transport supply improvements for both of study areas under assumption of the present day car usage and daily travel-time budget.

The most ambitious supply scenarios placed the rail network at the centre of the transport system. However, results show a very slight increase in potentially transferable travel and only a very slight decrease of car traffic dependence. In Paris study areas, the most ambitious scenario of supply improvement (HP2010 + 15,20,25) led to a **9%** potential reduction of car tours, which meant that **91% of car tours remained attached to the car speed**; they account for 93% of the previous car traffic (table 4). This impact is real albeit limited, both in terms of car trips and of car-kilometres with regard to the reference situation, where **93% of car tours remained attached to the car speed**.

The figures obtain for Lyon case study are disappointing to: in Lyon study areas, with the most ambitious scenario of supply improvement (HP2010+ rail +15,20,25) **89% of car traffic remained attached to the car speed** (table 6).

Our analysis explains this disappointing result as follows for both of study cases: the simulated public transport supply pattern remained essentially radial and only able to satisfy equivalent long radial distance car trips, but its spatial design was too inflexible for being able to capture the car trips made in the inner suburbs, which were statistically the most numerous. This observation should not allow us to conclude that the public transport supply which is planned in the framework of the forthcoming official plans, was of no importance for the Greater Paris and Lyon areas. Such plans are based partly on an increase in the population size living in the relevant areas, which is a non-considered factor in the simulations performed

here. We show that they could have only a limited effect on the additional modal share that the car acquired in the 90s, i.e. on the speed competition between car and public transport.

While the estimated effects of supply on the modification of present-day car usage in densely populated zones were real albeit limited, the effects of public transport supply *could be increased* by any accompanying strategy that aims to assist « transfers » to other modes i.e. any strategy that could reduce the speed of the car. We observe (table 7) in fact that an increase of 25%-30% of the daily travel-time budget of car drivers (reasonable hypothesis) could of course gear up the impact of public transport supply improvement on car speed dependence and could increase the potential role of alternatives modes. This confirms the hypothesis that is widely held in professional circles, namely that a change towards a different future can only occur if synergy is achieved between “combined” actions. But we could also observed that the greater impact of those two measures with regard to car usage regulation was the strategy of forcing car speed reduction: a 25% or 30% increase in individual daily travel time-budget (under reference PT supply) had a greater impact than supply improvement at constant daily travel-time budget (Table 4). If one subscribes to the ideal of reducing car use, one has first to make daily car trips longer, and secondly to develop some accompanying strategies to amplify the modal transfer to other modes.

Table 6: Potential dependence of car uses on car speed assuming an increasing public transport supply with **a constant daily travel-time budget**

More densely populated area of Paris	Public Transport Scenarios		
% Traffic dependent on « car speed »	(HP-HC 90) Reference	(HP, 99)	(HP 2010) +15/20/25
Car Trips	93%	92%	91%
Car –km	95%	94%	93%
Greater Lyon	Public Transport Scenarios		
% Traffic dependent on « car speed »	HP95 Reference	HP2010 PDU	HP2010+ fer + 15-20-25
Car Trips	87%	84%	83%
Car –km	94%	91%	89%

Source: INRETS, based on EGT (DREIF) 91-92;

LET, based on EM Lyon (SYTRAL) 1994-1995

Table 7: Potential dependence of car usage on car speed assuming an increasing public transport supply (as above) **and an increase in the daily travel-time budget**

More densely populated area of Paris: a 25% increase of travel-time budget	Public Transport Scenarios		
	(HP-HC 90) Reference	(HP, 99)	(HP 2010) +15/20/25
% Traffic dependent on « car speed »			
Car Trips	86%	82%	82%
Car –km	91%	87%	87%
Greater Lyon: a 30% increase of travel-time budget	Public Transport Scenarios		
% Traffic dependent on « car speed »	HP95 Reference	HP2010 PDU	HP2010+ fer + 15-20-25
Car Trips	78%	74%	72%
Car –km	87%	81%	77%

Source: INRETS, based on EGT (DREIF) 91-92;

LET, based on EM Lyon (SYTRAL) 1994-1995

4. Car use regulation and acceptability of travel time constraints

In order to evaluate whether car tours transferred could constitute a potential market for alternative modes, we tried to evaluate the impact of transfers for car users.

We conducted an analysis on two simulations: the first is based on the reference situation (individual travel-time budget and PT supply are unchanged); the second is based on a 25% or 30% increase in the daily travel-time budget and the PT supply constant.

The analysis of the first simulation demonstrated that strategies which involved the transfer of some or all daily individual car trips would result in gains in terms of travel-time budget for all the car drivers both of Paris and Lyon cases. The average gain in daily time spent in travel is consequent: 20 minutes for car drivers of Paris and 18 minutes for car drivers of Lyon (that is respectively a 15 and 20% reduction of their daily travel time) .

The evolution of the daily monetary travel-budget is quite different in Lyon and Paris cases. For 97% of the car drivers of Paris areas, the transfer strategy would result in gains of money, and the average gain is very important, more than 3 Euros and a reduction of 68% of their daily monetary budget. In Lyon case study, the monetary gain is in average less important as in Paris case study (0,23 Euros and a reduction of 15%), as the number of winners in money (76%). This difference could be explained by both the higher cost of car use in relation with the parking cost and the very lower cost of public transport use in Paris area than in Lyon area. In Lyon there is a very little difference between the unit cost of the two motorized modes usage: that could also explain the greater number of people who choice the car than in Paris.

In that first simulation where the winners in time and money could be very numerous and gains important, we could admit that the transfer is affordable to those car drivers. But, as we saw before, the car traffic reduction is here limited (5% - 6%).

The second scenario based on a 25% increase of the budget travel-time involved a 9% potential reduction in car-kilometres for 19% of car drivers (326 000) in Paris. Whether this

scenario did not change the situation of **91%** of present car traffic, the car's share in trips would fall **from 36%** (reference case) **to 31%**, which could be considered to be significant. Public transport would take 80% of the transfers. With regard to the impact of the transfers, the analysis demonstrated that strategies which involved the transfer would result in gains in terms of travel-time budget and daily monetary travel budget ¹ for 39% of cars drivers involved. Only 9% of drivers would lose both time and money and the majority are in a situation of bargaining over monetary gains or time loss. We feel that these few items of data on individual impacts show that the sacrifice required of many drivers is limited and probably acceptable in view of the fact that the monetary gains are substantial and the time losses virtually negligible; in straightforward terms, a policy that reduces car use would not penalize these drivers, as long as public transport pricing remains unchanged. The car traffic reduction were not so limited as before. The analysis of other scenarios, where transport public supply is reinforced, do not change radically the diagnostic; we observe that the supply improvement do not matter the growth of travel time-budget of car drivers concerned by a modal transfer (table 8).

Table 8: Potential modal transfer impacts on daily travel-time and monetary budgets
Simulations based on an increase of travel time budget and public transport supply constant

Paris case study		Time-budget (Minutes)		Monetary Budget (Euros 95)	
Car drivers concerned by a transfer with:	Car drivers concerned	Before Transfer*	After Transfer	Before Transfer*	After Transfer
Saving time and money	39%	135	115	5,26	1,54
Saving time and losing money	5%	83	70	0,61	0,85
Losing time and saving money	47%	97	109	3,70	1,63
Losing time and money	9%	89	102	1,40	1,74
Lyon case study		Time-budget		Monetary Budget	
Car drivers concerned by a transfer with:	Car drivers concerned	Before Transfer*	After Transfer	Before Transfer*	After Transfer
Saving time and money	40%	80	62	1,40	0,73
Saving time and losing money	11%	116	92	1,34	2,48
Losing time and saving money	32%	71	80	1,95	1,34
Losing time and money	17%	80	93	1,46	2,36

Paris case study		
Relative evolution	Time-budget	Monetary Budget
Saving time and money	-15%	-70%
Saving time and losing money	-16%	41%
Losing time and saving money	12%	-56%
Losing time and money	15%	24%

¹ The impacts of modal transfer on daily monetary travel budgets are evaluated for each car' driver by comparison of the marginal cost of their daily car use with the cost of transport public use at present price for the same mobility .

Lyon case study

Relative evolution	Time-budget	Monetary Budget
Saving time and money	-22%	-47%
Saving time and losing money	-21%	85%
Losing time and saving money	13%	-32%
Losing time and money	17%	60%

***Before transfer = in the reference situation**

Source: INRETS, based on EGT (DREIF) 91-92;

LET, based on EM Lyon (SYTRAL) 1994-1995

The simulation based on a 30% increase of travel time-budget of Lyon's car drivers differs from Paris with regard of the distribution of winners and losers in money because of higher costs of public transport uses. The car traffic reduction associated to the potential modal transfer is a little more important (11%) but the transfer is perhaps less affordable without an increase of the car cost usage.

The few figures we have given above, which of course only refer to potential changes, allow us to measure the "realm of the possible". This "realm of the possible" also provides a reduction in energy consumption and pollutant emissions. It does, however, pose a problem of social acceptability insofar as the sacrifice in terms of transferred vehicle-kilometres is distributed among a small fraction of the drivers involved (around 70% of car traffic reduction from 50% of car drivers). Also for employed persons and workers, the average time sacrifice required is greater than that required from senior managers and the intermediate professions; in addition, the big winners are over-represented among the population of Paris and the big losers are over-represented in the inner suburbs where the potential for adopting effective alternative modes is the lowest (not in Lyon).

Our analysis of car user potential responses to mode change shows that it is possible to conceive traffic policies that reduce car usage without major disturbance to existing routines for the majority of drivers. The potential changes are more important than demand models figure (Morellet, 2002). However such changes will result in an unequal burden that will fall less heavily on management and professional workers. It is likely to give birth to a debate on the social acceptability of policies to reduce car use and the measures, which are necessary to make the policies more tolerable, or more "politically" acceptable.

5. Conclusion

Improvements in individual mobility conditions for drivers in the Paris and Lyon conurbations (higher speed and lower cost of individual mobility) have contributed to the reduction of urban areas density, have led to a dominant car usage and to a dramatic reduction in walking and cycling, while the use of public transport has remained roughly constant. The car now highly dominates the other transport modes in many places including the Paris metropolitan area.

As a consequence of the car domination, a great part of the public opinion claims a reduction of the car use and the development of alternative forms of transport. The aim of this study is to determine whether those claims are consistent with the actual present car traffic speeds. More precisely, our aim was to try to answer some questions: have car drivers a good

appreciation of the car speed performance? How many are car users who could save time by using other modes of transport? What can be expected from a drastic growth of the public transport supply and/or from a reduction of the car speed in order to reduce the car usage and consequently the car traffic flows.

The results of our analysis suggest that only a few car drivers would save time by using other modes if the same activity patterns are retained (our hypothesis). The choice for the faster travel mode of the great majority of car travellers is confirmed by the method used. For the great majority of car drivers in this area, speed reduction would be synonymous with mobility reduction. As Goodwin (2001) states, we should make a distinction between car-dependent people and car-dependent trips. In the very densely populated area of Paris, where the public transport supply is excellent, the to-day car users are mainly car-dependent people, and the challenge of reducing the attractiveness of the car (especially regarding speed and flexibility) is a difficult objective for any transport policy.

Of course, our results show that the greater the constraints on car are (congestion, travel time irregularities, parking problems etc.), the greater is the part of the other modes. But whatever the constraints on car we have tested, we observe that the traffic involved of the “irrational” car users (those users who could have gained to use other modes without an increase in their daily travel-time budget) is small.

Can we fight against those speed addicts that are the to-day car users? Our first results assert, as has been argued elsewhere (Morellet, 2002), that this aim is very difficult but not impossible to achieve. It emerges from this analysis that any policy can only reduce the car modal share by a few percentage points without seriously modifying individuals’ activity patterns and travel time for the great majority of drivers. Reducing car speed (by reducing the road space capacity or parking facilities) could be a more appropriate policy. This latter policy is more efficient than any increase in public transport supply. Public transport supply improvements, whatever how great, are not able « alone » to achieve any decrease the car dominance: in order to be efficient, public transport improvements have to be accompanied with car speed modification if the individual cost of mobility remains unchanged.

It emerges also from our analysis that achieving anything more than a 25% vehicle-kilometre reduction in the Parisian context (30% in the Lyon context) would certainly require measures and approaches which cannot be part of our methodology as described here. Those more ambitious objectives with regard to car use reductions could not be achieved in any case, without threatening individual activity schedules, localisation patterns, travel speeds, transport players and services as our procedure has demonstrated that present-day alternatives to the car have limits in the context of a less ambitious scenario.

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