ECONOMIC EVALUATION OF AN URBAN TOLL HIGH SPEED ROAD NETWORK

EXAMPLE OF THE LASER PROJECT FOR THE PARIS CONURBATION

Roger MARCHE, Francis PAPON

INRETS - 2, Av. du Général Malleret-Joinville, 94114 ARCUEIL, FRANCE

1 - INTRODUCTION

The master plan for the development of the Ile de France region aims at reinforcing its position as economic and cultural metropolis within Europe, and rebalancing its economic activities within the region and improving the life conditions of the Ile de France population in terms of housing, transport and environment. Projects are being studied for public transport: new RER lines and metro line extensions (extensions to existing lines, METEOR project). The motorway projects (Cf. fig. 1) are designed to improve traffic in the suburbs and alleviate traffic conditions on the Paris "périphérique".

In July 1987, GTM Entrepose proposed to build a high speed underground road system beneath Paris and the inner suburbs and to operate the system; the project is to be toll financed.This network, the LASER (Liaison Automobile Souterraine Expresse Régionale) would permit usage by private cars and small commercial vehicles.

The purpose of LASER is to complete, in the Paris urban area center, the network of motorways and expressways in the Ile de France region. Its first purpose is to offer a new high quality service to car users who prefer to pay a toll and gain time. For the communities, in particular the City of Paris, it is also an opportunity of promoting an ambitious policy of management of the surface roadways: bus and taxi traffic, car parking, pedestrian traffic, quality of the environment.

1.1 - General characteristics of LASER

A Working Group was formed in early 1988 by the City of Paris to look into the project in depth. The Working Group associated the City of Paris, the Police Prefecture, GTM Entrepose and its engineering subsidiary SEEE in charge of study, and experts (CETUR, DREIF and INRETS). For INRETS, the main participants in this expertise, under the direction of Georges DOBIAS, were Simon COHEN for analysis and traffic control aspects, François BARBIER ST-HILAIRE, Roger MARCHE and Francis PAPON for demand models and general economy of the project.

In 1987 (1), GTM Entrepose had proposed (C.f. Fig. 1):

- a "complete" network which could be built for the 2000 horizon, comprising five radial legs (completing the grid system comprising the motorways and the expressways around Paris) connected at the center of Paris by means of a "coronary arterial" ensuring exchanges in different directions ;

- the first phase, to be put into service in 1995, would correspond to the link between the La Défense business district and the A6 motorway to the South of Paris (legs B and E).

The Working Group studied the line-layout and outline variants for the different stations.

The most likely project is illustrated in figure 1 :

- for the complete system, the main modification of the initial project relates to the layout of the coronary arterial designed better to serve the SNCF stations ;

- as to the first phase, the start up of legs B and E would be completed by the production, at least partial, of leg D in order to facilitate also exchanges with Eastern Paris, the Eastern Ile de France region and the Charles de Gaulle airport ;

- at the 2010 or 2020 horizon, the system could be extended by a ring-road inside the Paris "périphérique" and other lines leading out to the suburbs.

Figure 1 - THE LASER NETWORK AT THE 2000 HORIZON

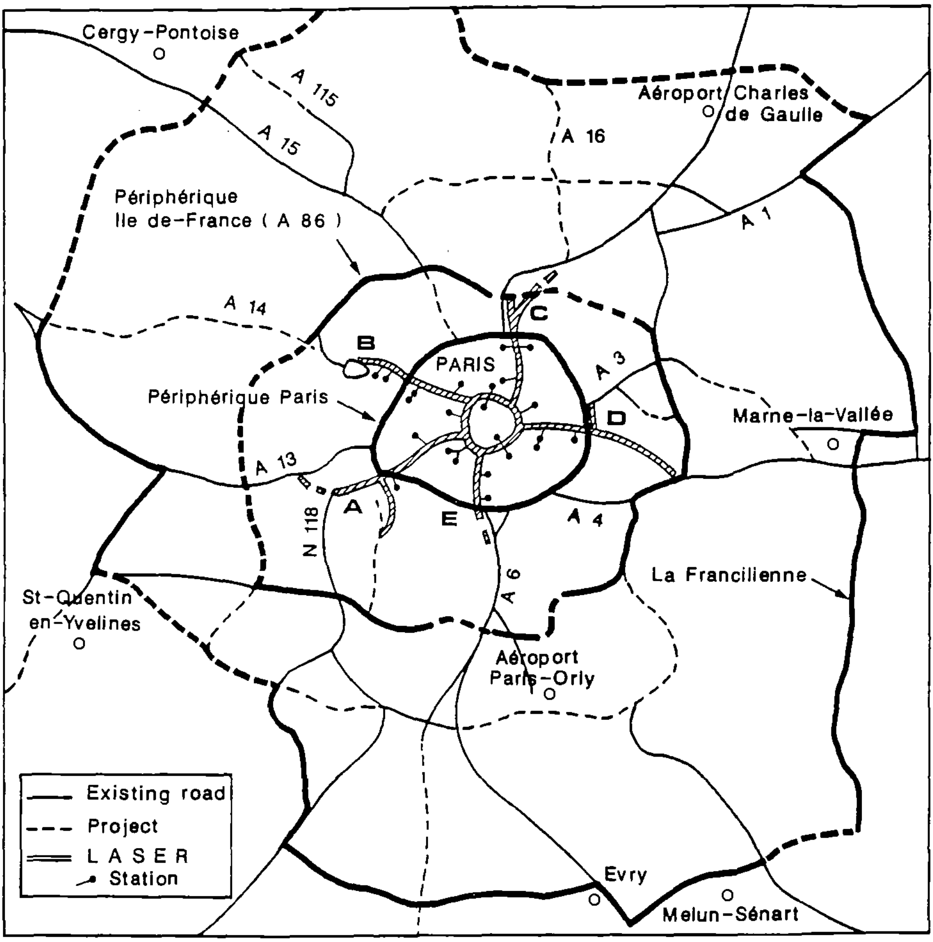


Table 1 shows the main physical characteristics of a complete LASER system.

Table 1 - CHARACTERISTICS OF THE LASER SYSTEM FOR THE 2000 HORIZON (main tunnel)

Length:	49 km
Internal diameter:	9.75 m
Number of lanes:	3 lanes in each direction, 2.80 m wide, 2 superimposed directions
Height beneath ceiling:	2.40 m
Vehicle gauge, height:	1.85 m
Traffic speed :	60 to 70 km/h
Practical capacity, 3 lanes:	4000 vehicles/h

A second underground high-speed system project for cars operating on a toll basis was put forward in November 1988 by the companies BOUYGUES and SPIE Batignolles: the project 3R (Réseau Rapide Régional) caters for 1 East-West line (between A4 and A14) and 2 North-South lines (one between A1 and expressway N 118 one between A3 and A6).

1.2 – Contents of the paper

The most thorough studies concerned the first phase of the project. To have a more global view of the economy of a system such as LASER, we have decided to present the complete system to you. This paper will be confined to the general economy of the project, leaving aside other aspects which have been studied by the Working Group:
- detailed analysis of traffic through LASER and therefore of the practical capacity of the network;
- management of the local aspects of the surface system in the immediate surroundings of the stations and at the points of junction with the regional network;
- operational and safety devices, toll perception devices;
- co-ordination with surface traffic control.

In succession we will present:
- in chapter 2, a brief description of the economic and social context of the Ile de France region and of travelling therein;
- in chapter 3, the methods used for estimating the LASER demand;
- in chapter 4, the financial balance of the project;
- in chapter 5, the economic balance of the LASER project, taking account of accompanying actions on the surface;
- in chapter 6, the main conclusions.

This paper takes account of the many files drawn up as part of the study, most of which are currently restricted (2). Some quantitative data have been estimated by the authors, more particularly by the extrapolation of data limited to part of the network; the orders of magnitude obtained are sufficient to illustrate the project economy. Nevertheless, the results presented only engage the responsibility of the authors.

2 - THE ECONOMIC AND SOCIAL CONTEXT AND TRAVELLING WITHIN THE ILE DE FRANCE REGION

A reliable demand model can only be produced if sufficiently accurate data are available on the space-time structure of travelling, taking account of the trip purposes, the previous and future trends of such travel. Naturally, it is also necessary to be able to estimate correctly the costs and time taken on travel.

For the Ile de France region, the statistical set-up is particularly rich as far as the trips of the resident population of the region are concerned, thanks to "overall transport surveys" carried out in 1976 and 1983-1984 by DREIF and RATP (which we will refer to as EGT 1976 and EGT 1983), by samples of households.

In the following, we give the characteristic outlines of the structure and of the 1976-1983 trend from these EGT's (3). Then we will indicate the future trends.

2.1 – Population and employment

In the 1982 Census, it appeared that 10.1 million people lived in RIF (Région Ile de France), 87% in the Paris conurbation. Note that the growth of the total population of RIF between the two Censuses in 1975 and 1982 was very slight: less than 0.3% per annum.

Table 2 indicates the geographical structure of the households living in the RIF, concerning the persons and the active within these households as well as the employment figures.

2.2 – Household cars

Table 2 shows the automobile equipment of the households. The RIF automobile fleet has increased approximately by 25% between the 1976 and 1983 EGT's: 10% for Paris, 25% for the inner suburbs and 35% in the outer suburbs.

2.3 – Household trips

Table 3 indicates the origin-destination structure of "motorized" individual trips carried out on average per working day.

As far as evolution between the 1976 and 1983 EGT's is concerned:
- for all the different modes, trips within Paris and between Paris and the suburbs are stable whereas growth is considerable for suburban trips (+12% over 7 years);
- this stability for the first 2 categories and the growth of the third appear for public transport and for car trips.

The statistics produced by the RATP and road traffic counts in the central of the conurbation concerned by LASER reveal a substantial growth (approximately 1% per annum) over the last decade. This is perhaps due to the growth of suburb-to-suburb travel via Paris but more particularly expresses the increased number of trips outside the EGT field and more particularly:
- for public transport, trips by RIF visitors (provincial and foreign) arriving by railway stations and airports;
- for automobiles, trips by visitors to RIF by car or taxi and a large number of trips of small commercial vehicles ; these trips represent 25 to 30% of those recorded by the EGT.

Table 2 - HOUSEHOLD RESIDENT POPULATION IN RIF IN 1983

		Paris	Smaller ring (1)	Larger ring (2)	RIF total
In main residence					
Households	Thousands	1101	1505	1374	3980
	%	27.7	37.8	34.5	100
Population	Thousands	2122	3780	3912	9814
	%	21.6	38.5	39.9	100
	Per household	1.93	2.51	2.85	2.47
Active	Thousands	1035	1790	1745	4570
	%	22.6	39.2	38.2	100
Employment	%	36.5	41.8	21.7	100
Household automobiles (3)					
	Thousands	580	1317	1541	3438
	%	16.9	38.3	44.8	100
	Per household	0.53	0.88	1.12	0.86

(1) Departments: 92 - Hauts de Seine, 93 - Seine St Denis, 94 - Val de Marne
(2) Departments: 77 - Seine and Marne, 78 - Yvelines, 91 - Essonne, 95 - Val d'Oise
(3) Vehicles available to household (owned or provided by 3rd party); cars and small commercial vehicles (less than 1000 kg payload)
Source: EGT 1983

Table 3 - "MOTORIZED" TRIPS (1) OF RIF RESIDENTS (2) PER WORKING DAY IN 1983

Main means of transport	Within Paris		Between Paris and suburbs		In suburbs		RIF total (2)	
	Thousands	%	Thousands	%	Thousands	%	Thousands	%
Public transport	1949	61.0	2261	59.9	1731	14.4	5941	31.2
Car (3)	1039	32.5	1357	35.7	8981	74.6	11367	59.8
Others (two-wheels)	209	6.5	169	4.4	1334	11.0	1712	9.0
Total	3197	100	3777	100	12046	100	19020	100

(1) Therefore excluding travel on bicycle or on foot
(2) Excluding travel with one destination outside RIF (212,000 in 1983)
(3) Including small commercial vehicles
Source: EGT 1983

2.4 – Car parking

Table 4 indicates the number of parking movements in Paris during the working day, of the RIF household cars that have moved.

Between the 1976 and 1983 EGT's:

- like the RIF resident trips concerning Paris (Cf. paragraph 2.3), the number of parking movements has varied little: stability for on-street parking and 10 % increase for off-street parking ;
- paying parking has practically doubled both on-street and off-street.

Table 4 - NUMBER OF PARKING MOVEMENTS IN PARIS DURING THE WORKING DAY FOR CARS (1) OF RESIDENT HOUSEHOLDS IN RIF IN 1983

	Public road		Off-road		Total	
	Thousands	%	Thousands	%	Thousands	%
Free	616	66.0	340	68.4	956	66.8
Paying	318 (2)	34.0	157	31.6	475	33.2
Total	934	100	497	100	1431	100

(1) Including small commercial vehicles
(2) Including illegal parking
Source : EGT 1983

2.5 – Future trends

Drawing up the LASER demand model involves:

– forecasting the space-time evolution to the 1995 or 2000 horizon, that of the "natural" demand for travel i.e. the demand with a constant transport supply ;
– the estimation of the elasticity of this demand to the projected modifications concerning the transport supply level.

To make any relatively accurate forecasts of the natural demand for travel by car, it would be essential to establish an ambitious model which not only takes account of the regional development project (space structure and socio-economic characteristics of households, employment and other activities for which travel is carried out), but also of the competition between cars and public transport.

The method used for projecting the origin-destination matrices to the 1995 horizon for travel by car during working days, obtained by the 1983 EGT, consisted simply in a reasonably extrapolation of previous trends leading to:

– a slight growth of trips within Paris and exchanges between Paris and the suburbs: +8% in 12 years;
– a more substantial growth of travel in the suburbs: +22%.

3 – METHODS OF ESTIMATING THE LASER DEMAND

3.1 – The demand diverted from the surface roadways

The model used by GTM is a simple and solid model based on the following principles:

– the Ile de France region has been subdivided into 41 areas corresponding to points of choice between the surface route and the route using LASER: 17 areas for Paris, 24 areas for the suburbs;
– the distribution of the demand between surface roads and LASER, for each origin-destination pair, depends upon the difference of the generalized costs (traffic costs + time cost) with the incorporation of a statistical distribution of time costs by hour ;
– taking account first of the variation of the travel time according to the time of the day and second, of statistical distributions of the different time values according to the trip purpose, 9 models of demand have been distinguished which combine 3 different periods of the day (depending upon the time of departure and for the 13 heavy traffic hours retained within the working day, from 7 am to 8 pm : morning peak from 7 am to 8.30 am, evening peak from 5 pm to 7 pm ; normal hours) and

3 categories of trip purpose (with the hierarchy of activities at the origin and destination: professional trips, travelling to or from the customary place of work, other private trips).

The distributions of the hourly costs in FF 1988 were obtained by adjusting log-normal distributions to the distributions of time EGT 1983 trips according to the income of the household and making any necessary corrections (income received by household for private travel and hourly working cost for professional trips; occupancy rate of vehicles; updating from 1983 to 1988). Table 5 gives the values retained which have been modulated according to the income level of the car user residential areas.

Table 5 - HOURLY COST OF TIME: LOG-NORMAL LAWS C (h)

	Professional trips	Commuting	Other private
Median value (F1988/h)	173	67	55
Mean value (F1988/h)	196	74	64
Standard deviation s of ln h	0.499	0.460	0.548

It was important to estimate the order of magnitude and the approximate location of traffic alleviation at the surface resulting from diversion toward LASER. Accordingly, for each origin-destination pair, the model takes account of two surface routes: with and without the use of the Paris "périphérique". The total demand was first spread between the two routes then diversion toward LASER was applied to the two corresponding parts.

To verify the digital values of the hourly time costs, the only example of a motorway toll at a relatively high level in an urban area was used: the use of motorway A8, West of Nice. Therefore, INRETS analyzed the origin-destination survey made in November 1985 completed by journey time records, in December 1988 (4). The results confirm the fact that hourly costs are high, in particular for professional trips but the intervals of confidence of the estimators are very large.

The second innovation consisted in constructing a statistical model of the demand illustrated in figure 2 (5). It has been observed that:

- in the generalized cost differences between routes with LASER and without LASER, the travel cost differences are negligible with respect to the toll and thus the decision to use or not use the system is dependent solely on the gain in time;
- for a given category of trip purpose, and for a given period of the day, the statistical distribution of the demand according to the time gained by LASER, with a zero toll, follows a log-normal distribution relatively accurately. Therefore, it is the same for the distribution of the demand according to the costs of time D(h), for a given toll ;
- therefore, the two log-normal distributions D(h) and C(h) can be combined.

Accordingly, the model based on a two variables log-normal distribution makes it possible to :

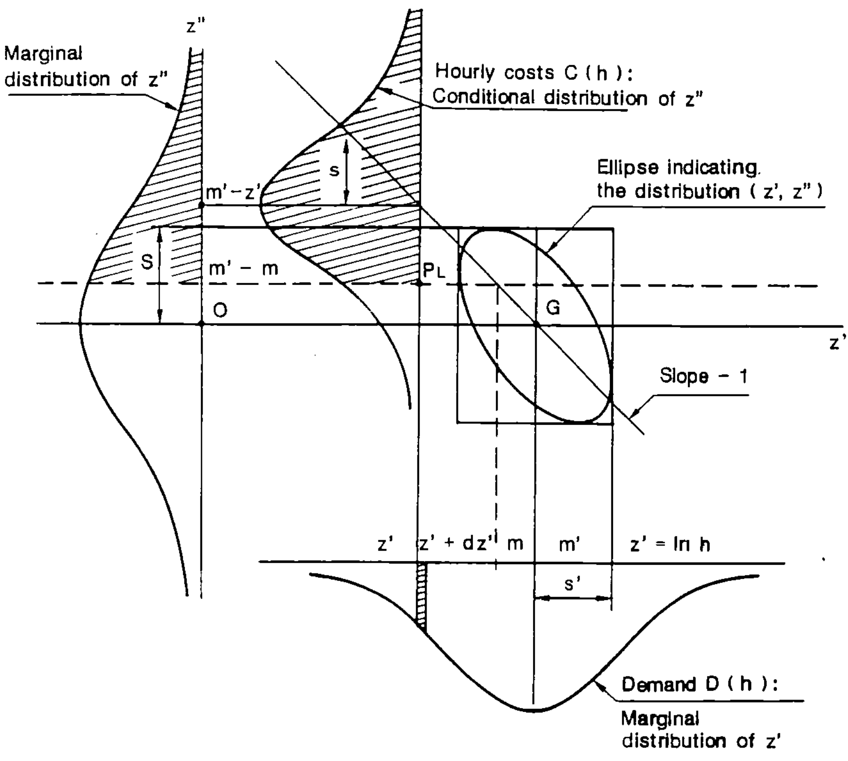
- estimate the demand for a given toll: this is the hatched area of the marginal distribution of "z";
- because it is easy to connect m' to the toll and since $S^2 = s^2 + s'^2$, relatively simply mathematical formulae can be used for checking the numerical results of the model and more particularly to study the sensitivity of the results to the hypotheses, by modifying the values of the parameters.

In particular, the following were tested:

- the influence of uncertainties on the values of the parameters (m and s) of the time hourly cost distribution;

- the introduction of a time gain variability aspect as procured by LASER, linked more particularly with the extent of the zones, leading to a modification of parameter s'.

Figure 2 - THE LOG-NORMAL MODEL OF THE DEMAND



3.2 – Demand induced within LASER

LASER patronage diverted from the surface roads benefit from generalized costs which are lower than those corresponding to surface travel. This factor forms the economic surplus for this patronage (consumer rent) and leads to an "induced" demand which may originate from the diversion of public transportation and to increased mobility.

On the proposal of INRETS (6), the induced demand was estimated by applying to the surface traffic diverted demand reasonable elasticity coefficients (-a) with respect to the generalized average cost of LASER patronage :

- the application of an elasticity coefficient (-1) would correspond to the preservation of a "generalized cost budget";
- because the considered generalized cost is only partial (the travel costs are marginal costs and between choice points of the routes only; excluding parking costs), it appears more justifiable to consider a value of a less than 1;
- estimations have been made with a = 1/3 for commuting trips and a = 2/3 for other trips ;
- however, variants have been tested, including a > 1 for other private trips for which destination transfer might be considered.

However, it was essential to check that the elasticity coefficient applied to commuting trips led to a result compatible with the possible diversion of high-speed public transport (RER lines and suburban trains). So, a specific model was produced for this purpose (7).

4 – THE LASER DEMAND AND LASER'S FINANCIAL PROFITABILITY

4.1 – Conditions of application of demand models

Let us remind that the 9 demand models (3 categories of trip purposes, for 3 time periods) concern "full" periods of "working" days (13 h x 240 d). It should be specified that the corresponding origin-destination matrices:

- derived from the 1983 EGT but are based on the demand model of the DREIF (evening peak period) adjusted to EGT;

- take account of corrections: exclusion of trips shorter than 3 km as the crow flies; projection to 1995 horizon (Cf. paragraph 2.5, values modulated between peak periods and normal periods); increase to take account of vehicles beyond the range of EGT (Cf. paragraph 2.3; also modulations according to the periods).The situation of surface travel conditions is known through trip time records made in 1985 by the City of Paris and in 1981 by DREIF for the remainder of the region. It was considered reasonable to preserve these journey times for 1995 in the hypothesis that the LASER project is carried through because:
- the current situation (1988) appears to be somewhat deteriorated ;
- there are few improvements to be expected (impact upon the city center of the continued construction of the Ile de France ring-road, limited impact of LASER because of the accompanying measures considered for recovering the surface).

It should be specified that the speeds retained for LASER (main tunnel) are 60 km/h at peak periods and 70 km/h during normal periods.

4.2 – LASER demand

For a given period of the working day, and for traffic diverted from the surface:

- it has been seen that the demand curves according to tolls, taking account of the purpose for travel, are similar to the accumulative log-normal curves;
- when the purposes are put together, the demand curve comes close to a negative exponential;
- around the optimum toll level, the income curve is relatively flat;
- naturally, the optimum toll is higher for peak periods.

The induction rate (induced demand/diverted demand) around the optimum toll is around 12%.

One highly important result is that the total demand for LASER (diverted demand + induced demand) is coherent with the practical capacity. However, in peak periods it will probably be necessary to limit the demand somewhat on certain branches by increasing the toll.

It should also be observed that the hypothesis of a toll proportional to the distance within LASER has been tested. This hypothesis which encourages short trips is rather unfavorable concerning the financial profitability and public interest (alleviated surface traffic to a less degree).

The main characteristics of the LASER demand are as follows (complete network; 13 full hours on working days):

Average toll:	25 FF 1988 per trip
Number of trips:	25,000 vehicle entries/h
Into main tunnel and access branches:	
– average trip length:	11 km
– average load per lane:	900 vehicles/h.

4.3 – Financial profitability of LASER

The tolls for the 3120 full hours of the working days should supply close on 2 billion FF 1988 receipts. The network is assumed to be opened 19 h per day (closed at very low periods during the night).

Rougher estimations of the demand and of the tolls have been made for the other 3815 opening hours (1,250 h full hours, Saturdays, Sundays and holidays; 2,565 slack hours). They lead to the following supplements with respect to the full hours of working days: 70 to 75% of trips and of vehicles-km, almost 40% of the receipts.

Taking account of the uncertainties, particularly concerning time hourly costs, annual receipts can be estimated at 2.5 to 3 billion FF 1988.

By extrapolating the estimations made by GTM Entrepose for the first phase, the costs relative to the complete network are approximately as follows:
- investment cost: 20 billion FF 1988, tax inclusive (including VAT), and 24 billion FF 1988 taking account of the compound interests during the construction of the successive phases;
- annual operating costs : 200 million FF 1988, tax inclusive.

Net annual receipts (tolls minus operating costs i.e. 2.3 to 2.8 billion FF 1988) referred to the investment cost, reveal an immediate financial profitability rate of 10 to 12%. Thus the project may be financed on private funds.

4.4 – LASER patronage

For working-day full hours, the distribution of the LASER demand according to the trip purposes is approximately as follows in terms of the number of vehicles and the number of vehicles-km: professional trips: 75%, commuting 15%, other private trips 10%.

So, LASER customers are mainly car users travelling for professional purpose. Among the annual patronage, this professional trips represents approximately 60% of the demand and two thirds of the receipts.

Finally, the distribution of LASER vehicles according to geographic travel categories, is indicated for full hours on working days: in Paris: 16% ; between Paris and the suburbs: 72% ; from suburbs to suburbs : 12%.

5 – ECONOMIC BALANCE SHEET OF LASER FOR THE COMMUNITY

5.1 – Surplus of LASER patronage

The analysis of the curves of demand as a function of the toll and the log-normal model demonstrate that the value given by LASER customers to the obtained gain in time is approximately twice the amount of the toll they would pay. In other words, these customers would benefit from an economic surplus (consumer rent) of the same order of magnitude as receipts probably more than 80% of receipts.

In terms of annual overall values, for the complete network:

- it should be noted that the receipts are estimated at 2.5 to 3 billion FF 1988, hence a minimum surplus of 2 to 2.5 billion 1988;
- the demand is approximately 140 million vehicles and 1.5 billion vehicles-km, corresponding to an average toll of around 20 F/vehicle and 1.8 F per vehicle-km, hence a minimum average surplus of 16 F per trip and 1.5 F per vehicle-km;
- the total time spent within LASER would be approximately 30 million hours and would have been approximately twice that for surface roads;
- the gain of 30 million hours (on average 13 minutes per vehicle) would be paid for on average at around 90 F/h whereas the usage value is around 160 F.

5.2 – Accompanying surface traffic measures

Gradually as the LASER network is extended, the terminal trips of LASER customers around the Paris stations would become fewer.

If the traffic induced in LASER is taken into account (approximately 11% of the LASER demand), the demand model for the complete network would demonstrate that the alleviation of surface traffic in Paris and the inner suburbs would represent more than 80% of the vehicles-km travelled through LASER.

For peak hours on working days:

- traffic in LASER would be approximately 300,000 vehicles-km/h;
- this represents an alleviation of approximately 250,000 vehicles-km/h, corresponding to a capacity of around 500 km of roads with traffic lights jonctions;
- this alleviation would be subdivided approximately between 150,000 vehicles-km/h for Paris (including the "périphérique") and 100,000 vehicles-km/h for the suburbs;
- by comparison with surface traffic (1.1 million vehicles-km/h for Paris and 1 million vehicles-km/h for the inner suburbs), this leads to relative alleviations of approximately 15% for Paris and 10% for the suburbs.

If the capacity thus set free at the surface was left to automobile traffic, it would be greatly recovered by the induced traffic. Hence:

- a low gain in trip time and therefore a moderate economic surplus of surface users;
- a worsening of the parking situation;

- a certain diversion of public transport leading to loss of receipts for RATP and SNCF.

Thus, the LASER network is an opportunity for better management of surface road space because the set free capacity can be assigned to usages leading to far greater economic surpluses. These "accompanying measures" have been recommended by experts. They are destined to use a substantial share of the set free capacity:

- to improve bus and taxi traffic by means of reserved lanes and traffic light control;
- by continuing the parking policy and offering well designed places (at the surface or underground), but paid at the right price;
- to improve the pedestrian traffic and the living conditions of city dwellers: widened sidewalks, creation of pedestrian areas and landscaped spaces, elimination of illegal parking.

5.3 – The economic balance sheet for the community

The INRETS appraisal estimated the costs and advantages of the community for various levels of recovery of surface road space for the first phase of the project. The following estimations correspond to extrapolations for the complete network in the hypothesis of recovery for buses and pedestrians corresponding to approximately one third of the liberated capacity with this recovery located mainly in Paris.

The following were examined:

- state surplus: VAT on LASER and tax on dealer profit, (low) variation of fiscal receipts on car usage, (low) increase in public transport deficit corresponding to traffic diverted toward private cars;
- surplus of surface road users: buses, taxis and cars;
- surplus of pedestrians and residents;
- the cost of the accompanying measures and parking balance sheet, including new car parks that the LASER concessionary intends to construct.

The elements of this economic balance for the collectivity are as follows:

a) investment cost, tax exclusive, including compound interests : 21 billion FF 1988;
b) net annual receipts, tax exclusive: 1.9 to 2.4 billion FF 1988;
c) LASER customer surplus: 2 to 2.5 billion FF 1988;
d) other surpluses (defined previously): 2 to 2.5 billion FF 1988.

It will be noted that the surpluses linked with the fitting of the surface road space are of the same order of magnitude as the LASER customer surplus and net receipts. This produces an economic profitability ratio three times higher than the financial profitability ratio, i.e. 28% to 35%.

6 – CONCLUSIONS

6.1 – Economic and social interest of LASER

The congested traffic on surface roads in the center of the conurbation (Paris and inner suburbs) is leading to a situation which is very remote from the economic optimum (maximization of economic surplus) whereby traffic should be limited by an urban toll related to the "marginal social cost" of the congestion. The public opinion is not ready favorably to welcome an urban toll such as this, in that it is considered as an excessive charge by automobile users, in particular households with modest income living in the center of the conurbation.

The high social cost of parking on the public road space justifies the policy to extend paying parking and to raising prices. This policy is well received by most car uses in that they can quickly find parking places. But a very severe parking policy (limitation of places, high prices) would not alone resolve the problem of traffic: it would not be justified by the economic theory and would not have sufficient impact.

The first characteristic of the LASER network is its moderate construction cost permitted by technical progress made in the area of large diameter tunnel drilling whereby twice three lanes can be constructed for cars and small commercial vehicles when geological conditions are favorable. This construction cost is lower than the real estate value alone of the roads needed to ensure provision for the same number of vehicles-km/h.

In addition, the gain in time obtained by LASER and the fact that the travel time within LASER is "guaranteed" give the customers a high usage value:

- the demand is sufficient for project financing (investment and operation) to be assured by the tolls collected;
- the user surplus remains very high and enables customers to accept paying parking, even if relatively costly, all the more so that parking can go hand-in-hand with high quality service (nearness of interregional railway stations, possibility of reservation and easy payment connected with teletoll functions).

The second characteristic of the LASER network is that it is a new high-quality service product open to car users who can choose to pay this high quality service or to use the ordinary system. When compared to the kilometer travelled, the toll is far higher than that of inter-regional motorways but the gain in time is far higher too.

The third characteristic is that the LASER network is an opportunity for an ambitious policy for travelling and for living conditions to be improved in the conurbation center by assigning part of the set free road capacity at the surface usages whose economic value is higher than that of automobile traffic:

- improved traffic for buses and taxis;
- moderate improvement in surface traffic but whereby more expensive but better developed parking is more widely accepted: easy use for users and less hinderance for traffic, pedestrians and residents;
- improved pedestrian traffic and improvement in residential environment (landscaped areas, less noise and pollution, improved safety).

Social equity is generally defined by the condition that no users be left out from a project. This is the case of car users who will be using surface roads either because they are making trips for which LASER is not designed to afford any gain in time, or because they consider that the gain in time obtained by LASER is not worth the toll. Indeed, these users would benefit from travelling conditions at least equal to what they would be without LASER.

6.2 – Methodological thinking

Studies of the LASER project have made it possible to enrich thinking about the economic and social interest of high speed urban toll ways through major conurbations. To make relatively accurate estimations, new models will have to be developed:

- the effect of tolls has been brought into the models with capacity constraints, in particular DAVIS (8);

- to better understand capacity constraints, it might be worth renewing the dynamic traffic flow models such as PHEDRE (9);
- it would be advisable to bring in the parking prices.

However, we must not underestimate the heavy task represented by:
- first, the generation of suitable data base relative to demand and supply;
- second, the estimation of the parameters defining the functions of demand.

As far as these parameters are concerned:
- the analyses made in the West of Nice gave orders of magnitude for statistical distributions of time hourly costs;
- but the methods of survey of the "stated preferences" type might be considered to estimate, at least in terms of relative values, the effects of different parameters such as: the journey time and the guaranteed time, the driving comfort, the price and quality of parking.

Naturally, when the first phase of the high-speed toll underground network has been put into service, it will be necessary to establish a model of the "revealed preferences" type once the adequate data have been collected.

REFERENCES

1 – F. LEMPERIERE, A. BROTO, P. GRAVOST and I. de MAUBLANC (GTM), "Pour traiter la circulation parisienne, le LASER remède miracle ou gadget 7". Revue Générale des routes et aérodromes, n° 654, July-August 1988.

2 – Documents, currently restricted, by GTM Entrepose and the LASER Working Group (1988-1989).

3 – DREIF and RATP. "Les déplacements des Franciliens, Enquête globale de transports 1983-1984" June 1988

4 – In (1): F. PAPON "Note de travail n° 8, Analyse des valeurs du temps dans les Alpes Maritimes", INRETS, 6 March 1989

5 – In (1) R. MARCHE "Note de travail LASER 88.7, Estimation du trafic induit dans LASER". INRETS, 26 December 1988

6 – In (1) : R. MARCHE "Note de travail LASER 88.3, Surplus et demande induite", INRETS, 18 May 1988.

7 – In (1): F. PAPON, "Calcul de l'impact de LASER sur les transport collectifs". INRETS Appraisal Report, Appendix E, 13 January 1989.

8 – F. BARBIER ST HILAIRE, "Système DAVIS-TRIBUT", INRETS, 17 January 1989

9 – M. DANECH-PAJOUH, "PHEDRE. Un outil d'evaluation des conditions de circulation urbaine", Revue Recherche transports sécurité, INRETS, September 1986.