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July 1981

LONG-TERM URBAN TRANSPORTATION PLANNING METHODOLOGY IN FRANCE A REVIEW

L. J. A. Ferreira

Working Papers are intended to provide information and encourage discussion on a topic in advance of formal publication. They represent only the views of the authors and do not necessarily reflect the view or approval of the sponsors.

This work was carried out whilst the author was employed by the National Institute for Transport and Road Research, C.S.I.R., Pretoria.

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ABSTRACT

L.J.A. FERREIRA (1981) Long term urban transportation planning methodology in France - a review.

An outline of the general principles underlying urban transportation planning in France is given here. Also reviewed is the methodology used when carrying out long-term transportation studies.

There is an attempt in France to co-ordinate transport and land-use planning through a process of continuing dialogue between those responsible for urban planning. This reliance on individuals' intuitions distinguishes the approach from the more conventional exercises which attempt to model the interaction between land use and transport.

The approach followed uses simplified techniques for travel forecasting purposes. This allows for alternative transport plans to be considered quickly and cheaply at the expense of using travel demand models lacking a sound behavioural base.

CONTENTS

LONG TERM URBAN TRANSPORTATION PLANNING METHODOLOGY IN FRANCE - A REVIEW

1. INTRODUCTION

1.1 The overall planning process

In 1967 the French Government defined a process for land-use planning in built-up areas which requires two separate plans to be established for each town of more than 10,000 inhabitants:-

i) A long-term land use plan (30 or 40 years into the future) known as SDAU. (Schema Directeur d'Amenagement et d'Urbanisme)

ii) A medium term land-use plan laying down land uses on a zonal basis. This is known as P.O.S. (Plan d'Occupation du Sol)

In 1972, both principles and methodology for urban transportation studies were laid down so as to integrate land-use planning with transport requirements.

The following five levels were identified for transportation studies:-

Level 1: Long-term strategic studies interacting with the SDAU and to be financed by the Central Government. The main purpose of these studies is the establishing of the major corridors for transportation facilities for cities of 20,000 or more inhabitants.

Level 2: Medium-term studies (20 to 25 years) to determine exact land requirements for a specific transportation facility. These studies must take the medium-term land use plans (POS) into account. The process of developing level 2 plans is a long and difficult one and is usually completed only after level 3 studies are undertaken.

Level 3: Investment programming studies. These are five-year plans containing a detailed priority list of trnasportation improvements to be undertaken. Such studies are done at the city level and updated annually.

Level 4: Exact estimates of costs of specific projects.

Level 5: Detail design and documentation for specific projects.

The present report is concerned with planning at the strategic level, i.e. level 1, and it is to such studies that our attention will now be turned.

1.2 Strategic transport studies

1.2.1 Objectives These studies are undertaken in conjunction with the long-range land-use plans which were mentioned in the previous section under the name of SDAU studies. Towns of more than 10,000 inhabitants are required to produce such SDAU plans and a great number of them have already completed the corresponding level 1 transportation studies. The final aim of such transport studies is the elaboration of two documents:

i) A long-term plan (30 to 40 years)

ii) A medium-term plan which will serve as the basis for studies of a more detailed nature. (level 2)

The process involves the development of a number of land-use and transport alternatives which are then evaluated and discussed amongst all interested parties until the best compromise solution is achieved. The overall objective is to achieve compatibility between a proposed land-use plan and the transport facilities which will serve that particular urban structure. Apart from identification of problem areas, the studies should bring forward the risks of incompatible alternatives and make the necessary recommendations. It is possible, for example, that a particular land-use strategy will result in the necessity to build transport infrastructures which are unacceptable for economic, environmental or other reasons. In this case it is the task of such strategic studies to revise the land-use plans accordingly. It is this constant interaction between transport and land-use which makes the french approach such an attractive proposition. Transport plans are not developed in isolation but rather in a climate of dialogue between urban planners, engineers and local officials. The establishment and progress of this dialogue is essential to the success of the studies.

In order to evaluate quickly a large number of options, studies need to use simple and understandable procedures. The simplicity of the methods used goes a long way towards bridging the gap between planners and engineers on one hand and local politicians and administrators on the other. In this way a transport system, compatible with the proposed land-use structure can be established to meet pre-set objectives. These objectives are themselves arrived at through the dialogue set in motion by the studies and referred to earlier.

1.2.2 Institutional framework A Steering Committee is created to discuss fundamental problems and review study progress. The commission in charge of preparing the SDAU, which incorporates the various political and administrative authorities of the area, may serve as the Steering Committee. In this case, the tasks of the Commission are enlarged to encompass long-term transport studies.

A more operational working group is set up to prepare the study program, discuss study methods and compile the final reports. This group, known as the Technical Committee, may include:

i) City Engineer (or engineers if more than one city is involved);
ii) Regional Authority representatives (if such authority exists);
iii) Public Transport representatives (bus operators and railways).

The Technical Committee will supervise a more restricted study team which has the task of carrying out the study.

1.2.3 Methodology The urban division of SETRA (Service d'etudes techniques des routes et autoroutes), has compiled a set of manuals which give guidance on the methodology to be followed when conducting transport planning at the strategic level 1.The general approach recommended is of the form shown in figure 1.

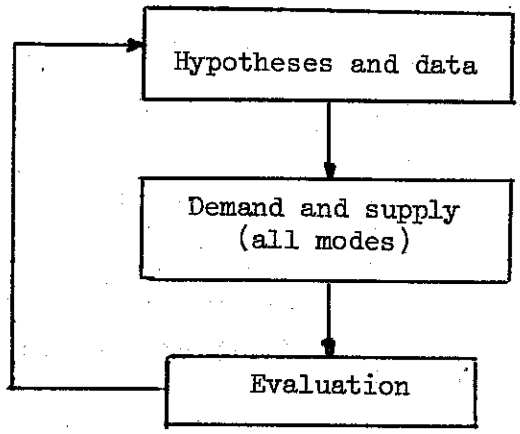


Figure 1: Strategic transport planning process

An iterative process is adopted whereby both land-use and transport strategies are revised after the evaluation stage and the whole process stopped when a plan is able to satisfy predicted demand whilst preserving the environmental quality of urban life.

The various components of the approach outlined in Figure 1 will now be looked at. Emphasis is placed on standardisation as far as data collection is concerned (i.e. trip purposes, modes, definitions etc. must be the same for all studies). A manual on Home-Interview Surveys was also compiled by SETRA in an effort to achieve uniformity. By 1974 a total of 19 Home-Interview-Surveys using this standard were carried out in France for cities of 200,000 or more inhabitants. The results of these surveys, which are available in a standardised form, have been used throughout the procedure developed by SETRA to arrive at a set of factors (ranging from propensity to travel to modal-split factors) which are then applied to any new study after study area size and any other special features have been taken into account. The data which are required for a particular study area fall into five categories:

i) Distribution of population and employment throughout the study area;
ii) Public transport inventories;
iii) Screenline and cordon counts;
iv) Existing capacity of road network and parking supply in the central area;
v) Information on the urban structure.

This will enable separate maps to be drawn showing the difficulty of acquiring land; possible highway corridors; possible public transport corridors and potential parking space available.

Although the establishment of a quantified hypothesis for urban development is the task of those responsible for the preparation of the SDAU, it is desirable that the transport study team be associated with the development of the different land-use alternatives. In practice, land-use strategies should not be more than two to four in number. This is found to be sufficient for the most important implications to come to the surface.

The most important phase of the process is the development of highway and public transport networks to meet the predicted demand for movement in the study area. Due to its importance the methods used in the development of such networks will be discussed in detail in the following chapters.

For evaluation purposes, the following five sets of criteria are usually used:-

i) Costs
ii) Accessibility
iii) Environmental evaluation
iv) Impact on urban development
v) Unexpected events.

1.2.4 Cost of strategic studies Considering the importance of this stage in the planning process, the costs, which are said to be fairly moderate, consist of:-

- The coding of the different land-use hypotheses;
- Trip generation and distribution for base year and 2 design years (1990 and 2010) for 2 or 3 different long-term hypotheses.
- Recommendations for future highway network.

A gap of one year occurs between the start and the end of a sketch plan.

2. METHODOLOGY FOR HIGHWAY NETWORK DEVELOPMENT

2.1 General principles and main objectives

An urban highway network must have as its main objective the improvement of people's accessibility without deterioration of their quality of life. The essential problem in most urban areas is that of Central Area accessibility. Three types of trips to the centre can be considered:

i) Internal trips - Such trips are made wholly within the central area and are expected to grow only moderately in the future. According to French experience, 50% growth in such trips is predicted in the next 30 years.

ii) Trips to the central area from outlying residential areas - these are likely to increase at a fast rate. It is suggested that they will in fact have a 100% growth from 1965 to 1985.

iii) Through trips - these are expected to have the highest growth rate due to the expected growth in population and economic activity in the outlying areas. One of the major problem areas is therefore the development of a satisfactory scheme to protect the central area from those journeys which have no business there.

Figure 2 shows the sequential procedure recommended to arrive at a medium-term network. Having estimated future traffic demand, one can recognise four main stages in network development:-

i) Syntheses and visualisation of the requirements;
ii) Selection and evaluation of the alternatives to protect the centre;
iii) Progressive development of the network;
iv) Formulation of conclusions.

These conclusions will be presented under three main headings:-

A. Generation of long-term alternatives - The first objective of strategic planning can be said to be the evaluation of a wide range of alternative networks in conjunction with the various land-use plans proposed. In practice each land-use alternative does not usually generate more than one or two basic transport network alternatives.

B. The intermediate stage network - This can be obtained by reducing the long-term network length either through the omission of some links and/or by reducing the dimensions of links.

C. A summary of the quantitative analysis - In the final analysis a rough estimate should be given on the investment costs of the networks as well as on the number of central area parking places to be provided.

A detailed description of the methods used at each stage of the process outlined in Figure 2 will be the subject for the remainder of this chapter.

2.2 Study area and the zoning system

All studies should work from a base zoning system. This base system which will serve as a starting point for all other configurations is required for the purpose of data collection as well as for the forecasting stage. Zones in this first system should be homogenous in terms of land-use and traffic generating power, as far as is practically possible. The system should also be coherent with the existing highway network, it

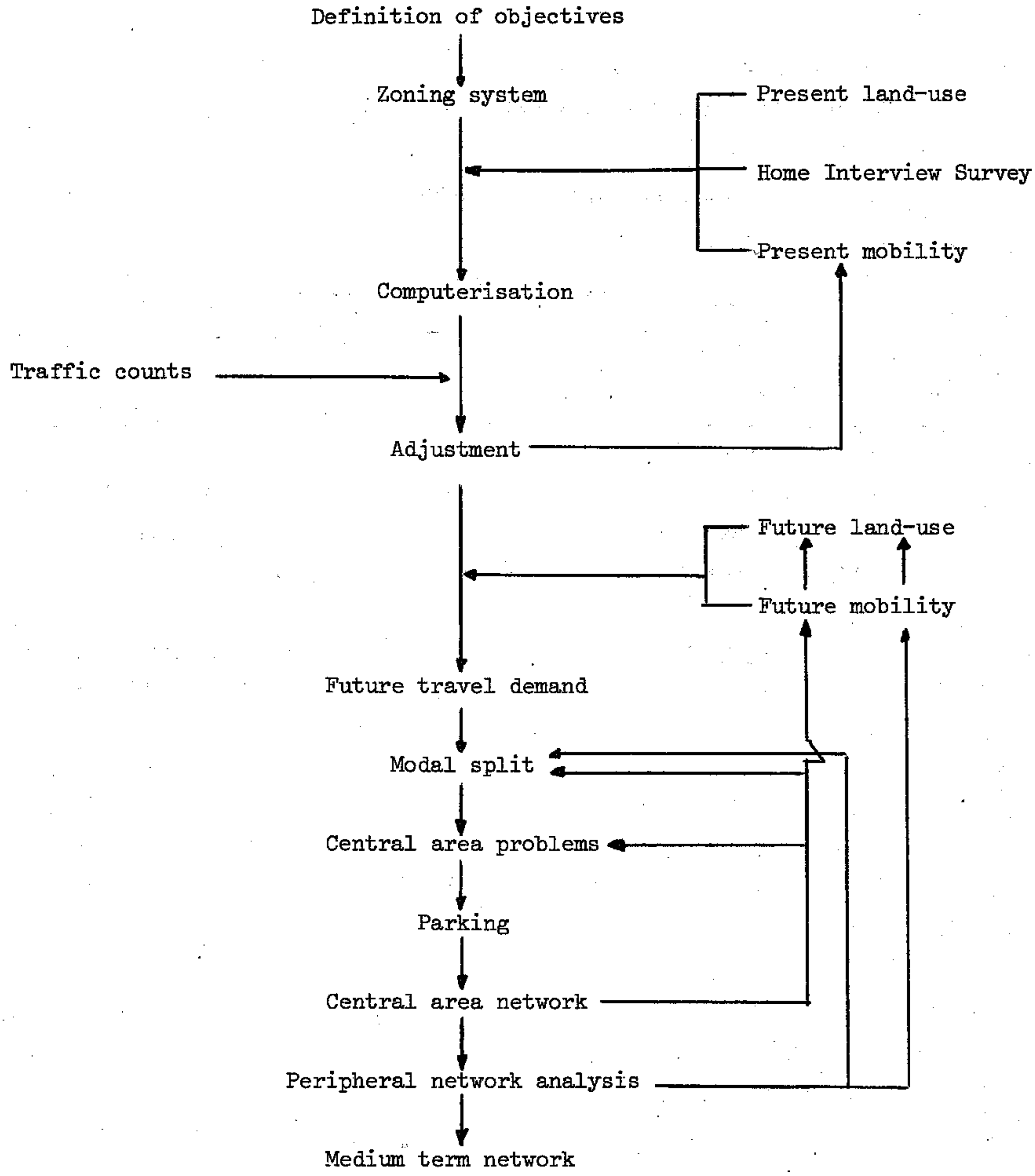


Figure 2: Methodology flow chart for highway network development

should respect natural barriers and finally it must lend itself to easy adaptation.

For small towns, the size of zones varies between 2,000 and 10,000 people per zone. For larger cities, it is permissible to go up to 30,000 people per zone.

Table 1 below shows typical values for the number of zones for different size towns.

Table 1 : Relationship between number of zones and size of town.

Population (000's)	50	100	200	400
Number of zones	20	30	40	50

For small towns, two zoning systems should be considered. One for the town itself and known as the internal zoning system and another comprising the area of influence of the town - external zoning.

2.2.1 Adapting the zoning system Several zoning configurations are used for various phases of the study. For trip generation estimates, the base system of zoning is normally used but a second system is required for the trip distribution stage. For this phase, zones should be of similar size and very small size zones should be avoided. Another zoning configuration is needed for modal split analysis emphasising existing or future public transport corridors. This is achieved by having smaller zones in the vicinity of such corridors.

When analysing the problems of the central area, such as traffic flow and parking, small zones, with a maximum mean diameter of 500 metres, are needed in the centre. In this case, the outlying areas of the town will have to be divided into larger units.

The choice of central area can also cause some problems. It is usually taken as the area of high density and with high service employment concentration. Sometimes a central area is defined as that area of the urban region which will give the following:-

$$\frac{\text{Service employment in the centre}}{\text{Total population of study area}} = \frac{1}{15}$$

2.3 Estimating travel demand

2.3.1 Trip generation For the strategic level of planning, six trip purposes are considered:-

1) Home - work
2) Work - home
3) Home - other
4) Other - home
5) Non-home based
6) Commercial

The calculation of work trips can be done in two ways. Either in the same manner as all other trips are calculated or by estimating first of all the number of workers who live in i and work in j and thus construct a matrix of workers where T_{ij} represents number of workers as opposed to the actual number of trips.

Before proceeding to explain how trip generation rates are arrived at it is useful to consider the following definitions:-

Zone emissions - number of trips with origin in the zone.

Zone attractions - number of trips with destination in the zone.

Trip productions - number of trips made by one person for a specified time period.

Emission and attraction factors:- These zone factors represent the number of "units" in the zone which are likely to be an origin (or destination) for the trip being considered. For example, the number of active persons in a zone represents the emission factor for the Home-work trips. An attraction factor for the Home-other trips of a zone is usually taken to be a linear combination of service employment, total employment and the total number of residents in the zone.

The following procedure to estimate trip generation has been widely used in the past:-

a) Calculate the emissions for each zone from detailed hypotheses of trip productions per person (or per household) per day.

b) Calculate the total number of trips in the Study Area. This is done by summing all trip emissions.

c) Calculate the attractions for each zone by apportioning the total number of trip destinations to each zone according to the attraction factors, on a pro rata basis.

The procedure recommended for future use is very similar in nature to that described above. The only difference is the a priori prescription of the total number of trips for each purpose considered. Comparison between different studies is therefore made easier by the introduction of this mean trip production per person. It is also easier to set an objective of mean mobility for such studies.

The recommended procedure calculates trip emissions and attractions for each zone by asking two questions:-

a) What is the total number of trips in the Study Area, for each trip purpose?

b) Where are the origins and destinations of these trips?

The first question is answered by calculating the total population and the mean trip production per person as set in the mobility objective. The second question involves the distribution of trips amongst zones according to emission and attraction factors. Such factors include correction coefficients to allow for the variation in the mean trip production from zone to zone. Correction factors are defined according to the following zone type classification:-

i) Hypercentre - strong service employment
ii) Centre - as defined by zoning system
iii) First ring - predominantly residential uses with little service employment
iv) Outer ring - contains recent developments of residential and industrial uses.

A detailed analysis of trip generation estimates for each trip purpose will now be given:-

1. Home - work trips:- for each zone i one obtains the total number of workers W_i and the total employment $(EMP)_i$. The percentage of workers who do not have to travel to work, denoted by λ_i, is determined from a curve which gives λ_i against the percentage of industrial and commercial businesses in zone i. This curve has been calibrated for 16 French towns. Absenteeism is also taken account of by introducing a factor giving the rate of those expected to be present at work per day. This factor, denoted by p is usually given the value of 90%. The number of workers travelling is therefore given by the expression: - $pW_i\ (1-\lambda_i)$.

The table below gives the expressions for trip emissions and attractions for each of the two approaches that can be followed.

Method	Emission	Attraction
Active workers	$E_i = pW_i\ (1-\lambda_i)$	$A_i = p(EMP)_i - \lambda_i W_i p$
Trips	$E_i = p.W_i\ d\ \mu e_i(1-\lambda_i)$	$A_i = p.\ d.\ \mu a_i(EMP)_i$ $- \lambda_i\ p.\ d.\ \mu a_i\ W_i$

where:- d = number of home - work trips per worker

μe_i = correction coefficient for zone i for work trips (emission)

μa_i = correction coefficient for zone i for work trips (attraction)

the parameters d, μe_i, μa_i, p and λ_i are all given from past studies.

2. Home - other trips:- the following emission and attraction expressions are used for such trips:

Emission

$$E_i = r.\ \mu e_i (POP)_i$$

Attraction

$$A_i = r.\ \mu a_i\ \{(POP)_i + \alpha(E_i^3)\}$$

where:- r = number of home - other trips per person per day

α = relative attractive power of service employment

E_i^3 = service employment in zone i

$(POP)_i$ = total population of zone i.

3. Non-home based trips:- the corresponding expressions for such trips take the form:-

Emission

$$E_i = k\ \mu e_i\ \{(POP)_i + \alpha E_i^3\}$$

Attraction

$$A_i = k\ \mu a_i\ \{(POP)_i + \alpha E_i^3\}$$

where all symbols are as defined earlier and k is the coefficient equating total attractions to total emissions.

2.3.2 <u>Trip distribution and the FABER model</u> For trip distribution purposes the gravity model concept is normally used. This takes the form:-

$$T_{ij} = E_i A_j f(d_{ij})$$

where T_{ij} = number of trips from zone i to zone j

E_i = emissions of zone i

A_j = attractions to zone j

and $f(d_{ij})$ = travel resistance function of the form $f(d_{ij}) = e^{-\alpha d_{ij}}$

where d_{ij} is the straight line distance between the two zones and α is the calibrating constant.

Having calculated home - work and home - other trip matrices, the work - home matrix is arrived at by taking 93% of the home - work matrix transposed. The other - home matrix is taken as the home - other transposed matrix plus 7% of the home - work transposed.

Computer programs have been developed to carry out trip generation and distribution analysis. The set of such programs known as the FABER transport demand model requires as input two types of data, namely zonal and study area data.

At the zonal level, we can distinguish between socio-economic and geographic variables. The former comprises total population; active population and employment, whilst the latter is made up of centroid and sub-centroid co-ordinates; internal distances and the number of sub-centroids in each zone.

Study area data can be sub-divided into two classes:

1) Geographic - total number of zones; deterrence function coefficients to be used in the gravity model and interzonal distances.
2) Mobility data - number of trips by workers for the home - work trip purpose (d); number of trips per person for the home - other category (r) and finally the number of trips per person for the non-home based type (x).

FABER runs on IBM 370/115 and is available in two versions which differ only on the maximum number of zones allowed (100 or 40). The memory storage for the 100 and 40 zone versions is 150 and 110k respectively.

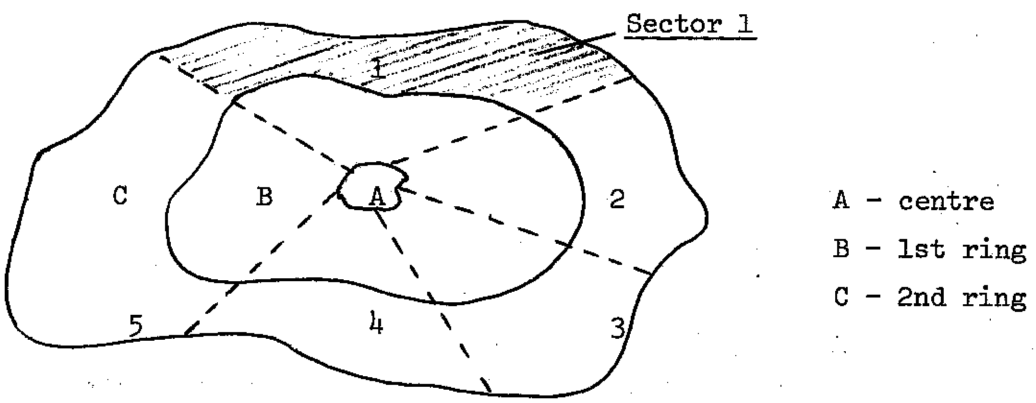
The output of the model, trip interchange matrices, must be validated and adjusted by means of the results obtained from screenline counts. Vehicle counts (mode and occupancy rates) are taken at various stations along a screenline so that almost all traffic crossing the screenline is taken account of.

Because the model is usually input with data from a base-year different from the date at which the counts are taken, a preliminary adjustment is necessary to bring the two figures to a common time base. This is achieved with the help of results obtained from a permanent counting station, located in a busy arterial, which gives the rate of growth of traffic.

External and through trips are accounted for by means of cordon counts. The cordon is usually placed so that it encircles part of the Study Area (the centre, for example). In this way traffic counts will also provide a check on internal trips of a radial nature. Counts can either be carried out automatically or manually, the latter providing also information about the type of vehicle and its occupancy. Aerial photography is also used to give directional and intersection flows.

Through traffic figures are extrapolated for the design year(s) by applying growth factors based on past trends. External traffic figures are also projected into the future by the application of similar growth factors to those used for internal trip projections.

2.3.3 Coarse desire-line diagrams To be able to fully appreciate the extent of the major traffic corridors, the Study Area is divided into much larger units than those of the base zoning system. It is usual practice to have a centre (or a hypercentre) and a small number of sectors and/or rings, as shown in the sketch below.



Desire lines, for both the base and design years, are then drawn showing the flows from each sector to the centre and between each sector.

This type of study at a macro-level of analysis will provide important information so that decisions can be taken at an early stage. The desire-line diagrams will distinguish between internal traffic in the central area and radial flows from the first and second rings as well as peripheral traffic flows. The latter are a very important element due to its expected rapid growth. Perhaps the main task of such maps is to bring to light any inconsistencies of the various land-use alternatives with their corresponding transportation options. It is possible to abandon those alternatives which are seen, at this stage, to be quite unrealistic in terms of the levels of traffic flows generated. By unrealistic flows it is meant here those which will require road construction which is not possible to implement.

Another corollary of desire-line studies is the identification of possible strategies for protecting the CBD from that traffic which has no business there. The possibility of a ring-road around the CBD, for example, can be investigated at this stage by considering the flows entering the area.

2.3.4 <u>Modal split</u> No model is used to predict future modal utilisation. The procedure followed involves making use of past trends in modal split together with the investigation of the existing situation. This is done through the use of existing data as far as possible together with information gathered from manual traffic counts, roadside interviews, and questionnaires for public transport operators. It is only when the existing situation is well understood that future estimates can be made.

Rates of use are calculated, either by interviews or by taking mean rates from similar towns, for each trip purpose and for each type of trip interchange. The following is a table of all cases considered.

<u>Table 2 : Types of journeys considered in modal split</u>.

Modes	Private car, public transport and two-wheelers
Trip purposes	Home-based, work and other, non-home based
Type of journey	Radial 1 (from first ring to centre), Radial 2 (from ring 2 to centre), and peripheral

Two basic options are open when deciding on future modal utilisation. Either adopt a continuation of the present trend away from public transport (H1), or make a strong effort to bring people back to public transport use (H2). When deciding on which path to follow several factors must be taken into account namely:-

i) Study Area size

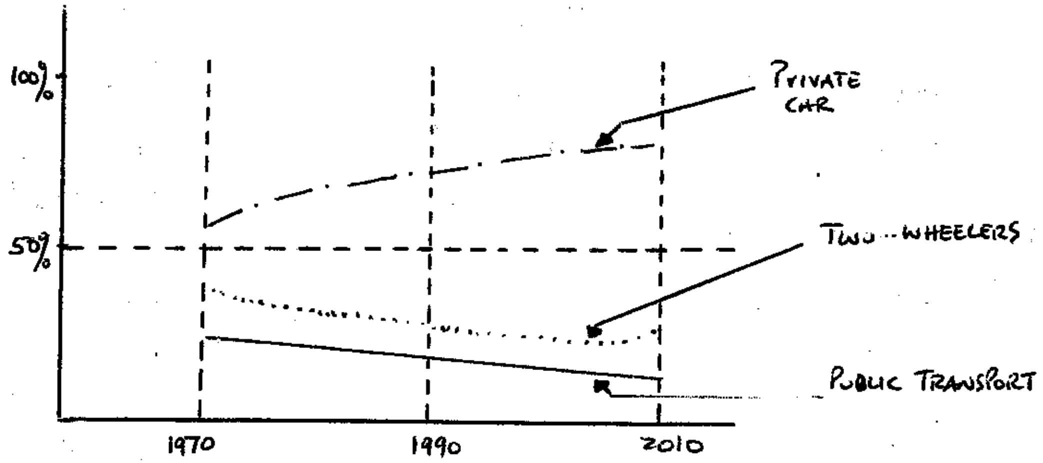
ii) Relative costs of private and public transport

iii) Type of urban development thought desirable.

This last factor is of paramount importance. Clearly public transport is geared to high density residential development whilst low-density more dispersed land-uses will have to be served by the private car. The diagram below illustrates the relationship between transport and land-use.

Desired land-use	→	Transport network adopted	→	Spontaneously induced land-use

Modal split can be represented either graphically or on a matrix form showing rates of use by mode and purpose for the four zone types considered. With a graphical approach we will have 12 graphs of the form shown below. (4 journey types x 3 trip purposes)



Present rates of use are projected into the future by means of the following equations:-

$$\alpha = \alpha_o \; f(\lambda, N)$$
$$\beta = \beta_o \; f(\lambda, N)$$
$$\gamma = 100 - (\alpha + \beta)$$

where

N = Number of years from base to design-year

λ = Rate of decrease of public transport and two-wheelers per annum, for the last ten years.

$f(\lambda, N)$ = function of decreasing rates of use.

α_o, β_o = percentage use of two-wheelers and public transport for the base year, respectively.

α, β, γ = percentage use of two-wheelers, public transport and private cars in design year, respectively.

The flow diagram below serves to illustrate the method followed.

1. Use of existing data

↓

2. Calculation of present and future rates of use. Drawing of utilisation curves (or matrices)

↓

3. Calculation of conversion factors to translate person trips into passenger car units (PCU).

Once utilisation curves are established, the next step is to convert person-movements into passenger-car-units (PCU) for the purposes of network evaluation. The following is an example of how this conversion is carried out.

Consider the case of 10,000 person-trips being undertaken for the home - work purpose, the type of journey being Radial 2. (See earlier definition.) Standard rates have been arrived at, from date of past studies, for both occupancy factors and equivalent PCU, as shown:-

Mode	Public transport	Private car	Two-wheelers
Equivalent PCU	2	1	0.2 to 0.25

Load factors by mode and trip purpose:-

Trip purpose \ Mode	Public transport	Private car	Two-wheelers
Home-based work	30	1.2	1
Home-based other	20	1.5	1
Non-home based	20	1.2	1

Using these figures one can construct the following table, regarding the example mentioned above.

Mode	Public transport	Private car	Two-wheelers
Rate of use %	26	46	28
Occupancy factor	30	1.2	1
Equivalent PCU	2	1	0.2
% Heavy goods vehicles (HGV)	10		

Calculations: for the case of 10,000 person trips we have:

for public transport $\dfrac{10{,}000 \times 0.26 \times 2}{30} = 170$

for private car $\dfrac{10{,}000 \times 0.46 \times 1}{1.2} = 3830$

and for the two-wheelers $\dfrac{10{,}000 \times 0.28 \times 0.2}{1} = 560$

Sub-total = 170 + 3830 + 560 = 4560

Total = 4560 + 10% (HGV) = 5016 PCU

$\therefore$ Conversion factor = $\dfrac{10{,}000}{5016} = \underline{0.5}$

2.4 Central area parking

2.4.1 Methodology The method used to analyse central area parking can be seen as consisting of three different stages:-

1) Evaluating the demand for parking by purpose for the medium and long terms.
2) Calculating present parking supply and future potential supply.
3) Deducing the parking deficit taking into account environmental and land-use objectives.

Three parking purposes are considered:-

i) Residential - parked vehicles near the place of residence.
ii) Work - medium and long-term parking obtained from the home - work trip matrix.
iii) Business and shopping - this is short-term parking (usually less than 3 hours), calculated from the home - other, other - home, and non-home based trip matrices.

The following types of parking spaces are examined on the supply side of the equation:-

A) On-street - (i) unrestricted
(ii) parking meters
(iii) illegal parking
(iv) risk of illegal parking if duration exceeded (blue zones)

B) Off-street

C) Private parking space - private residential or space provided by employer.

2.4.2 Estimating demand The total demand, for each zone, is calculated by summing the demands for the three purposes defined above, i.e.

$$D_{(Total)} = D_{(Work)} + D_{(Short\ duration)} + D_{(Residents)}$$

Parking demand for work trips is calculated from the private car commuters trip matrix (peak hour). The number of cars parked at the peak hour, V, is given by:-

$$V = M \frac{\Theta p}{T_{oc}}$$

where M = number of commuters going to work in the central area by car
T_{oc} = mean occupancy rate
Θp = rate of presence of these commuters at the peak hour of parking.

T_{oc} is obtained from a curve which gives T_{oc} against study area population calibrated from the results of studies undertaken in 16 towns. Θp varies little with the size of study area but increases with the rate of use of the private car. A value for this variable is again given by previously calibrated curves.

Shopping and personal business parking demand is evaluated from trip matrices for the home - other and the non-home based trip types.

Let - N_1^1 = number of home - other trips by car to the centre
N_2^1 = number of cars used for those N_1^1 trips i.e. $N_2^1 = N_1^1 / T_{oc}^1$

where T_{oc}^1 is defined as before
If T_p^1 represents the rate of presence of private vehicles for the home-other trips,

then the number of cars parked at the peak-hour of parking, N^1, is given by:-

$$N^1 = N_2^1 \times T_p^1$$

$$N^1 = \frac{N_1^1 \, T_p^1}{T_{oc}^1}$$

A similar procedure is followed for the case of non-home based trips.

To calculate parking demand at the place of residence, the total number of private vehicles is estimated for each zone. From this figure we then subtract the number of vehicles which will be absent during the peak hour. The total number of vehicles, P_c, is given by:

$$P_c = R_c \times m_c$$

where R_c = central area population

and m_c = rate of motorisation of central area residents. (Number of vehicles per person, which was of the order of 0.25 in 1970 and is estimated to reach 0.4 in 1990.) Assuming that 5% of the total number are actually travelling during the peak-parking hour, then the total parking potential will be given by $P_{cp} = 0.95\ P_c$. From this figure we must subtract the number of vehicles used by the central area residents for work, V_c; for other purposes, N_c^1; as well as for non-home based trips, N_c^{11}. The total demand for this type of parking is therefore given by D_R where:-

$$D_R = 0.95\ P_c - V_c - N_c^1 - N_c^{11}$$

Note: It is possible to evaluate directly and rapidly the total demand for parking (all purposes) with the help of an equation of the form:

$D_{Total} = kE$ where E = total number of places of employment in the central area.

and K = coefficient representing the rate of motorisation.

($k = 0.8m - 0.195$, with m = average number of cars/household.)

2.4.3 Supply and demand The problem of equilibrium between the demand for and supply of parking is a complex one. The simple difference between future predicted demand and present supply gives only a very simplified version of events. One must consider also what type of supply will be possible to satisfy the various types of demand. This will serve as a basis for the development of a parking policy whose main phases will be:-

i) Confronting the number of places to be built (by type: parking lots, meters, other) with the real possibilities for development, which must take account of the difficulties in construction and the land-use constraints.

ii) Solving the problems of cost and financing.

iii) Establishing a pricing policy. (This task is outside the scope of level 1 studies.)

When considering what level of supply is necessary, it is important to take account of the fact that on-street parking tends to decline with time as environmental and traffic management considerations have a tendency to reduce on-street parking space. Another factor influencing the estimates for future parking supply is the fact that some of the off-street supply existing at present is being considered for other purposes.

2.5 The highway network

Having considered the problems associated with Central Area parking the next stage in the process calls for the examination of a satisfactory network of roads. This is done by looking at the Central Area and the periphery separately and proposing road schemes for these two parts of the urban area.

A study of the road network for the Central Area is carried out using as a control mechanism the traffic counts undertaken at screenlines. There are usually two perpendicular screenlines dividing the study area into four parts. This analysis must evaluate the efficiency of the network in diverting through traffic from the Centre which is usually achieved by means of ring-roads encircling the Central Area. The way in which the network is capable of adequately catering for Central Area traffic is investigated. If the proposed scheme fails to give proper Central Area functioning, then it is usually possible to attribute this failure to one or more of the following reasons:-

i) Parking capacity is exceeded

ii) Capacity at one of the screenlines is exceeded

iii) Capacity at the inner ring road is exceeded.

If any of the above cases occur then it is necessary to incur a certain cost so that one is able to preserve the level of environmental quality previously set and still achieve the required level of accessibility. If either the screenline or the parking capacity is exceeded, it is necessary to revise the modal split hypothesis previously considered and/or the Centra Area employment hypothesis. This feed-back iterative process is undertaken so that capacity meets the required demand adequately.

Having examined the Central Area system, the outlying area of the town is then studied, having as reference the vehicular trip matrices arrived at earlier. In this way, a complete Study Area network, usually based on a system of radials, ring-roads and service arterials, can be put forward to meet predicted demand. It is to the loading of such a network by a simple traffic assignment procedure that we now turn our attention.

2.5.1 Assignment The loading of vehicle trips on to a proposed network is achieved by a simple manual procedure aided by a computer program known as AFSIMZ. The following are the inputs required for that program:-

i) A list of all links (maximum number of links is 400)
ii) A list of all nodes (origin and destination)
iii) A description of the percentage of trips between each zone paid to be assigned to all successive nodes.

In this method of assignment, common sense, rather than sophisticated capacity restraint or multipath techniques, is used. Traffic is split between possible paths, according to what the analyst believes to be reasonable. The proposed network consisting of two or three ring-roads and several radials is very much a simplified and sketchy system at this level of analysis. In this way, a trip from an origin i to any destination j will have to be made via either a single path or via two different paths. In this latter case, traffic is usually split on a 50 - 50 basis according to the analyst's judgement.

Predicted flows are assigned to the proposed network in order to estimate capacity deficits and thus the required size of the different highway links.

The final network proposed is reached by an iterative process which starts with a basic system for both the Central Area and the periphery of the Study Area. This iterative process calls for a great deal of skill and initiative on the part of the study team. A considerable amount of discussion between all interested parties usually takes place before a compromise solution is found in the final analysis. The process can call for a complete revision of earlier assumptions if there is inconsistency between land-use and modal split hypotheses and the development of the corresponding highway network.

3. METHODOLOGY FOR PUBLIC TRANSPORT NETWORK DEVELOPMENT

3.1 Main objectives

The main purpose of public transport studies at the strategic level of planning is the identification of a long-term public transport policy and the introduction in the SDAU of the necessary means to develop that policy. It is essentially the long-term protection exercise to rehabilitate public transport by reserving corridors for fixed-track systems, for example. It is also important at this stage to identify the process which will achieve a good transition from the present state of affairs to the public transport system desired in the future.

To achieve these overall aims, we can identify three different sub-goals of long-term public transport studies:-

i) To define a public transport network which will be consistent with the orientation and objectives of the long-term land-use plans (SDAU).

ii) To define the medium-term network.

iii) To guide the technological choice of future systems.

Regarding the first objective we can distinguish two fundamental roles of a public transport network. One is the preservation of Central Area activities by giving a good level of accessibility to that area. This is all the more important if we consider the adverse effect of the private vehicle as a means of access to the Centre. Another public transport role is in the enhancement of the desired development of growth areas within the urban complex by ensuring that those areas are adequately serviced by public transport.

The definition of a medium-term network is essential to determine investment levels for the different proposed alternatives. It is also important to know the order of priority given to the various components of a network because whatever is built first can have a profound effect on the way the city will develop. The compatability between the different land-use/transport options can only be appreciated if we take into account the effects of the first public transport lines both on the growth areas and on the CBD.

3.2 General principles of the method used

The analysis for long-term planning of public transport systems must be carried out at two levels, namely the metropolitan and the urban corridor level. At the Study Area level, the study will ensure proper integration of the transport services with the land-use envisaged. The second level, i.e. corridor analysis, will permit the identification of possible corridors for public transport lines and the subsequent detailed study of such corridors. These corridor studies are usually done for the medium-term and it is recommended that they should follow rather than precede the long-term metropolitan studies. That is, the corridor studies should be seen as a means of achieving the long-term overall objectives. The vital point being the generation of alternative public transport strategies which are compatible within themselves and the evaluation of these alternatives in the face of the objectives set.

Three main criteria are proposed for the development of public transport networks:-

i) the level of demand;

ii) accessibility;

iii) effect on urban structure.

The level of demand reflects the overall mobility of the community and is generally considered in two ways. Firstly for each origin-destination pair and secondly for the whole Study Area, i.e. the overall network mobility. For the city level an equation of the type given by (A) can be used.

$$N = 150 + 50P \qquad (A)$$

where N = number of public transport trips per year

and P = population (in millions) with $0.2 < P < 2$

Accessibility for each zone will reflect, for example, the percentage of total employment which is less than M minutes away from each residential zone. It is possible in this way to establish a set of local indicators expressing the quality of urban life.

The power inherent in a public transport system to influence residential location is well recognised. This is particularly true of fixed-track lines with their ability to determine residential development in the vicinity of proposed stations.

3.3 The study of a public transport network

A number of preparatory tasks must be completed before the study proper can be undertaken. These include: the selection of a zoning system which will take into account the major traffic generators; a complete inventory of existing public transport infrastructure and type of services provided; and finally, the identification of the main possibilities and urban constraints to the development of a public transport network. Having taken stock of the present situation, we can proceed to develop a public transport network. This can be achieved in three phases:

i) development of a network which will serve the maximum possible area;

ii) priorities for a medium-term network;

iii) justification of the network.

The main objective of the first phase is to obtain a schematic network which will adequately cater for the main traffic generators as well as giving satisfactory service to the whole of the urban area as envisaged in the long-term land-use plan (SDAU). To achieve this we must carry out the following tasks:

a) To identify the main activity centres (both central and peripheral) which could serve as adequate interchange points.

b) To define a radial-concentric mesh which will give either a rate of coverage higher than X% (to be defined), or a rate of coverage higher or equal to that given by the present bus system.

c) To calculate total demand for all public transport modes.

d) To calculate, on the basis of this first network, and for some critical zones, the public transport accessibility indicators. A detailed description of such indicators is given in section 3.4

e) To identify those zones which are very accessible but sub-urbanised, and those with very low accessibility but very urbanised. To revise the overall picture made up of the public transport network and the spatial distribution of activities and residential areas.

f) To refine the network in the light of the above analysis.

In order to develop priorities for a medium-term network the following steps must be taken:-

g) To list those main traffic generators which must be served first.

h) To identify corridors where a fixed-track public transport system might be located.

i) Organise Central Area and peripheral networks to match expected medium-term demand.

j) To calculate the rates of public transport utilisation for the whole Study Area.

k) To determine the section (or sections) of the network which justify their own right-of-way for the medium-term, on the basis of the first level of analysis.

Finally, justifying the network proposed involves:

l) Locating public transport stations and interchanges with reference to the urban land-use alternatives. A revision of these alternatives may be necessary in the light of possible technical difficulties encountered in constructing infrastructure facilities.

m) Giving a detailed account of the public transport system (bus and/or rail) for the medium-term (15 years), with special reference to the possibilities for right-of-way systems.

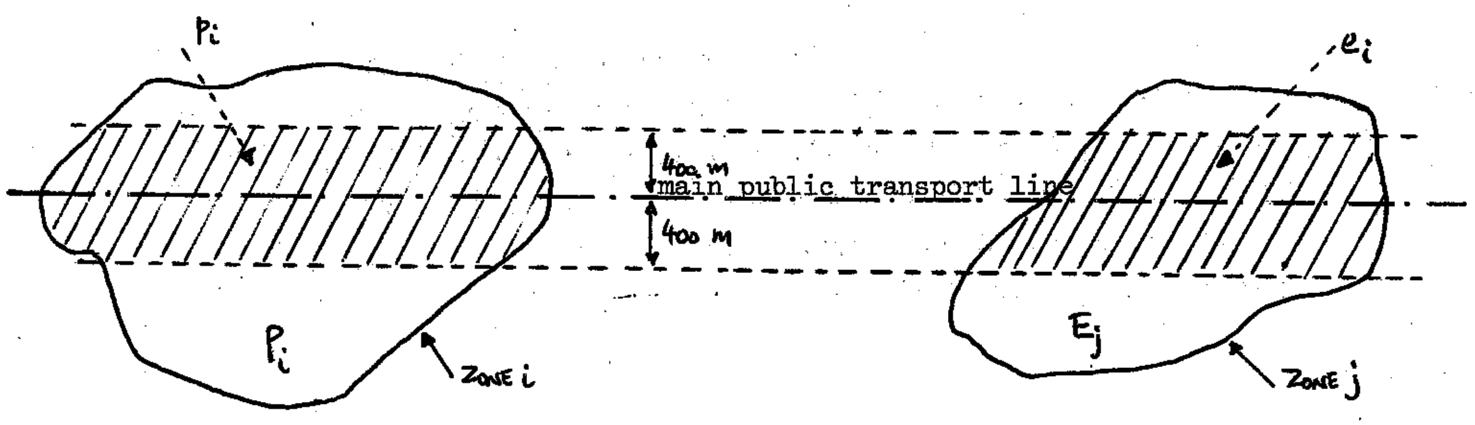
n) Revising the demand calculations in the light of l) and m).

o) Calculating the gains in accessibility related to the line or lines where right-of-way systems are proposed.

3.4 Predicting public transport utilisation

We have already seen how modal split analysis is dealt with in section 2.3.4. Here our concern is with the estimation of public transport use once it is decided to adopt a policy which strongly favours public transport.

It is necessary to distinguish between essential and non-essential trips when considering modal use. For essential journeys, the peak-hour zone-to-zone movements are investigated. Consider a public transport line serving an origin i and a destination j, as shown in sketch A. The percentage of public transport trips is given by:



Sketch A: Area of influence of a public transport line

$$\% \text{ P.T.} = \lambda_i \lambda_j \; T + (1 - \lambda_i) \lambda_j \; T^1 \qquad (1)$$

where $\lambda_i = \dfrac{p_i}{P_i}$ with p_i = population of i within a 800m band of the public transport line (see sketch A)

and P_i = total population of zone i

$\lambda_j = \dfrac{e_j}{E_j}$ with e_j = employment in j within the 800m band

and E_j = total employment in zone j

and T and T^1 represent the proportion of public transport trips for two types of journeys; single trip with no transfers and multimode and/or transfer trips respectively. Values for these two parameters are given in table 3.4.

The total number of public transport trips, per person per annum, is summed over all zone-to-zone movements to obtain the total number of public transport trips. The latter can then be compared with the corresponding figure for similar urban areas which have already adopted a public transport oriented policy.

Principal mode / Type of destination		Fixed track (%)	Bus with reserved lane (%)	Conventional bus (%)
Central destinations (strong parking constraints)	T	80 ± 10	60 ± 10	40 ± 10
	T^1	60 ± 10	40 ± 10	20 ± 10
Peripheral destination (with weak parking constraints)	T	50 ± 10	30 ± 10	10 ± 5
	T^1	30 ± 10	10 ± 5	5 ± 5

Table 3. Percentage use of public transport

3.5 Accessibility indicators

These are local measures dependent upon what one wants to have access to (employment, shopping, etc.) and also upon the means at one's disposal to reach the different types of destination. The measures must reflect the fact that not all possible destinations are at an equal distance. The attractiveness of each destination must be given by a function representing the travel difficulty..

A destination zone j is characterised by:

i) its importance, expressed by the number of possible destinations for the trip purpose considered;

ii) its attractiveness for the residents of an origin zone i.

Such attractiveness will decrease as travel time increases. The accessibility of j for the residents of zone i and for trip purpose k, a_{ij}^k, is given by:

$$a_{ij}^k = N_j^k f(t_{ij})$$

where N_j^k = number of trips destined for j for trip purpose k

$f(t_{ij})$ = travel function

and t_{ij} = time or generalised cost.

For all destinations we have:

$$A_i^k = \sum_j N_j^k f(t_{ij})$$

where A_i^k is the general expression of accessibility for zone i and purpose k. The travel function $f(t_{ij})$ can take the forms t_{ij}^{-a} or $e^{-kt_{ij}}$. It is usual practice to calibrate different travel functions according to mode.

Two different types of indicators are proposed. The gravitational form as discussed above and the so-called isochrone indicators. In this latter type, an all-or-nothing approach is introduced after choosing a particular isochrone. In the Paris region, for example, isochrones were chosen to indicate accessibility by determining the number of employment places situated within less than 40 minutes from each zone of residences. Although such indicators are less theoretically appealing, they give the non-specialist a better notion of accessibility. Four areas where accessibility indicators can be applied will now be discussed.

1) Local impacts of different public transport networks can be evaluated with the help of accessibility indicators. Maps can be developed showing the accessibility levels for each alternative network so that a zone-by-zone comparison can easily be undertaken. A graphical representation can also be adopted (number of zones vs. employment reached in less than M minutes), showing the different levels of accessibility of several zones for one particular public transport alternative.

2) The way in which different sections of the community are affected by the proposed schemes can also be detected through accessibility measures. The effect, if we want to compare accessibility levels of the motorised and non-motorised sections, private vehicle trips must be separated from those made by public transport. Accessibility indicators are then estimated for the two modes so that a comparison can be made. The Washington Metro Study has used this concept when determining accessibility levels. The equation used is of the form:

$$A = \sum_{p=1}^{k} Q_p \left(\sum_{m=1}^{s} M_m O_{pm} \right)$$

where A = local accessibility indicator

Q_p = percentage of trips undertaken for purpose p

M_m = percentage of trips by mode m

O_{pm} = ratio between the number of real destinations to the desired destinations reached within a given travel time, for mode m and purpose p.

If, for example, the community judges that it is indispensable to be able to reach 80% of employment in less than 40 minutes and if, using the network under test, only 40% are reached, then

$$O_{pm} = \frac{40}{80} = 0.5$$

A transport system which completely satisfies the needs in opportunities of the residents, by purpose and mode, will have a value of A = 100. A can be evaluated for an existing network to determine the present deficiencies.

3) Accessibility measures will help in the establishment of urban growth patterns. They can serve to detect the desire of the urban population to locate their places of residence in order to minimise the transport costs for their main activities.

4. Accessibility indicators have also been used as an explanatory variable when determining modal choice. This application has allowed modal split to be partly explained on the basis of the ratio of public transport to private vehicle accessibility. Modal split is therefore carried out prior to trip distribution.

3.6 Public transport as a complement to other modes

When developing a public transport network, particular attention must be paid to intermodal co-ordination. To guide the choice of two feeder systems and the location of transfer points, three main criteria must be observed:

i) spatial coherence

ii) time-wise coherence

iii) pricing coherence

and these will now be discussed.

i) Consider a public transport fixed-track line radial from the centre to the periphery. The distance from the centre to the first transfer point, d, must be such that:

$$d \geqslant A \frac{V_1 V_2}{V_2 - V_1}$$

where A = transfer time

and V_1 and V_2 = speeds of the two modes.

For example, A = 3 minutes the following distances (in metres) are obtained:-

Table 4. Relationship between modal speeds and distance to transfer points

V_1 \ V_2	15	18	21	24
12	3000	1800	1400	1200
15		450	2625	2000
18			6300	3600

ii) Physical coherence by itself is not sufficient. The modes must be compatible with relation to time. Time-table co-ordination is extremely difficult for the bus system due to problems of time-table adherence of this mode. Co-ordination of both frequencies and time-tables is necessary if waiting and transfer times are to be minimised.

iii) This last criterion poses the difficult problem of fare co-ordination. This is outside the scope of strategic long-term studies and should be considered at a more detailed level of study. The following are some examples of fare co-ordination in Europe:

a) Tickets valid for the whole of the public transport network during a given time - tramway and bus in Hanover.

b) Tickets valid for a given time inside a zone - Metro - Tramway - bus for two zones in Hamburg.

c) Price of ticket is a function of the location of the destination within two or three concentric zones around the origin station. This is irrespective of whether the trip involves a transfer or not.

d) Reduced price co-ordinated season tickets.

4. CONCLUSIONS

The philosophy underlying transportation planning in France appears, on the whole, to be sound and logical. By stressing the need for close contact between land-use planning and the provision of transport and giving that contact a real meaning, the French seem to have attempted to put into practice what several other countries have recognised in principle but have had considerable difficulty in translating into practical terms. Transportation plans, both long and medium-term, form an integral part of urban planning and are incorporated into the land-use plans (SDAU and POS). In preparing the SDAU (long-term land-use plans) estimates are made of the amount and distribution of economic activity as well as the distribution of population. Other features such as public buildings, parks and recreational areas are identified. The transportation studies estimate future peak-hour traffic volumes and central area parking space requirements. Future infrastructure needs are then estimated under a range of alternatives from heavy transit orientation to private transport emphasis. A dialogue between local politicians, planners, engineers and economists then follows to arrive at the best possible compromise solution.

Although the transportation phase of urban planning is initially developed to serve one proposed land-use plan, it is argued that the subsequent process of dialogue amounts to the examination of several alternatives in the end. This is so because there is provision in the methodology followed to revise initial land-use proposals in the light of the problems that might be encountered when the transport facilities necessary to serve the original land-use scenario are investigated.

The likelihood of co-ordination between transport and land-use planning will be enhanced by the incorporation of long-term transport studies into the land-use planning process and facilitated by the dialogue between these two fields. This is not, however, a sufficient condition to ensure compatibility between transport and land-use proposals, since it is left to the experts in both camps to reach consensus about the consequences of their actions.

One positive aspect of this planning process is the simplicity and therefore the speed with which one is able to evaluate several alternative transportation plans. This is a result of the simple methods used for the development of both highway and public transport networks.

It is recognised that at the strategic level of planning, when one is talking about 20 or 30 years into the future, there is little point in using very sophisticated techniques for travel demand forecasting, when there is considerable margin for errors in the estimation of inputs such as future levels of economic activity, population, car ownership rates etc. This basic premise seems to run through the entire process of long-term transportation planning in France, so that studies at this level take usually between 6 months and one year to complete. As part and parcel of this simple approach it is felt here that the notion of having not one but several zoning systems for the different stages of the planning process, is one that deserves further consideration. In a process where the outputs of one model are the inputs to the next, varying the zoning system from stage to stage seems to have serious implications. There will be a need to disaggregate the results of one step and re-aggregate them according to the zoning system of the next step.

As far as the travel forecasting techniques are concerned, they must be in tune with the simple approach followed. Models must be simple, easy to understand, cheap and quick to use. Because members of both the "Steering" and "Technical" Committees are not normally transport specialists, it is important that the techniques used be easily understood. This is particularly true of strategic long-term planning when political representatives and administrators have their first contact with transport demand modelling. The need for quick and cheap travel estimation techniques arises from the necessity to investigate a large number of alternatives and from the need to satisfy the study program schedule. If the technical committee meets once every month, then it is desirable that the process of evaluating proposed alternatives should take as little time as possible.

This simplified approach has a high price attached to it. The models used throughout are not based on any causal relationships. Furthermore, the levels of service of both the highway and the public transport networks are not taken into account when forecasting travel demand. The assumption that the only factors affecting the amount of travel are population and employment levels limits the type of alternatives that can be considered.

To judge the accuracy of the simplified techniques used, a study was carried out in France, which compared observed with model values, from the results of some 17 home interview surveys throughout the country. The accuracy obtained with a simple trip generation model (3 trip purposes and 3 variables) seems satisfactory at this level of planning (see table below).

Trip purpose	Model error (%)
Home - work	7
Home - other	10
Non home based	15

Note: Observed and model values were compared on a system of 11 zones established for all 17 towns considered.

For the trip distribution model, the error was found to be of the order of 25%. Furthermore, the form of the friction function was not found to be a very sensitive factor with respect to trip purpose. This led to the recommendation that a unique function be used for all trip purposes for long-term strategic planning.

A cautionary note must be sounded regarding the extensive use of rates, factors and curves established from the home interview surveys of past studies. By using these established sets of figures, new studies are able to reduce the amount of money and time spent on data collection. Nevertheless, the use of such a data bank implies that a considerable amount of data must be collected in a standardised form for various size towns before one can confidently use such data in a new setting.

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