26/12/19

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National Transport policy of India:-

* The policy should be conceived to achieve the goals and objectives.
* The policy should lay down how by regulation, taxation, subsidies or encouragement, the Goverment intends to accomplish the task of achieving the goals & objectives.
* The policy should be implemented by Govt. by legislative & planning measures.
* To recognize the need to lay down a broad policy framework for Co-ordinated development of transport, the Govt. of India have been appointing Committees from time to time to advise on future goals to be pursued.
* The Committee on Transport policy and Co-ordination (Tarlok Singh Committee) was one of such committee.
* An examination of the issue was undertaken in a comprehensive way by NTPC (National Transport policy Committee) or popularly known as "Pandey Committee" Constituted by Govt. in 1978 to prepare a comprehensive national transport policy for the Country for the next decade or so, keeping in view, the objectives & priorities set out in the 5 year plans.

* The NTPC report was made available in the year 1980 & many of major recommendations of this report have been accepted by Govt. of India.
* Some of the Important recommendations of the NTPC report relate to the liberalisation of the transport sector, inclusion of transpolt in the Priority Sector, optimal in-er-modal mix between railway & road transpolt based on resource-cost consideration and energy conservation.
* A no. of suggestions were made on the road development, these include the need to take into account the requirements of roads in rural, hilly and tribal areas in the next perspective road development plans, strengthening of National Highway system, increase in funds for the maintenance of roads and to connect all the villages with all-weather low-cost roads within next 20 years.
* Seperate recommendations were also made for various factors connected with the development and growth of road transpolt by the year 2001.

Fundamentals of Transportation ①

There are 3 fundamentals which governs the transportation.

1) Demand
2) Supply
3) Transport System.

1) Demand based Transport planning :-

Demand is constituted and represented with no. of trips which are characterized by 3 parameters.

1) Trip length
2) Trip Intensity
3) Trip orientation

These parameters will generate an overview, how the demand is concentrated and dissiminate over the space to meet the activities spread over a space.

Trip length represents the average length of travel (or) maximum length of travel by an individual is performing in a day as a performer of the activity.

Ex:- Employee will travel every day to the office and the distance between home and office will be the maximum trip length which accounted for.

Trip Intensity represents no. of trips ② performing from a house/colony and if it is plotted on length scale of the trip. The intensity represents the no. of trips travelling along the length of the trip represents from those colonies.

Trip orientation is representing the configuration of attraction zones when trips are getting merged for various purposes. The purpose ~~can~~ may be business/Education, social Trips, working trips etc.

By plotting all these demand interactions, the road length, density, geometrics and functionalities can be visualised on the area and basic road network can be developed. ~~~~ ~~~~ ~~~~ In an urban area, Arterial, Sub-Arterial & partly collector streets can be planned. Successively, local streets will be connected among the zones of residences.

This approach is called "Demand based Transport planning."

31

Trip Generation

31·1. Introduction and Definitions

The first phase of the transportation planning process deals with surveys, data collection and inventory. The next phase is the analysis of the data so collected and building models to describe the mathematical relationship that can be discerned in the trip-making behaviour. The analysis and model building phase starts with the step commonly known as Trip Generation.

Trip geneation is a general term used in the Transportation Planning Process to cover the field of calculating the number of trip ends in a given area. The objective of the trip generation stage is to understand the reasons behind the trip making behaviour and to produce mathematical relationships to synthesise the trip-making pattern on the basis of observed trips, land-use data and household characteristics.

Since a considerable confusion can occur in the meaning of the various terms used in trip generation, it is desirable to understand the extact meaning of the various terms. A *trip* is a one-way person movement by a mechanised mode of transport, having two *trip ends,* an *origin* (the start of the trip) and a *destination* (the end of the trip). Trips are usually divided into *home-based* and *non-home-based. Home-based trips* or those having one end of the trip (either origin or destination) at the home of the persons making the trip, while *non-home based trips* are those having neither end at the home of the person making the trip. The trip ends are classified into *generations* and *attractions*. A *generation* is the home end of any trip that has one end at the home (*i.e.* of a home-based trip), and is the origin of a trip with neither end home based (*i.e.* of a non-home-based trip). An *attraction* is the non-home end of a home-based tirip, and is the *destination* of a trip with neither end home-based (*i.e.* of a non-home-based trip).

The above definitions are further classified by the following examples. Consider a trip from home to work and the return trip from work to home, vide Fig. 31·1. Both these trips are home-based, because one end of the trips is the home. Both these trips are considered to have been generated at the home zone and attracted to the work zone. We thus have two work-purpose trip end generations in the home zone and two work-purpose attractions in the work zone. Consider another example of the trip from the place of work to shop and return to the place of work, as is usual during the lunch recess,

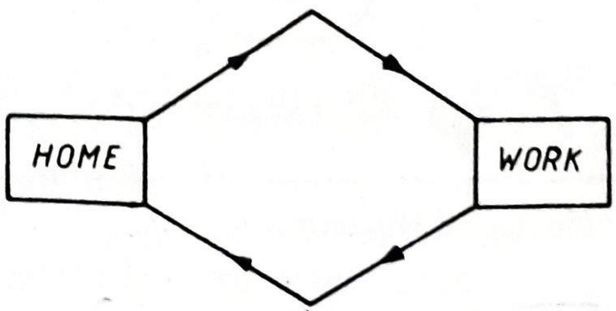

Fig. 31·1. Home-based trips.

vide Fig. 31·2. Both these trips are non-home-based, because neither end of the trip is the home of the person making the trip. Both these

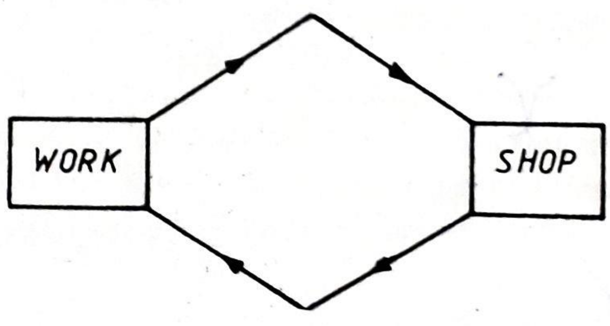

Fig. 31·2. Non-home-based trips.

trips are considered to have been generated at the work zone and attracted to the shop zone. We thus have two shopping-purpose trip end generations in the work zone and two shopping-purpose attractions in the shopping zone.

By the above definitions, the total number of trip generations in any area should be equal to the total number of attractions.

Role of Transportation in the Economic Development of Nations :-

* Transport Infrastructure is one of the key factors on which country's growth depends.

* When the Transportation developments increase the accessibility of Public and businesses to reach the Jobs, goods, services and activities, the productivity also increases.

* Because of its intensive use of Infrastructures the transport sector is an important Component of the economy and a Common tool used for development.

* At the Aggregate level, efficient transportatio reduces costs in many economic sectors, while inefficient transportation increases these costs.

* In general, Transport projects that improve overall accessibility (ie; they improve businesses ability to provide goods and services, and people's ability to access education, employment and Services) and reduce Transportation costs. (Including Travel time, vehicle operating costs, road and parking facility costs.)

* one of the Key measures of macroeconomics is economic growth, and logistics and transport play a key part in this.
* To encourage economic growth, Governments need to invest in logistics infrastructure such as Roads, Railways, Airports and ports.
* In a mixed economy, one of the ways of measuring the Success of Goverment's influence on the economy is by comparing how it has affected logistics and transport growth.

Transportation planning in the developing world

Decision to adopt planning

↓

Problem, definition formulation of goals

↓ Problems, constraints. Potentials, forecasting

Solution generation

↓

Solution Analysis

↓

Evaluation of possible alternatives & choice

↓

Implementation

↓

Operation

↓

Performance assessment & review

Systems approach to transport planning

→ Survey & analysis of existing conditions

→ forecast, analysis of future conditions & plan synthesis

→ Evaluation

(P.T.O)

32

Trip Distribution

32·1. What is Trip Distribution

After having obtained an estimate of the trips generated from and attracted to the various zones, it is necessary to determine the direction of travel. The number of trips generated in every zone of the area under study has to be apportioned to the various zones to which these trips are attracted. Thus, if g_i is the number of trips ends generated in zone i and a_j is the number of trip ends attracted to zone j, trip distribution stage determines the number of trips t_{i-j} which would originate from zone i and terminate in zone j.

The distribution of trips between zones can best be understood by a matrix, given in Fig. 32·1.

origin → Row
Destination ↓ column.

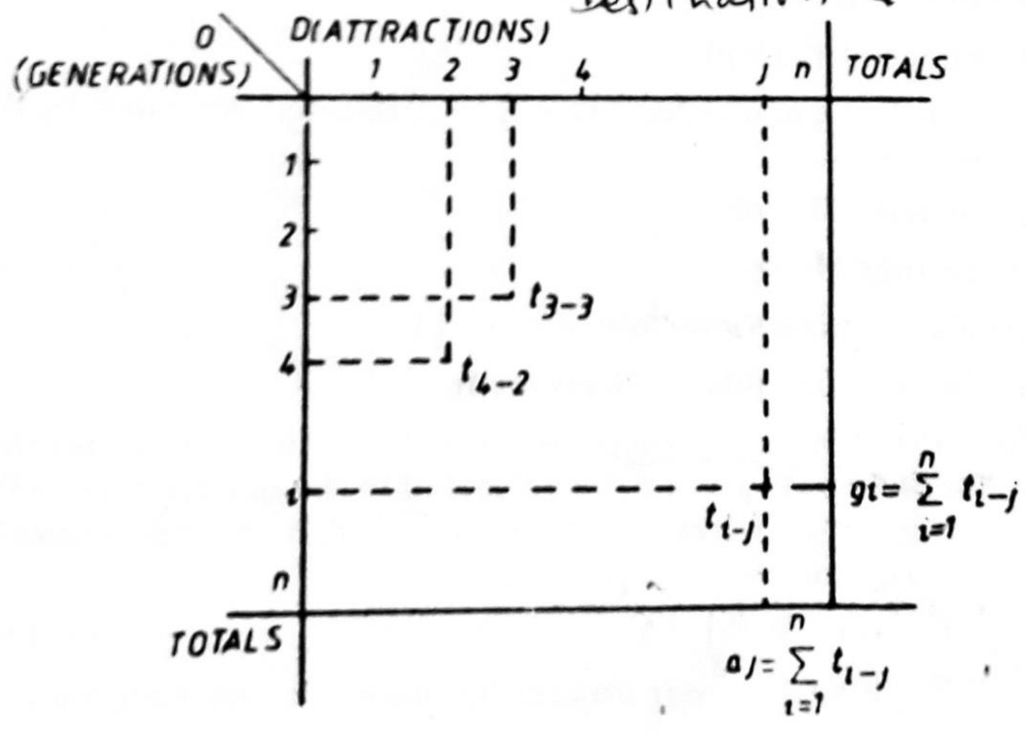

Fig. 32·1. O-D Matrix.

The horizontal axis of the matrix represents the zones of attractions (destinations, D), 1, 2, 3, ...j...n and the vertical axis represents the zones of generations (origin, O), 1, 2, 3,...i...n. The number of trips indicated at the intersection of any zone of origin and attraction *e.g.* t_{i-j} represents the number of trips originating in zone i and terminating in zone j. The total of any individual row, i, represents the total number of trips generated in zone, *i.e.* g_i. Similarly the total of any individual column, j, represents the number of trips terminating in zone j, *i.e.*, a_j.

32·2. Method of Trips Distribution

There are two types of trip distribution methods, *viz*.,

(*i*) Growth factor methods. — Small studies

(*ii*) Synthetic methods.

Growth factor methods have been used in earlier studies but have yielded place now to the more rational synthetic models. A description of the growth factor methods is, however, given here because they are still used in small studies and they serve to provide the historical background before the more recent methods are discussed.

The following are the important growth factor methods :

(*i*) Uniform factor method.

(*ii*) Average factor method.

(*iii*) Fratar method.

(*iv*) Furness method.

The synthetic methods that will be discussed here will be the following :

(*i*) Gravity Model.

(*ii*) Tanner Model.

(*iii*) Intervening opportunities model.

(*iv*) Competing opportunities model.

The growth factor methods are based on the assumption that the present travel patterns can be projected to the design year in the future by using certain expansion factors. This can be represented by the general formula :

$$\boxed{T_{i-j} = t_{i-j} \times E} \qquad ...(32.1)$$

GF)

where T_{i-j} = design year (future) number of trips from zone i to zone j.

t_{i-j} = observed based year number of trips from zone i to

Synthetic models utilise the existing data to discern a relationship between trip making, the resistance to travel between the zones and the relative attractiveness of the zones for travel. Once a model is established on the basis of the present day data, the model can be used to predict the future pattern-of travel between zones.

32·3. Uniform (Constant) Factor Method

This is the oldest of the growth factor methods and assumes that the growth rate for the whole area is valid for predicting future inter-zonal trips. A single growth factor, E, for the entire area under study is calculated by dividing the future number of trip ends expected in the survey area for the design year by the trip ends in the base year. The future trips between zones i and j, T_{i-j}, are then claculated by applying the uniform factor E to the base year trips between zones i and j. Thus :

$$\boxed{T_{i-j} = t_{i-j} \times E}$$

The following simple example makes the method clear :

O \ D	1	2	3
1	60	100	200
2	100	20	300
3	200	300	20

The distribution of present trips among the zones 1, 2 and 3 are given in the O.D matrix above. The future trips generated in zones 1, 2 and 3 are expected to be 360, 1260 and 3120 respectively. It is required to distribute the future trips among the zones.

O \ D	1	2	3	t_i	T_i
1	60	100	200	360	360
2	100	20	300	420	1260
3	200	300	20	520	3120
				Total = 1300	4740

t_i in the above matrix represents the row totals, *i.e.* totals of the trips generated in the three zones at present. T_i represents the future trips generated in the three zones. The total trips generated at present is 1300 and the total trips generated in the design year is 4740, thus giving a value of :

$$E = \frac{4740}{1300} = 3{\cdot}646$$

Multiplying the cells in the matrix by the uniform factor of E = 3·646, the following matrix results :

O \ D	1	2	3	T_i Calculated	T_i (given)
1	218	365	729	1312	360
2	365	73	1094	1532	1260
3	729	1094	73	1896	3120
				Total = 4740	4740

It will be seen that even though the trips have been distributed resulting in a total of 4740 trips, which is the same as the total of future trips as per data given, the totals the trips generated in each zone as now calcualted do not tally with the values given. This is because of the assumption of a uniform growth rate for all the zones. The method, therefore, suffers from certain disadvantages, which are enumerated below :

(*i*) The assumption of a uniform growth rate for the entire study is not correct, because each zone will have its own growth rate and the rate of growth of traffic movement between any two zones will be different.

(*ii*) The method under-estimates movements where present-day development is limited and over-estimates movements where present-day development is intensive.

(*iii*) If the present trip movement between any two zones is zero, the future trip movement also becomes zero as per this method. This may rarely be the case in reality.

34

Modal Split

34·1. General Considerations

Modal split is the process of separating person-trips by the mode of travel. It is usally expressed as a fraction, ratio or percentage of the total number of trips. In general, modal split refers to the trips made by private car as opposed to public transport (road or rail).

An understanding of modal split is very important in transportation studies. Future transportation pattern can only be accurately forecast if the motivations that guide the traveller in his choice of the transportation modes can be analysed. Though the factors that govern the individual's choice of mode are complex, a study of the same is of great utility. Considerable attention is being given recent years to this aspect of transport planning.

34·2. Factors Affecting Modal Split

The factors that affect choice among alternative modes are heterogenous and numerous and it is convenient to discuss the factors under some broad categories as below :

1. Characteristics of the trip ;
2. Household characteristics ;
3. Zonal characteristics ;
4. Network characteristics.

These will now be examined in detail.

1 **Characteristics the trip**

(*i*) *Trip purpose*. The choice of mode is guided to a certain extent by the trip purpose. To give an example, home based school trips have a high rate of usage of public transport. On the other hand, home-based shopping journeys can have a higher rate of private car usage, for the simple reason that it is more convenient to shop when travelling in a personalised transport.

(*ii*) *Trip length*. The length can govern an individual's choice of a particular mode. A measure of the trip length is also possible by the travel time and the cost of travelling.

2 **Household characteristics**

(*i*) *Income*. The income of a person is a direct determinant of the expenses he is prepared to incur on a journey. Higher income groups are able to purchase and maintain private cars, and thus private car trips are more frequent as the income increases.

(*ii*) *Car ownership*. Car ownership is determined by the income and for this reason both income and car ownership are inter-related in their effect on modal choice. In general, families which own a car prefer private car trips, and in contrast families without car patronise public transport in the absence of any other alternative.

(*iii*) *Family size and composition*. The number of persons in the family, the number of school-going children, the number of wage earners, the number of unemployed, the age-sex structure of the family, and some other factors connected with the socio-economic status of the family profoundly influence the modal choice. Some of these factors are responsible for certain "captive" trips in public transport, such as those due to old age pensioners, school children, crippled and infirm persons and those who do not wish to drive. Normally, the principal family wage earner, usually the husband, takes priority in driving in the single car household, while the housewife and childern must take to public transit, solicit a ride with friends or walk.

3 **Zonal characteristics**

(*i*) *Residential density*. The use of public transport increases as the residential density increases. This is because of the fact that areas with highest residential density are inhabited by persons with lower income, with lower levels of private car ownership. It is also found that higher density areas are served well by public transport system and such areas are oriented towards a better use of the public transport system.

(*ii*) Concentration of workers.

(*iii*) Distance from *CBD*.

4 **Network characteristics**

(*i*) *Accessibility ratio*. Accessibility ratio is a measure of the relative accessibility of that zone to all other zones by means of mass transit network and highway network.

(*ii*) *Travel time ratio*. The ratio of the travel time by public transport and travel time by private car gives a measure of the attractiveness or otherwise of public transport system. The travel time by public transport system is itself composed of :

(a) time spent walking to public transport vehicle at origin,

(b) time spent for waiting for public transport vehicle,

(c) time spent in public transport vehicle,

(d) time spent in transfer from one public transport vehicle to another, and

(e) time spent walking from public transport vehicle at destination.

Travel time by private car is composed of

(a) time spent driving the car,

(b) time spent in parking at destination, and

(c) time spent in walking from parked vehicle to destination.

It is generally found that as the travel time ratio increases, the usage of the public transport system falls down. Typical relations found (Ref. 5) are given in Fig. 34·1.

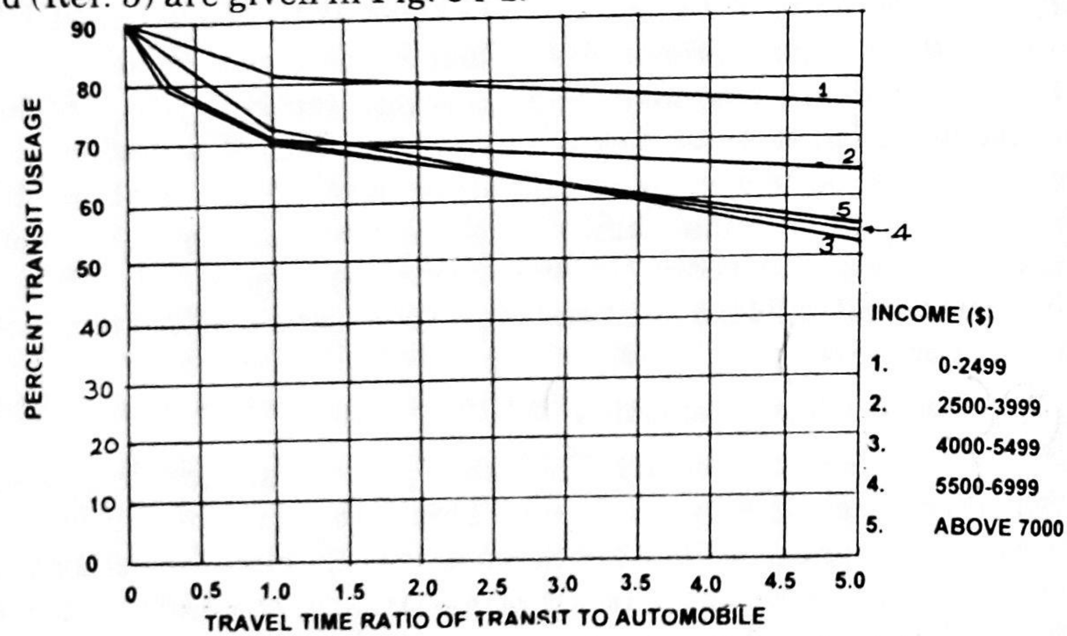

Fig. 34·1. Variation of modal split related to economic status and travel time ratios (Ref. 5).

(iii) *Travel cost ratio.* The ratio of cost of travel by public transport and cost of travel by car is one of the most important factors influencing modal choice. In assessing the cost of travel by cars, the possibility of any arrangement of pooling cars for journey to work is also a consideration. The importance of travel cost is related to the economic status. People with high incomes are unmindful of cost and prefer more expensive modes (Ref. 4).

Apart from the factors mentioned above, there are some others transport system and the presence of luggages in the hand, is another factor most frequently weighed by the travellers in deciding between private car or a public transport. The relative safety of travel is yet another factor which may be a consideration with some. The opportunity to read can be a factor favouring travel by rail. Waiting, transferring, overcrowding, standing and long walking are some considerations most unfavourable to public transport usage.

Traffic Assignment

33·1. Purpose of Traffic Assignment

Traffic assignment is the stage in the transport planning process wherein the trip interchanges are allocated to different parts of the network forming the transportation system. In this stage (*i*) the route to be travelled is determined and (*ii*) the inter-zonal flows are assigned to the selected routes. The application of traffic assignment are (Ref. 1) :

(*i*) To determine the deficiencies in the existing transportation system by assigning the future trips to the existing system.

(*ii*) To evaluate the effects of limited improvements and additions to the existing transportation system by assigning estimated future trips to the improved network.

(*iii*) To develop construction priorities by assigning estimated future trips for intermediate years to the transportation system proposed for those years.

(*iv*) To test alternative transportation system proposals by systematic and readily repeatable procedures.

(*v*) To provide design hour traffic volumes on highway and turning movements at junctions.

Thus the assignment process is useful both to the transports planner and the highway designer ; to the former, because of the need to evaluate how the proposed transport system will work, and to the latter, for geometric design of individual links and intersections.

The advent of the modern digital computers has facilitated the growth of assignment techniques, which involve computations too laborious for manual handling.

PUBLIC TRANSPORTATION
Module-1
Principles of planning, evaluation, selection, adoption, financing and implementation of alternative urban Transportation systems

AKELLA NAGA SAI BABA

20/05/2020

- In the transport planning, suggesting alternative urban transport systems is a big task which involves planning of infrastructure, evaluating the functionality, selection of particular links/mode of transport, adopting as scientifically justified one, keeping an insight on the financing & implementation.

For Example:-

- The financing can be utilized as Govt. funding from Tax, revenues of the city travelers, surcharge on the fuel consumption, funding form world bank, private participation etc.,
- The payback of construction cost will be either by Toll or by opening the neighborhood land for commercial establishments.
- The recent projects in Hyderabad city relating to the roads like ORR is opened for Toll based payback in the investment and MRTS is with leasing of neighborhood land within the right of way of MRTS for commercial establishments and through ticketing for transportation.

In order to justify this two projects, there are three important issues to be considered by the planner.

1) Assessment of travel demand like demand profile development.
2) Development of an existing and proposed network profile called as development of supply profile.
3) Study on the existing transport systems & feasibility to adopt new transport systems acceptable to the existing road network & the demand.

As a planner, one can justify this two projects with the following lead.

Demandcatchment:-

- for (Hyderabad city) HMDA, it has an intention area of 7500 square kilometers with a concentric type of land use having the influence of around 50Km radius from the CBD.
- The outer ring road suggested will be of around 100 Km with a right of way of around 200 mts.
- Similarly the MRTS with a route length of around 150Km in all the 3 phases and with a right of way of around 200 mts.
- This is the static area which is circum scribed the Hyderabad city transversely and longitudinally cross the Hyderabad city with rail transport system as MRTS.

- These two are considered to be static structures and influenced by the characteristics of travel demand which makes these two projects operative.
- When the planning is proposed, the shadow price and benefits should be properly visualized and justified has the evaluating criteria.
- If the planner fails to justify and select the corridors, the approach of construction is giving to be objectionable to many people.

- In fact, any transport system should be social calls, academic calls sake and sustainable to the environment.
- It is because the transportation will change the land use, migration, changes the socio-economic characteristics & culture of the people.
- As a planner, we should keep this in mind and visualize the problem and project in a scientific way.

- Demand catchment Lead will be developed with two approaches:-

  1) Conceptual approach

  2) Conventional approach

1) conceptual approach:-

- In conceptual approach, where the demand profile is referred with three characteristics viz.,

1) Trip Length (T_L)

2) Trip Intensity (T_I)

3) Trip Orientation (T_O)

2) The Conventional approach:-

In this approach, by conducting the home interview survey in a equi distributed manner of a sample size of 1% to 0.5 % and expanding to the 100%.

- The information collecting will be the trips with attributes like -- - -purpose(n),

  -origin(i),

  -Destination(j),

  -Mode of transport(m),

  -route of travel(r),

  -time of travel(t),

Represented as ---- $T^{n}ijmrt$

- By processing this data on a base map of a road network, the need for either outer ring road (or) MRTS can be justified, and the transparency on the vision document of master plan can be justified as scientific/opportunistic.

- In order to consolidate the demand catchment and recommended certain new infrastructure comparable to the existing roads and planning for new transport system sustainable to the demand be analyzed from the demand catchment.
- Demand is measured with trips and trips can be configured from the survey data into two perspectives.

1) Dividing the trips into four sub- groups

- External – External
- External – Internal
- Internal –External
- Internal – Internal
- Study area will be divided into certain sectors, zones and sub zones.
- Beyond the study area, the influenced area will be divided into certain sectors probably the direction wise of state boundary, district boundary wise etc.
- If the External – External profit to the study area is dominant, construction of ring roads are essential.

- similarly if the External – Internal, and Internal – External are higher to the extent, whether domains in the traffic split, designing of radial roads and flyovers and the important functional roads are essential.
- If the Internal–Internal traffic is between 30 to 50%, then planning the internal road network of the city with respect to connectivity & Mobility is essential.
- Change of functionality of a road from local street to collector street and collector street to sub arterial and new connectivities are essential to plan in a city area over a time.

2) After conducting the home interview survey(or)road side interview survey, with classified volume counts, trips will be characterized into three perspectives like

1) Trip Length
2) Trip Intensity and
3) Trip Orientation

- From the Trip length point of view, the user average Travelling distance will be classified like 7to8Km, 3to7Km and less than 3Kms and if the average trip length is more than 8Kms and is of 50% dominates among the other trip lengths facilitating, MRTS for such a group of people is advisable.
- Similarly for a average trip length maker, trip length of 3 to 7 Km, planning of Bus (or) private vehicles giving certain concessions, Privileges on road utility tax, fuel consumption, may encourage the public transport.
- Similarly the average travel length is less than 3 Kms, encourage the slow moving vehicles with dedicated lengths will be a planning mode for suggesting alternative urban transport systems.

- In order to evaluate the road network against the demand, the supply network and its configuration should be visualized into three perspectives.

1) The No. of Junctions
2) The Road Density
3) The Shape of Network

1) The No. of Junctions:-

- The No. of Junctions should be optimally located as major & minor, which should be designed with respect to roads configured in the city.

For Example:-

- For arterial roads, there should be one Junction for every 2 Km of travel length.
- It should taken by 10 % of total road density for sub arterial, 1 junction for one Km and beyond and it should be of 20 % of total road density for collector streets there should be one junction of every ½Km & beyond & this represents should 30% for local street for every 0.5 Km of length and it represents 50% of total road lengths.
- This pattern should be used to analyze the deficiency of existing road network.

2) The Road Density:

- For an ideal city, the road density should be 18-33 Km for every one sq.Km of geographical area and all these roads should change this functionality over a time due to change of land use & change of demand catchment.

For Example:-

- Local street should change to collector street and the arterial roads should change to expressways (or) free ways in a time period.

3) The shape of net work:-

- In order to promote a good access, multi connectivity, optimal spacing, the shape of road network for any city should be pre-defined with the geographical area of a city is of uniform shape like a circular, square(or) rectangular then configuring the network like grid, circular, radial & Pre-structure are essential.

- Lastly the system compatibility should be visualized by considering quick intensity and orientation along the trip length.
- In order to recommend certain new mode of transport like MRTS, Identification of routing is essential.
- The routing should meet the demand catchment where the trip length of average of 8 Kms should be occupied in the route of MRTS to the extent of 50 %.
- If the routing is made in that manner, it is acceptable to the road user.

- For the demand profile survey, desire line diagram representing trip length, trip Intensity & trip orientation should be plotted.
- This facilitates the routing pattern by virtue of orientation and trip Intensity to that category will facilitate for scheduling of vehicles.

- Similarly the desire line diagram is plotted of trip length of less than 3 Km, the dedicated lines for slow moving vehicles, its orientation & the road geometrics can be identified.
- By considering the external to internal and internal to external traffic from every zone centroid, the other roads like radial roads and pre-structured roads can be identified.
- In this way, the principles of planning from three perspectives like demand, supply and system can be evaluated with the mutual perspectives and selection can be made on types, geometrics and density for adopting in a city.


THE END

PUBLIC TRANSPORTATION Module-1 Formulation of Community Goals & Objectives

AKELLA NAGA SAI BABA

22-05-2020

Formulation of Community Goals & Objectives

- In the urban areas, every city will have certain goals & objectives in reference to the interaction on multiple activities, because of the urbanization acting intervention on everyday, by every person is important.
- where as, in a family of the rural community, the head of house will interact for activity in a constant way, where as in urban area, every family member will interact.
- Normally, the road user community will have goals like the less travel time, less Travel cost, more comfort, convenience, safest travel, highly secured travel & consistency in service.

Formulation of Community Goals & Objectives

Similarly community will have:-

- Travel distance should be limited.
- Social equity should be inclusive in interaction
- There should be equipotential land use attraction nearer to affordable travel, and at the same time, the denial of certain privilege should be prohibited.
- When these goals and objectives are to be fulfilled, the domain of transportation planning should be made such that, both system owner & community will mutually depends on shadow notice & shadow benefit.

Formulation of Community Goals & Objectives

<u>For Example:</u>-

- A new infrastructure should open under a system-Toll tax system, it should be opened with privilege crisis or paneled connectivity should be prevailed with a different benefits on travel time & cost.
- The system owner should always be put on long term beneficiaries, where as the community should be benefited immediately.

Formulation of Community Goals & Objectives

<u>Example:-</u>

- Cost of primary road with elevated highways, ITS architecture, for time sensitive travel & a transit corridor & ground as fedal road for privilege group of people who are sensitive to travel cost.
- Similarly there should be a road network, which is secondary having good connectivity, accessibility & mobility to the road network of primary sensitive to the travel cost.
- This approach will Subdue the difference social privilege, promote the level of service in reference to safety, which is of most concerned in urban roads.

Formulation of Community Goals & Objectives

- In process of construction of ORR, a sudden changes in road, met with many accidents during construction of ORR partially and at initial stages.
- That much accident cost can be avoided, if a primary road network with journey cost, connected secondary road networks are planned.
- This is the planning deficiency, observed in outer ring road construction.

Formulation of Community Goals & Objectives

- Whenever we propose MRTS & BRTS, this transport systems should be opened in voting the level of service by facilitating parallel privileges to the community.
- In many times, planners will forget change of functionality of road & incorporation of hierarchy in road construction, but attempt many times and promote the transport systems hierarchically.
- In other words, to reduce the gap between system owner & community, planning should always interface multi-access & connectivity.

Formulation of Community Goals & Objectives

- Before opening any PPP(public- private-partnership) mode of any project, the shadow per project cost should be equal to the new infrastructure, construction cost & alternative infrastructure construction cost.
- This was observed as lapse in the policy of MRTS in fixing the ticket cost & routing strategy where competition from public transport and buses are attempted, and reconstructed.
- And the user is exposed the travel cost by MRTS compared with private vehicle.

Formulation of Community Goals & Objectives

This sort of planning should be avoided and the following are the some of community appreciated interventions.

1) Travel time district concept –where all the interactions will be job to shopping etc., within a radius of 2½ to 5Km.
2) Network with Multi access & connectivity.
3) Social privileges for travelling on public transport.
4) No differential shadow benefits in prime, between system owner and community.


THE END

PUBLIC TRANSPORTATION Module-1 Inventory Of Existing Conditions

AKELLA NAGA SAI BABA

25/05/2020

Inventory Of Existing Conditions

E-E-E

E-Engineering
E-Enforcement
E-Education

Inventory Of Existing Conditions:-

- Land use Audit
- Road Surface Condition
- Traffic Audit
- Network Audit
- Risk Audit
- Geometric Audit
- Road User Audit
- Topographic/Terrain Audit
- Soil Audit

Inventory Of Existing Conditions

Technology:-

1) Satellite -

- Land use & land cover;
- soil/Geo-morphological profile/Elevator;
- Terrain condition in general;
- Network characteristics.

2) Laser Technology -

- Topographic geometrics ;
- Mobile Mapper / Terrestrial Scanner--- 3Dimensional view of all structures

Inventory Of Existing Conditions

3) Conventional Testing:-

- Soil,
- water table,
- Moisture content etc.,

4) Traffic Survey -

Collection of data - Organization of surveys:-

- Road side Interview survey ;
- Classified Volume Count Survey,
- Home interview Survey etc.

Inventory Of Existing Conditions

- Objective –Travel demand Factors influencing travel demand

What factors?

- Accident studies
- Infrastructure design
- Traffic
- Highway

Inventory Of Existing Conditions

Output of Projects:-

- Technologies by a high resolution satellites.

Inventory Of Existing Conditions

<u>Inventory Of Existing Conditions:-</u>

In the field of transport planning, there are three dynamics, a planner should looking:-

1) The prevailing conditions at base level
2) Change of prevailing conditions for future of horizon level, time
3) Why the prevailing conditions are generated from history?

Inventory Of Existing Conditions

- Where ever come out inventory with respect to transport planning, the out put should be under these three dynamics with the heads like:-

1) Demand profile
2) Supply Profile
3) System Profile
4) Land Use Profile
5) Engineering Profile

Inventory Of Existing Conditions

- To initiate inventory, one must know the basic objectives of transport planning.

The objectives are like:-

1) Accidental studies
2) Infrastructure planning
3) Traffic management
4) Designing of highway infrastructure and impact studies on environment, land use and traffic.

Inventory Of Existing Conditions

- In order to address these projects, one must identify the factors which must influence for generation of different problems.
- In general, the following are the Audits one should conduct like:-
- Land use Audit
- Road Surface Condition
- Traffic Audit
- Network Audit
- Risk Audit
- Geometric Audit
- Road User Audit
- Topographic/Terrain Audit
- Soil Audit

Inventory Of Existing Conditions

- The following are the technologies which will widely used for conducting the inventory on tracking directly and static features.

1) Satellite and GPS Technology
2) Collecting information on land use and land cover-soil geo-morphological data with terrestrial technology.
3) Terrain and network characteristics from spatial technologies by high resolution satellites.

Inventory Of Existing Conditions

4) Laser beam technology to capture features on topography, geometric statistics.

5) Mobile mapper and terrestrial scanner working with photogrammetry and laser beam to generate three dimensional view on all the assets and conventional surveys to characterize the soil, material and moisture contents.

Traffic surveys with manned & unmanned to collect information on the traffic dynamics by:-

- Road side interview,
- Classified volume counts,
- Spot speeds,
- Head ways,
- Delay studies,
- Home Interview survey etc.,

Inventory Of Existing Conditions

- By conducting all these surveys and processing them will facilitate the basic inputs for planning.
- Planning will depend on the five profiles like:-

1) Demand profile
2) Supply Profile
3) System Profile
4) Land Use Profile
5) Engineering Profile

Inventory Of Existing Conditions

1) Demand profile:-

- Trips- T^n ijmrt
- n-purpose of trip
- i-origin of trip
- J-destination of trip
- m-mode of travel
- r-route of travel
- t-time of travel(off peak/peak)

Business corridors:-

-Trip length

-Trip intensity

-Trip orientation

home interviews

Inventory Of Existing Conditions

2) supply profile:-

- junctions
- Nodes
- Links
- Paths
- Shape of network

Inventory Of Existing Conditions

3) Geometric function

4) Land use profile:-

mobile mapper- 1 cm with in 0.5*0.5m

5) Engineering profile:-

Total station-terrain topography

- Traffic jams junctions should be visualized.


THE END

Chapter 7

Trip generation

7.1 Overview

Trip generation is the first stage of the classical first generation aggregate demand models. The trip generation aims at predicting the total number of trips generated and attracted to each zone of the study area. In other words this stage answers the questions to "how many trips" originate at each zone, from the data on household and socioeconomic attributes. In this section basic definitions, factors affecting trip generation, and the two main modeling approaches; namely growth factor modeling and regression modeling are discussed.

7.1.1 Types of trip

Some basic definitions are appropriate before we address the classification of trips in detail. We will attempt to clarify the meaning of journey, home based trip, non home based trip, trip production, trip attraction and trip generation.

Journey is an out way movement from a point of origin to a point of destination, where as the word "trip" denotes an outward and return journey. If either origin or destination of a trip is the home of the trip maker then such trips are called home based trips and the rest of the trips are called non home based trips. Trip production is defined as all the trips of home based or as the origin of the non home based trips. See figure 7:1

Trips can be classified by trip purpose, trip time of the day, and by person type. Trip generation models are found to be accurate if separate models are used based on trip purpose. The trips can be classified based on the purpose of the journey as trips for work, trips for education, trips for shopping, trips for recreation and

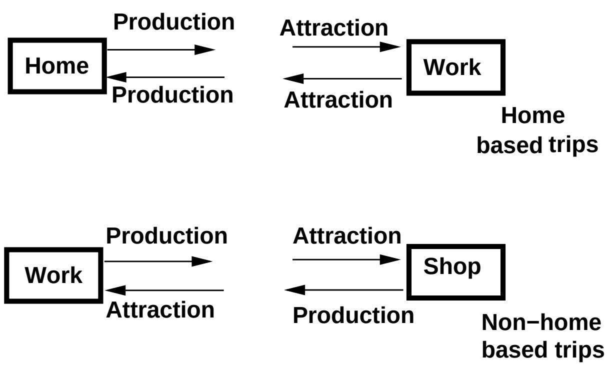

Figure 7:1: trip types

other trips. Among these the work and education trips are often referred as mandatory trips and the rest as discretionary trips. All the above trips are normally home based trips and constitute about 80 to 85 percent of trips. The rest of the trips namely non home based trips, being a small proportion are not normally treated separately. The second way of classification is based on the time of the day when the trips are made. The broad classification is into peak trips and off peak trips. The third way of classification is based on the type of the individual who makes the trips. This is important since the travel behavior is highly influenced by the socio economic attribute of the traveler and are normally categorized based on the income level, vehicle ownership and house hold size.

7.1.2 Factors affecting trip generation

The main factors affecting personal trip production include income, vehicle ownership, house hold structure and family size. In addition factors like value of land, residential density and accessibility are also considered for modeling at zonal levels. The personal trip attraction, on the other hand, is influenced by factors such as roofed space available for industrial, commercial and other services. At the zonal level zonal employment and accessibility are also used. In trip generation modeling in addition to personal trips, freight trips are also of interest. Although the latter comprises about 20 percent of trips, their contribution to the congestion is significant. Freight trips are influenced by number of employees, number of sales and area of commercial firms.

7.2 Growth factor modeling

Growth factor modes tries to predict the number of trips produced or attracted by a house hold or zone as a linear function of explanatory variables. The models have the following basic equation:

$$T_i = f_i t_i \tag{7.1}$$

where T_i is the number of future trips in the zone and t_i is the number of current trips in that zone and f_i is a growth factor. The growth factor f_i depends on the explanatory variable such as population (P) of the zone , average house hold income (I) , average vehicle ownership (V). The simplest form of f_i is represented as follows

$$f_i = \frac{P_i^d \times I_i^d \times V_i^d}{P_i^c \times I_i^c \times V_i^c} \tag{7.2}$$

where the subscript " d" denotes the design year and the subscript "c" denotes the current year.

Example

Given that a zone has 275 household with car and 275 household without car and the average trip generation rates for each groups is respectively 5.0 and 2.5 trips per day. Assuming that in the future, all household will have a car, find the growth factor and future trips from that zone, assuming that the population and income remains constant.

Solution

Current trip rate $t_i = 275 \times 2.5 + 275 \times 5.0 = 2062.5$ trips / day.

Growth factor $F_i = \frac{V_i^d}{V_i^c} = \frac{550}{275} = 2.0$

Therefore, no. of future trips $T_i = F_i t_i = 2.0 \times 2062.5 = 4125$ trips / day.
The above example also shows the limitation of growth factor method. If we think intuitively, the trip rate will remain same in the future.

Therefore the number of trips in the future will be 550 house holds $\times$ 5 trips per day = 2750 trips per day .

It may be noted from the above example that the actual trips generated is much lower than the growth factor method. Therefore growth factor models are normally used in the prediction of external trips where no other methods are available. But for internal trips , regression methods are more suitable and will be discussed in the following section.

7.3 Regression methods

The general form of a trip generation model is

$$T_i = f(x_1, x_2, x_3, ...x_i, ...x_k) \tag{7.3}$$

Where xi's are prediction factor or explanatory variable. The most common form of trip generation model is a linear function of the form

$$T_i = a_0 + a_1 x_1 + a_2 x_2 + ...a_i x_i ... + a_k x_k \tag{7.4}$$

where a_i 's are the coefficient of the regression equation and can be obtained by doing regression analysis. The above equations are called multiple linear regression equation, and the solutions are tedious to obtain manually. However for the purpose of illustration, an example with one variable is given.

Example

Let the trip rate of a zone is explained by the household size done from the field survey. It was found that the household size are 1, 2, 3 and 4. The trip rates of the corresponding household is as shown in the table below. Fit a linear equation relating trip rate and household size.

Household size(x)				
	1	2	3	4
Trips	1	2	4	6
per	2	4	5	7
day(y)	2	3	3	4
Σy	5	9	12	17

Solution The linear equation will have the form $y = bx + a$ where y is the trip rate, and x is the household size, a and b are the coefficients. For a best fit, b is given by

$$\begin{aligned}
b &= \frac{n\Sigma xy - \Sigma x \Sigma y}{n\Sigma x^2 - (\Sigma x)^2} \\
a &= \bar{y} - b\bar{x} \\
\Sigma x &= 3 \times 1 + 3 \times 2 + 3 \times 3 + 3 \times 4 = 30 \\
\Sigma x^2 &= 3 \times (1^2) + 3 \times (2^2) + 3 \times (3^2) + 3 \times (4^2) = 90
\end{aligned}$$

$$\begin{aligned}
\Sigma y &= 5+9+12+17 = 43 \\
\Sigma xy &= 1\times 1+1\times 2+1\times 2 \\
&+ 2\times 2+2\times 4+2\times 3 \\
&+ 3\times 4+3\times 5+3\times 3 \\
&+ 4\times 6+4\times 7+4\times 4 \\
&= 127 \\
\bar{y} &= 43/12 = 3.58 \\
\bar{x} &= 30/12 = 2.5 \\
b &= \frac{n\Sigma xy - \Sigma x\Sigma y}{n\Sigma x^2 - (\Sigma x)^2} \\
&= \frac{((12\times 127)-(30\times 43))}{((12\times 90)-(30)^2)} = 1.3 \\
a &= \bar{y} - b\bar{x} = 3.58 - 1.3\times 2.5 = +0.33 \\
\bar{y} &= 1.3x - 0.33
\end{aligned}$$

7.4 Summary

Trip generation forms the first step of four-stage travel modeling. It gives an idea about the total number of trips generated to and attracted from different zones in the study area. Growth factor modeling and regression methods can be used to predict the trips. They are discussed in detail in this chapter.

7.5 Problems

1. The trip rate (y) and the corresponding household sizes (x) from a sample are shown in table below. Compute the trip rate if the average household size is 3.25 (Hint: use regression method).

	Householdsize(x)			
	1	2	3	4
Trips	1	3	4	5
per	3	4	5	8
day(y)	3	5	7	8

Solution Fit the regression equation as below.

$$\begin{aligned}
\Sigma x &= 3\times 1+3\times 2+3\times 3+3\times 4 = 30 \\
\Sigma x^2 &= 3\times(1^2)+3\times(2^2)+3\times(3^2)+3\times(4^2) = 90 \\
\Sigma y &= 7+12+16+21 = 56 \\
\Sigma xy &= 1\times 1+1\times 3+1\times 3 \\
&+ 2\times 3+2\times 4+2\times 5 \\
&+ 3\times 4+3\times 5+3\times 7
\end{aligned}$$

$$
\begin{aligned}
& + \quad 4 \times 5 + 4 \times 8 + 4 \times 8 \\
& = \quad 163 \\
\bar{y} & = \quad 56/12 = 4.67 \\
\bar{x} & = \quad 30/12 = 2.5 \\
b & = \quad \frac{n\Sigma xy - \Sigma x \Sigma y}{n\Sigma x^2 - (\Sigma x)^2} \\
& = \quad \frac{((12 \times 163) - (30 \times 56))}{((12 \times 90) - (30)^2)} = 1.533 \\
a & = \quad \bar{y} - b\bar{x} = 4.67 - 1.533 \times 2.5 = 0.837 \\
y & = \quad 0.837 + 1.533x
\end{aligned}
$$

When average household size =3.25, number of trips becomes,
$y = 0.837 + 1.533 \times 3.25 = 5.819$

PUBLIC TRANSPORTATION
MODULE-1
TRANSPORTATION MODELLING
TRIP GENERATION

AKELLA NAGA SAI BABA

27/05/2020

TRIP GENERATION

- Trip generation is the first stage of the classical first generation aggregate demand models.
- The trip generation aims at predicting the total number of trips generated and attracted to each zone of the study area.
- In other words, this stage answers the questions to “how many trips” originate at each zone, from the data on household and socio economic attributes.

TRIP GENERATION

- In this section, basic definitions, factors affecting trip generation, and the two main modeling approaches; namely
- 1)Growth factor modeling and
- 2)Regression modeling are discussed.

Types of trip:-

- Some basic definitions are appropriate, before we address the classification of trips in detail.
- We will attempt to clarify the meaning of journey, home based trip, non home based trip, trip production, trip attraction and trip generation.

TRIP GENERATION

- Journey is an out way movement from a point of origin to a point of destination, where as the word "trip" denotes an outward and return journey.
- If either origin or destination of a trip is the home of the trip maker, then such trips are called home based trips and the rest of the trips are called non home based trips.

TRIP GENERATION

- Trip production is defined as all the trips of home based or as the origin of the non home based trips.
- See figure 7:1

TRIP GENERATION

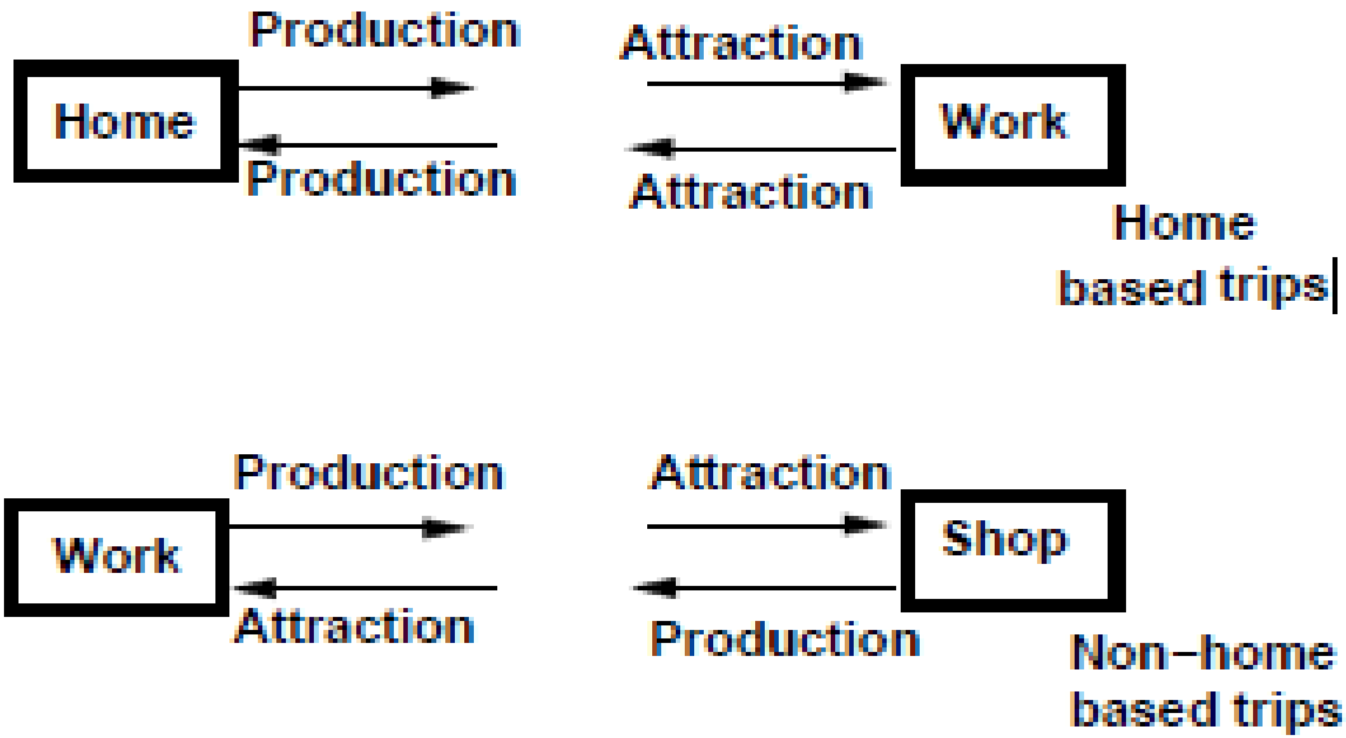

Figure 7:1: trip types

TRIP GENERATION

- Trips can be classified by:-
- trip purpose,
- trip time of the day, and
- by person type.
- Trip generation models are found to be accurate, if separate models are used based on trip purpose.

TRIP GENERATION

- The trips can be classified based on the purpose of the journey as:-
- trips for work,
- trips for education,
- trips for shopping,
- trips for recreation and
- other trips.
- Among these, the work and education trips are often referred as mandatory trips and the rest as discretionary trips.
- All the above trips are normally home based trips and constitute about 80 to 85 percent of trips.

TRIP GENERATION

- The rest (15 to 20%) of the trips namely non home based trips, being a small proportion are not normally treated separately.
- The second way of classification is based on the time of the day, when the trips are made.
- The broad classification is divided into peak trips and off peak trips.
- The third way of classification is based on the type of the individual who makes the trips.

TRIP GENERATION

- This is important, since the travel behavior is highly influenced by the socio economic attributes of the traveler and are normally categorized based on the:-
- income level,
- vehicle ownership and
- house hold size.

TRIP GENERATION

<u>Factors affecting trip generation:-</u>

- The main factors affecting personal trip production includes:-
- income,
- vehicle ownership,
- house hold structure and
- family size.

TRIP GENERATION

- In addition, factors like:-
- value of land,
- residential density and
- accessibility are also considered for modeling at zonal levels.
- The personal trip attraction, on the other hand, is influenced by factors such as roofed space available for industrial, commercial and other services.
- At the zonal level, zonal employment and accessibility are also used.

TRIP GENERATION

- In trip generation modeling, in addition to personal trips, freight trips are also of interest.
- Although the latter comprises about 20 percent of trips, their contribution to the congestion is significant.
- Freight trips are influenced by:-
- number of employees,
- number of sales and
- area of commercial firms.

TRIP GENERATION

1) Growth factor modeling:-

- Growth factor models tries to predict the number of trips produced or attracted by a house hold or zone as a linear function of explanatory variables.
- The models have the following basic equation:-
- $T_i = f_i t_i$ ----------------------------(7.1)
- where T_i is the number of future trips in the zone and
- t_i is the number of current trips in that zone and
- f_i is a growth factor.

TRIP GENERATION

- The growth factor (f_i)depends on the explanatory variable such as population (P) of the zone , average house hold income (I) , average vehicle ownership (V).
- The simplest form of (f_i)is represented as follows:-

TRIP GENERATION

$$f_i = \frac{P_i^d \times I_i^d \times V_i^d}{P_i^c \times I_i^c \times V_i^c} \quad (7.2)$$

where the superscript " d" denotes the design year and the superscript "c" denotes the current year.

Example

Given that a zone has 275 household with car and 275 household without car and the average trip generation rates for each groups is respectively 5.0 and 2.5 trips per day. Assuming that in the future, all household will have a car, find the growth factor and future trips from that zone, assuming that the population and income remains constant.

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TRIP GENERATION

Therefore, no. of future trips $T_i = F_i t_i = 2.0 \times 2062.5 = 4125$ trips / day.

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Therefore growth factor models are normally used in the prediction of external trips where no other methods are available.

But for internal trips , regression methods are more suitable and will be discussed in the following section.

TRIP GENERATION

2) Regression methods

The general form of a trip generation model is

$$T_i = f(x_1, x_2, x_3, \ldots x_i, \ldots x_k) \qquad (7.3)$$

Where xi's are prediction factor or explanatory variable.

The most common form of trip generation model is a linear function of the form

$$T_i = a_0 + a_1 x_1 + a_2 x_2 + \ldots a_i x_i \ldots + a_k x_k \qquad (7.4)$$

TRIP GENERATION

- where a_i 's are the coefficient of the regression equation and can be obtained by doing regression analysis.
- The above equations are called multiple linear regression equation, and the solutions are tedious to obtain manually.
- However for the purpose of illustration, an example with one variable is given.

TRIP GENERATION

Example:-

- Let the trip rate of a zone is explained by the household size done from the field survey. It was found that the household size are 1, 2, 3 and 4. The trip rates of the corresponding household is as shown in the table below. Fit a linear equation relating trip rate and household size.

TRIP GENERATION

Household size(x)	1	2	3	4
Trips	1	2	4	6
per	2	4	5	7
day(y)	2	3	3	4
Σy	5	9	12	17

TRIP GENERATION

Solution:-

The linear equation will have the form

$y = bx + a$

where y is the trip rate, and

x is the household size,

a and b are the coefficients.

For a best fit, b is given by

TRIP GENERATION

$$b = \frac{n\Sigma xy - \Sigma x \Sigma y}{n\Sigma x^2 - (\Sigma x)^2}$$

$$a = \bar{y} - b\bar{x}$$

$$\Sigma x = 3 \times 1 + 3 \times 2 + 3 \times 3 + 3 \times 4 = 30$$

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TRIP GENERATION

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&= 127 \\
\bar{y} &= 43/12=3.58 \\
\bar{x} &= 30/12=2.5 \\
b &= \frac{n\Sigma xy-\Sigma x\Sigma y}{n\Sigma x^2-(\Sigma x)^2} \\
&= \frac{((12\times 127)-(30\times 43))}{((12\times 90)-(30)^2)}=1.3 \\
a &= \bar{y}-b\bar{x}=3.58-1.3\times 2.5=+0.33 \\
\bar{y} &= 1.3x-0.33
\end{aligned}
$$

TRIP GENERATION

<u>**Summary:-**</u>

- Trip generation forms the first step of four-stage travel modeling.
- It gives an idea about the total number of trips generated to and attracted from different zones in the study area.
- Growth factor modeling and regression methods can be used to predict the trips.
- They are discussed in detail in this chapter.

TRIP GENERATION

Problems:-

The trip rate (y) and the corresponding household sizes (x) from a sample are shown in table below. Compute the trip rate if the average household size is 3.25 (Hint: use regression method).

TRIP GENERATION

	Householdsize(x)			
	1	2	3	4
Trips	1	3	4	5
per	3	4	5	8
day(y)	3	5	7	8

Solution Fit the regression equation as below.

$$
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&+ 3\times 4 + 3\times 5 + 3\times 7
\end{aligned}
$$

TRIP GENERATION

$$
\begin{aligned}
&+ \quad 4\times 5+4\times 8+4\times 8 \\
&= \quad 163 \\
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\bar{x} &= \quad 30/12 = 2.5 \\
b &= \quad \frac{n\Sigma xy - \Sigma x\Sigma y}{n\Sigma x^2 - (\Sigma x)^2} \\
&= \quad \frac{((12\times 163)-(30\times 56))}{((12\times 90)-(30)^2)} = 1.533 \\
a &= \quad \bar{y} - b\bar{x} = 4.67 - 1.533\times 2.5 = 0.837 \\
y &= \quad 0.837 + 1.533x
\end{aligned}
$$

When average household size =3.25, number of trips becomes,

$y = 0.837 + 1.533\times 3.25 = 5.819$


THE END

Public Transportation Module-1 Trip Distribution

Akella. Naga Sai Baba

01-06-2020

Trip Distribution

Summary:-

- The second stage of travel demand modeling is the trip distribution.
- Trip matrix can be used to represent the trip pattern of a study area.
- Growth factor methods and gravity model are used for computing the trip matrix.
- Singly constrained models and doubly constrained growth factor models are discussed.

Trip Distribution

- The decision to travel for a given purpose is called trip generation.
- These generated trips from each zone is then distributed to all other zones based on the choice of destination.
- This is called trip distribution which forms the second stage of travel demand modeling.

Trip Distribution

- There are a number of methods to distribute trips among destinations; and two such methods are
- growth factor model and
- gravity model.
- **Growth factor model:-** It is a method which respond only to relative growth rates at origins and destinations and this is suitable for short- term trend extrapolation.

Trip Distribution

- **Gravity model:-** In this method, we start from assumptions about trip making behavior and the way it is influenced by external factors.
- An important aspect of the use of gravity models is their calibration, that is the task of fixing their parameters so that the base year travel pattern is well represented by the model.

Trip Distribution

Definitions and notations:-

Trip matrix:-

- The trip pattern in a study area can be represented by means of a trip matrix or origin-destination (O-D)matrix.
- This is a two dimensional array of cells where rows and columns represent each of the zones in the study area.
- The notation of the trip matrix is given in figure 8:1.

Trip Distribution

Zones	1	2	…	j	…	n	O_i
1	T_{11}	T_{12}	…	T_{1j}	…	T_{1n}	O_1
2	T_{21}	T_{22}	…	T_{2j}	…	T_{2n}	O_2
$\vdots$	…	…	…	…	…	…	$\vdots$
	T_{i1}	T_{i2}	…	T_{ij}	…	T_{in}	O_i
$\vdots$	…	…	…	…	…	…	$\vdots$
n	T_{ni}	T_{n2}	…	T_{nj}	…	T_{nn}	O_n
D_j	D_1	D_2	…	D_j	…	D_n	T

<u>Figure 8:1: Notation of a trip matrix</u>

where Dj = iTij ,
Oi = jTij , and
T = ijTij

Trip Distribution

- The cells of each row (*i*) contain the trips originating in that zone which have as destinations the zones in the corresponding columns.
- T_{ij} is the number of trips between origin *i* and destination *j*.
- O_i is the total number of trips between originating in zone *i* and D_j is the total number of trips attracted to zone *j*.

Trip Distribution

- The sum of the trips in a row should be equal to the total number of trips emanating from that zone.
- The sum of the trips in a column is the number of trips attracted to that zone.
- These two constraints can be represented as:- $\Sigma_j T_{ij} = O_i$ $\Sigma_i T_{ij} = D_j$ If reliable information is available to estimate both O_i and D_j, the model is said to be doubly constrained.
- In some cases, there will be information about only one of these constraints, the model is called singly constrained.

Trip Distribution

Generalized cost:-

- One of the factors that influences trip distribution is the relative travel cost between two zones.
- This cost element may be considered in terms of distance, time or money units.
- It is often convenient to use a measure combining all the main attributes related to the dis-utility of a journey and this is normally referred to as the generalized cost of travel.

Trip Distribution

Growth factor methods:-

Uniform growth factor:-

- If the only information available is about a general growth rate for the whole of the study area, then we can only assume that it will apply to each cell in the matrix, that is a uniform growth rate.
- The equation can be written as:-
- $T_{ij} = f \times t_{ij}$ ----------------------- (8.2)

Trip Distribution

- where f is the uniform growth factor
- t_{ij} is the previous total number of trips,
- T_{ij} is the expanded total number of trips.
- Advantages are that they are simple to understand, and they are useful for short-term planning.
- Limitation is that the same growth factor is assumed for all zones as well as attractions.

Trip Distribution

<u>Example:-</u>

- Trips originating from zone 1,2,3 of a study area are 78,92 and 82 respectively and those terminating at zones 1,2,3 are given as 88,96 and 78 respectively. If the growth factor is 1.3 and the cost matrix is as shown below, find the expanded origin-constrained growth trip table.

Trip Distribution

	1	2	3	o_i
1	20	30	28	78
2	36	32	24	92
3	22	34	26	82
d_j	88	96	78	252

Trip Distribution

Solution:-

- Given growth factor = 1.3,
- Therefore, multiplying the growth factor with each of the cells in the matrix gives the solution as shown below.

Trip Distribution

	1	2	3	O_i
1	26	39	36.4	101.4
2	46.8	41.6	31.2	119.6
3	28.6	44.2	33.8	106.2
D_j	101.4	124.8	101.4	327.6

Trip Distribution

Doubly constrained growth factor model:-

- When information is available on the growth in the number of trips originating and terminating in each zone, we know that there will be different growth rates for trips in and out of each zone and consequently having two sets of growth factors for each zone.
- This implies that there are two constraints for that model and such a model is called doubly constrained growth factor model.
- One of the methods of solving such a model is given by Furness who introduced *balancing factors* a_i and b_j as follows:-
- $T_{ij} = t_{ij} \times a_i \times b_j$ -- (8.3)

Trip Distribution

Advantages and limitations of growth factor model:-

Advantages of this method are:-

- Simple to understand.
- Preserve observed trip pattern.
- useful in short term-planning.

The limitations are:-

- Depends heavily on the observed trip pattern.
- It cannot explain unobserved trips.
- Do not consider changes in travel cost.
- Not suitable for policy studies like introduction of a mode.

Trip Distribution

<u>Gravity model:-</u>

- This model originally generated from an analogy with Newton's gravitational law.
- Newton's gravitational law says, $F = GM_1 M_2 / d_2$ Analogous to this, $T_{ij} = CO_i D_j / c_{ij^n}$
- Introducing some balancing factors,
- $T_{ij} = A_i O_i B_j D_j f(c_{ij})$
- where A_i and B_j are the balancing factors,
- $f(c_{ij})$ is the generalized function of the travel cost.
- This function is called *deterrence function* because it represents the disincentive to travel as distance (time) or cost increases.

Trip Distribution

<u>**Some of the versions of this function are:-**</u>

$$f(c_{ij}) = e^{-\beta c_{ij}} \tag{8.4}$$

$$f(c_{OJ}) = c_{ij}^{-n} \tag{8.5}$$

$$f(c_{ij}) = c_{ij}^{-n} \times e^{-\beta c_{ij}} \tag{8.6}$$

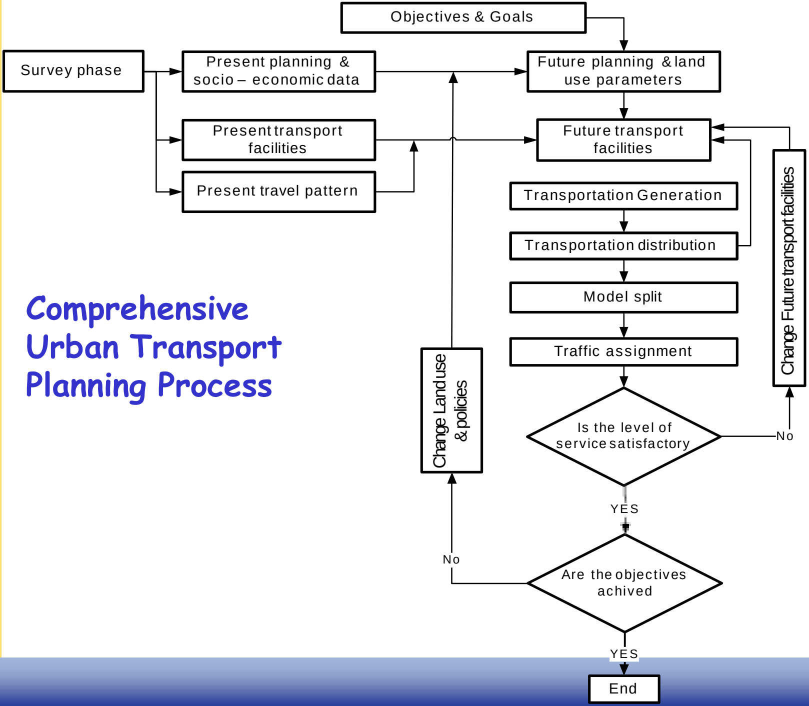
- The first equation is called the exponential function,
- Second one is called power function where as the
- Third one is a combination of exponential and power function.


THE END

Modal Split and Traffic Assignment

A.NAGA SAI BABA

Comprehensive Urban Transport Planning Process



Modal Split

Definition:

- Is the process of separating person-trips by the mode of travel.
- Usually expressed as a fraction, ratio, or percentage of the total number of trips.





Factors Affecting Modal Split

Characteristics of the trip

Trip purpose, trip length.

Household Characteristics

Income, Car ownership, family size and composition.

Zonal Characteristics

Residential density, concentration of workers, distance from CBD.

Network Characteristics

Accessibility ratio, travel time ratio, travel cost ratio.

Mode choice depends on:

- Travel time (in Vehicle + waiting)
- Travel cost
- Socio-economic status of user (income, family size,….)
- Level of travel service (comfort, Safety, speed, ……..)

The variable defining the model is a function called the **Utility Function**

Utility Function (Multi-Nomial Logit function)

$$\boxed{P\%_{(m)} = \frac{e^{um}}{\sum_{e=1}^{m} e^{um}}}$$

$P\%_{(m)}$ = the probability of choosing mode (m) of transportation

e = exponential base

um = the utility function of different modes

if we assume an urban area with **bus**, **car** and **taxi** modes

% for **bus** mode will be: $P\%_{(b)} = \frac{e^{ub}}{\sum(e^{ub}+e^{uc}+e^{uT})}$

% for **car** mode will be: $P\%_{(c)} = \frac{e^{uc}}{\sum(e^{ub}+e^{uc}+e^{uT})}$

% for **Taxi** mode will be: $P\%_{(T)} = \frac{e^{uT}}{\sum(e^{ub}+e^{uc}+e^{uT})}$

Utility Function

The general utility function is usually of the form:

$$u_m = K_m + K_1 * t_m + K_2 * \frac{x_m}{d} + K_3 * \frac{c_m}{Y}$$

Where:

K_m = mode specific constant

t_m = in vehicle time (minutes-one way)

x_m = out of vehicle time (minutes-one way)

d = distance (miles - one way)

c_m = cost (piasters - one way)

Y= annual income (pounds)

m is A for Auto, B for Bus, T for Taxi, t for train

Example

Considering a user choosing between two modes an **auto** and a **public Bus** considering the following situation:

Auto	Bus
t_A= 11 min	t_B= 14 min
x_A = 5 min	x_B = 8 min
c_A = 122 piasters	c_B = 50 piasters

If **d** was **7 miles**. And it is also given that the annual income of the user is **3000 pounds**.

And his value parameters as collected from data collection are:

K_1 = -0.03 **k_2 = -0.34** **k_3 = -50**

The values of the mode specific constants are assumed to be

k_A = -0.13 **k_B = zero**

Solution

$k_1 = -0.03$ $k_2 = -0.34$
$k_3 = -50$

Auto	Bus
$t_A = 11$ min	$t_B = 14$ min
$x_A = 5$ min	$x_B = 8$ min
$c_A = 122$	$c_B = 50$
$k_A = -0.13$	$k_B = -0$

$$u_m = K_m + K_1 * t_m + K_2 * \frac{x_m}{d} + K_3 * \frac{c_m}{Y}$$

u_A = -0.13 – 0.03 (11) - 0.34 (5/7) -50 (122/3000)
= -0.13 – 0.33 - 0.243 – 2.03 = **-2.74**

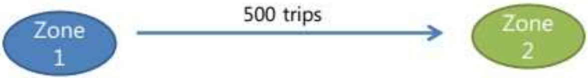
u_B = 0 – 0.03 (14) - 0.34 (8/7) -50 (50/3000)
= 0 – 0.42 – 0.39 – 0.83 = **-1.64**

$$P\%_A = \frac{e^{uA}}{(e^{uA}+e^{uB})} = \frac{0.0646}{(0.0646 + 0.194)}$$

$P\%_A$ = 25% and in the same way we get **$P\%_B$ = 75%**

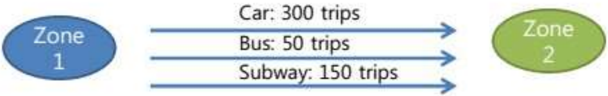
Review

- Trip Distribution



- Mode Choice

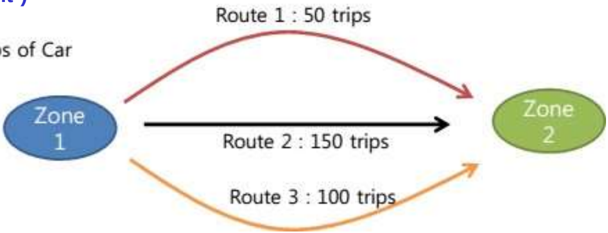
(Modal Split)

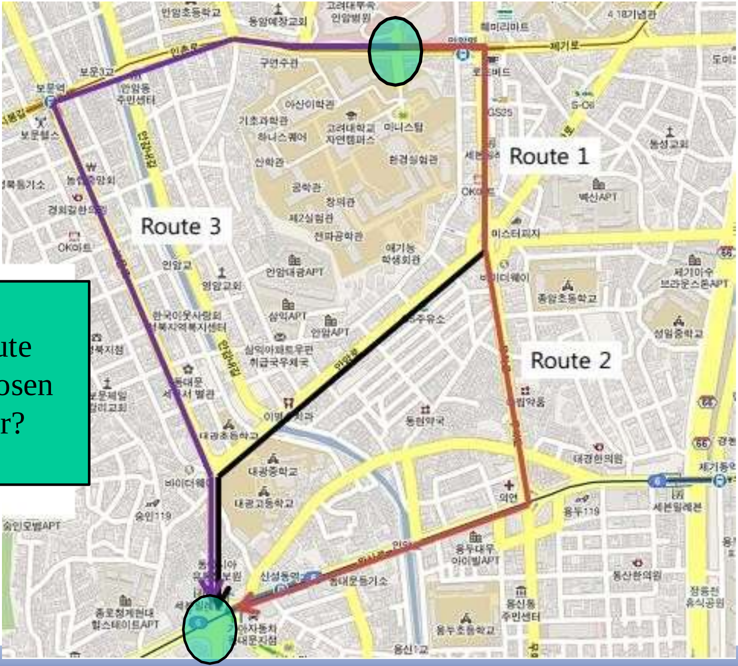


(Traffic Assignment)

- Route Choice

Among 300 trips of Car





Which route will be chosen by the user?

Traffic Assignment

Definition: is the stage in the transportation planning process where in the trip interchanges are allocated to different parts of the network forming the transportation system.

In this stage:

i. The route to be travelled is determined.
ii. The inter-zonal flows are assigned to the selected routs.

General principles

- All assignment techniques are based on route selection.
- The choice of the route is made on the basis of a number of criteria as **Journey time**, **length**, **cost**, **comfort**, **convenience**, **safety.**

➔ **(Travel Resistance)**

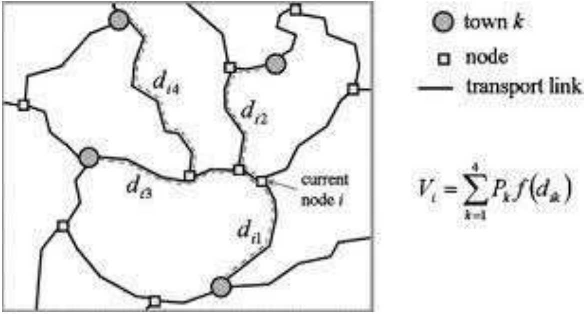
- **Journey time** is often considered the sole criterion since length and cost can be considered as a function of time in most cases.

Transport Link

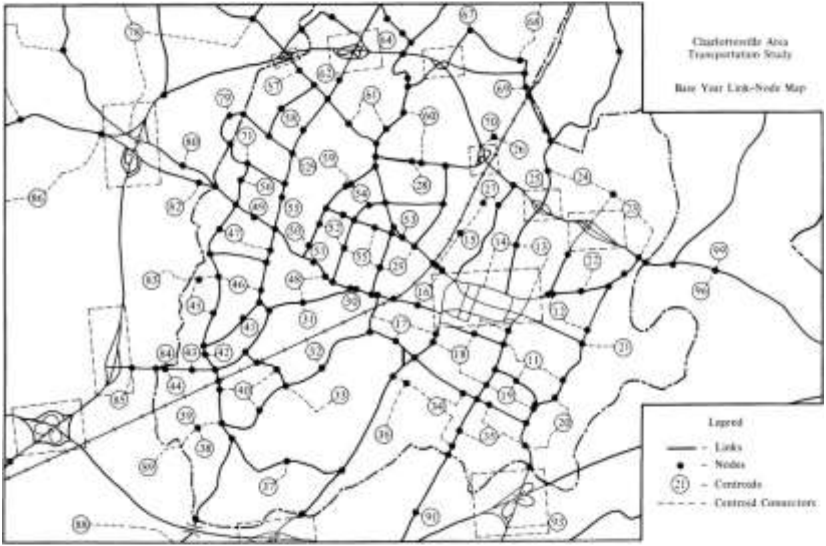
As a first step, the highway network is described by a system of links and nodes.

A link is a section of a highway network between two intersections.

A node is either a centroid of a zone or the intersection of two or more links.



Link-Node Map for Highway System



SOURCE: Virginia Department of Transportation

Traffic Assignment Methods

- All or Nothing
- Capacity Restraint

All or Nothing Method

Most commonly used method.

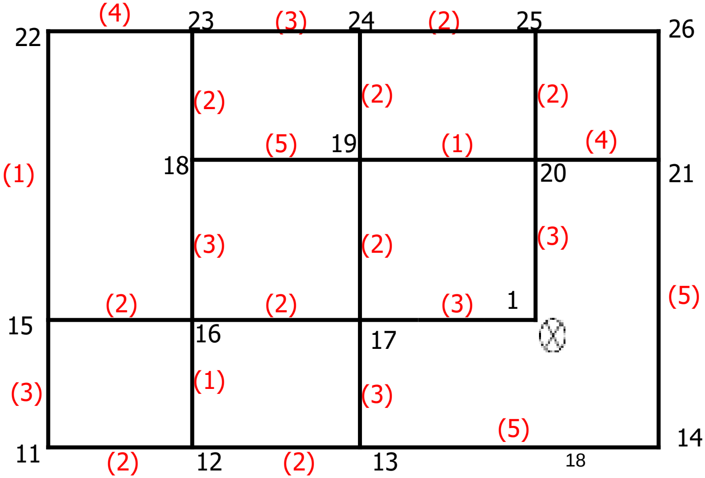
Example: **Minimum Path Tree**

All traffic will choose the route where the **travel resistance is least**.

Travel Resistance:

- Time
- Distance
- Cost
- Generalized Cost

Example



(4)
23
(3)
24
(2)
25
22
26
(2)
(2)
(2)
(5)
19
(1)
(4)
(1)
18
20
21
(3)
(2)
(3)
(5)
(2)
(2)
(3)
1
15
16
17
(3)
(1)
(3)
(5)
14
11
(2)
12
(2)
13
18

Starting from centroid 1 we go to each connecting link and choose the least travel time

$T_{1-20} = 3$ $T_{1-17} = 3$

the time is the same , if we begin with the node with lower number node 17 is noted:

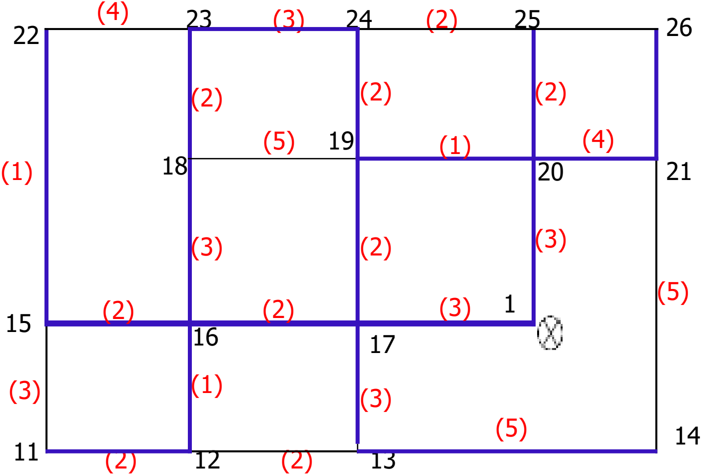
$T_{1-17-19} = 5$ $T_{1-17-16} = 5$ $T_{1-17-16} = 6$

The next closest node to centroid 1 is 20

$T_{1-20-19} = 4$ $T_{1-20-25} = 6$ $T_{1-20-21} = 7$

There are two routes to reach 19 from centroid 1, i.e. 1-17-19 and 1-20-19. the rout 1-20-19 is shorter in time, therefore is chosen

The process is repeated until all nodes have been covered by the shortest path. **The minimum path tree** for this highway network is given in figure



MODULE- 2

DATA COLLECTION AND INVENTORIES

COLLECTION OF DATA:

The first stage in the formulation of a transportation plan is to collect data on all factors likely to influence travel behaviour. This stage involves conducting number of surveys such as inventory of existing land use patterns, inventory of existing transport facilities, the socio-economic factors collection and transportation surveys to collect existing travel pattern information. The work involved is voluminous and the cost of this data collection also will be very high. Because of these two factors, the surveys need to be done in a well organised fashion following standard procedures and guidelines already established. This unit describes the various surveys to be done and also the principles to be followed while conducting surveys.

STUDY AREA:

First of all, the area for which transportation plans are to be prepared, has to be defined very clearly. Transportation planning can be done at national level, at regional level or at urban level. For planning transportation facilities at urban level, the area to be taken into consideration is to be clearly identified and delineated. On a map, a line can be drawn encompassing the urban area to be studied and this line should enclose all the areas within city that influence the urban travel. Actually, this line or boundary does not represent any physical feature; that's why it is called an imaginary line. This imaginary line encompassing study area is called **external cordon line** or simply **external cordon.**

There are certain guidelines in fixing an external cordon for a given urban area. These guidelines can be summarised as follows:

1. The external cordon should circumscribe all the areas which are already built-up and which are influencing daily travel. The land use patterns and socio-economic data can help in identifying these areas.
2. The external cordon should also enclose all the areas which have a potential for growth during plan period and which are likely to influence future urban travel. Normally a transportation plan is carried out for a target period such as 20 years. So there is a likelihood of some new areas developing within this 20 years and these newly developed areas may be influencing future travel i.e., after 20 years. So the areas that have growth potential are to be enclosed by external cordon.
3. The external cordon should also encompass all the areas of systematic daily travel oriented towards centre of the city. That means, if there is daily traffic to city centre from outlying and suburban areas, they are also to be included in the study area.
4. The external cordon should also satisfy some technical requirement . It should be uniform and continuous in its course. The movements should cross it only once. The line should intersect the roads emanating from city at points where it is safe and convenient to carryout traffic studies. The number of such intersecting points should be manageable.
5. The external cordon should be compatible with earlier studies or studies planned for future.

   Fig 3.1 shows a simple diagram of a study area external cordon and the road network.

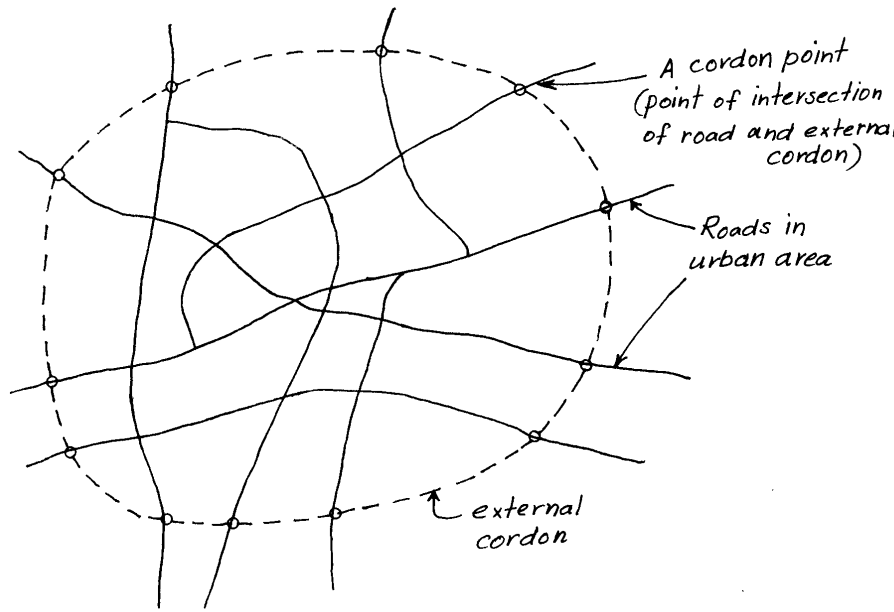


Fig Definition of a study area

ZONING

The objectives of aggregate sequential transportation planning process are to

a) determine where journeys begin and end
b) determine the factors that influence trip generation
c) establish main corridors of movements.

However, the mass of the data collected relates to individual trips, house holds and centres of employment. In its crude form, the data is difficult to analyse and interpret. To overcome this problem and to bring in some order for analysis, the study area is to be divided into number of smaller traffic zones.

The purpose of such subdivision is to facilitate the spatial quantification of land use and economic factors that influence travel. Subdivision of study area into zones helps in geographically associating the origins and destinations of travel. Zones with in the study area are called **internal zones** and those that lie beyond the external cordon are called **external zones.** Zones can be further subdivided into sub-zones if required.

The following points are to be given due consideration while dividing the study area into number of zones.

a) Land use is the most important factor in establishing zones for a transportation survey. It is only when the origin and destination zones reflect the land use properly, can traffic generated with in the zones be predicted, measured and quantified accurately. Therefore the zones should have a homogeneous land use. The predominant land uses for establishing zones are residential, commercial, recreational, industrial, employment etc.

b) Anticipated changes in the land use should be considered when subdividing the study area into zones.

c) It is advisable to follow the subdivision adopted by other agencies for data collection. This can facilitate correlation of data. Especially, subdivision adopted for census operation is very useful because census provides large data needed for transportation planning.

d) The zones should not be too large so as to cause errors in data. At the some time, they should not be too small so as to cause difficulty in analysing the data. As a guideline a population of 1000 - 3000 may be optimum for a small area and a population of 5000 - 10000 may be optimum for a large area. In residential areas, the zone should accommodate roughly 1000 house holds.

e) The zones should preferably have a regular geometric shape for easy determination of centroid which represents either the origin or the destination of travel.

f) Natural physical barriers such as canals, rivers etc can be convenient zone boundaries.

g) In addition to external cordon lines, there may be a number of internal cordon lines arranged as concentric rings around the centre of the city. The purpose of having internal cordon is to check the accuracy of data collected from home interview survey. If there is a physical barrier, such as a river or a railway line, running across the study area, it can be used to check the accuracy of data collected from home interview survey. If there are no such barriers present, an imaginary line running across the study area, approximately dividing it into two equal halves can be established and wherever it meets a road, data can be collected about traffic and it can be compared with data collected from interviews. Such lines are called **screen lines.**

Types of Movements

There are basically four types of movements for which data is to be collected through surveys. They are

(1) Internal - Internal movements
(2) Internal - External movements
(3) External - Internal movements
(4) External - External movements

They are illustrated in fig 3.2

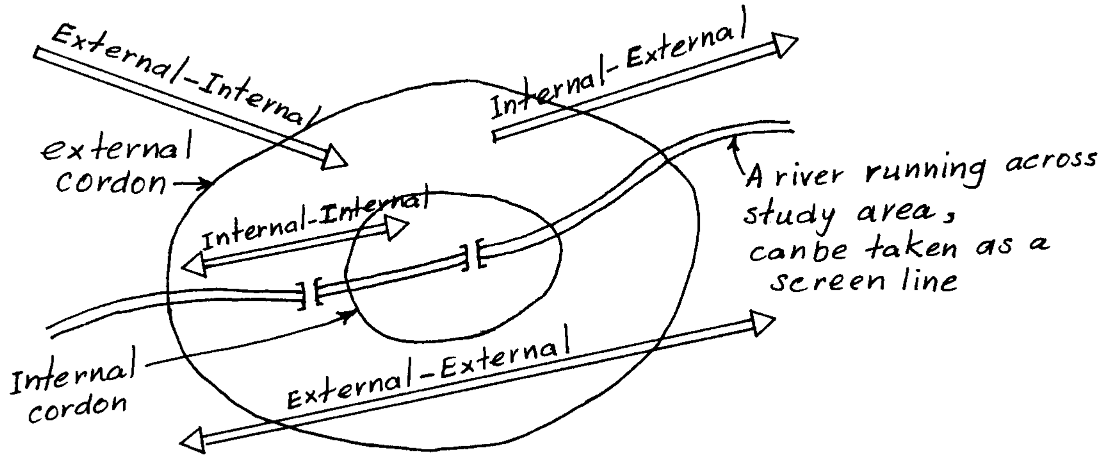


Fig. Types of Movements

For large urban areas, internal - internal travel is heavy. The best way of obtaining internal - internal travel is home interview survey with checks by screen line surveys. The other types, namely internal - external, external - internal and external - external can be studied by conducting surveys at cordon points. They are known as cordon surveys.

TYPES OF SURVEYS FOR DATA COLLECTION:

The data collection can be done

(a) at the home
(b) During the trip or
(c) at the destination end of the trip.

(a) While collected at home, the data can be wide ranging and can cover all the trips made during a given period.
(b) The data collected during the trip is of limited scope since data can be obtained only about the trip intercepted.
(c) At the destination end, the direct interview type of survey provides data on major traffic attractors and the demand for parking.

The Transportation surveys normally employed for data collection are listed below.

a) home interview survey
b) commercial vehicle surveys
c) taxi surveys
d) Road side interviews
e) Post card questionnaire surveys

f) Registration number surveys
g) Tag on car surveys
h) Public transport surveys.
i) Inventory of transportation facilities

Each of these surveys are discussed in detail in the subsequent articles.

(a) HOME INTERVIEW SURVEY:

Home interview survey is one of the most reliable survey methods for collection of travel data. In this type of survey, normally, the data collected includes the general characteristics of the house hold also, that will have influence on trip making. The information on travel patterns includes the number of trips made, their origins, destinations, purpose of each trip, travel mode, time of travel, walking time, waiting time etc. The household information includes the type of dwelling unit, number of residents, age of residents, vehicle ownership, family income, number of employed persons in house and so on. Based on this data it is possible to relate the amount of travel to household and zonal characteristics and to develop mathematical models for trip generation.

Because of wide variety of data that can be collected by the home interview survey and the high cost involved in carrying out the survey, it is necessary to standardise the procedure for such survey. One such procedure is given by Bureau of Public Roads, London that describes how the interview is to be conducted and what information is to be collected.

It is impractical and unnecessary to interview all the residents of the study area. Since travel patterns tend to be uniform in a particular zone, it is sufficient if a sampling procedure is employed. The size of the sample is normally determined based on the population of the study area. Bureau of Public Roads, London has given the standards regarding home interview survey sample and they are given below:

Standards for sampling size for home interview survey

Population of study area	**Sample size**
< 50,000	1 in 5 households
50,000 - 1,50,000	1 in 8 house holds
1,50,000 - 3,00,000	1 in 10 house holds
3,00,000 - 5,00,000	1 in 15 house holds
5,00,000 -10,00,000	1 in 20 house holds
> 10,00,000	1 in 25 house holds

Normally in a home interview survey, full interview method is adopted. It involves interviewing as many members of the selected house as possible and directly recording all the information. The information to be collected from home interview survey broadly can be classified into two groups namely

1) **house hold information** and
2) **journey information.**

1) The household information contains information such as address, size of household, age and sex of household members, occupations, places of work, number of motor vehicles owned, household income and so on.

2) The journey information includes the details of all the journeys made during the previous 24 hours such as number of trips, origins and destinations of trips, modes used for travel, travel times, route taken etc. The usual practice is to have the household information on the front side of a standard format and the travel information on the back side of the form. A typical survey format in which the data is expected to be recorded is shown in table.

Table :

Home Interview survey format (Front)

Interviewer's No.__________

Team No.______ Date______

REVISITS Interviewer's

Sl. No.	Date	Time	No.
1			
2			
3			
4			

Supervisor's No.__________

Date ______

Notes for revisit or __________

Reason incomplete__________

Edited No.______ Date ______ Field Checked No. ______ Date______ Edited ______ Checked ______

Edited______ Coded ______ Checked ______

PART I A HOUSEHOLD INFORMATION

Sheet ______of______

Registration No.(s) of sample vehicle(s) if applicable	Survey type	1	2	Sample No.	3	4	5	6

Name	Address	Sub-zone of night garage or household Tel. No.	7	8	9

A—INTERVIEW ADDRESS

B—HOUSE UNIT TYPE
1. Luxury 1—2 unit
2. Self-contained flat
3. Self-contained floor
4. Low-cost society
5. Resettlement
6. Squatter unit
7. Non-subdivided room
8. Sub-divided room, cubicle
9. Other space
10. Hotel room
X Not applicable

[10]

C—HOUSE OWNERSIHP
1. Owned by member of household
2. Government or company staff quarters
3. Otherwise rented from Government
4. Rented privately
5. Other

[11]

D—IF RENTED
1. Furnished
2. Unfurnished

[12]

Monthly Rent including rates
O Owned not rented
Y Information refused
X Paid by another person or firm, or unknown

1. Rs. 1—50
2. Rs. 51—100
3. Rs. 101—150
4. Rs. 151—300
5. Rs. 301—500
6. Rs. 501—1000
7. Rs. 1001—1500
8. Rs. 1501—2000
9. Over Rs. 2001

0 Owned, not rented

[13]

E—NUMBER OF PARKING SPACES USED BY HOUSEHOLDS (For non-car owning households, marks 'X' in each box)

Private covered	14	Private open	15
Public off-street	16	Public on-street	17

F—NUMBER OF PERSONS IN HOUSEHOLD—all persons	18	19	Persons aged 6 yr and over	20	21	Persons in work	22	23

G—NUMBER OF CARS AVAILABLE YESTERDAY	Owned	24	Owned+Other=Total	25	26
NUMBER OF MOTOR-CYCLES AVAILABLE YESTERDAY	Owned	27	Total	28	29

H—DAY OF WEEK 1 Mon. 2 Tues. 3 Wed 4 Thurs 5 Fri. and MONTH 6 June 7 July 8 Aug. 9 Sep	30	31

PART I B PERSON INFORMATION

J—Person No.	K—Person Identity	L—Sex and Language	M—Interviewed ? Yes No	N—Made Trips ? Yes No	O—Has D.L. ?	P—Place of work or education (address)					
						Q—Industry		R—Employment Status			
									38	39	40
32 | 33		34			35	36	37				
									38	39	40
32 | 33		34			35	36	37				
									38	39	40
32 | 33		34			35	36	37				

S— District of origin of family

T— Usual language of household

Part I C For Office use Trip summary

CODING FOR PERSON INFORMATION

L—SEX AND LANGUAGE

Male	Female	
1	2	Language I
2	4	Language II
3	6	Other

U—HOUSEHOLD INCOME GROUP

1. Rs. 0—300
2. Rs. 301—600
3. Rs. 601—1000
4. Rs. 1001—1500
5. Rs. 1501—2000
6. Rs. 2001—3000
7. Rs. 3001—5000
8. Rs. Over 5001

Q—INDUSTRY

Y Primary school
X Sec. Sch. and misc
0 Univ. or further ed
1 Retail trade
2. Wholesale and commerce
3. Manuf. and processing
4. Transport and Communications
5. Construction and maintenance

X Retired | 76

Y No Answer

R—EMPLOYMENT STATUS

1. Self employed, alone
2. Self-employed, with employees
3. Managerial
4. Supervisor or craftsman
5. Semi-skilled
6. Unskilled

V..E.F.	77	78	79	80

Table :

Home Interview Survey format (Back)

Sheet______	Home Interviews Part II—TRIP INFORMATION FORM			R RELATION TO HOME
of______	A Survey type | 1 | 2	B Sample number | 3 | 4 | 5 | 6	C Subzone | 7 | 8 | 9	1. Origin home
H Industry	D Number of sample cars in household | 10	E Number of sample motor cycles in h-hold | 11		2. Destination home
I Employment Status	F Day of week yesterday | 12	G Month | 13		3. Neither home
J Sex and language	N ORIGIN Address and location O Land use	P DESTINATION Address or location O Land use		
K Person	L Trip No. | M Hour			
14				
15				
16				
17	18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27	28 | 29 | 30	31 | 32	33
14				
15				
16				
17	18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27	28 | 29 | 30	31 | 32	33

S TRIP PURPOSE	T Mode	U For Office Use	For driver trips only				Y For Modes 1, X, 2, Y SAMPLE CAR OR MOTOR CYCLES USED ?	Z For Modes 3 and over ANY CAR OR MOTOR CYCLE AVAILABLE ?
			V OCCUPANCY		W PARKING	X OWNERSHIP		
			This household	Others				
1 To work	1—0 Car driver				1 On-st. (free)	1 Private	1 Yes	3 N.A.
2 As part of work	X—0 M Cy driver				2 On-st. (meter)	2 Company	2 No	
3 Personal business	2—0 Car passenger				3 Public off-st, (free)	3 GOVT.		
4 Shopping (conv)	Y—0 M Cy passenger				4 Public off-st. (paid)	4 Others		
5 Shopping (goods)	3—0 Taxi				5 Private non-res.			
6 Recreation	4—0 Public car				6 Private residen			
7 Social	5—0 Bus				7 To servicing			
8 Education	6—0 Tram				8 Did not park			
9 Home	7—0 Railway							
X Serve as passenger	8—0 Ferry							
	9—0 Other incl. walking							
34 | 35	36 | 37	38	39	40	41	42	43	44
34 | 35	36 | 37	38	39	40	41	42	43	44

For home interview survey, the selection of sample house holds is to be done on random basis. Normally electoral list can be used for randomly picking the house addresses. Wide publicity is to be given through newspapers and TV about the survey and its objectives. The selected households are to be given prior intimation that on a particular day the enumerators would come for the collection of data. The enumerators or interviewers are to be trained properly.

b) COMMERCIAL VEHICLE SURVEYS:

Commercial vehicle surveys are to be carried out to get information regarding commercial vehicles such as trucks, local lorries, pickup vans travelling in the study area. These surveys can be carried out either by using Road side Interview technique or by Questionnaire surveys. The road side interview technique is discussed in detail in subsequent articles. In questionnaire survey, transport operators are supplied with survey forms and they are expected to return after filling up the required information.

d)ROAD SIDE INTERVIEW SURVEY:

Road side interview survey is the method normally adopted for **screen line survey or cordon survey.** As the name suggests, this technique involves stopping the vehicles at the selected point of the road and eliciting information from the driver and other road users. The information can be obtained by direct interview or by giving them questionnaire forms with prepaid postage so that they can fill them leisurely and post them at a later date. There are certain guide lines related to selecting survey points and sampling.

The survey points are normally selected along the junction of the cordon line or screen line with roads. For small towns, a simple circular cordon at the periphery of the town should be sufficient and the road side interview at cordon points can give required data. For medium size cities, two cordon lines are necessary one being the external cordon at the edge of urban area and the other, an internal cordon encompassing **central business district** of the city. Central Business District (CBD) is the area where the activity is highest and around which the city has developed. In such case, road side interview conducted at both the cordons can give sufficient travel information. However, for large cities, fixing up internal cordons and screen lines are complicated . Therefore along with external cordon surveys through road side interview , home interview survey is to be done necessarily if accurate travel data is to be obtained.

As it is impractical to stop all the vehicles and interview all the drivers, some sampling method is to be adopted. The number of samples depends on the amount of traffic moving and the number of interviewers available. The sampling can be done either based on time or on volume.

For example, interviewing all the vehicles arriving in ten minutes and allowing the vehicles in next 10 minutes to move without stopping is a sampling method based on time.

On the other hand, interviewing every 5 th or 10 th vehicle is volume based sampling. As interviewing may consume some minutes of time, care should be taken that during that time the traffic flow is not interrupted. Depending on specific requirements and objectives the survey can be done for 24 hours, 16 hours or 12 hours. However, vehicle counts are to be done for 24 hours period. Care should be taken in designing the survey form such that the data collected is complete in all aspects. A typical survey form is shown in table.

Table 3.3 Sample Roadside Interview From

Day Date	Wet ☐ Dry ☐	Separate Count? Yes ... No ...	Recorded by	Sheet No.

Site		Private	Sample	Total
Direction		Bus		
Half-hour starting at		Goods		

Veh. Type	No. of occupants	Last stop	Next stop	Last land use	Next land use	Trip purpose

Vehicle Type	*Land use*	*Trip purpose*
0. Motor cycle	0. Residential	0. To work
1. Car	1. Hotel, guest house, restaurant	1. Work to home
2. Taxi	2. School college, University	2. Other to home
3. City Bus	3. Offices	3. Shopping
4. Light Commercial	4. Shops, markets	4. Business (own or employed)
5. Heavy Commercial (truck)	5. Industrial, docks, utilities	5. Personal affairs

i)INVENTORY OF TRANSPORT FACILITIES:

Any transportation planning process should make it a point to identify the deficiencies in the existing system and then improvement plans are to be prepared accordingly. The inventory of existing transport facilities serves this purpose. The inventory consists of :

a) Inventory of streets or road network
b) Traffic volume, composition, peak and off-peak periods
c) Travel time studies
d) Inventory of public transport
e) Inventory of parking

a) Inventory of streets

An understanding of extent and quality of road network can lead to formulation of better improvement plans. The inventory should cover details such as classification of road system, lengths, cross sectional dimensions, type and condition of surface, capacities of various road sections and junctions, number of intersections and the type of controls etc.

b) Traffic Details

Data pertaining to traffic volume and composition can be used to check the accuracy of the home interview survey data and cordon survey data. The variation of traffic volume over different time periods of day, different days of week and different months is needed. The 24 hours traffic count is also required to fix up the peak period and off peak period at different locations.

c) Travel Time Studies

Travel time between different zones is an important indicator of efficiency of the existing transportation system. Studies are to be conducted to find out travel time between different zones, by different modes. The details about the delays, causes for delays and locations where delay occurs are also to be collected.

d) Inventory of Public Transport

This includes information regarding bus services such as the bus routes, frequencies, bus stop locations, operating speeds, capacities of buses and economic performance of the bus services. Information regarding fare is also needed. If a local train facility is available, all these details pertaining to train services are also to be collected.

e) Parking Inventory

Parking surveys should be done to estimate the demand for parking and also to assess the existing parking facilities. Data collected should include the on-street and off street parking locations, their capacities, type of parking control such as parking fee collection or parking control by time, duration of parking etc.

EXPANSION FACTORS:

Most of the survey methods discussed above are based on sampling techniques and so the sample data collected must be expanded to represent the whole population. This is achieved though expansion factors. The expansion factors are calculated for each zone in the study area.

The expansion factor used for home interview study is basically the total universe i.e., the total number of households in the study area divided by the total number of successful interviews. This is calculated for each traffic zone based on the following formula.

$$\text{Expansion Factor} = \frac{A - \frac{A}{B}\left(C + \frac{C}{B} \times D\right)}{B - C - D}$$

where A = total number of addresses on the original list;

B = total number of house holds selected as sample;

C = number of sample addresses that are ineligible

(e.g: non-residential, demolished)

D = number of sample addresses where no response was obtained

(refusal to give information, locked)

The external cordon survey expansion factor is usually derived for each class of vehicle, time interval and direction of flow used at the survey point. It is calculated as follows:

$$\text{Expansion Factor} = \frac{A}{B}$$

where A = the number of vehicles of specified class counted passing though survey point for the relevant time interval

B = the number of vehicles interviewed, of the same class, for the same time interval.

Supposing 5000 trucks pass the survey point in a 24 hours period and 500 trucks are interviewed during the same 24 hours, the expansion factors is = $\frac{5000}{500} = 10$

ACCURACY CHECKS:

It is desirable to check the accuracy of the survey data before the process of data analysis. This can be done by conducting some field studies.

Home interview survey: The data collected regarding the number of people in a households during home interview study can be expanded to find out the total population of zone and this can be checked against census data. However, care must be taken to account for change that have taken place after census data was collected. Expanded home interview data should not vary by more than ± 15 percent of the adjusted census data.

The travel patterns as obtained from home interview study can be checked by screen line surveys. The screen line chosen should be preferably a natural barrier such as a river or a railway with comparatively few crossing points. Traffic counts can be carried out on a screen line and they can be checked with the sample data obtained.

Types Source of Data:-

1) Primary source
2) Secondary source

Primary Source – Data collected by contact with a person
Secondary Source – Data collected in Absence of a person

Primary Source –

(1) Home Interview survey

(2) Cordon survey
- Road side Interview
- Tag on car Method
- License plate

(3) Terminal Survey
- Post card questionnaire Survey
- Direct Interview at Terminal
- Commercial vehicles survey

(4) Video graphic Survey

Secondary Source –

(1) R TO Department	- Vehicles Registered
(2) Education Department	- Primary, Secondary professional
(3) Commercial Tax department	- Floor space of shopping centre
(4) Births & Death details from Municipality	- Demographic details like age, Male, Female ration etc.
(5) Police Department	- Accident data

(6) Industrial Department	- No. of workers
(7) Employment department	- Unemployed youth
(8) Income tax Department	- Economic profiles
(9) RTC	- Transit riders, concessional travelers
(10) Tourist Department	
(11) Medical Department	
(12) Valuation Department	
(13) Land use Department	

SUMMARY:

This unit introduces the concept of study area and zoning principles. Different kinds of studies needed for data collection for urban transportation planning are elaborately discussed. The expansion factors and accuracy checks needed are briefly discussed.

REVIEW QUESTIONS:

a) Define study area. Explain the guidelines for fixing up external cordon.
b) What is zoning? Why it is necessary? Explain the principles to be adopted for zoning.
c) List out the types of surveys needed for data collection for urban transportation planning. Explain in detail the home interview survey.
d) Write short notes on the following:
   a) Road side interview method
   b) Registration Number Plate Survey
   c) Post-card questionnaire survey

e) What kind of surveys are to be done under inventory of existing transport facilities? Explain.
f) What is the use of Expansion Factors and Accuracy checks? How are they to be carried out?

*****

Origin and Destination Survey – Roadside Interview Method

Date: Name of Town: Sheet No.:

Survey Location: Name of Interviewer: Weather conditions:

Location (km): Direction of Travel: Hours:

From: To:

Sl. No.	Time of interview	Vehicle type	Registration number	Trip origin	Trip destination	No. of persons in the vehicle	Goods carried		Whether likely to halt in the town		Trip purpose	Route course (via)	Whether a bypass will be desirable if not state reasons
							Type	Tonnage	No. of halts	Purpose of halts			

Source: IRC: 102-1988.

Typical Form for Commercial Vehicle Survey

<table>
<tr><td>Firm/Owner</td><td rowspan="4">Visit
1
2
3
4
5</td><td>Time</td><td>Date</td><td>Interviewer's Name</td><td>Sheet of</td></tr>
<tr><td>Address</td><td colspan="4" rowspan="3">Comments: Ser. No.

Zone No.</td></tr>
<tr><td>Person Interviewed</td></tr>
<tr><td>Telephone No.</td></tr>
</table>

Part I. Business Information

A. Nature of Business Male/female

B. Total Number of employees

C. Number of vehicles operating from address

Cars	Parked on premises	Parked elsewhere
Light Goods	Parked on premises	Parked elsewhere
Heavy Goods	Parked on premises	Parked elsewhere

D. Day of travel

E. Total number of trips made on day of travel

F. Type and number of vehicles interviewed

Vehicle No.

Vehicle Reg. No.

Part II. Vehicle Trip Information

<table>
<tr><td>G</td><td>H</td><td>I</td><td>J</td><td>K</td><td colspan="2">L</td></tr>
<tr><td rowspan="2">Vehicle Type</td><td rowspan="2">Vehicle Number</td><td rowspan="2">Trip Number</td><td rowspan="2">Origin Address</td><td rowspan="2">Destination Address</td><td colspan="2">Time of Trip</td></tr>
<tr><td>Start

AM
PM</td><td>Finish

AM
PM</td></tr>
<tr><td colspan="2"></td><td colspan="2">Nature of Business:</td><td colspan="2">Nature of Business:</td><td></td></tr>
<tr><td colspan="2"></td><td colspan="3"></td><td>AM
PM</td><td>AM
PM</td></tr>
<tr><td></td><td></td><td colspan="2">Nature of Business:</td><td colspan="2">Nature of Business:</td><td></td></tr>
</table>

Sample Roadside Interview Form

Day Date	Wet Dry	Separate Yes… Count ? No…		Sheet No.
Site		Private	Sample	Total
Direction		Bus		
Half-hour starting at		Goods		

Veh. Type	No. of occupants	Last Stop	Next stop	Last land use	Next land use	Trip purpose

Vehicle Type	Land use	Trip purpose
0. Motor cycle	0. Residential	0. To work
1. Car	1. Hotel, guesthouse, Restaurant	1. Work to home
2. Taxi	2. School, College, University	2. Others to home
3. City Bus	3. Offices	3. Shopping
4. Light Commercial	4. Shops, markets	4. Business (own or employed)
5. Heavy Commercial (truck)	5. Industrial, docks, utilities	5. Personal affairs
6. Passenger Vehicle (truck)	6. Hospitals, doctors	6. School
7. Country Bus	7. Cultural recreational and other	7. Eat meal
	8. Police, military, fire stations	8. School/recreational
	9. Transport terminals, bus stops	9. Serve passenger

Sample Registration Number Plate Survey Form

		Sheet No.	
Site : Okhla			Weather : Overcast
Observation point : Mathura Road			Observer :BNG
Movement Observed: Delhi-bound			Recorder :OPB
Sheet starting time : 8-00 A.M.			Date : 24-1-76
Sample : Registration Numbers ending with : all even numbers, including zero. Vehicle class : All			
Column Start Time			
8-00	8-05	8-10	8-15
DLQ 2660	DLX 742	JKN 528	UPS 584
DLM 2832	DLN 3856		PUN 4973
DLP 8485	HRP 9485		DLQ 947

Origin and Destination Survey – Roadside Interview Method

Date:	Name of Town:	Sheet No.:
Survey Location:	Name of Interviewer:	Weather conditions:
Location (km):	Direction of Travel:	Hours:
		From: To:

Sl. No.	Time of interview	Vehicle type	Registration number	Trip origin	Trip destination	No. of persons in the vehicle	Goods carried		Whether likely to halt in the town		Trip purpose	Route course (via)	Whether a bypass will be desirable if not state reasons
							Type	Tonnage	No. of halts	Purpose of halts			

Source: IRC: 102-1988.

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A. Nature of Business Male/female

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Light Goods	Parked on premises	Parked elsewhere
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D. Day of travel

E. Total number of trips made on day of travel

F. Type and number of vehicles interviewed

Vehicle No.

Vehicle Reg. No.

Part II. Vehicle Trip Information

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<tr><td>Start
AM
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AM
PM</td></tr>
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PM</td><td>AM
PM</td></tr>
<tr><td></td><td></td><td colspan="2">Nature of Business:</td><td colspan="2">Nature of Business:</td><td></td></tr>
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Sample Roadside Interview Form

Day Date	Wet Dry	Separate Yes… Count ? No…		Sheet No.

Site		Private	Sample	Total
Direction		Bus		
Half-hour starting at		Goods		

Veh. Type	No. of occupants	Last Stop	Next stop	Last land use	Next land use	Trip purpose

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2. Taxi	2. School, College, University	2. Others to home
3. City Bus	3. Offices	3. Shopping
4. Light Commercial	4. Shops, markets	4. Business (own or employed)
5. Heavy Commercial (truck)	5. Industrial, docks, utilities	5. Personal affairs
6. Passenger Vehicle (truck)	6. Hospitals, doctors	6. School
7. Country Bus	7. Cultural recreational and other	7. Eat meal
	8. Police, military, fire stations	8. School/recreational
	9. Transport terminals, bus stops	9. Serve passenger

Sample Registration Number Plate Survey Form

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Site : Okhla	Weather : Overcast
Observation point : Mathura Road	Observer : BNG
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Sheet starting time : 8-00 A.M.	Date : 24-1-76

Sample :

Registration Numbers ending with : all even numbers, including zero.

Vehicle class : All

Column Start Time			
8-00	8-05	8-10	8-15
DLQ 2660	DLX 742	JKN 528	UPS 584
DLM 2832	DLN 3856		PUN 4973
DLP 8485	HRP 9485		DLQ 947

PUBLIC TRANSPORTATION MODULE- 2 DATA COLLECTION AND INVENTORIES

AKELLA NAGA SAI BABA

- **COLLECTION OF DATA**:
- The first stage in the formulation of a transportation plan is to collect data on all factors likely to influence travel behaviour.
- This stage involves conducting number of surveys such as inventory of existing land use patterns, inventory of existing transport facilities, the socio-economic factors collection and transportation surveys to collect existing travel pattern information.
- The work involved is voluminous and the cost of this data collection also will be very high.
- Because of these two factors, the surveys need to be done in a well organised fashion following standard procedures and guidelines already established.
- This unit describes the various surveys to be done and also the principles to be followed while conducting surveys.

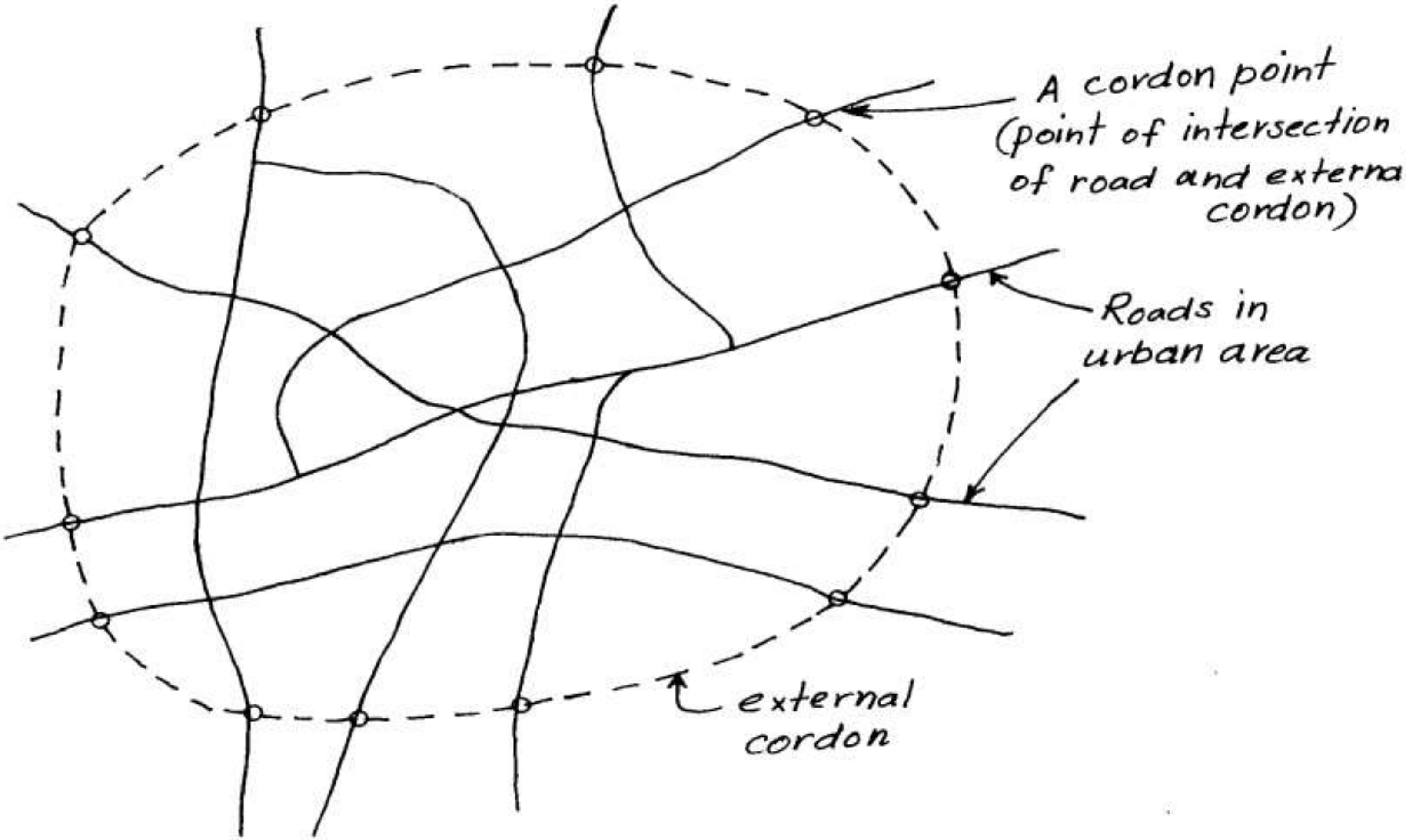
- **STUDY AREA:**
- First of all, the area for which transportation plans are to be prepared, has to be defined very clearly.
- Transportation planning can be done at national level, at regional level or at urban level.
- For planning transportation facilities at urban level, the area to be taken into consideration is to be clearly identified and delineated.
- On a map, a line can be drawn encompassing the urban area to be studied and this line should enclose all the areas within city that influence the urban travel.
- Actually, this line or boundary does not represent any physical feature; that's why it is called an imaginary line.
- This imaginary line encompassing study area is called **external cordon line** or simply **external cordon.**

- **There are certain guidelines in fixing an external cordon for a given urban area. These guidelines can be summarised as follows:**

1. The external cordon should circumscribe all the areas which are already built-up and which are influencing daily travel. The land use patterns and socio-economic data can help in identifying these areas.
2. The external cordon should also enclose all the areas which have a potential for growth during plan period and which are likely to influence future urban travel. Normally a transportation plan is carried out for a target period such as 20 years. So there is a likelihood of some new areas developing within this 20 years and these newly developed areas may be influencing future travel i.e., after 20 years. So the areas that have growth potential are to be enclosed by external cordon.
3. The external cordon should also encompass all the areas of systematic daily travel oriented towards centre of the city. That means, if there is daily traffic to city centre from outlying and suburban areas, they are also to be included in the study area.
4. The external cordon should also satisfy some technical requirement . It should be uniform and continuous in its course. The movements should cross it only once. The line should intersect the roads emanating from city at points where it is safe and convenient to carryout traffic studies. The number of such intersecting points should be manageable.
5. The external cordon should be compatible with earlier studies or studies planned for future.

Fig 3.1 shows a simple diagram of a study area external cordon and the road network.

Fig Definition of a study area



- **ZONING**
- The objectives of aggregate sequential transportation planning process are to

a) determine where journeys begin and end

b) determine the factors that influence trip generation

c) establish main corridors of movements.

- However, the mass of the data collected relates to individual trips, house holds and centres of employment. In its crude form, the data is difficult to analyse and interpret. To overcome this problem and to bring in some order for analysis, the study area is to be divided into number of smaller traffic zones.

- The purpose of such subdivision is to facilitate the spatial quantification of land use and economic factors that influence travel.
- Subdivision of study area into zones helps in geographically associating the origins and destinations of travel.
- Zones with in the study area are called **internal zones** and those that lie beyond the external cordon are called **external zones.**
- Zones can be further subdivided into sub-zones if required.

- **The following points are to be given due consideration while dividing the study area into number of zones**

a) Land use is the most important factor in establishing zones for a transportation survey. It is only when the origin and destination zones reflect the land use properly, can traffic generated with in the zones be predicted, measured and quantified accurately. Therefore the zones should have a homogeneous land use. The predominant land uses for establishing zones are residential, commercial, recreational, industrial, employment etc.

b) Anticipated changes in the land use should be considered when subdividing the study area into zones.

c) It is advisable to follow the subdivision adopted by other agencies for data collection. This can facilitate correlation of data. Especially, subdivision adopted for census operation is very useful because census provides large data needed for transportation planning.

d) The zones should not be too large so as to cause errors in data. At the some time, they should not be too small so as to cause difficulty in analysing the data. As a guideline a population of 1000 - 3000 may be optimum for a small area and a population of 5000 - 10000 may be optimum for a large area. In residential areas, the zone should accommodate roughly 1000 house holds.

e) The zones should preferably have a regular geometric shape for easy determination of centroid which represents either the origin or the destination of travel.

f) Natural physical barriers such as canals, rivers etc can be convenient zone boundaries.

g) In addition to external cordon lines, there may be a number of internal cordon lines arranged as concentric rings around the centre of the city. The purpose of having internal cordon is to check the accuracy of data collected from home interview survey. If there is a physical barrier, such as a river or a railway line, running across the study area, it can be used to check the accuracy of data collected from home interview survey. If there are no such barriers present, an imaginary line running across the study area, approximately dividing it into two equal halves can be established and wherever it meets a road, data can be collected about traffic and it can be compared with data collected from interviews. Such lines are called **screen lines.**

- **Types of Movements**
- There are basically four types of movements for which data is to be collected through surveys. They are
- Internal - Internal movements
- Internal - External movements
- External - Internal movements
- External - External movements

They are illustrated in fig

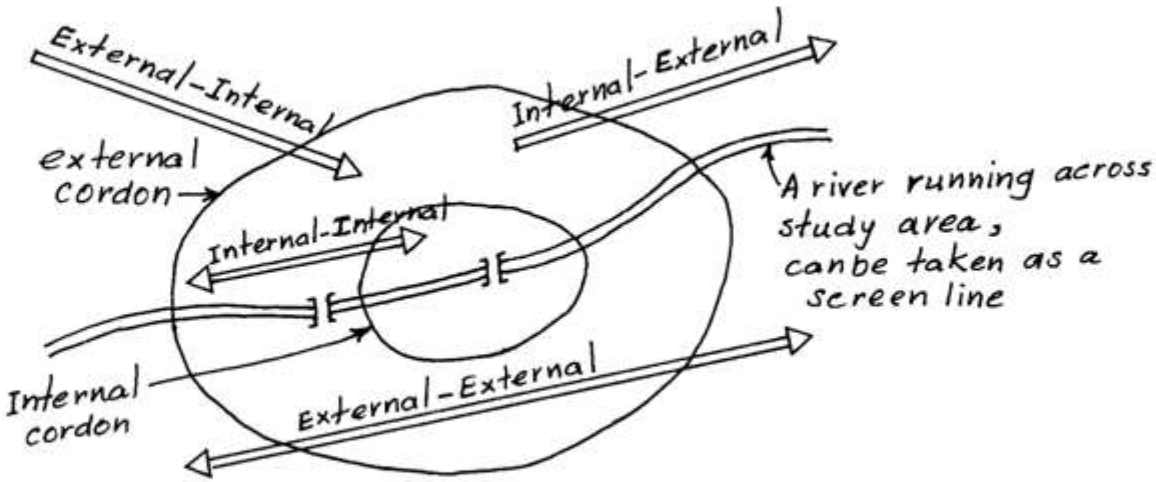


Fig. Types of Movements

- For large urban areas, internal - internal travel is heavy.
- The best way of obtaining internal - internal travel is home interview survey with checks by screen line surveys.
- The other types, namely internal - external, external - internal and external - external can be studied by conducting surveys at cordon points. They are known as cordon surveys.

- **TYPES OF SURVEYS FOR DATA COLLECTION:**

The data collection can be done

a) at the home

b) During the trip or

c) at the destination end of the trip.

a) While collected at home, the data can be wide ranging and can cover all the trips made during a given period.

b)The data collected during the trip is of limited scope since data can be obtained only about the trip intercepted.

c) At the destination end, the direct interview type of survey provides data on major traffic attractors and the demand for parking.

- **The Transportation surveys normally employed for data collection are listed below.**

a)home interview survey

b) commercial vehicle surveys

c) taxi surveys

d) Road side interviews

e)Post card questionnaire surveys

f) Registration number surveys

g) Tag on car surveys

h) Public transport surveys.

i) Inventory of transportation facilities

HOME INTERVIEW SURVEY

HOME INTERVIEW SURVEY:-

- Home interview survey is one of the most reliable survey methods for collection of travel data.
- In this type of survey, normally, the data collected includes the general characteristics of the house hold also, that will have influence on trip making.
- The information on travel patterns includes the number of trips made, their origins, destinations, purpose of each trip, travel mode, time of travel, walking time, waiting time etc.
- The household information includes the type of dwelling unit, number of residents, age of residents, vehicle ownership, family income, number of employed persons in house and so on.
- Based on this data it is possible to relate the amount of travel to household and zonal characteristics and to develop mathematical models for trip generation.

HOME INTERVIEW SURVEY(CONTD...)

- Because of wide variety of data that can be collected by the home interview survey and the high cost involved in carrying out the survey, it is necessary to standardise the procedure for such survey.
- One such procedure is given by Bureau of Public Roads, London that describes how the interview is to be conducted and what information is to be collected.

HOME INTERVIEW SURVEY(CONTD...)

- It is impractical and unnecessary to interview all the residents of the study area.
- Since travel patterns tend to be uniform in a particular zone, it is sufficient if a sampling procedure is employed.
- The size of the sample is normally determined based on the population of the study area.
- Bureau of Public Roads, London has given the standards regarding home interview survey sample and they are given below:-

HOME INTERVIEW SURVEY(CONTD...)

- **Standards for sampling size for home interview survey:-**

Population of study area	Sample size
< 50,000	1 in 5 households
50,000 - 1,50,000	1 in 8 house holds
1,50,000 - 3,00,000	1 in 10 house holds
3,00,000 - 5,00,000	1 in 15 house holds
5,00,000 -10,00,000	1 in 20 house holds
> 10,00,000	1 in 25 house holds

HOME INTERVIEW SURVEY(CONTD...)

- Normally in a home interview survey, full interview method is adopted.
- It involves interviewing as many members of the selected house as possible and directly recording all the information.
- The information to be collected from home interview survey broadly can be classified into two groups namely:-

1) **house hold information** and
2) **journey information.**

HOME INTERVIEW SURVEY(CONTD...)

1. The household information contains information such as address, size of household, age and sex of household members, occupations, places of work, number of motor vehicles owned, household income and so on.
2. The journey information includes the details of all the journeys made during the previous 24 hours such as number of trips, origins and destinations of trips, modes used for travel, travel times, route taken etc.

   The usual practice is to have the household information on the front side of a standard format and the travel information on the back side of the form.

   A typical survey format in which the data is expected to be recorded is shown in table.

HOME INTERVIEW SURVEY FORMAT (FRONT)

Interviewer's No. ________

Team No. ________ Date ________

REVISITS Interviewer's

Sl. No.	Date	Time	No.
1			
2			
3			
4			

Supervisor's No. ________

Date ________

Notes for revisit or ________

Reason incomplete ________

Edited No. ______ Date ______ Field Checked No. ______ Date ______ Edited ______ Checked ______

Edited ______ Coded ______ Checked ______

PART I A HOUSEHOLD INFORMATION

Sheet ______ of ______

Registration No.(s) of sample vehicle(s) if applicable | Survey type | 1 | 2 | Sample No. | 3 | 4 | 5 | 6 |

Name | Address | Sub-zone of night garage or household Tel. No. | 7 | 8 | 9 |

A—INTERVIEW ADDRESS

B—HOUSE UNIT TYPE
1. Luxury 1—2 unit
2. Self-contained flat
3. Self-contained floor
4. Low-cost society
5. Resettlement
6. Squatter unit
7. Non-subdivided room
8. Sub-divided room, cubicle
9. Other space
10. Hotel room
X Not applicable

| 10 |

C—HOUSE OWNERSHIP
1. Owned by member of household
2. Government or company staff quarters
3. Otherwise rented from Government
4. Rented privately
5. Other

| 11 |

D—IF RENTED
1. Furnished
2. Unfurnished

Monthly Rent including rates
O Owned not rented
Y Information refused
X Paid by another person or firm, or unknown
1. Rs. 1—50
2. Rs. 51—100
3. Rs. 101—150
4. Rs. 151—300
5. Rs. 301—500
6. Rs. 501—1000
0 Owned, not rented
7. Rs. 1001—1500
8. Rs. 1501—2000
9. Over Rs. 2000

| 12 | 13 |

E—NUMBER OF PARKING SPACES USED BY HOUSEHOLDS (For non-car owning households, marks 'X' in each box)

Private covered | 14 | Private open | 15 |

Public off-street | 16 | Public on-street | 17 |

F—NUMBER OF PERSONS IN HOUSEHOLD—all persons | 18 | 19 | Persons aged 6 yr and over | 20 | 21 | Persons in work | 22 | 23 |

G—NUMBER OF CARS AVAILABLE YESTERDAY Owned | 24 | Owned + Other = Total | 25 | 26 |

NUMBER OF MOTOR-CYCLES AVAILABLE YESTERDAY Owned | 27 | Total | 28 | 29 |

H—DAY OF WEEK 1 Mon 2 Tues. 3 Wed 4 Thurs 5 Fri. and MONTH 6 June 7 July 8 Aug. 9 Sep | 30 | 31 |

PART I B PERSON INFORMATION

J—Person No.	K—Person Identity	L—Sex and Language	M—Interviewed ? Yes No	N—Made Trips ? Yes No	O—Has D.L. ?	P—Place of work or education (address)	
						Q—Industry	R—Employment Status
							38 | 39 | 40
32 | 33		34			35	36 | 37	
							38 | 39 | 40
32 | 33		34			33	36 | 37	
							38 | 39 | 40
32 | 33		34			35	36 | 37	

S— District of origin of family

T— Usual language of household

Part I C For Office use Trip summary

X Refused | 76

Y No Answer

V.E.F.	77	78	79	80

CODING FOR PERSON INFORMATION

L—SEX AND LANGUAGE

Male	Female	
1	2	Language I
2	4	Language II
3	6	Other

U—HOUSEHOLD INCOME GROUP

1. Rs. 0—300
2. Rs. 301—600
3. Rs. 601—1000
4. Rs. 1001—1500
5. Rs. 1501—2000
6. Rs. 2001—3000
7. Rs. 3001—5000
8. Rs. Over 5001

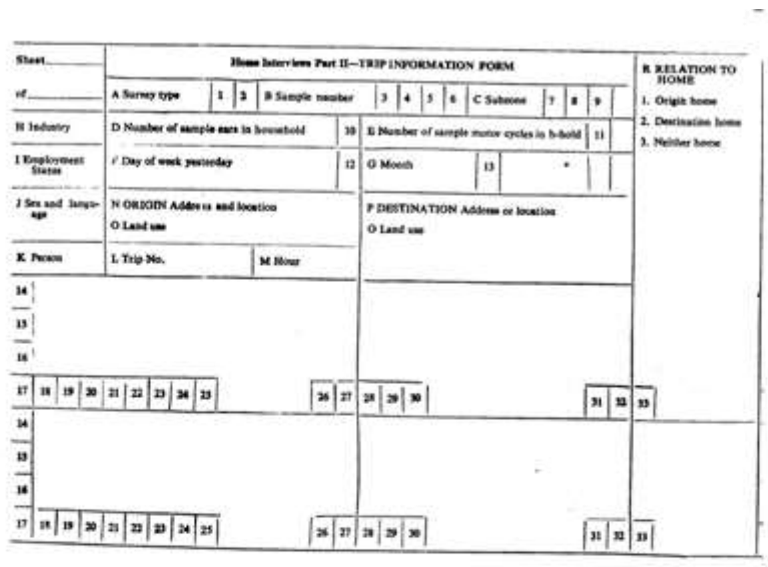
Q—INDUSTRY

Y Primary school
X Sec. Sch. and misc
0 Univ. or further ed
1 Retail trade
2. Wholesale and commerce
3. Manuf. and processing
4. Transport and Communications
5. Construction and maintenance

R—EMPLOYMENT STATUS

1. Self employed, alone
2. Self-employed, with employees
3. Managerial
4. Supervisor or craftsman
5. Semi-skilled
6. Unskilled

HOME INTERVIEW SURVEY FORMAT (BACK)


Sheet ____ of ____

Home Interviews Part II—TRIP INFORMATION FORM

A Survey type 1 2 B Sample number 3 4 5 6 C Subzone 7 8 9

D Number of sample cars in household 10 E Number of sample motor cycles in h-hold 11

F Day of week yesterday 12 G Month 13

H Industry

I Employment Status

J Sex and language

K Person

L Trip No.

M Hour

N ORIGIN Address and location

O Land use

P DESTINATION Address or location

O Land use

R RELATION TO HOME

1. Origin home
2. Destination home
3. Neither home

14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33

14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33

HOME INTERVIEW SURVEY(CONTD...)

S TRIP PURPOSE	T Mode	U For Office Use	For driver trips only V OCCUPANCY		W PARKING	X OWNERSHIP	Y For Modes 1, X, 2, Y SAMPLE CAR OR MOTOR CYCLES USED ?	Z For Modes 3 and over ANY CAR OR MOTOR CYCLE AVAILABLE ?
			This house hold	Others				
1 To work 2 As part of work 3 Personal business 4 Shopping (own) 5 Shopping (goods) 6 Recreation 7 Social 8 Education 9 Home X Serve as passenger	1—0 Car driver X—0 M Cy driver 2—0 Car passenger Y—0 M Cy passenger 3—0 Taxi 4—0 Public car 5—0 Bus 6—0 Tram 7—0 Railway 8—0 Ferry 9—0 Other incl. walking				1 On-st. (free) 2 On-st. (meter) 3 Public off-st. (free) 4 Public off-st. (paid) 5 Private non-res. 6 Private residen 7 To servicing 8 Did not park	1 Private 2 Company 3 GOVT. 4 Others	1 Yes 2 No	3 N.A.
34 | 35	36 | 37	38	39	40	41	42	43	44
34 | 35	36 | 37	38	39	40	41	42	43	44

HOME INTERVIEW SURVEY(CONTD...)

- For home interview survey, the selection of sample house holds is to be done on random basis.
- Normally electoral list can be used for randomly picking the house addresses.
- Wide publicity is to be given through newspapers and TV about the survey and its objectives.
- The selected households are to be given prior intimation that on a particular day the enumerators would come for the collection of data.
- The enumerators (or) interviewers are to be trained properly.

COMMERCIAL VEHICLE SURVEYS

b) COMMERCIAL VEHICLE SURVEYS:

- Commercial vehicle surveys are to be carried out to get information regarding commercial vehicles such as trucks, local lorries, pickup vans travelling in the study area.
- These surveys can be carried out either by using Road side Interview technique or by Questionnaire surveys.
- The road side interview technique is discussed in detail in subsequent articles.
- In questionnaire survey, transport operators are supplied with survey forms and they are expected to return after filling up the required information.

ROAD SIDE INTERVIEW SURVEY

c)ROAD SIDE INTERVIEW SURVEY:-

- Road side interview survey is the method normally adopted for **screen line survey or cordon survey.**
- As the name suggests, this technique involves stopping the vehicles at the selected point of the road and eliciting information from the driver and other road users.
- The information can be obtained by direct interview or by giving them questionnaire forms with prepaid postage so that they can fill them leisurely and post them at a later date.
- There are certain guide lines related to selecting survey points and sampling.

ROAD SIDE INTERVIEW SURVEY(CONTD...)

- The survey points are normally selected along the junction of the cordon line or screen line with roads.
- For small towns, a simple circular cordon at the periphery of the town should be sufficient and the road side interview at cordon points can give required data.
- For medium size cities, two cordon lines are necessary one being the external cordon at the edge of urban area and the other, an internal cordon encompassing **central business district** of the city.
- Central Business District (CBD) is the area where the activity is highest and around which the city has developed.

ROAD SIDE INTERVIEW SURVEY(CONTD...)

- In such case, road side interview conducted at both the cordons can give sufficient travel information.
- However, for large cities, fixing up internal cordons and screen lines are complicated .
- Therefore along with external cordon surveys through road side interview , home interview survey is to be done necessarily if accurate travel data is to be obtained.
- As it is impractical to stop all the vehicles and interview all the drivers, some sampling method is to be adopted.

ROAD SIDE INTERVIEW SURVEY(CONTD...)

- The number of samples depends on the amount of traffic moving and the number of interviewers available.
- The sampling can be done either based on time or on volume.

ROAD SIDE INTERVIEW SURVEY(CONTD...)

- For example, interviewing all the vehicles arriving in ten minutes and allowing the vehicles in next 10 minutes to move without stopping is a sampling method based on time.

ROAD SIDE INTERVIEW SURVEY(CONTD...)

- On the other hand, interviewing every 5 th or 10 th vehicle is volume based sampling.
- As interviewing may consume some minutes of time, care should be taken that during that time the traffic flow is not interrupted.
- Depending on specific requirements and objectives the survey can be done for 24 hours, 16 hours or 12 hours.
- However, vehicle counts are to be done for 24 hours period.
- Care should be taken in designing the survey form such that the data collected is complete in all aspects.
- A typical survey form is shown in table.

TABLE - SAMPLE ROADSIDE INTERVIEW FORM

Day Date	Wet ☐ Dry ☐	Separate Yes ... Count ? No ...	Recorded by	Sheet No.

Site		Private	Sample	Total
Direction		Bus		
Half-hour starting at		Goods		

Veh. Type	No. of occupants	Last stop	Next stop	Last land use	Next land use	Trip purpose

Vehicle Type	*Land use*	*Trip purpose*
0. Motor cycle	0. Residential	0. To work
1. Car	1. Hotel, guest house, restaurant	1. Work to home
2. Taxi	2. School college, University	2. Other to home
3. City Bus	3. Offices	3. Shopping
4. Light Commercial	4. Shops, markets	4. Business (own or employed)

INVENTORY OF TRANSPORT FACILITIES

- Any transportation planning process should make it a point to identify the deficiencies in the existing system and then improvement plans are to be prepared accordingly.
- The inventory of existing transport facilities serves this purpose.
- The inventory consists of :-

a) Inventory of streets or road network

b) Traffic volume, composition, peak and off-peak periods

c) Travel time studies

d) Inventory of public transport

e) Inventory of parking

INVENTORY OF TRANSPORT FACILITIES(CONTD...)

a) Inventory of streets :-

- An understanding of extent and quality of road network can lead to formulation of better improvement plans.
- The inventory should cover details such as classification of road system, lengths, cross sectional dimensions, type and condition of surface, capacities of various road sections and junctions, number of intersections and the type of controls etc.

INVENTORY OF TRANSPORT FACILITIES(CONTD…)

b) **Traffic Details:-**

- Data pertaining to traffic volume and composition can be used to check the accuracy of the home interview survey data and cordon survey data.
- The variation of traffic volume over different time periods of day, different days of week and different months is needed.
- The 24 hours traffic count is also required to fix up the peak period and off peak period at different locations.

INVENTORY OF TRANSPORT FACILITIES(CONTD...)

c) **Travel Time Studies:-**

- Travel time between different zones is an important indicator of efficiency of the existing transportation system.
- Studies are to be conducted to find out travel time between different zones, by different modes.
- The details about the delays, causes for delays and locations where delay occurs are also to be collected.

INVENTORY OF TRANSPORT FACILITIES(CONTD...)

d) Inventory of Public Transport:-

- This includes information regarding bus services such as the bus routes, frequencies, bus stop locations, operating speeds, capacities of buses and economic performance of the bus services.
- Information regarding fare is also needed.
- If a local train facility is available, all these details pertaining to train services are also to be collected.

INVENTORY OF TRANSPORT FACILITIES(CONTD...)

e) Parking Inventory:-

- Parking surveys should be done to estimate the demand for parking and also to assess the existing parking facilities.
- Data collected should include the on-street and off street parking locations, their capacities, type of parking control such as parking fee collection or parking control by time, duration of parking etc.

EXPANSION FACTORS

EXPANSION FACTORS:-

- Most of the survey methods discussed above are based on sampling techniques and so the sample data collected must be expanded to represent the whole population.
- This is achieved though expansion factors. The expansion factors are calculated for each zone in the study area.

EXPANSION FACTORS(CONTD...)

- The expansion factor used for home interview study is basically the total universe i.e., the total number of households in the study area divided by the total number of successful interviews.
- This is calculated for each traffic zone based on the following formula.

EXPANSION FACTORS(CONTD...)

$$\text{Expansion Factor} = \frac{A - \frac{A}{B}\left(C + \frac{C}{B} \times D\right)}{B - C - D}$$

where A = total number of addresses on the original list;

B = total number of house holds selected as sample;

C = number of sample addresses that are ineligible

(e.g: non-residential, demolished)

D = number of sample addresses where no response was obtained

(refusal to give information, locked)

EXPANSION FACTORS(CONTD...)

- The external cordon survey expansion factor is usually derived for each class of vehicle, time interval and direction of flow used at the survey point.
- It is calculated as follows:-

EXPANSION FACTORS(CONTD...)

$$\text{Expansion Factor} = \frac{A}{B}$$

where A = the number of vehicles of specified class counted passing though survey point for the relevant time interval

B = the number of vehicles interviewed, of the same class, for the same time interval.

Supposing 5000 trucks pass the survey point in a 24 hours period and 500 trucks are interviewed during the same 24 hours, the

$$\text{expansion factors is} = \frac{5000}{500} = 10$$

ACCURACY CHECKS

ACCURACY CHECKS:-

- It is desirable to check the accuracy of the survey data before the process of data analysis.
- This can be done by conducting some field studies.

HOME INTERVIEW SURVEY

Home interview survey:-

- The data collected regarding the number of people in a households during home interview study can be expanded to find out the total population of zone and this can be checked against census data.
- However, care must be taken to account for change that have taken place after census data was collected.
- Expanded home interview data should not vary by more than $\pm$ 15 percent of the adjusted census data.

HOME INTERVIEW SURVEY(CONTD...)

- The travel patterns as obtained from home interview study can be checked by screen line surveys.
- The screen line chosen should be preferably a natural barrier such as a river or a railway with comparatively few crossing points.
- Traffic counts can be carried out on a screen line and they can be checked with the sample data obtained.

Types Source of Data:-

•Primary source

•Secondary source

Primary Source – Data collected by contact with a person

Secondary Source – Data collected in Absence of a person

Primary Source –

•Home Interview survey

•Cordon survey - Road side Interview

(1)Tag on car Method

(2)License plate

•Terminal Survey - Post card questionnaire Survey

(1)Direct Interview at Terminal

(2)Commercial vehicles survey

•Video graphic Survey

Secondary Source –

- R TO Department - Vehicles Registered
- Education Department - Primary, Secondary professional
- Commercial Tax department - Floor space of shopping centre
- Births & Death details from Municipality - Demographic details like age, Male,Female ration etc.
- Police Department - Accident data
- Industrial Department - No. of workers
- Employment department - Unemployed youth
- Income tax Department - Economic profiles
- RTC - Transit riders, concessional travelers
- Tourist Department
- Medical Department
- Valuation Department
- Land use Department

SUMMARY

SUMMARY:-

- This unit introduces the concept of study area and zoning principles.
- Different kinds of studies needed for data collection for urban transportation planning are elaborately discussed.
- The expansion factors and accuracy checks needed are briefly discussed.

REVIEW QUESTIONS

REVIEW QUESTIONS:-

a) Define study area. Explain the guidelines for fixing up external cordon.

b) What is zoning? Why it is necessary? Explain the principles to be adopted for zoning.

c) List out the types of surveys needed for data collection for urban transportation planning. Explain in detail the home interview survey.

d) Write short notes on the following:-

i) Road side interview method

ii) Registration Number Plate Survey

iii) Post-card questionnaire survey

e) What kind of surveys are to be done under inventory of existing transport facilities? Explain.

f) What is the use of Expansion Factors and Accuracy checks?

How are they to be carried out?


THE END

9.0 INTRODUCTION

The first stage in the formulation of a transportation plan is to collect data on all factors that are likely to influence travel pattern. The work involves a number of surveys so as to have an inventory of existing travel pattern, an inventory of existing transportation facilities and an inventory of existing land use and economic activities. It also helps in the building up of a local authority database used for policy & priority determination or in allocating costs & income on a jointly operated venture.

9.1 DEFINITION OF STUDY AREA

Transportation planning can be at the national level, regional level or at the urban level. For planning at the urban level, the study area should embrace the whole conurbation containing the existing and potential continuously built-up areas of the city.

The imaginary line representing the boundary of the study area is termed as the 'external cordon'. The area inside the external cordon line determines the travel pattern to a large extent and as such is surveyed in great detail.

The selection of the external cordon line for an urban transportation study should be done carefully due to the following factors.

i. The external cordon lines should circumscribe all areas which are already built-up and those areas which are considered likely to be developed during the period of study.

ii. The external cordon line should be compatible with previous studies and the area of studies planned for the future.

iii. The external cordon line should be continuous and uniform in its course so that movement crosses it once. The line should intersect roads where it is safe and convenient to carry out traffic surveys.

9.2 ZONING

The defined study area is sub-divided into smaller areas called zones. The purpose of such a sub-division is to facilitate the spatial quantification of land use and economic factors which influence travel pattern. The data collected on individual household basis cannot be conveniently considered and analysed unless they are aggregated into small zones.

Sub-division into zones further helps in geographically associating the origins and destinations of travel. In large study projects, it is more convenient to divide the study area into sectors, which are sub-divided into smaller zones.

A convenient system of coding of the zones will be useful for the study. One such system is to divide the study area into 9 sectors. Each sector is sub-divided into 10 zones. A sub-zone bearing a number 481 belongs to sector 4 and to zone 8 in that sector and is sub-zone 1 in that zone.

Zones are modelled as if all their attributes and properties were concentrated in a single point called the zonecentroid. The centroids are connected to the nearest road junction or rail station by centroid connectors. Both centroid and centroid connectors are notional and it is assumed that all people have same travel cost from the centroid to the nearest transport facility which is the average for a zone. The intersection from outside world is normally represented through external zones. The external zones are defined by the catchment area of the major transport links feeding to the study area. Although the list is not complete, few guidelines are given below for selecting zones.

1. Zones should match other administrative divisions, particularly census zones.
2. Zones should have homogeneous characteristics, especially in land use, population etc.
3. Zone boundaries should match cordon and screen lines, but should not match major roads.
4. Zones should be as smaller in size as possible so that the error in aggregation caused by the assumption that all activities are concentrated at the zone centroids is minimum.
5. The zones should have a homogenous land use.
6. Natural or physical barriers such as canals, rives etc can form convenient zone boundaries.

9.3 TYPES OF MOVEMENTS

The basic movements for which survey data are required are:

i. Internal to Internal

ii. Internal to External

iii. External to Internal

iv. External to External

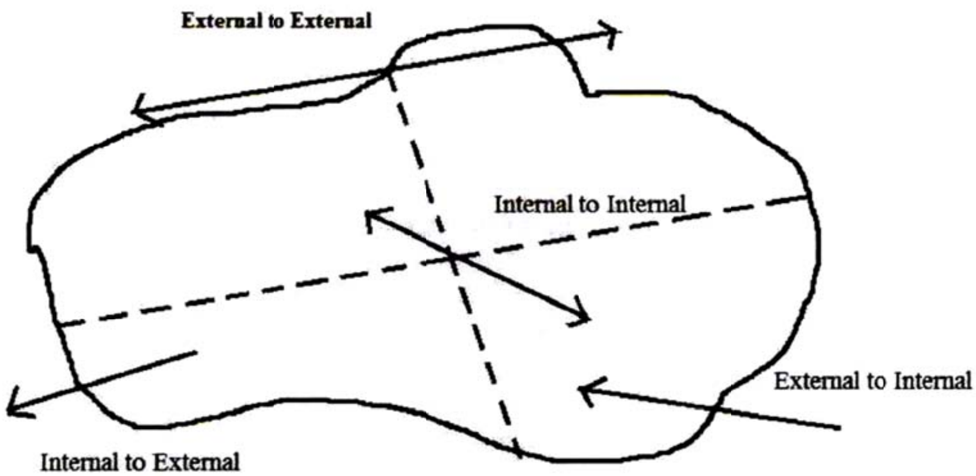


Figure 9.1: Basic Movements in a Transportation Survey

For large urban areas, the internal to internal travel is heavy whereas for small areas having small population the internal to internal travel is insignificant. The internal to internal and internal to external travels can be studied by home interview technique. The external to external and external to internal travels can be studied by cordon surveys. The internal to internal travel can also be surveyed by home interview technique

Movement Type

i) Business movement

ii) Commuter movement

iii) Holiday movement

iv) Other private movement

Data Collection Techniques

1. Home Interview Survey

i) Telephone survey

ii) Mail back

iii) Face to face

2. Commercial Vehicle Survey

   i) Stop line survey

   ii) Innovative Commercial Vehicle Tracking Methods

3. Intermediate Public Transport Survey
4. Cordon-Line Survey
5. Post Card Questionnaire Survey
6. Registration – Number Survey
7. Tag – on – Vehicle Survey
8. Group Survey
9. Observation Survey
10. In Depth Survey
11. Online Web Survey

9.4 TYPES OF SURVEYS

9.4.1 Home-interview survey

Home-interview survey is one of the most reliable type of surveys for collection of origin and destination data. The survey is essentially intended to yield data on the travel pattern of the residents of the household and the general characteristics of the household influencing trip-making. The information on the travel pattern includes number of trips made, their origin and destination, purpose of trip, travel mode, time of departure from origin and time of arrival at destination and so on. The information on household characteristics includes type of dwelling unit, number of residents, age, sex, race, vehicle ownership, number of drivers, family income and so on. Based on these data it is possible to relate the amount of travel to household and zonal characteristics and develop equations for trip generation rates.

It is impractical and unnecessary to interview all the residents of the study area. Since travel patterns tend to be uniform in a particular zone. The size of the sample is usually determined on the basis of the population of the study area. And the standards given by the Bureau of Public Roads as shown in below table.

Table 9.1 Standards for Sampling Size for Home-interview survey

Population of Study Area	**Sample Size**
Under 50,000	1 in 5 households
50,000 – 150, 000	1 in 8 households
150,000 – 300,000	1 in 10 households
300,000 – 500,000	1 in 15 households
500,000 – 1,000,000	1 in 20 households
Over 1,000,000	1 in 25 households

Standard Practice now is instead to calculate the sample size which will achieve the desired precision for key indicators at the required level of confidence. One such equation is given by Traffic Appraisal manual.

$$n = p(1-p)N^3/[(E/1.96)^2(N-1) + p(1-p)N^2]$$

Where,

n = required number of households in an area of interest

E = accuracy level

P =Proportion of households in the area with attributes of interest.

The usual procedure is for an interviewer to call on a household on a scheduled data and to leave a copy of the home interview questionnaire. This questionnaire is broadly divided into :

a) General household characteristics – number of residents, vehicles owned, income, dwelling type.
b) Characteristics about family members – occupation, sex, age.
c) Individual travel information – trip origin and destination, purpose, land – use, travel time and transport mode.

Once the questionnaire is ready, the next step is to conduct the actual survey with the help of enumerators. Enumerators has to be trained first by briefing them about the details of the survey and how to conduct the survey. They will be given random household addresses and the questionnaire set. They have to first get permission to be surveyed from the household. They may select a typical working day for the survey and ask the members of the household about the details required in the questionnaire. They may take care that each member of the household should answer about their own travel details, except for children below 12 years. Trip details of children below 5 years are normally ignored. Since the actual survey may take place any time during the day, the respondents are required to answer the question about the travel details of the previous day. There are many methods of the administration of the survey and some of them are discussed below:

1. **Telephonic:** The enumerator may use telephone to an appointment and then conduct detailed telephonic interview. This is very popular in western countries where phone penetration is very high.

2. **Mail back:** The enumerator drops the questionnaire to the respondent and asks them to fill the details and mail them back with required information. Care should be taken to design the questionnaire so that it is self explanatory.

3. **Face-to-face:** In this method, the enumerator visits the home of the respondent and asks the questions and fills up the questionnaire by himself. This is not a very socially acceptable method in the developed countries, as these are treated as intrusion to privacy. However, in many developed countries, especially with less educated people, this is the most effective method.

9.4.2 Commercial Vehicle Survey

A similarly styled survey of non-residential land uses could be designed to collect information on goods movements, but transport resources are rarely allocated to such an ambitious project. Instead, urban freight flows are usually measured indirectly from commercial vehicle survey.

Commercial vehicle surveys are conducted to obtain information on journeys made by all commercial vehicles based within the study area. The addresses of the vehicle operators are obtained and they are contacted. Forms are issued to drivers with a request that they record the particulars of all the trips they would make.

9.4.3 Innovative Commercial Vehicle Tracking Methods

Roadside interviews are the most suitable avenue to collect data about intercity movements. However, it is impossible to use roadside surveys in an urban environment due to safety issues. In addition, with emerging privacy concerns, it is becoming increasingly difficult to conduct roadside interviews. It would be almost impossible to conduct roadside surveys in about a decade from now. MTO is currently in the process of investigating the use of non-intrusive GPS data to supplement, and eventually replace, data collected form roadside surveys. The number of trucks equipped with GPS receivers, which records the location of the vehicle every few seconds, have been increasing steadily over the past few years. In addition to providing detailed origin-destination information, The GPS technology provides many other potential benefits, including:

1. Coverage of urban freight movement with detailed route's and performance indicators.
2. Link level congestion analysis – travel time, speed
3. Near real-time international border transit time monitoring.
4. Tools and reporting systems to measure economic impacts delays due to incidents.
5. Fuel consumption and pollution analysis using GPS units that include engine data retrievers.
6. Impacts of High Occupancy Vehicle (HOV) lanes on General Purpose Lane (GPL) traffic.

These survey can be carried out in different ways as follows –

1) Direct interview survey

2) Post card distribution & collection survey
3) Pre-paid questionnaires distribution & collection survey.

Stop Line Survey : It is through that response bias can be overcome or is not likely to be serious. It may be possible to dispense with the interview site altogether and instead hand out the forms at a natural stop-line, Such as at traffic signals, thus avoiding all disruption to traffic.

9.4.4 Intermediate Public Transport Survey

These survey can be carried out in different ways as follows:

1) Direct interview survey
2) Post card distribution and collection survey
3) Pre paid questionnaires distribution and collection survey

In order to assess the number of bus passengers passing through an external cordon, the survey can either be by direct interview with the passengers or by issuing post-card questionnaires. Direct interview is likely to result in large delays and requires a large number of interviews.

In order to minimize the delays, the interviewer may enter the vehicle and carry out the interviews when the vehicle is in motion. Post-card questionnaires eliminates delays, but are likely to evoke poor response or contain and element of bias.

An external cordon rail survey can be carried out by interviewing the passengers on trains. Alternatively, pre-paid questionnaires may be distributed to persons residing at stations outside the survey area. These questionnaires may also be collected at the stations inside the survey area.

9.4.5 Cordon-Line Survey

These provide useful information about trips from and to external zones. For large study area, internal cordon line can be defined and surveying can be conducted. The objective of the survey is primarily to collect the origin and destination zones and for this many suitable methods can be adopted. It could be either recording the license plate number at all the external cordon points or by post-card method.

Screen lines divide the study area into large natural zones, like either sides of a river, with few crossing points between them. The procedure for both cordon-line and screen-line survey are similar to road-side interview. However, these counts are primarily used for calibration and validation of the models.

9.4.6 Post-Card Questionnaire Survey

In this survey, reply-paid questionnaires are handed over to each of the drivers or a sample of them at the survey points and requesting them to complete the information and return by post. The method avoids delay caused to the drivers by the direct roadside interview method but suffers from the disadvantage that the response may not be good. For this reason its use is not generally recommended for developing countries. It is possible to get a good amount of information from this method. The method is simpler and cheaper than many others.

A good amount of publicity is needed before the actual survey in order to get favourable response. It is reported that well planned and publicized post card questionnaire surveys have yielded returns of 50% or more.

This method can be used on roadways with higher traffic volumes because they require less interaction time with the driver. Drivers may not have to be directed off the roadway; rather, postcards can be quickly handed out in the traffic lanes to every vehicle as they stop at the roadside station. Like the roadside interview, adequate advanced warning signs and traffic control must be in place for the safety of the drivers and observers.

To complement roadside interviews, this method may be used when backups occur upstream from the interview site. In this case, postcards may be handed to the drivers and they are then permitted to leave. This will eliminate or reduce the delay and number of angry drivers who are stopped to take the interview. This method can be used as an alternative or in combination with roadside interviews (RSIs).

In this method, the same information is generally collected as in RSIs, but the survey is conducted via a postcard that is handed to the driver, completed after the trip, and mailed back. A given number of personnel could hand out more questionnaires than conduct roadside interviews.

The problem with this method is the lower response rate than with a roadside interview. In addition, more of the questions may be skipped or answered incorrectly. Generally, response rates for this method are between 15% and 30%. Furthermore, a lot of time has to be spent reducing returned survey forms, and more money is spent for printing them. There may be a bias in this type of survey, if non respondents (such as certain vehicle types or income levels) have different travel characteristics and demographics than respondents. For example, surveys may not be completed for several reasons: refusal to accept survey, failure to read it, failure to understand it, failure to complete it, and failure to send it back.

9.4.7 Registration – Number Survey

In the registration address technique vehicle registration numbers are recorded and their origin or destination is deduced from their registered address. Alternatively a questionnaire is sent to the registered address in order to collect information on the trip details. For commercial vehicles the registered address often bears no relationship to the trip origin or destination, particularly for vehicles engaged in long distance travel. Furthermore, a mail questionnaire would be subject to a low response rate in the same way as the postcard reply technique. An added complication is that by the time a particular driver received a questionnaire the exact details of the trip may have been forgotten. First of all, the area to be surveyed is defined, and the roads intersecting cordon lines are identified. At each survey point, one or two observers are stationed to record the data in each direction of travel. One can call out the registration number of the vehicle and the other can record. Time should be recorded at regular intervals. If actual time at entry and exit are noted, an estimate of the journey speed of the vehicle can also be had. The type of vehicle and as well as the full registration number are noted. The analysis consists of tallying the numbers of vehicles at points of entry and exit.

9.4.8 License Plate Follow-Up Survey Technique

This technique uses one of methods described above in order to record license plates at a particular roadside station. A list of license plates is then supplied to the Department of Motor Vehicle (DMV) to obtain contact information for the vehicle owner. A survey is sent to the vehicle owner, who is then asked to respond to a survey of questions regarding the specific trip on which their license plate was recorded. In order to obtain contact information of vehicle owners from the DMV, the full license plate must be recorded. Depending upon the recording method and the requirements of each DMV, the license plates may or may not have to be transcribed into a specific format. Once the contact information is obtained from the motor vehicles department, a survey of the vehicle owners can be conducted. It is critical that the date, time stamp, location, direction of travel, and other relevant information (such as how their vehicle was recorded and contact information obtained) be included in the information provided to the vehicle owner. This survey is usually conducted via a telephone interview or postcard mail-out with response via mail-in, telephone, and/or internet. License plate follow-up surveys have resulted in both successful and unsuccessful OD studies. They are beneficial in that they are unobtrusive like the license plate matching technique, but detailed information (trip purpose, true origin and destination, etc.) can still be obtained from the actual driver of the vehicle using that specific road. Below figure illustrates the types of trips that can be obtained from the license plate follow-up survey technique. Like the license plate matching technique, the lighter-shaded arrows represent the trips from one entry node to all other exit nodes (E-E trips). However, instead of one dark-shaded arrow that aggregates all E-I trips from the external station to the internal TAZs, information provided from the license plate follow up survey technique provides information on the distribution of the E-I trips to each of the TAZs inside the cordon line.

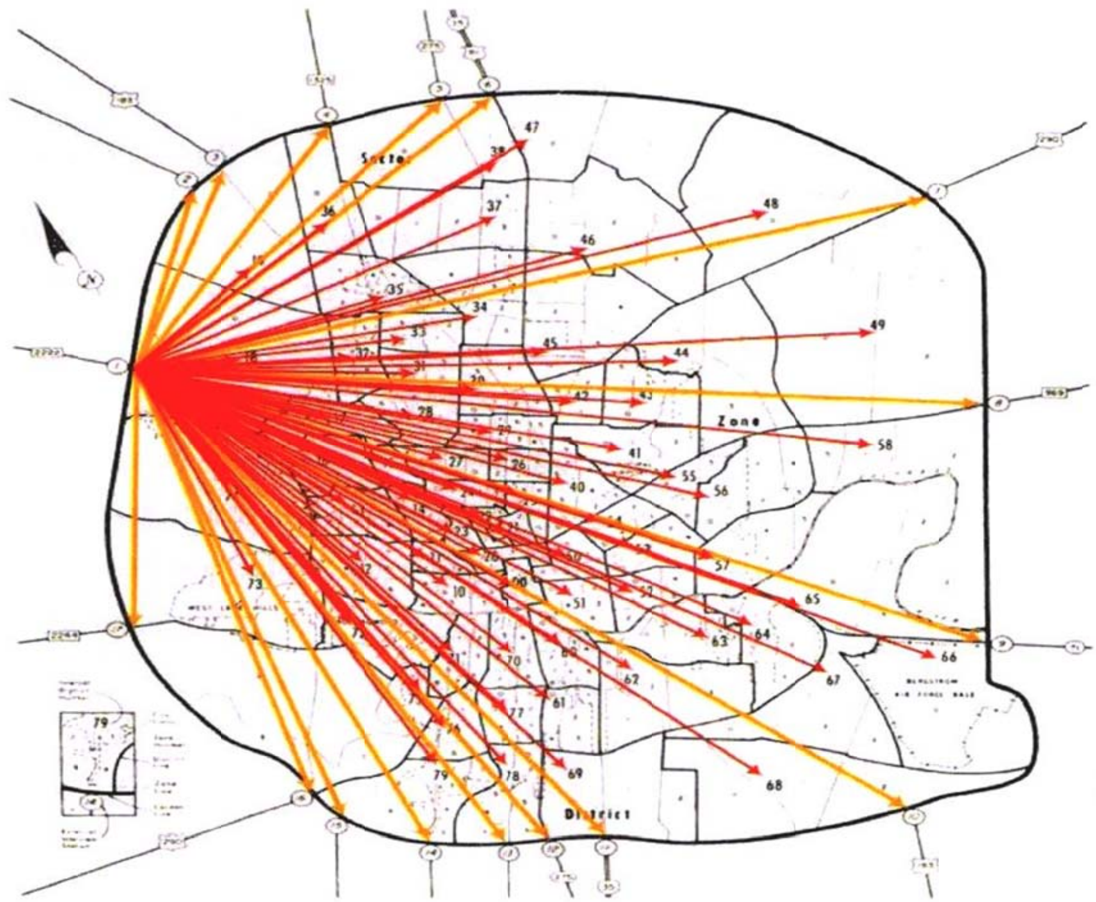


Figure: 9. 1 Types of Trips from License Plate Follow-Up Survey Technique

License plates must be recorded roadside using one of the methods described above in the license plate matching section. With this method, however, it is important to record the full license plate of the vehicle in order to contact the proper state motor vehicle department (the Indiana Bureau of Motor Vehicles does not have information on out-of-state license plates) and a partial license plate will not be useful. The advantage over license plate matching is that obtaining each and every passing license plate is not as critical because the plates are not being matched to another observation station, although it is still important to record as many license plates as possible. The license plates will likely have to be transcribed into an acceptable format and sent to each of the respective departments of motor vehicles to obtain addresses.

9.4.9 Tag – on – Vehicle Survey

In this method, drivers are stopped at roadside stations where a colour-coded identifier is placed on the bumper, front window, or radio antenna of passing vehicles. Each roadside station has one unique colour assigned to it. Data collectors at each station then record the passing vehicles' tag color (if it has one) to determine the percentage of vehicles coming from another station. Drivers are instructed to remove the identifier at their next destination. With this method, a time stamp will not likely be obtained. The tag-on-vehicle method is a combination of the VIS and matching techniques. Because the vehicles have to be stopped on the roadway in order for a tag to be placed on their vehicle, it is considered a VIS. However, the tags are monitored as they pass observers through subsequent stations on their trip, so it is also a type of matching technique. The advantages of the tag-on-vehicle method are that it is quicker to conduct than an RSI and easier to match between stations than license plates. However, time stamps may not be collected, unless the vehicle is stopped again at the second station to obtain that information.

On the downside, some motorists may not like the idea of physically attaching a tag to their vehicle, and may disapprove of its placement or remove it before their destination. Still other motorists may leave it attached even after they arrive at their destination, which may cause a significant number of false matches if the vehicle is spotted later in the study. In addition, litter could become a problem if tags are not secured or drivers do not dispose of them properly.

APPENDIX 1

Indian Institute of Technology Roorkee
Transportation Engineering Group
Department of Civil Engineering

Access Mode Choice Survey for Multimodal Transportation System

This study is taken up to understand the ***Access Mode Choice of the commuters for Multimodal Transportation System in New Delhi****. It is hereby assured that the* ***data collected would be kept confidential*** *and would be utilized for academic purposes only.*

Sample No……………….. **Date..……………………………**

Location ………………….. **Time ………………................**

Household Information

1. **Name –** ……………………………………………………………………………………...
2. **Address –** ……………………………………………………………………………………
   ………………………………………………………………………………………..
3. **House Ownership –**
   Own ◯ Rented ◯ Other ◯
4. **Household Size (No. of Members in House) –** ………
5. **Number of Earning Members –** ……….
6. **Total Monthly Household Income (in `) –** …………………
7. **Personal Information of Family Members –**

Sr. No.	Age	Sex	Education	Employment	Income (`)
1					
2					
3					
4					
5					
6					

8. **Vehicle Ownership –**
   Car – 0/1/2/>2 Two-wheeler – 0/1/2/>2 Bicycles – 0/1/2/>2

Income Categories –

≤ ` 7,500 = Poor Category (PC)
` 7,500 – ` 17,000 = Lower Middle Category (LMC)
` 17000 - ` 50000 = Middle Class (MC)
` 50,000 – ` 85,000 = Upper Middle Class (UPM)
≥ ` 85,000 = High Category (HC)

Access Mode Choice Information

Member 1

1. **Purpose of Trip –** Work / Education / Shopping / Other
2. **Initial Origin –** ………………………… 3. **Destination –** ……………………………….
4. **Main Mode used for journey –** Metro
5. **Access Modes available –**

(A) Walk (W) (B) Bicycle (BC) (C) Cycle Rickshaw (CR) (D) Auto Rickshaw (AR) (E) Taxi (T)

(F) Two-wheeler (TW) (G) Car (C) (H) Bus (B) (I) Other (O)

Arrange above access modes in sequence according to use and availability of access modes in following table

Sr. No.	Modes	1	2	3	4	5	6	7	8	9
a.	Mode used to reach at nearest Metro Station									
b.	Total distance from Home to Metro Station (in km)									
c.	In Vehicle Travel Time (in minutes)									
d.	Out Vehicle Time (in minutes) i.e. Walk Time + Waiting Time									
e.	Cost of Access (in `)									
f.	Parking Cost if any (in `)									

APPENDIX 2

Indian Institute of Technology Roorkee
Transportation Engineering Group
Department of Civil Engineering

Access Mode Choice Survey for Multimodal Transportation System

This study is taken up to understand the ***Access Mode Choice of the commuters for Multimodal Transportation System in New Delhi****. It is hereby assured that the* ***data collected would be kept confidential*** *and would be utilized for academic purposes only.*

Sample No................. **Date..................................**

Location .... **Time ....**

PERSONAL INFORMATION

Name – ....

Address – ....

Age – .... **Sex –** Male/Female **Education –** ≤ 10 / ≤ 12 /Graduate /PG

Monthly Income – Rs................ **Vehicle Ownership –** Car [ ] TW [ ] Bicycle [ ]

Trip Purpose – Work/Education/Shopping/Other

Access Distance to Metro/Bus (in km) – ....

Access Mode Used – Walk/Bicycle/Cycle Rickshaw/Auto Rickshaw/Two-wheeler/Car/Feeder Bus/Other

Travel Time (in min) – In Vehicle Travel Time [ ] Out Vehicle Travel Time (Walk + Wait) [ ]

Travel Cost (in Rs.) – [ ] **Parking Cost (in Rs.) –** [ ]

ALTERNATIVE CHOICE SET FOR WALK AS A MODE

Alternative / Attributes	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Walk Facility	Normal	Footpath	Footpath	Skywalk	Normal
Walk Time	15	15	14	15	17
Crossing Facility	Not Required	Signalized	Underpass	Overpass	Signalized
Commuter Response	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No

"Thank you for answering to the queries"

APPENDIX 3

Indian Institute of Technology Roorkee
Transportation Engineering Group
Department of Civil Engineering

Access Mode Choice Survey for Multimodal Transportation System

*This study is taken up to understand the **Access Mode Choice of the commuters for Multimodal Transportation System in New Delhi**. It is hereby assured that the **data collected would be kept confidential** and would be utilized for academic purposes only.*

Sample No……………….. **Date**……………………………

Location ………………….. **Time** ……………………………

PERSONAL INFORMATION

Name – ……………………………………………………………………………………………

Address – …………………………………………………………………………………………

Age – …………. **Sex –** Male/Female **Education –** ≤ 10 / ≤ 12 /Graduate /PG

Monthly Income – Rs……………… **Vehicle Ownership –** Car ☐ TW ☐ Bicycle ☐

Trip Purpose – Work/Education/Shopping/Other

Access Distance to Metro/Bus (in km) – …………

Access Mode Used – Walk/Bicycle/Cycle Rickshaw/Auto Rickshaw/Two-wheeler/Car/Feeder Bus/Other

Travel Time (in min) – In Vehicle Travel Time ☐ Out Vehicle Travel Time (Walk + Wait) ☐

Travel Cost (in Rs.) – ☐ **Parking Cost (in Rs.) –** ☐

ALTERNATIVE CHOICE SET FOR WALK AS A MODE

Alternative / Attributes	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
IVTT (Travel Time)	12	10	12	10	16
OVTT (Waitting + Walking Time	7	7	5	10	5
Fare	5	10	10	5	5
Comfort	Non AC	AC	AC	Non AC	Non AC
Commuters Response	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No

"Thank you for answering to the queries"

Origin and Destination Survey – Roadside Interview Method

Date:	Name of Town:	Sheet No.:
Survey Location:	Name of Interviewer:	Weather conditions:
Location (km):	Direction of Travel:	Hours:
		From: To:

Sl. No.	Time of intervie w	Vehicle type	Registration number	Trip origin	Trip destination	No. of persons in the vehicle	Goods carried		Whether likely to halt in the town		Trip purpose	Route course (via)	Whether a bypass will be desirable if not state reasons
							Type	Tonnage	No. of halts	Purpos e of halts			

Source: IRC: 102-1988.

Typical Form for Commercial Vehicle Survey

<table>
<tr><td>Firm/Owner</td><td rowspan="4">Visit
1
2
3
4
5</td><td>Time</td><td>Date</td><td>Interviewer’s Name</td><td>Sheet of</td></tr>
<tr><td>Address</td><td colspan="4" rowspan="3">Comments: Ser. No.
Zone No.</td></tr>
<tr><td>Person Interviewed</td></tr>
<tr><td>Telephone No.</td></tr>
</table>

Part I. Business Information

A. Nature of Business Male/female

B. Total Number of employees

C. Number of vehicles operating from address

Cars Parked on premises Parked elsewhere

Light Goods Parked on premises Parked elsewhere

Heavy Goods Parked on premises Parked elsewhere

D. Day of travel

E. Total number of trips made on day of travel

F. Type and number of vehicles interviewed

Vehicle No.

Vehicle Reg. No.

Part II. Vehicle Trip Information

<table>
<tr><td>G</td><td>H</td><td>I</td><td>J</td><td>K</td><td colspan="2">L</td></tr>
<tr><td rowspan="2">Vehicle Type</td><td rowspan="2">Vehicle Number</td><td rowspan="2">Trip Number</td><td rowspan="2">Origin Address</td><td rowspan="2">Destination Address</td><td colspan="2">Time of Trip</td></tr>
<tr><td>Start
AM
PM</td><td>Finish
AM
PM</td></tr>
<tr><td colspan="2"></td><td colspan="2">Nature of Business:</td><td colspan="2">Nature of Business:</td><td></td></tr>
<tr><td colspan="2"></td><td colspan="3"></td><td>AM
PM</td><td>AM
PM</td></tr>
<tr><td></td><td></td><td colspan="2">Nature of Business:</td><td colspan="2">Nature of Business:</td><td></td></tr>
</table>

Sample Roadside Interview Form

<table>
<tr><td colspan="4">Day Date   Wet Dry   Separate Count ? Yes… No…</td><td colspan="3"></td><td>Sheet No.</td></tr>
<tr><td colspan="4">Site</td><td></td><td>Private</td><td>Sample</td><td>Total</td></tr>
<tr><td colspan="4">Direction</td><td></td><td>Bus</td><td></td><td></td></tr>
<tr><td colspan="4">Half-hour starting at</td><td></td><td>Goods</td><td></td><td></td></tr>
<tr><td>Veh. Type</td><td>No. of occupants</td><td>Last Stop</td><td colspan="2">Next stop</td><td>Last land use</td><td>Next land use</td><td>Trip purpose</td></tr>
<tr><td></td><td></td><td></td><td colspan="2"></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="2"></td><td></td><td></td><td></td></tr>
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<tr><td></td><td></td><td></td><td colspan="2"></td><td></td><td></td><td></td></tr>
</table>

Vehicle Type	Land use	Trip purpose
0. Motor cycle	0. Residential	0. To work
1. Car	1. Hotel, guest house, Restaurant	1. Work to home
2. Taxi	2. School, College, University	2. Others to home
3. City Bus	3. Offices	3. Shopping
4. Light Commercial	4. Shops, markets	4. Business (own or employed)
5. Heavy Commercial (truck)	5. Industrial, docks, utilities	5. Personal affairs
6. Passenger Vehicle (truck)	6. Hospitals, doctors	6. School
7. Country Bus	7. Cultural recreational and other	7. Eat meal
	8. Police, military, fire stations	8. School/recreational
	9. Transport terminals, bus stops	9. Serve passenger

Sample Registration Number Plate Survey Form

		Sheet No.	
Site : Okhla			Weather : Overcast
Observation point : Mathura Road			Observer : BNG
Movement Observed : Delhi-bound			Recorder : OPB
Sheet starting time : 8-00 A.M.			Date : 24-1-76
Sample : Registration Numbers ending with : all even numbers, including zero. Vehicle class : All			
Column Start Time			
8-00	8-05	8-10	8-15
DLQ 2660	DLX 742	JKN 528	UPS 584
DLM 2832	DLN 3856		PUN 4973
DLP 8485	HRP 9485		DLQ 947

(3) OVERALL PLANNING PROCESS :-

The travel demand issue can be attempted in the overall planning from 3 perspectives:
(1) The demand catchment.
(2) supply network characterization.
(3) system consolidation.

Any planning will have the process of comprehenting the demand & its variations over a time & space suggesting at particular network with a defined characteristics and lastly connecting the demand and supply by a particular transport system. In the planning, we convert the travel demand in a special catchment by considering the attributes.

For example :- Developing the demand catchment by taking the purpose of travel into account. The purpose of travel can be the work based, recreation based, shopping, social and education based trips. All these purpose of travels varies with reference to demographic, social, economic, cultural interactions. Among these, work based and education based trips are more consistent and regular since the education is the social back ground which controls with academic status and work based trips are generators of economy to the individual at a society. Planning from this academic characteristics will cover the social interaction, cultural, recreational and health interactions rather the trip intensity, trip length, trip orientation are maximum for work based trips. By taking work based trips as basis, the demand catchment is going to be plotted from the centroid of a study area and the direction wise maximum trip length will be plotted. By Joining the extreme ends in all directions, the demand catchment can be identified.

Supply Network characterization:-

By considering the maximum Trip length, directional intensity, the shape of a network, density of the roads, running road length, no. of roads, no. of leads can be identified. By identifying the shape of network and geometrics of network, by taking the shape of demand catchment and intensity of traffic, the optimal network can be identified. ~~Lastly the system~~ Lastly the system consolidation can be attempted by taking the demand & Network characteristics into account. The higher functional roads and geometrics will be opened for transit corridor and remaining roads rather the Arterial roads can be opened for low volume service linkages, private vehicles & other modes of Transport vehicles. This is the overall planning process by taking demand issues into account. This approach is not exhaustive but the alternative plannings from landuse like origin and destination, the planning from route characterization, time & mode of transport will also generate the different planning process which will be commanding to overall planning process.

The mode based transport planning is another perspective where the demand is going to be disturbed its catchment & re-orient with respect to mode of transport and supply network will have change of geometrics & functionality & re-orient the mode based demand. The transport systems are opened to public not by completion but by intervention. This type of planning will act as a catalyst and re-orient the travel demands

Network characteristics, land use and system interventions. The concentrated business interactions, the academic interactions are deconcentrated and reoriented towards linear development. The best example is shopping malls, the recreation malls at Railway stations of MRTS and approach by many business man of the concentrated centres like koti, Sultanbazar. This planning will also generate a landuse Control and system consolidation optionally varied with Trip length and frequency

Public Transportation Module-III

Travel Demand Issues
AKELLA. NAGA SAI BABA
11-05-2020

Travel Demand Issues

$$T^{n}_{i,j,m,r,t}$$

- Where
- T = Trips
- n = Purpose of travel
- i = Origin of trip
- j = Destination of trip
- m = Mode of travel
- r = Route of travel
- t = Travel time
- If, $J_T = T_T$
- Risk will be nil & Pollution is nil

- T_L
- T_I Demand
- T_O

Travel Demand Issues

- The demand issues are to be tracked from different perspectives like in reference to supply and in reference to system and demand itself.
- Normally demand will be measured in no. of trips with purpose, origin, Mode, Destination, Route of travel & time of Travel.
- some times, we plan the demand by considering the supply characteristics into account like trip length, trip intensity and trip orientation.

Travel Demand Issues

- In certain cases, the demand issues will be deliberated with a system like an attempt to comprehend demand to the characteristics of transport system like MRTS working with a particular route length, a frequency, no. of seats like seating capacity and independent to the land use in a study area.
- In order to plan a demand based transport, there is a need to facilitate a system and a road network for every trip marker.

Travel Demand Issues

- But to make a viable planning, we consider the control parameters like land use, road network and demand catchment in to account.
- In the international planning, demand catchment is always comprehended to the defined travel time district like a comprehended trip length of maximum.

Travel Demand Issues

- For example:-
- for all the purposes, the road user should travel a maximum length of 15 Km.
- within this radius of 15 km, the land use planning, the road network planning and traffic impact planning will be attempted and certain policies like road tax, service tax and their benefits will be focused on this travel time district.

Travel Demand Issues

- In this way, the operational fencing, safety fencing, land use fencing, security fencing will be made transparent in the international planning of cities.
- In India, the transport planning is irregular in cities, because one person can travel a maximum trip length of 1 or 2 Km per day , where as, others can travel 60 to 80 Km per day.

Travel Demand Issues

- planning for such an uneven trip length is difficult and we fail to give a good level of service to the road user.
- In the supply based planning, the demand issues will be limited as comprehensive, consistent and defined travel characteristics, which makes the planning a supply oriented.

Travel Demand Issues

- for example, tracking of trip interactions with the attraction centres will promote the road network planning with a different functional connectivities.
- Similarly a system oriented planning will cover the demand catchment by intermodal co-ordination and a controlled trip length with a land use system as suggested in MRTS for Hyderabad city.

Travel Demand Issues

- In general, the demand issues should be looked at with the demand catchment, travel attributes like the purpose, origin, destination, mode of transport, route of travel and time of travel etc.
- In addition, the characteristics like trip length, trip intensity and trip orientation will be considered as an issue in a transport planning.

Travel Attributes

<u>Travel Attributes:-</u>

- i = Origin
- j = Destination
- m = Mode spilt
- r = Route Assignment
- t = Time of Travel
- n = Purpose of travel

Independent Variables

<u>Independent Variables:-</u>

1) Level of Service

- Time, Cause, Facility, Safety, Reliability etc.,

2) Socio- Economic Back Ground

- Family size, Family status, Average income, No. of Workers, No. of students, Average car ownership.

3) Activity

- Residential, Commercial, Road density, Recreational, Industrial.


THE END

21-6. Level of Service Concept in the HCM Manual

When a road is carrying a traffic equal in volume to its capacity under ideal roadway and traffic conditions, the operating conditions become poor. Speed drops down and the delay and frequency of stops mount up. The service which a roadway offers to the road user can vary under different volumes of traffic. The Highway Capacity Manual (Ref. 1, 16) has introduced the concept of "Level of Service" to denote the level of facility one can derive from a road under different operating characteristics and traffic volumes. The concept of levels of service is defined as a qualitative measure describing the operational conditions within a traffic stream, and their perception by motorists and/or passengers. The following are the factors which might be considered in evaluating the level of service :

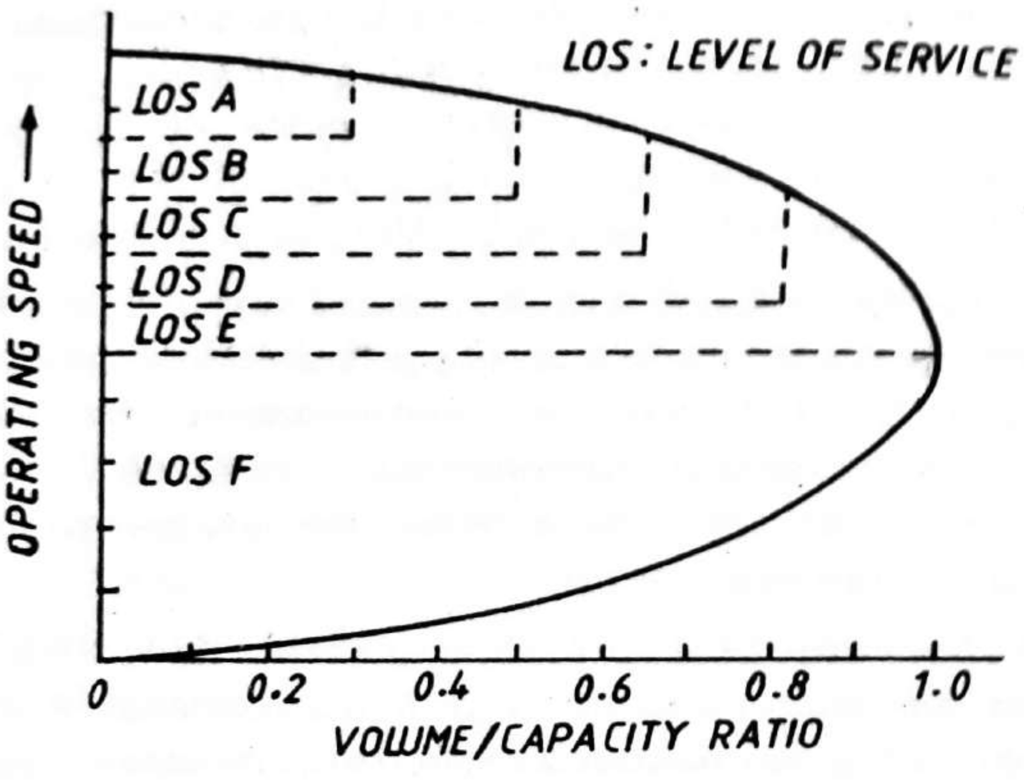


Fig. 21·1. Typical Speed Flow Curve for Multilane Highways.

PUBLIC TRANSPORTATION

MODULE-III

<u>Detailed Approach on 4 steps Travel Demand Estimation</u>

AKELLA NAGA SAI BABA

13/05/2020

Detailed approach on 4 steps travel demand Estimation

4 steps travel demand Estimation:-

This is generated from sequential based modeling which has four steps.

1) Trip generation- based on production and attraction factors
2) Trip distribution – growth factor models and synthetic (gravity) models
3) Modal split – choice of mode
4) Traffic Assignment – which route? (leading to future capacity analysis of roads)

Detailed approach on 4 steps travel demand Estimation

1) Trip Generation:-

- It represents the no. of trips produced & attracted from a zone and to a zone which is used for planning of the areas like residential colonies & shopping centers independently by considering the land use, demographic & socio- economic characteristics and the attraction potentials into account.

Trip Generation(Contd…)

- This first stage will generate an output which is insensitive to the supply characteristics like Level Of Service of the travel.
- Second step is Mathematical model suggested in trip generation (or) regression equation, category analysis & the expansion factor methods.
- The influencing variables considered in trip production are the population, no. of workers, no. of literates, family size & structure, average income, average car ownership & the residential built up area etc.,

Trip Generation(Contd…)

The factors affecting trip attractions are:-

1) No. of workers
2) Floor space of each attraction centre.
3) Average distance of access to the CBD etc.

2) Trip Distribution

2) **Trip Distribution:-**

- The No. of trips attracted among two zones will be modeled by this approach.
- This second stage will take the output of first stage in addition to the independent factors like generalized travel time, travel cost & travel distance.
- While developing a mathematical model, all the influencing variables of trip generation would be taken as input for development of relationship between trip distributed and trip generated.
- There are three modeling approaches generating from empirical and reflection concept, analytical scientific reasoning & probabilistic approaches.

Trip Distribution(Contd…)

I) Growth factor method
II) Gravity Model
III) Opportunity model

Trip Distribution(Contd…)

I) Growth factor method:-

In Growth factors method, the following are the different approaches suggested:-

1) Uniform Growth factor
2) Average Growth factor
3) Detroit Growth factor
4) Fratar Growth factor
5) Furness Growth factor
6) Time function iteration Growth factor method.

Trip Distribution(Contd…)

II) Gravity Model:-

In gravity model, 4 approaches are suggested.

1) Un constraint gravity model
2) Production constraint gravity model
3) Attraction constraint gravity model
4) Doubly constraint gravity model.

Trip Distribution(Contd…)

III) Opportunity model:-

Third method is opportunity model, having two different approaches:-

1) Competing opportunity model.

2) Intervening opportunity model.

3) Modal split

Modal Split

Definition:

- Is the process of separating person-trips by the mode of travel.
- Usually expressed as a fraction, ratio, or percentage of the total number of trips.




Factors Affecting Modal Split

Characteristics of the trip

Trip purpose, trip length.

Household Characteristics

Income, Car ownership, family size and composition.

Zonal Characteristics

Residential density, concentration of workers, distance from CBD.

Network Characteristics

Accessibility ratio, travel time ratio, travel cost ratio.

Mode choice depends on:-

- Travel time (in Vehicle + waiting)
- Travel cost
- Socio-economic status of user (income, family size,….)
- Level of travel service (comfort, Safety, speed, ……..)

The variable defining the model is a function called the **Utility Function**

4) TRAFFIC ASSIGNMENT

Traffic Assignment

Definition: is the stage in the transportation planning process where in the trip interchanges are allocated to different parts of the network forming the transportation system.

In this stage:

i. The route to be travelled is determined.

ii. The inter-zonal flows are assigned to the selected routes.

General principles

- All assignment techniques are based on route selection.

- The choice of the route is made on the basis of a number of criteria as **Journey time**, **length**, **cost**, **comfort**, **convenience**, **safety.**

➔ **(Travel Resistance)**

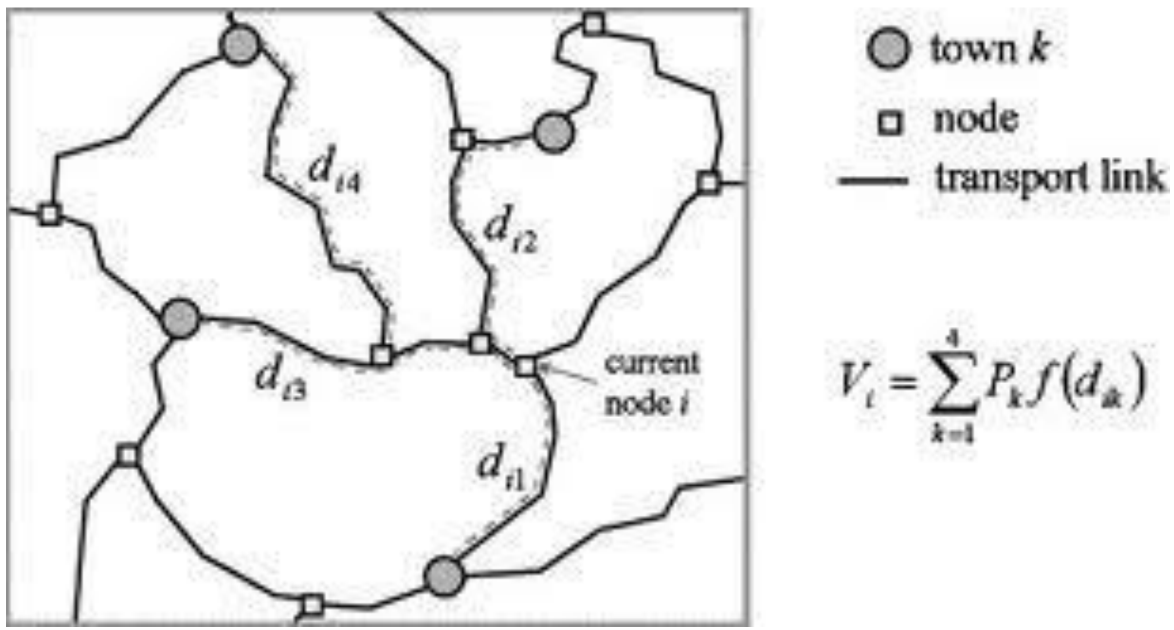
- **Journey time** is often considered the sole criterion since length and cost can be considered as a function of time in most cases.

Transport Link

As a first step, the highway network is described by a system of links and nodes.

A link is a section of a highway network between two intersections.

A node is either a centroid of a zone or the intersection of two or more links.



$$V_i = \sum_{k=1}^{4} P_k f(d_{ik})$$

Traffic Assignment Methods

- All or Nothing
- Capacity Restraint

All or Nothing Method

Most commonly used method.

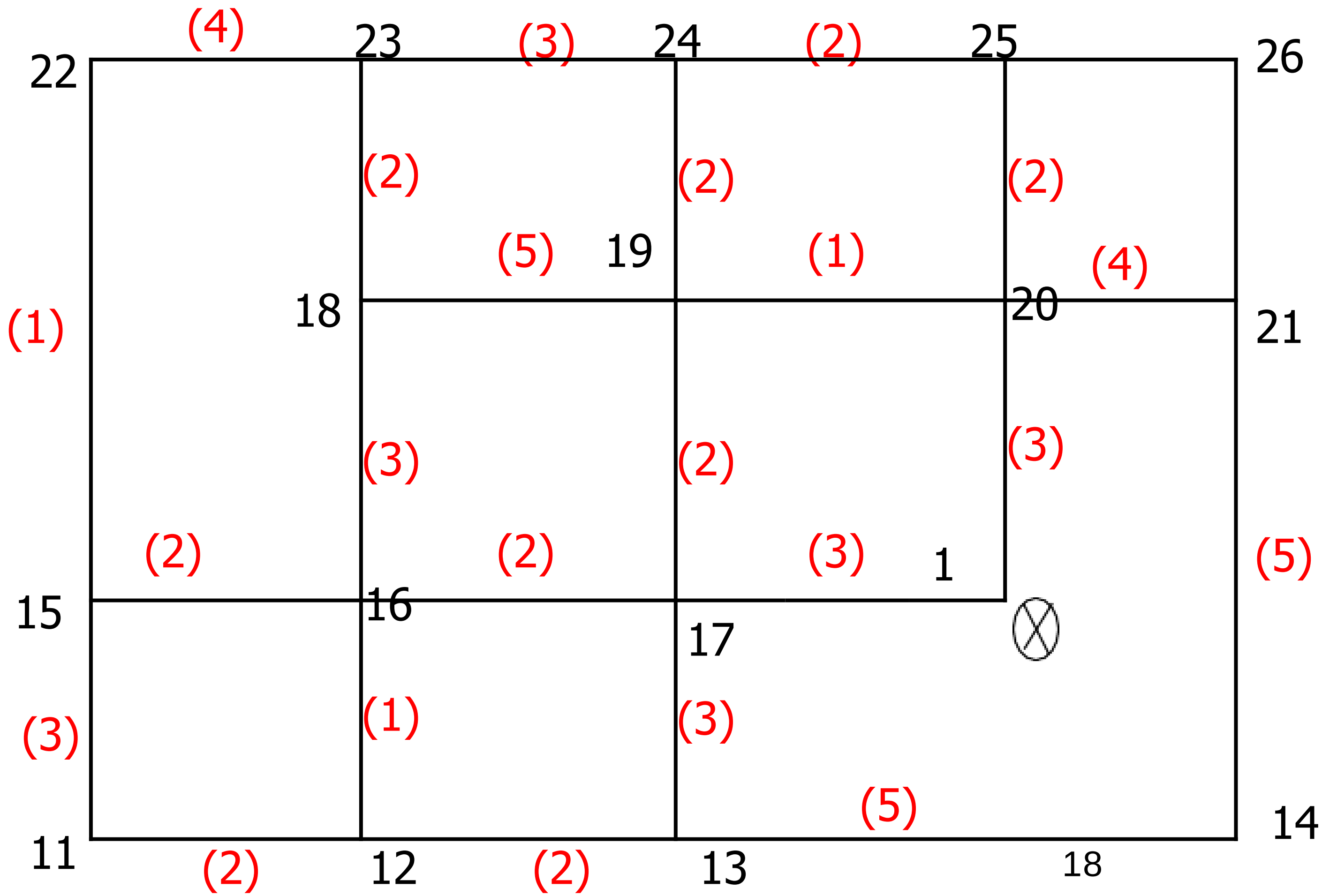
Example: **Minimum Path Tree**

All traffic will choose the route where the **travel resistance is least**.

Travel Resistance:

- Time
- Distance
- Cost
- Generalized Cost

Example



(4)
(3)
(2)
22
23
24
25
26
(2)
(2)
(2)
(5)
19
(1)
(4)
(1)
18
20
21
(3)
(2)
(3)
(2)
(2)
(3)
1
(5)
15
16
17
(3)
(1)
(3)
(5)
11
(2)
12
(2)
13
18
14

Starting from centroid 1 we go to each connecting link and choose the least travel time

$T_{1\text{-}20} = 3$ $T_{1\text{-}17} = 3$

the time is the same , if we begin with the node with lower number node 17 is noted:

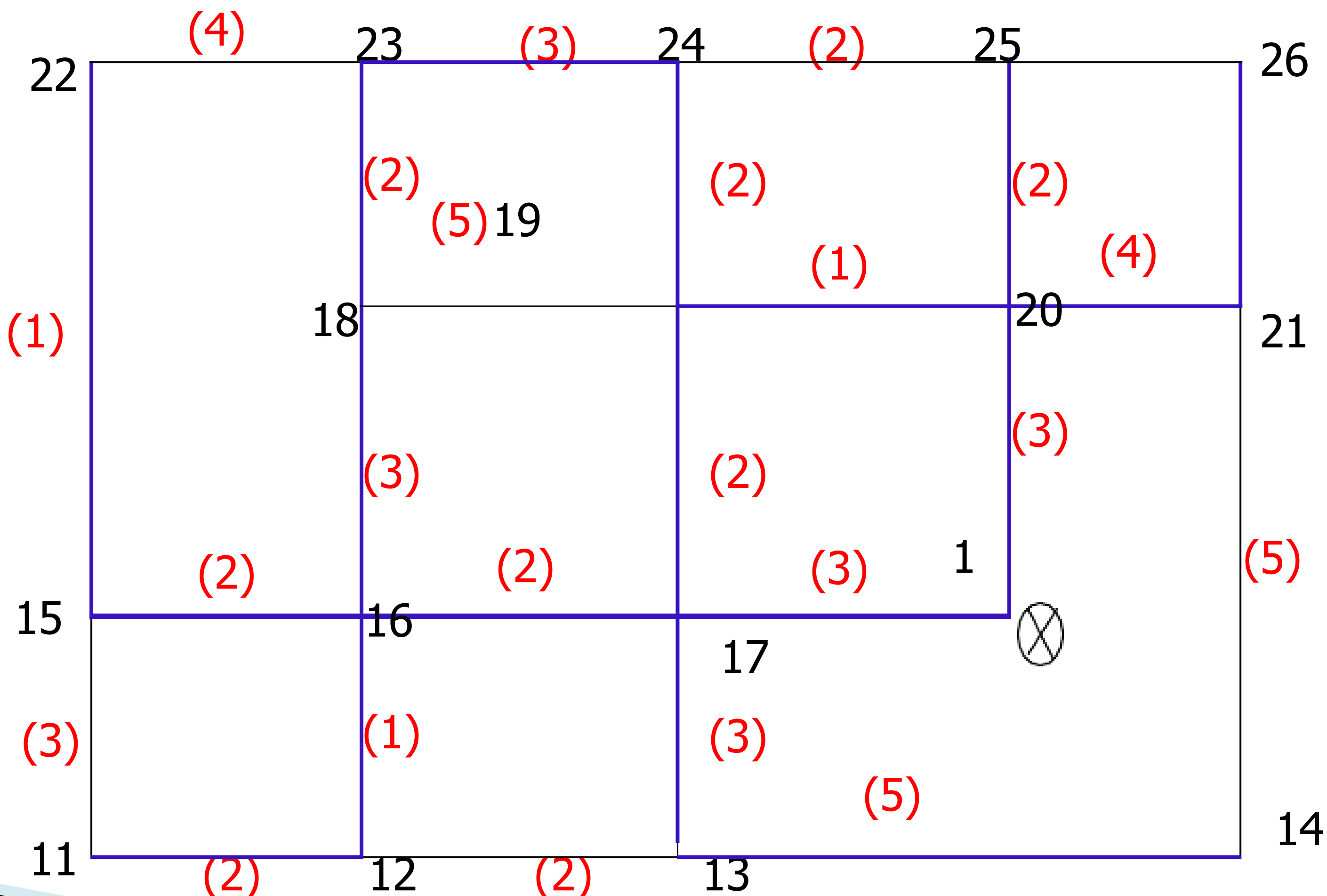
$T_{1\text{-}17\text{-}19} = 5$ $T_{1\text{-}17\text{-}16} = 5$ $T_{1\text{-}17\text{-}16} = 6$

The next closest node to centroid 1 is 20

$T_{1\text{-}20\text{-}19} = 4$ $T_{1\text{-}20\text{-}25} = 6$ $T_{1\text{-}20\text{-}21} = 7$

There are two routes to reach 19 from centroid 1, i.e. 1-17-19 and 1-20-19. the rout 1-20-19 is shorter in time, therefore is chosen

The process is repeated until all nodes have been covered by the shortest path. **The minimum path tree** for this highway network is given in figure




THE END


TRANSPORTATION
PLANNING

Transportation Planning

- Transportation planning is a preparation planning to move/transfer human, animal or other item to some place to another place. This planning will related to the operation of the highway system, geometry, and operation of traffic facilities

FUNCTION OF TRANSPORTATION PLANNING

- To identify highway system component
- To define transportation planning
- To recall the process and purpose of construction planning design
- To identify 4 models of transportation

IMPORTANCE OF TRANSPORTATION PLANNING

- **Efficiency** – to achieve efficient management and better management of existing resources
  - ❑ Effective use of transportation system
  - ❑ Uses of technology
  - ❑ Land use and resource controlling
- **Quality**
  - ❑ To reduce a negative impact to the traffic that produce a pollution
- **Equity**
  - ❑ to meet travel demand and response for all communities

TRANSPORTATION PLANNING PERIOD

Short Term (Action Plan)

- review matters that can be completed within three years and involve high costs.
- Example: program an engineers to optimize the use of existing transportation systems by installing various traffic control devices such as signs and signals

TRANSPORTATION PLANNING PERIOD

Long Term (≥ 5 years)

- This type of planning is more structured and complicated and it must be designed better than short term planning
- urban transportation planning process involves planning the next 20 to 25 year

CHARACTERISTICS OF TRANSPORTATION PLANNING

- determine the transportation needs
- make/built a transportation formulas
- study the profitability
- traffic/travel pattern is clear, stable and can be control
- Relationship between the various modes of transport.
- The transportation system can influence the development for that area and ready to serve it.

TRANSPORTATION PLANNING ELEMENT

PLANNING PROCESS

- **Studied/Research stage**
  - ✓ research and analysis that shows the current demand and the relationship of movement with the and environmental demands
- **Forecast stage**
  - ✓ formulating the plan, predict future travel demand and make a recommendation to fulfill traffic demand.
- **The evaluation stage**
  - ✓ to assess whether the proposals made satisfactory demand and provide maximum benefit to the community

MONITORING AND REVIEW

IMPLEMENTATION

PLANNING PROCESS

- Situation definition
- Problem definition
- Search for solution
- Analysis of performance
- Evaluation of alternative
- Choice of project
- Specification and construction

1. Situation definition	Involve all of the activities required to understand the situation that gave rise to the perceived need for a transportation improvement. Information about surrounding area, its people and their travel habits may be obtained.
2. Problem definition	To describe the problem in term of objectives to be accomplished by the project. Objectives are statements of purpose such as to reduce traffic congestion, to improve safety etc.
3. Search for solution	Consideration is given to variety of ideas, design, location, and system configuration that might provide solution to the problem.
4. Analysis of performance	To estimate how each of the proposed alternatives would perform under present and future conditions
5. Evaluation of alternative	To determine how well each alternative will be achieve the objectives of the project
6. Choice of project	Made after considering all the factors involved.
7. Specification and construction	Once the transportation project has been selected, the project move into the detailed design phase which each of the components of the facilities is specified

Situation definition

Inventory transportation facilities
Measure travel pattern
Review prior studies

Problem definition

Define objective
~Reduce travel time

Search for solution

Consider option
~Location and type
~Toll charge

Analysis of performance

For each option, determine
~Cost
~Traffic flow
~Impact

Evaluation of alternative

For bridge project, determine

~Benefit vs. cost

~Profitability

~Cost-effectiveness

Choice of project

Consider factors involved

~Revenue cost forecast

~Site location

~Political judgment

Specification and construction

Design the bridge

Contractor selection

Transfer of completed bridge to authority for operation and maintenance

PLANNING PROCESS

Inventory	**Land uses**
• include the establishment of the data for the evaluation of the existing travel demand and existing travel capacity • will involve 2 main task which is collecting and processing data.	• required a detailed assessment and forecasting in terms of distribution of area, population, employment, economic, social and land use activities.

Trip generation	Trip Distribution
• The first model of travel demand used in transportation planning process. • Used to predict which zone the traffic will flow.	• The second model travel demand used in transportation planning process. • To get a travel/traffic pattern (in/out) in a zone • Shows the total traffic in certain time, distance and cost

Modal Split

- to estimate the number of trips by different types of transport
- Limited to public and private transport only

Traffic Assignment

- Intended to give a traffic direction to which road in road/transport network.

Assessment

- contains the testing and evaluation of the alternatives selected before.
- emphasis on the ability of the traffic and environmental impact of each alternative strategy
- to choose and determine the best transportation system for future needs

Travel Demand Model

TRIP GENERATION

❖Is the process of determining the number of trips that will begin or end in each traffic analysis zone within a study area.
❖To develop a relationship between trip end production or attraction and land use.
To use the relationship to estimate the number of trips generated at some future date under a new set of land use condition.

TRIP DISTRIBUTION

❖trip distribution is a process by which the trip generated in one zone are allocated to another zones in the study area.
❖These trips may within the study area (internal – internal) or between the study area and area outside the study area (internal – external)
❖To get a travel/traffic pattern (in/out) in a zone

Travel Demand Model

MODAL SPLIT	❖Modal Split is that aspect of the demand analysis process that determines the number (or percentages) of trips between zones. ❖Depends on factors such as the traveler's income and the availability of transit service ❖limited to public and private vehicles only
TRAFFIC ASSIGNMENT	❖The final step in the forecasting process ❖To determine the actual street and highway routes that will be used and the number of vehicles that can be expected on each highway segment ❖to give a traffic direction to which road in road/transport network

Purpose of Travel Demand Model

- This process is important to be in transportation planning for:
  - provide new transportation system
  - improve the existing system
  - build highways, transit systems and other

- to determine the number of trips that will use the existing transportation system. trips taken in the form of vehicle / non-transport
  and private vehicles and public transport

TRANSPORTATION STUDIES IN PLANNING PROCESS

- Origin and Destination study (O-D)
- Traffic Volume Studies
- Spot speed studies
- Travel time and delay studies
- Parking studies

Origin and Destination study (O-D)

- To show the pattern and nature of daily trips made by the residents
- The main purpose of O-D study is to plan the transportation in urban city especially the type of land use, road/traffic network and public transportation system.

Application of O-D data

- Determine the traffic flow – if traffic congestion occurs, a short cut must be plan to give a comfortable travel to road user.
- Determine whether the existing road system is adequate or not
- Determine the suitable/best position of a bridge or new transport terminal to be constructed.
- Built a transportation models to make sure the transportation planning will be more easier and also make a prediction about the traffic pattern in the future.

Traffic Volume Studies

- To collect data on the number of vehicles / pedestrian that pass a point during a specified time period
- To know whether the existing road can accommodate the vehicles that using a road.
- ensure the smooth movement of vehicles and traffic safety

Application of traffic volume data

- Design for road rehabilitation
- Study the traffic at intersection
- Study of traffic control systems
- Forecast/predict traffic volumes
- Study of traffic accidents
- Analysis of costs - benefits for highway projects

Spot speed studies

- Conducted to estimate the distribution of speeds of vehicles in a stream of traffic at particular location.
- Carried out by recording the speed of a sample of vehicles at specific location
- Will be valid only for the traffic and environmental conditions that exist at the time of study.

Application of spot speed data

- Establish parameter for traffic operation such as speed zones, speed limits, and passing restriction
- Evaluate the effectiveness of traffic control devices such as variable message sign at work zone.
- Evaluate /determine the adequacy of highway geometric characteristic
- Evaluate the effect of speed on highway
- Determine speed trends.

Travel time and delay studies

- A travel time study determines the amount of time required to travel from one point to another on a given route.
- Information may also collected on the location, duration, and causes of delays.
- data also aid the traffic engineer in identifying problems at the location.

Application of time & delay data

- Determine the efficiency of a route with respect to its ability to carry traffic
- Identification of locations with relatively high delay and the causes for those delay.
- Determine the traffic times on specific link for use in trip assignment models
- Performance of economic studied in the evaluation of traffic operation alternative that reduce travel time.
- To evaluate the change in efficiency and level of service with time.

Parking studies

- The need of parking spaces is usually very great in the areas where land uses including business, residential and commercial activities
- Providing adequate parking space to meet the demand for parking in central parking district may affect the level of service.

Application of parking data

- To get the valid information (before and latest)
- To know whether it is adequate parking or not
- To provide information needed to enable the implementation of payment by the parties involved.

General policy of transportation planning

- **social aspects**
  - ✓ improve the social aspects as can be done safely and comfortably
- **economic aspects**
  - ✓ with the existence variety of travel pattern, activities such as employment, population and household income will be increase.
- **physical aspects**
  - ✓ create an efficient transportation system because there are various modes of transportation introduced

- in an effort to reduce traffic congestion in urban areas, the following elements have been introduced

capacity

- widening access, traffic lights, sidewalks, traffic lights, parking (cars, motorcycles, bicycles)

priority

- priority to bus routes, truck, space is limited (pedestrian), parking

restraint

- access control, incentives to use public transport, car sharing, land-use policy.

The role of transport policy

- high quality urban transport impacts on the pattern of living, including :

  1. affect / improve the productivity and economic growth
  2. provide increased accessibility and influence and prices and land use
  3. affect the standard of living
  4. affect the environment in the city


THE END

QUIZ 1

- Write down 4 travel demand models in transportation planning.
- Describe briefly one of the studies that undertaken in the planning process

CHAPTER -4

URBAN TRANSPORTATION SYSTEM PLANNING: CONCEPTUAL ASPECTS

4.1 TRANSPORTATION PLANNING PROCESSES

Urban transportation planning is the process that leads to decisions on transportation policies and programs. In this process, planners develop information about the impacts of implementing alternative courses of action involving transportation services, such as new highways, introduction of new modes of public transport etc, or parking restrictions. The fundamental objective of transportation is to provide efficient and safe levels of mobility required to support a wide spectrum of human needs for a heterogeneous variety of societal groups. Because these needs, goals, and objectives are continuously changing, transportation planning is also an ever-evolving process. The important steps of the transportation planning process are as given below:

Step 1: Forecasting target year population and economic growth for the subject metropolitan area.

Step 2: allocation of land use and socio – economic projections individual analysis zones according to land availability, local zoning and related public policies.

Step 3: specification of alternative transportation plans partly based on the result of Step 1 and Step 2.

Step 4: calculation of the capital and maintenance costs of each alternative plan.

Step 5: application of calibrated demand – forecasting models to predict target year equilibrium flows expected to use each alternative, given the land use and socio – economic projection of Step 2 and the characteristics of the transportation alternatives (Step 3).

Step 6: conversion of equilibrium flows to direct user benefits, such as savings in travel time and travel cost attributable to the proposed plan.

Step 7: comparative evaluation and selection of the best of the alternatives analysed based on estimated costs (Step 3) and benefits (Step 6).

This information is used to help decision-makers (elected officials or their representatives) in their selection of transportation policies and programs.

4.1.1 Problem definition

Problem is defined by defining the objective/goal of planning. The objective could be-

i. To develop a transport system that caters to all sections of society thereby promoting inclusive development.

ii. To develop a transportation system that is primarily sustainable in nature.

iii. To minimize system costs and provide self operation etc.

4.1.2. Identification of need

- Invcntory of existing state of system and a forecast of future condition (demand).
- Interpolation of objective.

4.1.3 Solution Generation and Analysis

Based on problem definition, transportation planners have to identify various alternatives and make choice about-

- Various modes like roadway (DA/PT), railway, waterways or airways.
- The technological aspect such as high speed train, raised monorails underground transit system, driver information system.
- Traffic engineering aspect such as changing or improving flow pattern by making certain road one way, reducing delay on arterial street by improving signalization or grade separated intersection, disallowing certain movement at intersection
- Regulatory aspect such as reserving land for only high occupancy vehicles, disallowing high polluting vehicles, imposing speed limit.

For example, to travel from Kanpur to Delhi following alternatives can be worked out.

- Facilitate train leaving Kanpur at 6:30 am and reaching Delhi at 10:30 am and again leaving Delhi at 5:30pm and reaching Kanpur at 10:30pm.
- Developing existing airport at Kanpur for small commercial flight
- Improve the existing road facilities providing operating speed 120 kmph.

Long term Vs short term planning :- (3)

Longterm planning	Short term planning
1) These are conceived for a time horizon of about 20 years. ~~[illegible]~~ They are also known as comprehensive plans, strategic plans and Master plans.	1) These have a small time horizon, say 5 years or less, and are intended to give quick releif to overcome transport bottlenecks. A typical example is traffic Engg. solutions like signalisation, one-way streets (or) tidal flow operations. short term plans are palliatives and involve low cost options.

6/ 1:00 ~ 0

(4) Assumptions in Demand Estimation / forecast :-

→ (1) As road traffic and public transport are closely related, these cross-relationships are taken into account in the demand forecast.

→ (2) Residential population, Employed population, and student population by income level are estimated by zone.

→ (3) for example - bus travel speeds are dependent on the congestion level of roads. slow travel speed of private motorised mode of transport can contribute to the modal shift to rail based transport.

→ (4) After the initial road and transit assignment, Impedance tables, Initial link travel speed and initial bus volume on the roads are estimated.

→ (5) These will be input to the second modal split and second road and transit assignment.

→ (6) finally, link volumes and performance indicators are the final outputs of the assignment.

(3) Demand function:-

→ (1) If transport costs are high, Demand is low as the consumers of a transport service (either frieght or passengers) are less likely to use it.

→ (2) If transport costs are low, the demand would be high as users would get more services for the same cost.

4

Sequential approach / model:

T_G – Trip generation

T_D – Trip ~~generation~~ Distribution

M_S – ~~Trip generation~~ Model split

R_A – ~~Trip generation~~ Route Assignment

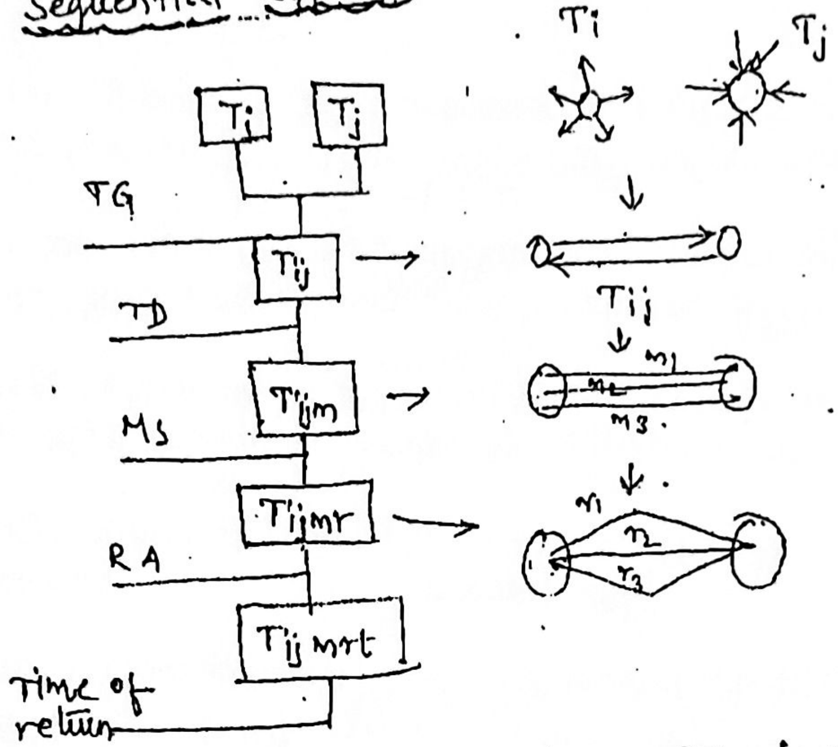
- In the sequential approach / model of travel demand is estimates from functional estimates of demand characteristics.
- The travel demand estimated from the first step will become input to the second stage of travel demand i.e. trip distribution (T_D). In this trip distribution the probability of trip interaction between i & j will be estimated as a trip rate from i^{th} station to j_1, j_2, j_3, stations.
- This trip rate analysis give the total no. of trips generated gives the no. of trips attracted.
- In this way the third step is mode split can be estimated by the probability of trip rate attracted for each mode multiplied by the no. of trips interacted between i*I can give its total no. of trips attracted by each mode.
- This approach is called system insensitive.

Trip Generation Models 13/10/05

1. Sequential approach
2. Sequential, recursive approach
3. Direct approach.

Models

(1) Sequential approach :-



→ This approach is called system insensitive.
→ output of one item becomes input to the other, so it is called as system insensitive.

Sequential recursive approach :-

⑥ Direct (or) simultaneous approach/model:

* All the stages will be considered in one step which is neither sensitive nor stable to the real time situation.
- This model is acceptable for macro level planning and this model facilitates cross elasticities among the user choices.

for example: There will be cancellation of selection of route, mode to travel a particular destination. If the planning is not relating with the route and mode choice developing model with trip distribution (or) trip generation (one alone) or sufficient.

MACRO MODELS.

(3) Direct or Simultaneous approach.

$\boxed{T_{ijmrt}}$

UNIT – III

GENERAL TRAVEL DEMAND MODELS AND REGIONAL TRANSPORT MODELS

1

AGGREGATE AND DISAGGREGATE MODELS:

- Aggregate and disaggregate models are critical concepts in travel demand modeling.
- Aggregate models: Average response of road user & Macro level planning (ex: Zone, country, city, and town).

(or) Travel by average response of group of people, group of individuals.

(or) The aggregated analysis which is most widely used is based on the assumption that continuous households exhibit a certain amount of similarity in travel characteristics.

This assumption allows the data in a zone to the grouped and the mean value of the independent variable used in further calculations.

Disadvantages of aggregated models:

1. The analysis masks the variations in the data.
2. The data is inefficiently utilized.
3. The zonal sample mean is not necessarily a reliable estimate of the population mean.
4. The model is dependent on the type of zoning system adopted.
5. The method is based on an important assumption that zones are to a large extent homogeneous with respect to travel and socio-economic characteristics.

While care is taken normally to select the zone boundaries to fulfill the above assumption. The variations within the zone can sometimes be large.

6. In the process of making the zones as small as possible to make them truly homogeneous. The planner increases the complexity of analysis, portably trip distribution and assignment.

2

Disaggregate Models:

- Individual response
- Useful for micro level planning
- (or) travel demand individually
- Business, shopping, recreation.
- (or) Disaggregate analysis though not and widely used, treats each household as an observation.
- In this process, all the enormous amount of data is used more affectively, resulting in a more meaningful description of the characteristics.

- As compared to aggregated analysis, disaggregated analysis produces better results and is considered more likely to be stable over time and to provide more reliable future estimates.

havioral Models: Describing about