Urban Transportation Planning
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Lecture No. # 08
Conceptual Aspects Contd.

This is lecture eight on urban transportation planning. We will continue our discussion on conceptual aspects in this lecture two, and hopefully complete our discussion on all aspects related to the concepts. You may recall that we have completed our discussion on problem definition aspect in systems engineering process through the previous two lectures. In the last lecture, we discussed about the five important components of problem definition phase starting from constraints, inputs, outputs, value function, and decision criterion. Finally, we saw the inter connectivity between all the six components in the problem definition phase. Since, it is a very important first step in the planning process, let us try to reinforce our ideas about all the components in the problem definition phase by recollecting the definition of the important terms that we saw in the previous class. You may remember first we discussed about constraints.

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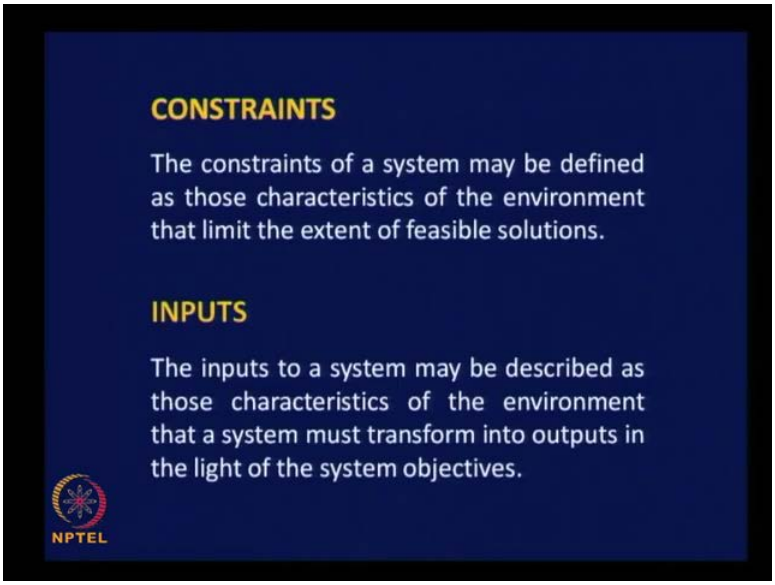

What is the definition of constraints? Just constraints can be defined as those characteristics of the environment that limit the extent of feasible solution. And the definition of inputs; input in simple term is nothing but the demand for the transportation

system, which will be derived from the social economic characteristic of the urban dwellers. But if you want to precisely define inputs in the context of system engineering process, we can define inputs as those characteristics of the environment that is system must transform into outputs in the light of the system objectives.

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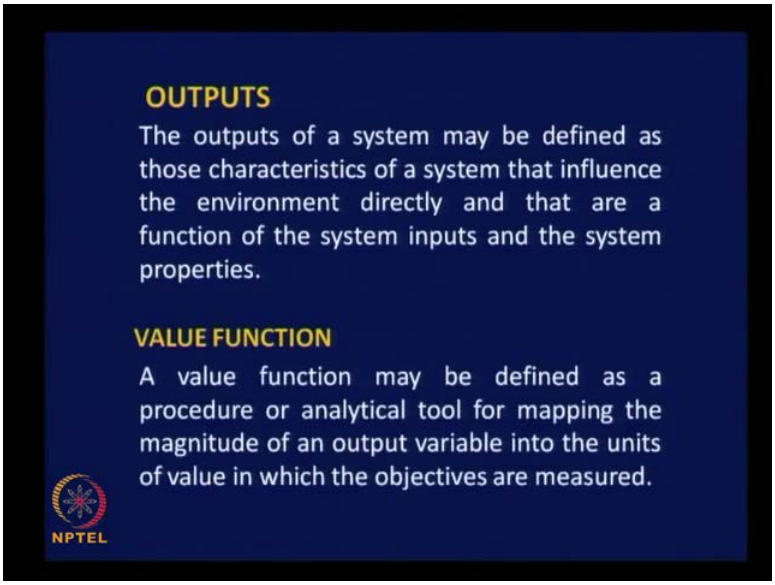

Then the term outputs; outputs as you may recall are nothing but the characteristics of the system that we plan for the urban area like speed, level of safety, cost, implication and so on. But in the context of engineering process, we can define the outputs in very general term as those characteristics of a system that influence environment directly and that are a function of the system inputs and the system properties. And then we discussed about value function; in very simple terms, you can recollect value function to be a simple analytical tool to assign money value for different types of outputs of a system. Is not it? And if you want to define the term value function in the systematic way, we can define it as a procedure or analytical tool for mapping the magnitude of an output variable into units of value, in which the objectives are measured.

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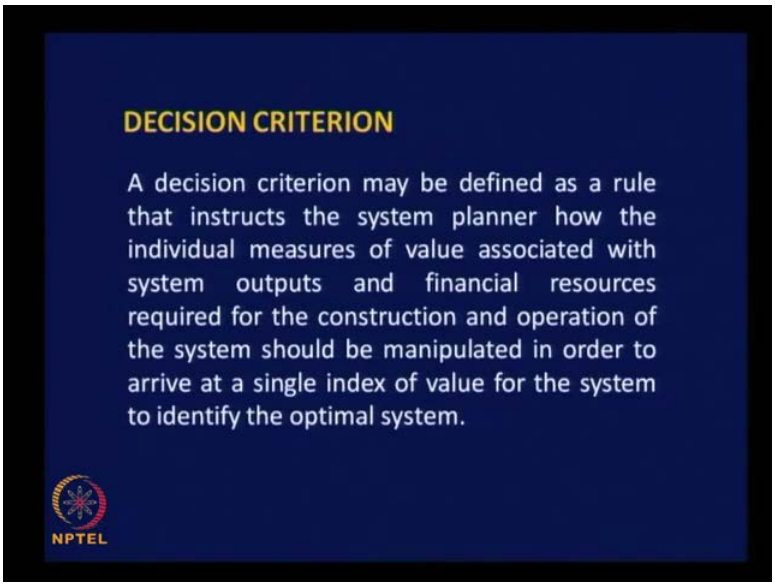

And then decision criterion as a name implies, you must have some criterion to choose the optimal system among the various alternatives we developed at the end of the planning process. Hence we can define the decision criterion as a rule that instructs the system planner, how the individual measures of the values associates with the system outputs and the financial resources required for the construction and operation of the system should be manipulated or compared or matched in order to arrive at a single index of value, like benefit, cost, ratio and so on for the system to indentify the optimal system.

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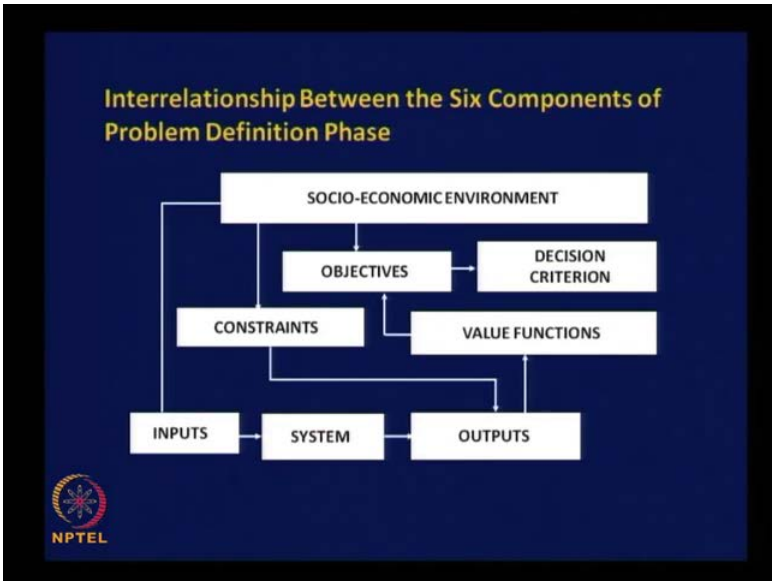

And of course this the inter connectivity between the different components, which you have seen in the previous class as you can see there are three components emulating directly from social economic environment and the fourth component outputs is derive from the system and output gets inputs from the constraints then value function is derive from the outputs then the value function are connected to the objectives and finally, we have the last step as decision criterion.

Let us now look out the problem definition phase in a lay persons point of view. What do we really mean by problem definition before we answer this question we should understand what exactly is the problem. What is a problem? The problem is nothing but planning for a transportation system to meet the future transportation requirements of an urban community that is the problem and this is the very general problem statement, and unless we have clarity to the statement we will not be able to proceed with or the planner will not be proceeds the planning process. That is what we do through the problem definition process.

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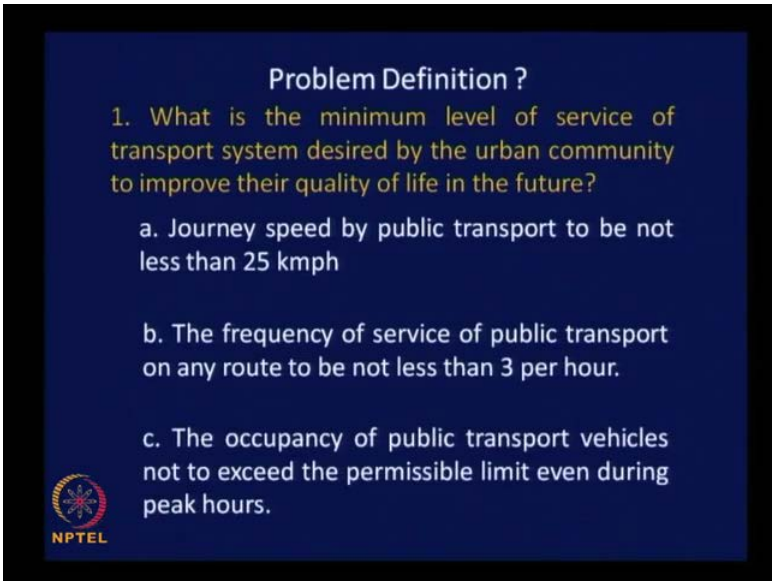

Let us first pose a general question as follows, what is the minimum level of services of transport system desired by the urban community to improve their quality of life in the future? The overall objective of community is to improve their quality of life in the future that is the expected goal of any urban community. So, if you can answer this question in very simple terms probably we can understand the three important terms

related to problem definition phase namely, goal, objective and standard. So what kind of system they except to improve their quality of life?

Let say the answers simple, answers are like this first they want to see the journey speed the public transport to be not less than 25 kilometers per hour, we would like to have the public transport system were in at least were able to move at the rate of 25 kilometer per hour that the desired of the urban community and the next rate desired would be the frequency of services of public transport on any route to be not less than 3 per hour at least there should be 3 bus services or 3 train services per hour on any route another important desire of urban community and third there should not be problem with occupancy in public transit vehicles the capacity should not be exceed everyone, should be able to get into the vehicle whenever, they want to travel by transit vehicle.

All these statements reflects the desired of the urban community. How do we get these statements? These statements are nothing but the standards about which we already discussed in details. Standards are derived from objective. Objectives are based from the community goal right. So, that is how we need to understand the terms goal objective and standards; just answering a simple question related to the desired of urban community to improve their quality of life in the future.

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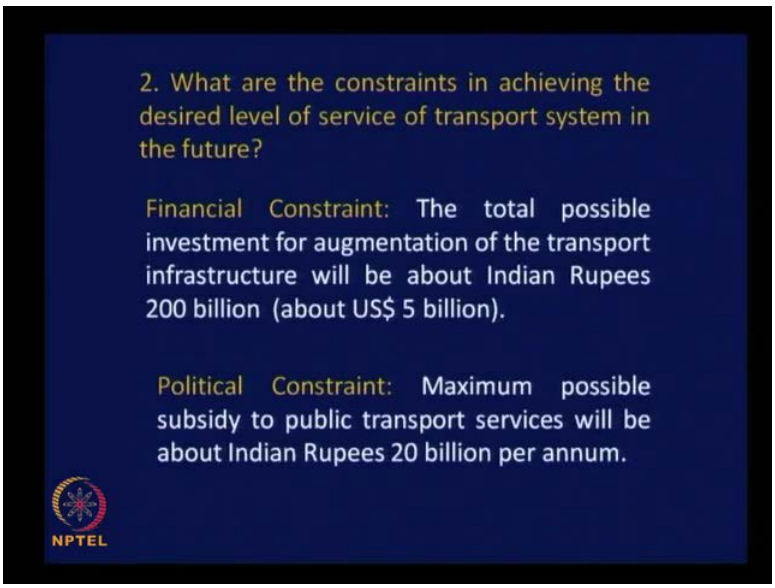

Next, let us look at this question. What are the constraints in achieving the desire level of the services transport system in the future? They clearly state at desired level of transport

system is possible to achieve that level of services or their constraints, if there are constraints that should be known right. The possible constraints has to be discussed or financial constraints if this aspects is made clear as stated here the total possible investment for augmentation of transport infrastructure will be about Indian rupees 200 billion or US dollars 5 billion in the horizon year, that is the possible investment from all sources. So, this is the financial constraints if this constrains known to the planner. Planner can definitely orient the planning process that this constraint is also taken care off.

Other constraints as we discussed earlier could be political in nature. They might say that the maximum possible subsidy to public transport services whether train or bus will be above Indian rupees 20 billon per annum - that is the maximum possible subsidy the government can provide. So, if this information is available to the planner than this constraint can be put into the planning process and while analyzing the system characteristics. Understanding the cost implication of transport system after taking into account the subsidy accepts, so all these statements are related to the component constrained in problem definition phase. Is not it?

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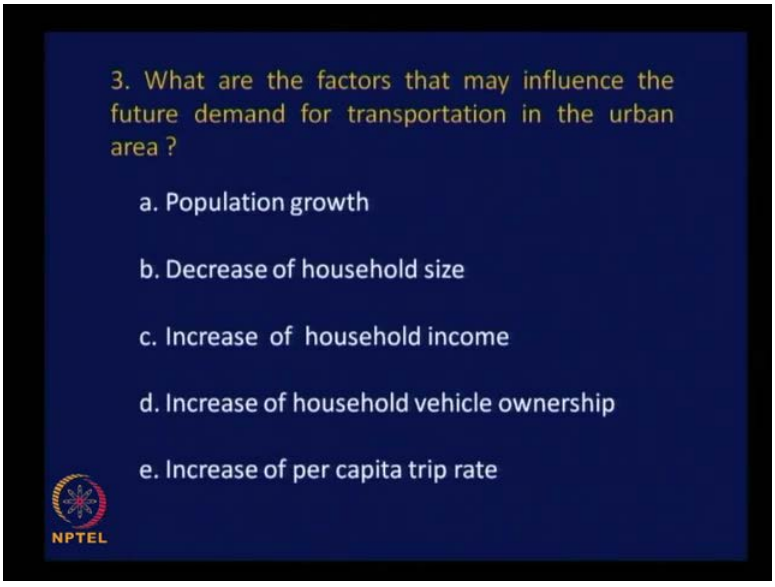

Next, let us put forth this question. What are the factors that may influences the future demand for transportation in the urban area. Why we are concerned about these factors? Because the planner should known what is the total travel demand, in the horizon year or

in the future for which the system has to be planned to quantify the travel demand we should understand the factors influence the demand for transportation. And how this factors are going to change compare to today's situation. To answer this question, the planner should be clearly informed that there is going to be pollution growth in that particular urban area. You may wonder why this should be given has an input, is it not? Understood, please understand there are cities around the world where population is decreasing. So, this is very important statement in a particular city, there is going to be population growth.

And decrease of household size. Household size is decreasing increase of household income increase of vehicle household ownership and possible increase of per capital at trip rate. So, this should be given as input to quantify the total travel demand in the future scenario all this things are related to which component in the problem definition phase. Inputs right inputs are nothing but the demand generated by the social economic characteristics of the urban dwellers. So, once you are able to answer the question you can understand the definition and implication of components inputs.

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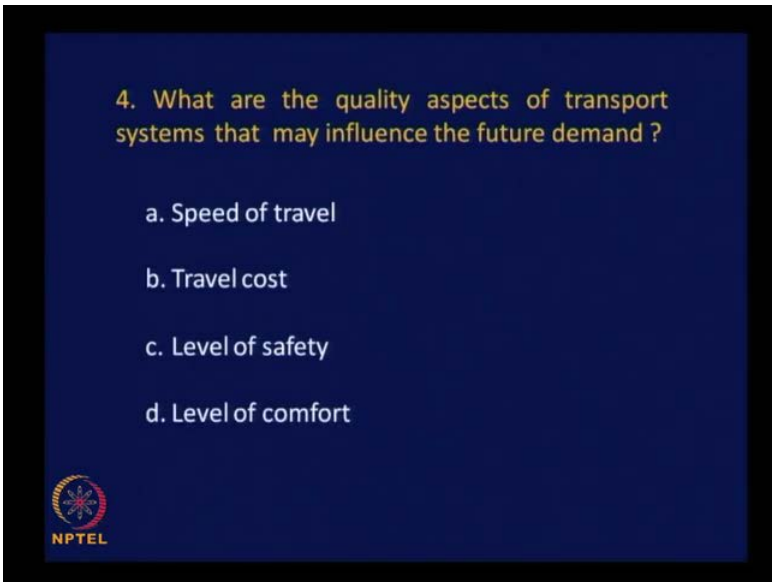

Let us put this question to us; what are the quality aspects of transport system that may influence the future demand? This question is related to, which component obviously, outputs of a system. Try to provide answer for this question; may be speed of travel might influences the demand for transportation very significant in the future. Then travel

cost, level of safety, level of comfort. So, the planner should get this idea very clearly so, these are all the factors that he or she will consider to quantify the services provided by the particular system that is the idea of this thing these aspects answer for this particular question then, how to assess the quality of future transport system their way to assess the quality are estimate or quantify. The quality of services provided by the particular transport system how do we do that

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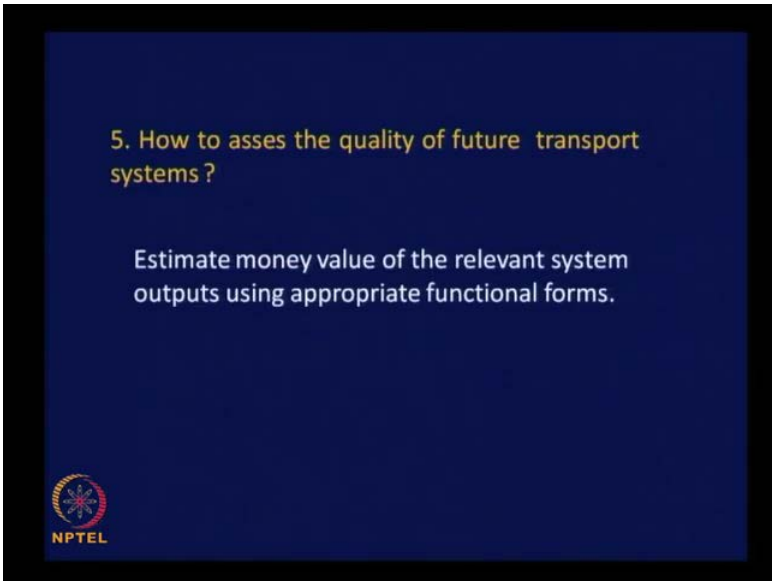

The answer is this estimate money value of relevant system outputs like speed, level of safety, and so on using appropriate functional forms. And it is a only way to answer this question and this question and answer for related to which component value function value function in the problem definition phase.

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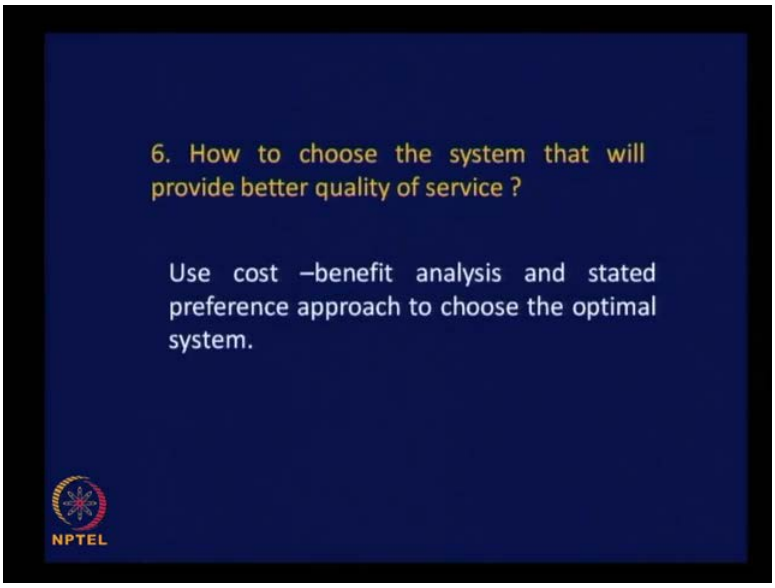

And then the last question how to choose the system that will provide the better quality of services when we have several alternatives, how do we choose the system that will provide better quality of services? How to decide obviously this question is related to decision criterion? What is the criterion? Use benefit cost analysis and stated preference approach to choose the optimal system combine both use ranking and waiting procedure and get a common base for comparison of various alternatives to choose optimal one. So, this is how I could like to understand the process of problem definition. If this information is provided to the planner before hand than he or she who is very clear as to how to proceed with the planning process. That is the idea of defining the problem with all the six important components.

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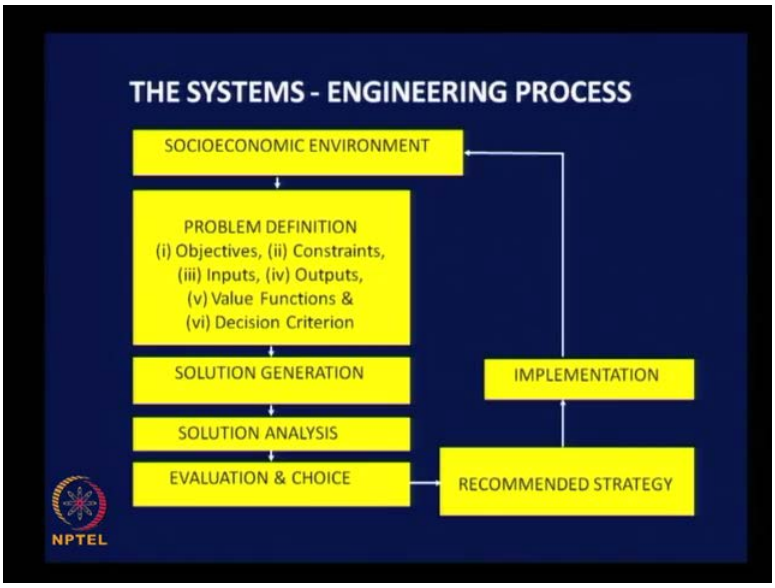

So, with this understanding, let us go further in the systems engineering process. You can realize now, that we have completed the decision on the details listed in the first two boxes only so, for and next step is solution generation. Then solution analysis evaluation in choice recommend strategy and implementation.

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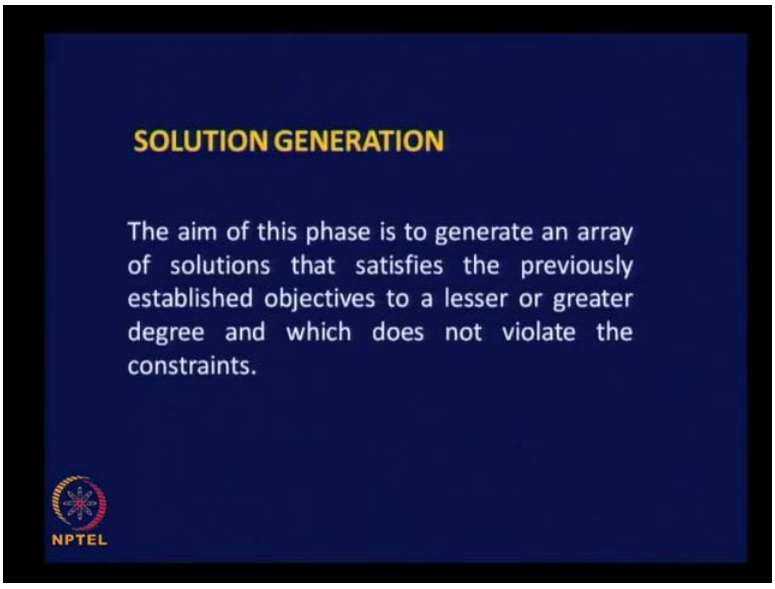

So, what do you mean by solution generation. As the term implies it nothing but generation of different alternative solutions to the transportation problem the aim of this phase is generate an array of solutions, that satisfies the previously established objectives

that is very important should satisfy the established objectives the requirement of urban community to a lesser or greater degree depending upon the system that we choice as an alternative to a lesser or greater degree and which does not violate the constraints very important aspect does not violate the constraints planner should not purpose the alternative which violates the constraints there is no use it cannot be considered as the alternative, because its violating the constraint then solution analysis, why solution analysis? We have to compare the alternatives unless we analysis the merits and demerits of each alternative in detail will not be able to compare. So, that is idea of analyzing the solution.

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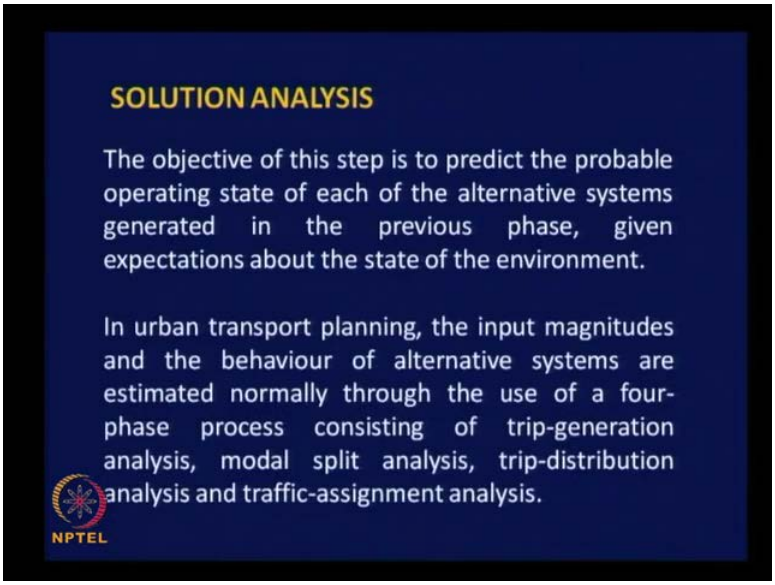

Solution analysis: The objective of this step is to predict the probable operating state in terms of speed, comfort, right cost and so on probable operating state of each other alternative systems right, generated in previous phase given expectation about the state of the environment, State of the social economic characteristics and land use pattern at the in the horizon year. Right, and this is normally done through a systematic analytical procedure. In urban transportation planning the input magnitudes and the behavior of the alternative systems are estimated. What is the input magnitude? The demand for transportation inputs, and the behavior of alternatives is nothing but study of the characteristics of the different alternative systems how they behave in the term of speed, cost and so on right, are estimated normally through the use of a 4 phase process, consisting of trip generation analysis, modal spilt analysis, trip distribution analysis and

traffic assignment analysis. In fact, we will be spelling quit sometime later on each of these four important steps; this just an indication of what we are going to do in the following classes.

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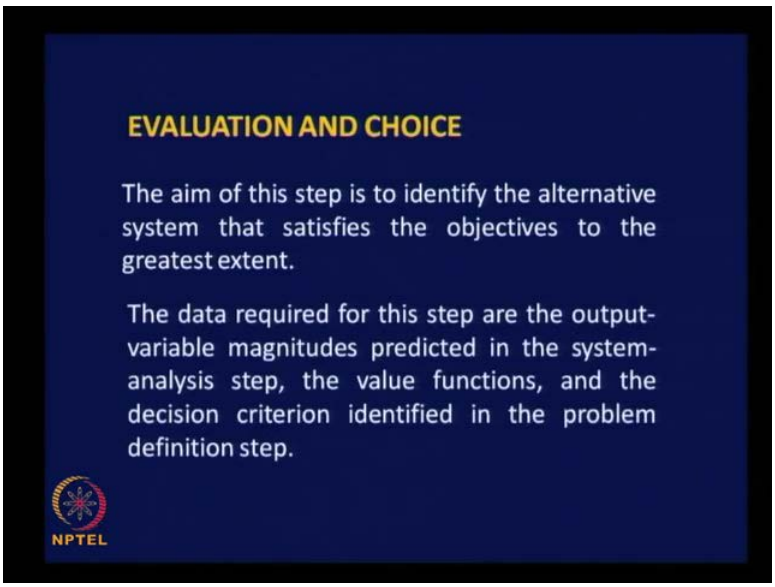

Then evaluation and choice we need to evaluative each of the alternatives and choice the optimal one the aim of this step is to identify the alternative system that satisfies the objectives to the greatest extent maximum possible extent the data required for this step are the output variable magnitudes credited in the system analysis step, value functions, and the decision criterion an all this things will go as the input in the evaluation choice process, indentify the problem definition step.

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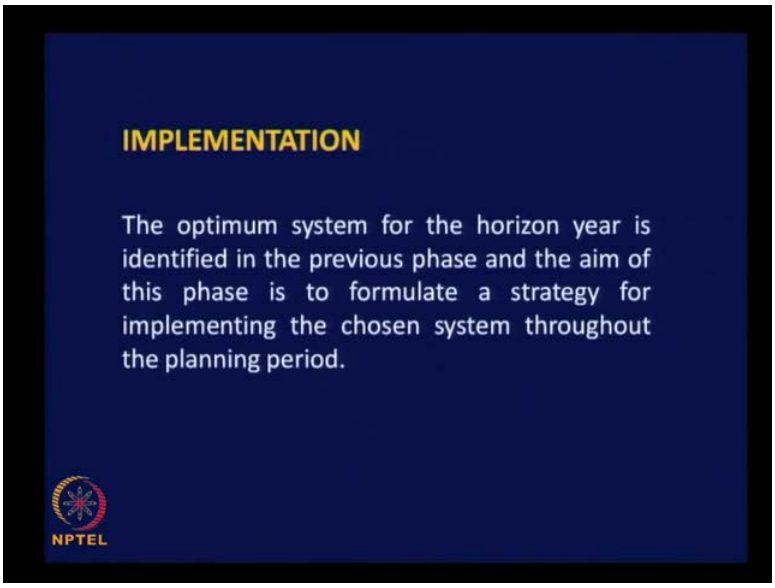

And finally, implementation with some particular strategy and the optimum system for the horizon year is indentified in the previous phase and the aim of this phase is to formulate this strategy for implementing the chosen system throughout the planning period that is what I said earlier strategy is normally facing the project implementation implementing the projects in phases. So, that it goes on throughout the planning period we fix targets what should be completed on fifth year, tenth year, fifteenth year, twenty year, and so on and carry out the development as per the plan strategy.

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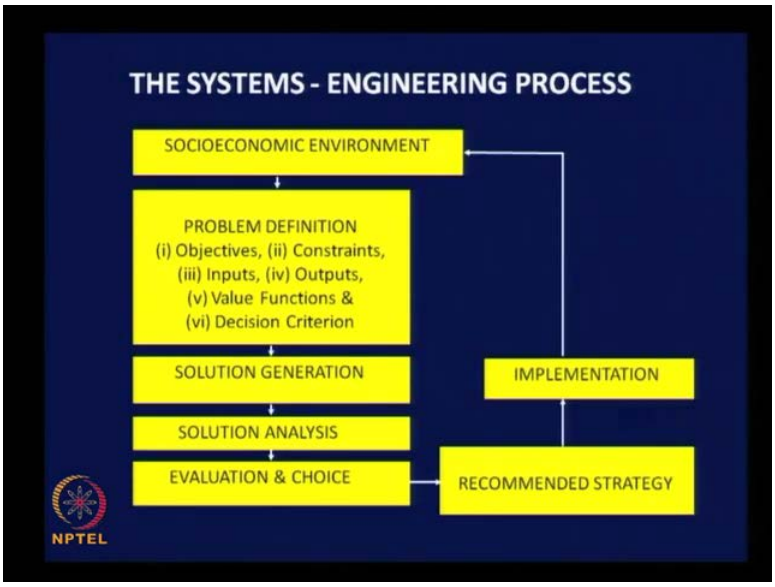

So, this covers all aspects related to the systems engineering process. Let us have a check whether we have covered all listed aspects, now we known clearly what do we mean by each of the steps in system engineering process, which can be directly applied for transportation system scanning process, right.

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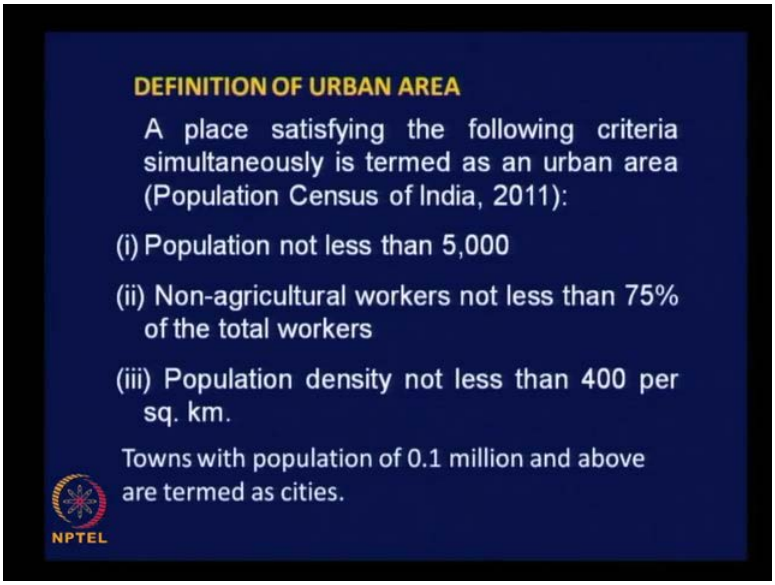

Now, what do we mean by an urban area there are some definitions given by are the population census department of government of India is just I given to as general information is not very specific to this particular course and population of the urban area should not be less than 5000. So, to qualify as an urban area the total population should be at least 5000 could be small town. Then non agricultural workers not less than 75 percent of the total workers. Census records have the records of total workers in the whole of the population. Right, total workers might constitute about say 30 percent of the whole of the population and for a particular area to be qualified as urban area the workers involved in agricultural operation should not be more than 25 percent that is condition to qualify a particular area has an urban area.

Population density not less than 400 per square kilometer. Right, if there is very square development scattered development than you cannot really call such area has urban areas there should be reasonable density of development and towns with population of point one million and above are termed as cities often we just interchange this term town and cities, but they say if the population is more than point 1 million such urban areas can be

termed as cities and other smaller urban areas could be termed as towns. So, this the guideline given by the census department. Now, let us get back to problem of quantifying the demand for transportation in the horizon year which will form the input for the problem definition phase.

How do we quantify the demand for transportation in the future year? You must have some frame work for example; if you want to analyze the demand at the micro level we should understand that trips made by the urban travelers emanate at home from home they travel to different places and come back in the evening right, in certain cases trips might emanate from work places shopping areas recreational centers and so, if you wish to analyze trips generated by each of the household each of the residential building in urban area there could be millions of buildings and large urban areas.

And if you collect data about the trips made by each of the households than it will be highly complex data said which is not that easily analyzed and behavior of the travel plan understood there is no need also to go to back micro level to plan for transportation system for an urban area, we can always think of aggregating the points of trip generation trip attraction so that we have a manageable amount of data base which can analyzed with clear understanding the results are which can be used to plan for the appropriate transportation system, how to aggregate and analyzed the travel pattern any suggestion?

Instead of considering each household as point of origin are destination why not just a mark of small area of more or less similar type of land use of radius say about 1 kilometer radius or one and a half radius even 2 kilometer radius depending upon the homogeneity of land use and consider that smaller area as a single unit and quantify the total trips produced or attract by that area similarly divide the entire urban space in the smaller land use parcels and treat each of these land use parcels as points of trip generation, but it work. For example; let say we are planning for the transportation system for this city ultimately at the end of the planning process. What is that we are going to process? We are going to process augmentation for the existing transportation infrastructure in the form of widening affords construction of great separation facilities construction of transport terminals or introduction of new transport services.

All this things need not taken into account what is happening on IIT campus, all the trips emulating from this campus is joining the main stream at one point or at few points. So, our concern is about the major links of the transportation network to consider the road network we are concerned about arterial rules, sub arterial and may be express phase if we have some. We are not very much concerned in the planning process about the minor roads which extent to connect the local communities that will automatically emanate so, keeping this in mind it is possible to divide the entire urban area into compact land use parcels with homogenous land use and fix a point for each of this areas as points of trip origin and trip destination, unless we do that we will not be able to create a manageable data base for the planning process, right.

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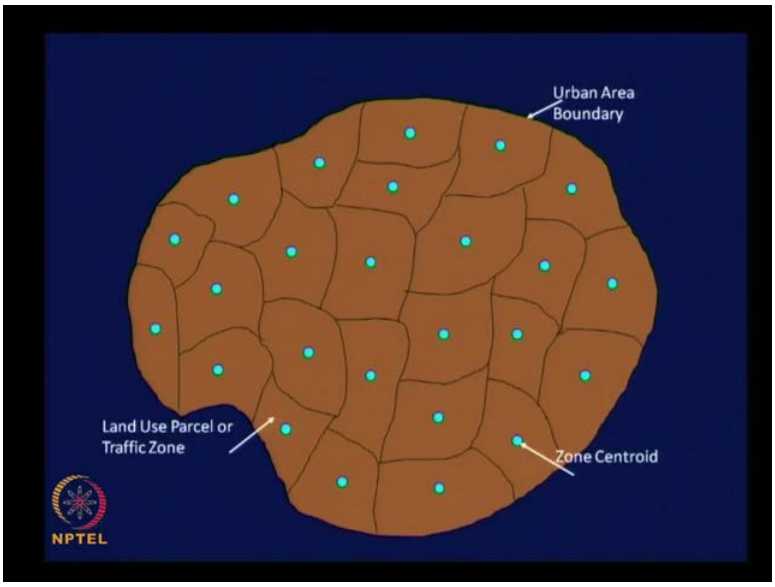

As the first step we need to delineate the urban space fix the boundary for our study area. This boundary normally extends beyond the municipal boundary of any town or city because normally people living in peripheral areas might also travel on regular bases daily bases into the city and go back home so, you must study the travel pattern very carefully and cover all the points of origin and destination which contribute for the regular travel pattern on daily bases in the urban area that should be the bases for fixing the boundary this is what in meant urban area boundary and then divide the area into smaller parts. We will discuss in detail later in transportation survey on what bases to divide urban areas into smaller land use parcels as of now you can assume that it is

possible to divide the urban area into smaller land use parcels based on certain conditions right.

And then we call this land use parcels has land use parcel or traffic zone, because we are going to assume that traffic is going to generate from this smaller land use parcels and another important aspect is fix 1 single point for each of this small land use parcels which is assume to be the trip generating point. We are going to assume that all the trips if there are 5000 trips generated from this campus we are going to assume that all the 5000 trips are generated from again there are circle only and from nowhere else. This is the approximation they going to make which may not affect our overall calculation at the macro level.

That is what meant by fixing the centroids for each of land use parcels, because this is what we call has zone centriod. Then analysis of travel pattern is easier what we are going to do from now on is just to study the movement pattern, mobility pattern between all these identify points a point one to all other points point 2 to all other points and so on right. So, that way it will be easy for us to understand the travel pattern and analyze the total transportation demand this is the first important step and then once we accept this process than we get into the analysis phase.

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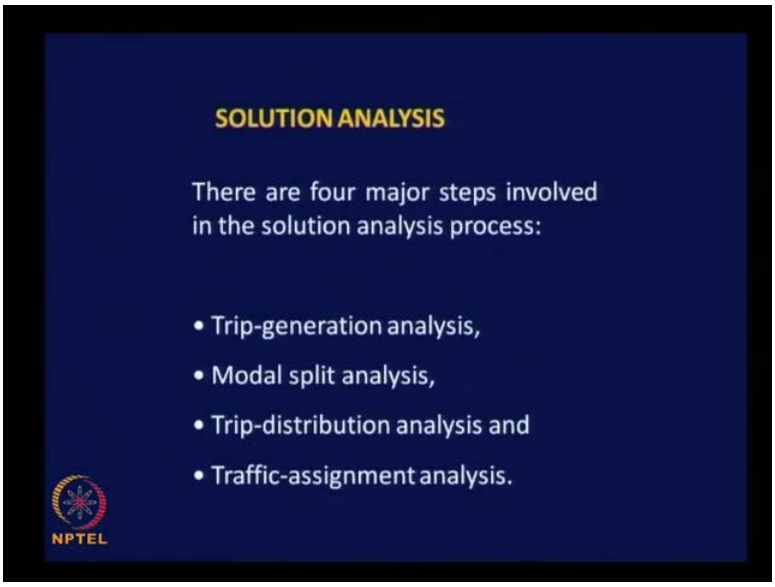

And the analysis phase involves as I mentioned 4 important steps; trip generation analysis, model spilt analysis, trip distribution analysis, and traffic assignment analysis

and there are other steps involved which are quite closely related to this 4 steps let us take the over view of the whole of the analytical process including the data collection process in the form of flow chart.

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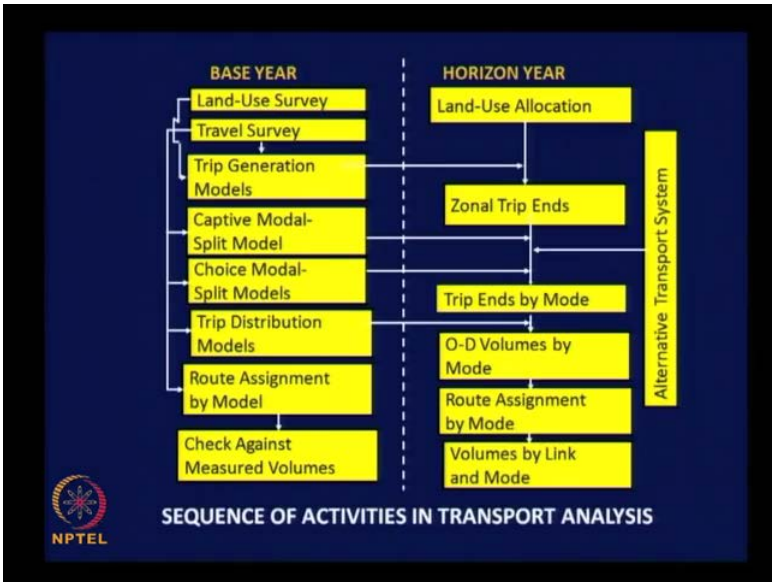

This flow chart gives you complete picture of data collection analysis and travel demand prediction for the horizon year I have divided the analysis into 2 parts 1 part pertains to base year condition the other part shown on right hand side pertains to horizon year condition. An inter connectivity between the steps are shown by arrows. Lets us first look at the different steps pertaining to the base year condition. The first important step is land use survey we know what are the category of urban land users, we must collect data with regard to type an intensity of use in each type of the land use over the entire urban area.

That data should be collected then travel survey you must have all the information related to travel pattern of the urban dwellers. This includes the related traffic service also concerning the way the vehicles the actual traffic experienced the terminals the fleets price of the traffic system and so on all the information will be collected while we do travel survey then this will go as input to the 4 important analytical steps namely trip generation, modeling than models split into 2 stages captive models, split models, choice models, split models, then drips distribution models, route assignment then check against measured volumes.

Were just briefly look at the procedure involved in each of this four major analytical steps. What exactly we are going to do in trip generation analysis? Trip generation has got two aspects trip production, and trip attraction. Later we will discuss in detail about these two aspects trip production or trip attraction are related to estimation of the trip produced and attracted by each of the traffic zones that we have identified earlier this is zone wise estimation of the total trip production and attraction we are not going to do anything about mobility or movement from one point to another. This exercise is concerned with quantifying the total trip ends produced trip ends attracted zone wise.

Will have some number of total trip produced and trips attracted for each of zones, How do we do that we will just try to relate the trip production with this set of causal factors. Trip attraction it is set of relevant causal factors. So, that is how we get some equation to quantify the trip production, and the trip attraction, next models spilt once you quantify the total trips we need to known the mode chosen by the travelers at each of the traffic zones for that it will be convenient for us first if we segregate the captive travelers. Who are the captive travelers? The travelers who are captive to particular mode are captive travelers. Let us say there are certain percentage of households with no vehicles not event bicycle then, what will be there mode of transportation. What will be their vehicle mode of transportation public transport only. So, there is no choice available to this section of the travelers and why include this section in mode choice analysis when they have no choice.

See you can segregate that portion of the travelers from your mode choice analysis and this process is what we called here has as captive model split model it is not really modeling it is a simple analytical producer of segregating captive travelers from the whole of the travelers then we will have dater pertaining to choice travelers only who have real choice than develop a model to understand the mode choice process identify the factors that will influent choice of mode of travelers then just develop an equation, which will give a idea about probability of choice of the particular mode by the particular type of the traveler and use this equation to get actual mode choice at each of the traffic zones.

We are indentified already in the previous step we have estimated the total trip production and attraction, after compilation of mode choice analysis. We will known how to the total. How many are what percentage will take transit, what percentage will

take motorized two wheeler, what percentage will take car, what percentage will go by foot all the information will be available again zone wise that is what will be doing in mode choice analysis then trip distribution. Now, we look at the interchange of trips between the zone centriods the points that we are already fixed and try to indentify first the factors that will influences the trip distribution. What are the possible factors that might influence the distribution of trips how people travel from one zone to another zone. One possibility is they home is located in one zone work place is in another zone.

So, they have to travel to that zone to go to work or if there are children's going to school might be located in different zone they travel to different zone, a shopping mall will be available in some other zone they travel one zone to another zone. So, indentify the causal factors, trip purpose as well as other related issues. Normally, when the distance of travel involve from a particular zone is more as a distance increases number of trip exchanged will be decreasing. Normally urban dwellers would like to minimize the intensity of travel that into different activities general trend is mode is the distance less is the trip interchange between zonal pairs.

So, all this information will be analyzed and will develop a model to explain the trip distribution process right. So, we will distribute the trips as person trips not in terms of vehicular trips even in the distribution process we distribute the trip has person trips. So, we can distribute the trips using an analytical technical and then check cross with the data that will be collecting during the base year condition then in the fourth step which is route assignment. We actually convert the person trips into equivalent vehicular trips. Why that is ? What we absorbed in the field that is what is happening actually in the field people travel using different modes. You cannot just model everybody travelling or walking on a road that is not the reality. So, we have to really convert the person trips into vehicular trips first and then if you considered the zonal pair zone 10 and 11 there could be several alternatives route available to go from one to eleven and different people might be taking different alternative routes.

So, we must understand the choice of the route by the traveler well be some factor influencing the choice of route. We must identify the factor and then try to develop the equation or model to explain the route choice process and then the converted a vehicular traffic as to be assigned along various routes bases on our calculation. Once you do that you actually reproducing the actual traffic flow by theoretical means we started with

quantifying the total trip production and trip attraction and the zonal level then understanding the choice of mode than understanding distribution of trips on space initially between zone centriods then assigning routes for these trips after converting the trips into equivalent vehicular trips.

Once you do these exercises if you known the road geometry of the entire road network on each link than you will be able to visualize theoretically. What will be the traffic volume over the entire road network after traffic assignment you should get information about traffic volume as well as composition. Another important aspect to be kept in mind in traffic assignment is that assignment of traffic by transit is easier because transit services is operated on fixed routes. So, once you known the origin and destination of the passengers you can easily understand the route which will be taken by the traveler and you can put all this kinds of traveler into that particular route.

So, transit assignment is simpler and assignment is more complex in the case of private or personal vehicle uses. Assignment has to be done in detail only for personal vehicle users transit is quite simple because route is already fixed. Once you assign the personal vehicle on the road along with the transit service may be the bus service we should be able to visualize the total traffic flow on the road network or we should known the total traffic volume as well as composition at any point of time in urban road network.

Do you think that it is possibility? It is possible provided we take care at every step to see that your theoretical model is valid you can cross check statistically logically and so, on and ensure that at every stage your equation are model is reproducing the reality. Trip production right mode choice trip distribution then route assignment. And once your able to theoretically are reproduced the actual traffic flow you have the advantage of comparing the theoretically productive traffic flow with the actual observed traffic flow for the base year condition, we are talking about base year analysis only.

You have the traffic flow information in the base year are the entire transportation network you can measure. The traffic volume and composition now you are theoretically estimating the same compare your estimated traffic volume on composition on each of the links it were field observed values. If the two values are matching you can be happy and your model is perfect. If not you have to go back work back and look for possible errors correct wherever required and then rework on the four steps and get again the

revised traffic volume compare with the actual traffic volume and iteratively do this exercises until there is the reasonable match between theoretically estimated traffic volume and filed observed traffic volume.

If it is matching then your model is able to explain the reality a reasonable extend why exerting our self to develop this kind of model what is the purpose. So, we can as well measure trip production, mode choice trip distribution, and route assignment for base a condition. Once you fix the zone boundary you can just actually conduct services and get the trip production value, trip attraction value, and so on. Why should we develop a model? Because we need to have some tool to predict the future trip production, future trip attraction, future mode choice, future trip distribution, and future traffic assignment that is a ultimate objective.

That is why there are interested to explain what is happening today theoretically. So, that these theoretical models can be used to predict the future scenario as accurately as possible that is what is shown on the right hand side. What we do for the horizon year we predict the land use allocation, which involves prediction are the population growth household changes and land use changes everything to together right. The future urban land use is predicted there are models available about which we will discuss later to predict the future land use pattern of an urban area. Once you do that you just use this model trip generation model use the land use data and get information about zonal trip ends.

Traffic zones will be there for future condition also if the area is going to expend extend your zoning process and fix a points of trip origin destination using the models you can find out the total trip ends produced and attracted at each of the traffic zones. So, once you use this model for the future condition you get zonal trip ends at of the traffic zones right. Then use the captive mode choice model and choice mode choice model and if you are going to introduced new modes that will become into the come into the choice process. So, introduced that also for the horizon year and user mode choice model to analyze the mode choice process for the horizon year condition and get the trip ends by mode.

If you’re going to introduced metro rail will get another new mode, but still your model is valued to analyze such situation also it is possible. So, you will get trips ends by mode

for each of the traffic zones for a horizon year condition then use your trip distribution model and understand the OD volumes by the mode for horizon year condition trip distribution for the horizon year condition. Then route assignment can be done directly from the OD volumes right there is no input required further for the horizon year condition and once assigned route you get volumes by link and mode for the future transportation network that is what we required.

So, once you get this volume we can check whether the available infrastructure is adequate or not. You may have a limited width of road, but after assignment of the horizon year condition you may get the double the capacity of existing road way, that means - definitely you need to widen that particular stretch of road. If it is an continuous set of links along a route that is going to be major traffic corridor. In if that is the situation than you can think of introducing new systems like light train metro rail system and so on one it is possible by this process to identify major traffic corridors and decide about the transport system it will suit your future requirement. So, this is what do we need to understand by the sequential activities in transport analysis process.

With this, we have developed some understanding about the problem definition process and the major analytical steps involved in development of demand models to ultimately get a future travel demand and required augmentation for a transportation infrastructure right. This is how I like to summarize today's discussion. In the next class, we will discuss about the first important analytical step namely trip generation analysis. With this, we will close our discussion for today.