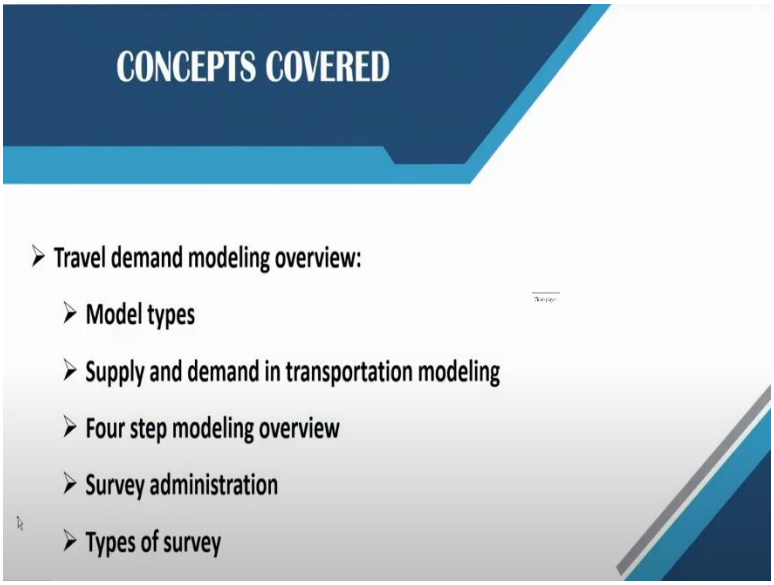
Introduction to Multimodal Urban Transportation System
Prof. Arkopal Kishore Goswami
Department of Ranbir and Chitra Gupta School of Infrastructure Design and management
Indian Institute of Technology - Kharagpur

Module No # 01
Lecture No # 04
Overview of urban transportation: Travel demand modelling overview

Welcome back friends. So far in our course we have introduced you to the urban transportation systems and some of its challenges. In this lecture we are going to give you an overview of how urban transportation systems are designed, or how the demand is determined so that you are able to build the necessary capacity in your city.

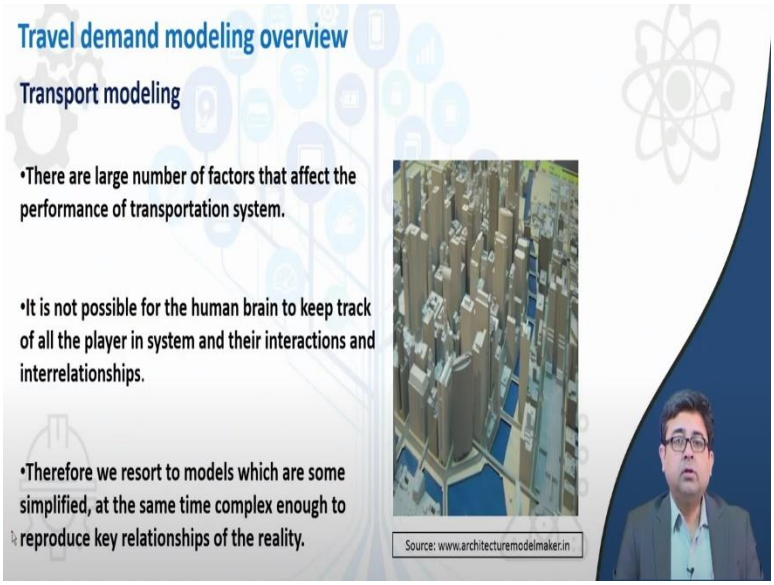
(Refer Slide Time 00:51)



So the demand modeling overview will give you, will show you, the different types of models that are used. I will tell you the importance of supply and demand in transportation modeling and take you through the most popular model, which is called the 4 step model, which is the used in determining the demand to finally understand how many lanes to build in your transportation network.

And we will let you know about how to go about and conducting these surveys which will give you the actual data that is needed to develop these models.

(Refer Slide Time 01:33)



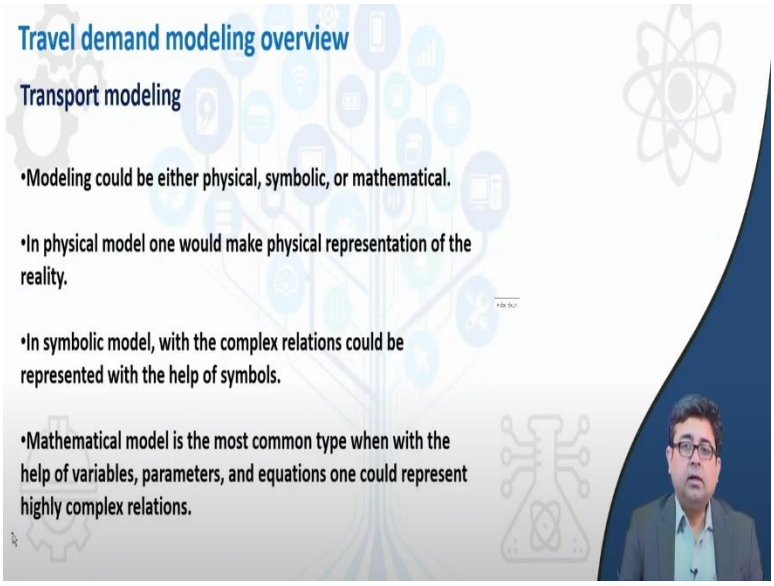
Now, this section provides a very brief overview of transportation modeling process. You have separate lectures in NPTEL lecture courses that provides you detailed information about transportation planning process and the modeling process. However in this course we would at least like you to be aware of these kind of modeling techniques. So that if you are more and more interested about these modeling techniques then you can go ahead and take different in-depth courses available on this topic.

So when we are looking at transportation modeling, essentially what we are trying to do is we are trying to understand where do people come from and where do people want to go, and which route they want to take. So we want to know where people are staying, where they want to go to, which route they want to take, and also what is the vehicle usually they want to prefer to use.

Do they want to use their own private vehicles, i.e. cars, 2 wheelers, or do they want to go on a bus, or do they want to take a metro? So if you combine these 4 aspects of need to travel, you would be able to determine, at a macro level, the demand for transportation in your city. And based on your demand, you can then provide for the capacity, i.e. you can provide for the number of lanes in a road, or number of bus routes in a city, or frequency of your metro rail, and so on and so forth.

So that is essentially what we would want you to be aware of when we are talking about transportation modeling.

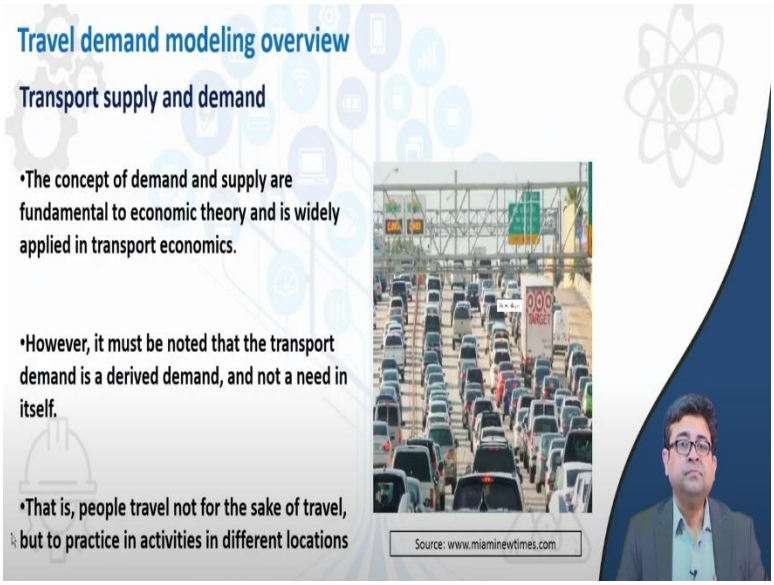
(Refer Slide Time 03:24)



I mean modeling in general, what a model essentially indicates is that it is a replica of the actual system or the actual network. So you can build a physical model, i.e. you can build a miniature car which looks like actual car, or you can have a symbolic model which determines a complex system using different symbols maybe, or you can develop mathematical/statistical models, which by the use of equations and different types of parameters try to explain how a system works.

So when we were talking about transportation modeling we are essentially talking about mathematical models.

(Refer Slide Time 04:12)



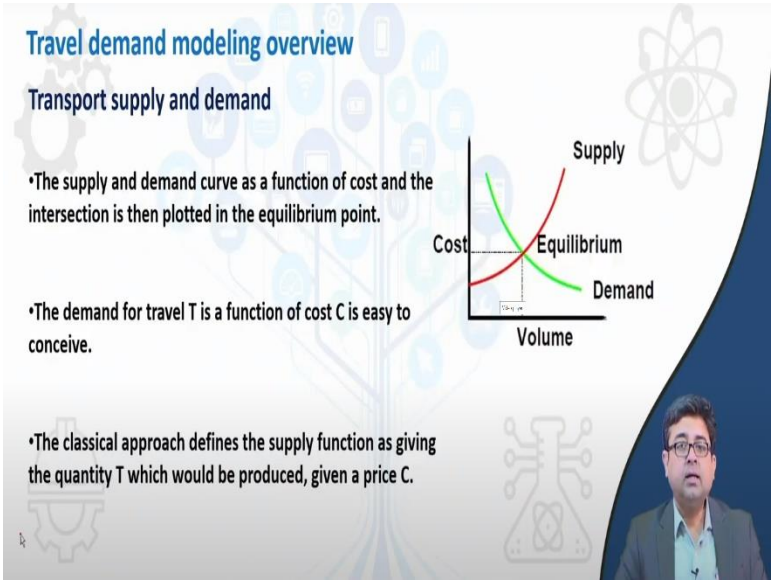
So this concept of travel supply and demand, so this is essential to the understanding of transportation modeling. So now the supply side of it is the availability of the roads in our city. So that is an example of supply. So I have 'n' kilometers of roads in my city. So that is the supply of the transportation network.

Or another example would be – "I have 49 bus routes in our in my city, and each of those bus routes have a bus frequency of 1 bus in every 10 minutes". So that tells me the capacity of the buses, and you know that every bus comes in every 10 minutes, i.e. 1 bus comes in every 10 minutes. So you have 49 such routes, then you know the capacity that the bus network can carry.

So that is the supply side of things. So now when we talk about demand side of things then you say that ok now you have, for example, 'n' kilometers of highways, but how many actual vehicles are there in your city that will use these highways? And for how much time will they use it? How much time or how many kilometers will they drive? So and you have to know both, the demand as well as the supply side. Determining the supply side if relatively stratighforward, because it is actually either existing or it is planned so you know that, say in the next 5 years, I am going to build 'n' kilometers of road. And I am going to have 'n' number of new buses in my fleet. But when it comes to demand you almost cannot absolutely know what the demand is. There may be new vehicles, people coming in to the city, buy new vehicles. So you cannot accurately predict or you cannot accurately count the demand. So what you essentially end up doing is, you end up estimating the demand.

So when you are trying to estimate the demand, that is where all the model or the demand models come in to play.

(Refer Slide Time 06:36)

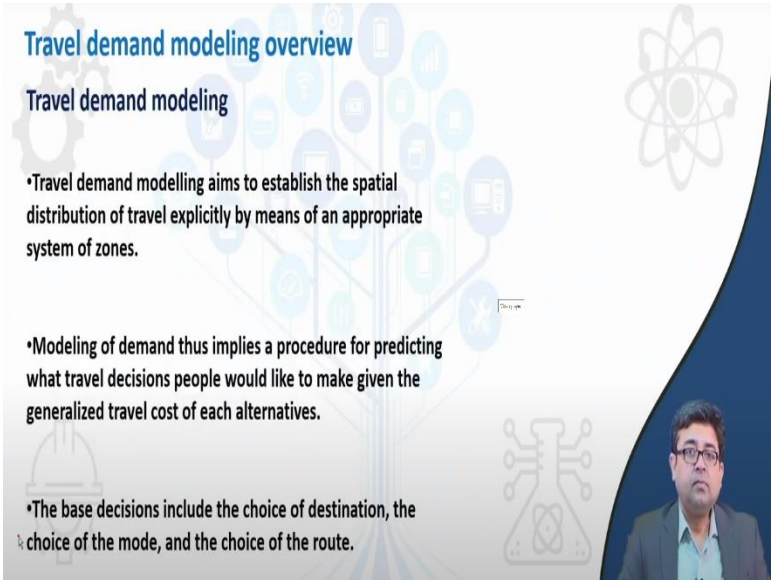


So, when you look at the supply and demand curve, and it is a classic economics example for anything, for any entity, when you look at the cost versus volume, you say that if the number of the supply of certain things, i.e. the volumes of certain things increase, the cost of it also starts increasing right. So if something is selling very well, for example a person manufacturing soaps starts seeing that soaps are selling very well, he increases the manufacturing or he increase the volume of a soaps manufactured and also more and more people get into the soap manufacturing business. So the cost that he gets out of selling these soaps keeps on increasing. So the supply keeps on increasing. The supply is always upward moving curve, whereas demand, as the volume of goods starts increasing, from the demands side, the people who want to use the soaps, the cost for them starts decreasing, as the competition brings down the cost for them. So that is the always a downward sloping curve. So similarly when you are looking at supply and demand from the point of view of transportation, you say that when you provide for multiple transportation systems in your city, usually the cost of traveling goes down.

When you only provide for one type of transportation, for example private motorized transportation, so then what happens is the cost for travel always remain high or keeps on increasing. So always the demand decreases as competition or the price for entity decreases as

competition increases. So you are always encourage to have multi model transportation network in your city which will eventually bring down the cost for your users.

(Refer Slide Time 08:57)



So when you look at transportation demand modeling, it aims to establish the spatial distribution of travel explicitly by means of appropriate system of zones. So we will look at it in the next slide in a step by step manner. But essentially what we are saying is that your city could be vast, so to exactly know where people are traveling, to and from maybe very difficult.

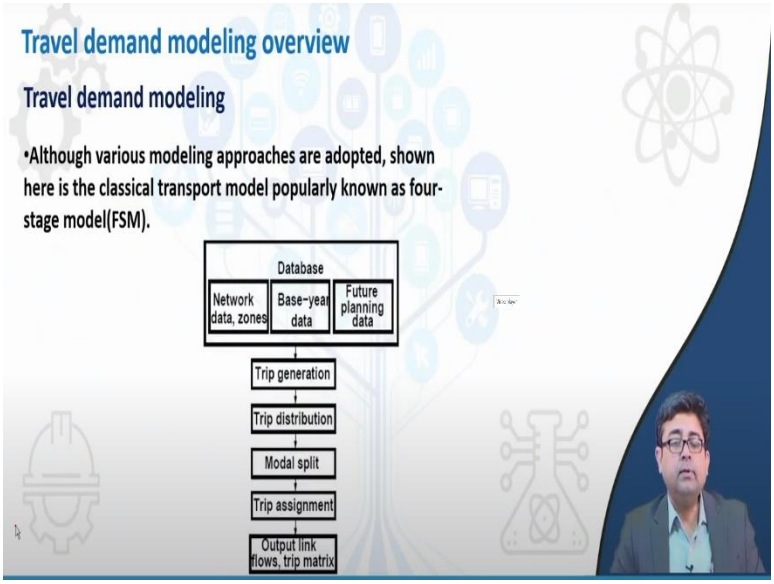
But on a macro level, on overall level, you can say that people usually in the morning would travel from where they live to where they work. So if you know the land uses or predominantly residential land usess, and the predominantly commercial or office land uses, so you would know or you could predict, with certain degree of the accuracy, that the traffic will flow in a direction which is from the residences to the office buildings.

Similarly in the evening it will be the opposite traffic flow. So that is a kind of a macro level prediction. However it becomes very difficult to predict it during the middle of the day and also during the weekend. In the weekend people take a lot of leisure trips in the middle of the day, the trips are usually taken by non-commuters.

So when non-commuters, meaning non-office goers, make their trips, that is when you really have difficulty in predicting where they are going and you need very large amounts of data about

the land uses and the trip purposes to predict exactly where people are going so that you ensure that you provide adequate capacity of your transportation systems to meet the needs of the traveling people.

(Refer Slide Time 11:09)

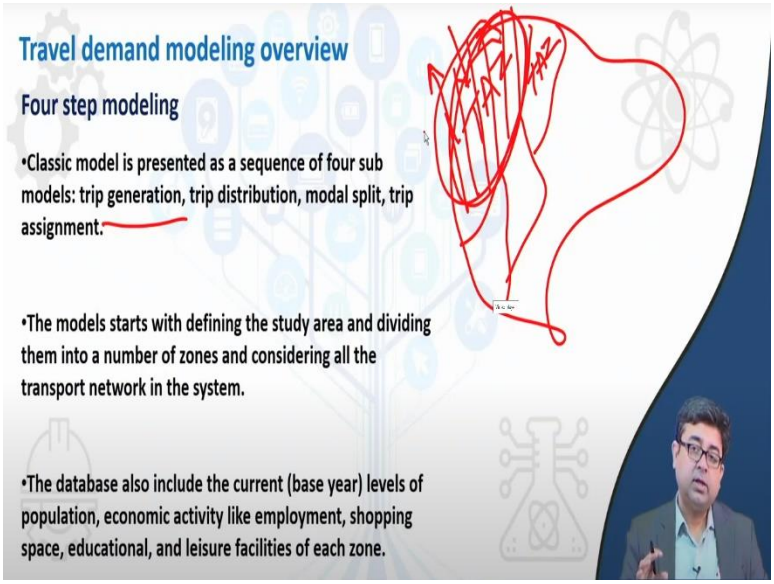


So in here what we will give you is a brief overview of the most popular 4-step model of travel demand estimation. This is the popularly called 4-stage model and the first stage in this is what is called, trip generation. The second step is trip distribution; third step is understanding the model split, or the choice of mode that you want to take, and finally what is the transportation network that you will be using when you are going from your origin to your destination.

So, by knowing these 4 steps you can, at a macro level or at a city level or at a municipality level, understand where your traffic needs are; where your transportation needs are. So let us look at each one of them one by one. But before that of course you have to have a certain amount of data that feeds into your model. So you have to know what is the existing network that you are working on, you have to know how many vehicles currently run on your network, and you also have to know some future planning based on the comprehensive plans that are available, comprehensive mobility plans that are available for your city, or the cities' master plan which must have incorporated at 20-30 year horizon plan must of incorporated how many roads there will be, how many kilometers of the roads there will be 20 years down the line. So all of that information has to be fed in to this model as an input and then this model would be able to

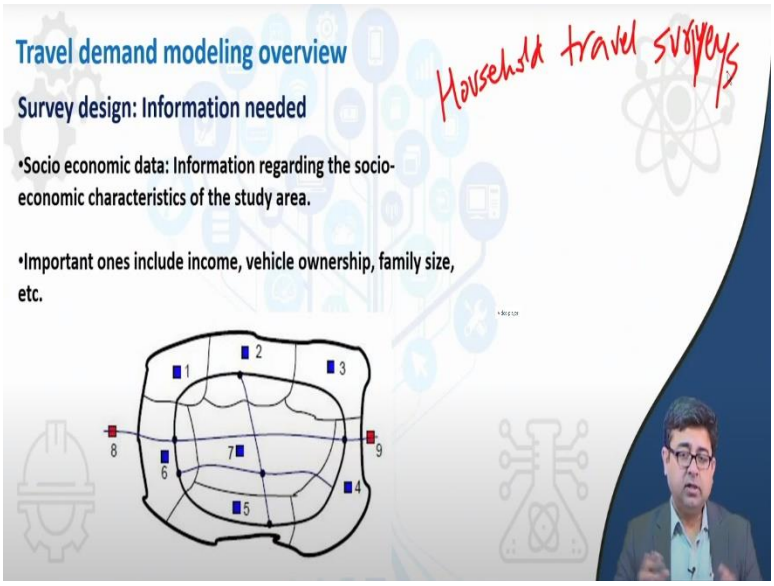
predict that how many trips or how many vehicles will be on the road in a the next year 5 years down the line, and so on and so forth.

(Refer Slide Time 13:21)



So the models starts, if I were to give you a basic example or a very basicexplanation of this in a nutshell, the first step in this is the trip generation. For trip generation usually what you develop is small zones of your city, which are usually called TAZ, or traffic analysis zone. So it divides the entire city into different traffic analysis zones. This is called a macro model because now it is going to use this zone at a macro level to predict how many trips are entering and exiting this zone. So remember we are not doing at micro level. So we are not tracking everybody's movement to realize or to predict how many trips are going to be coming out of your apartment on to the network. But we are doing at a macro level, i.e. at a level of a traffic analysis zone. So we divide a city into all of these zones and then we look for all the socio economic data for the families that are living within that zone itself, that acts as an input. Then we look at all the highway network or the roadway network within that zone, so that it can be fed into that model.

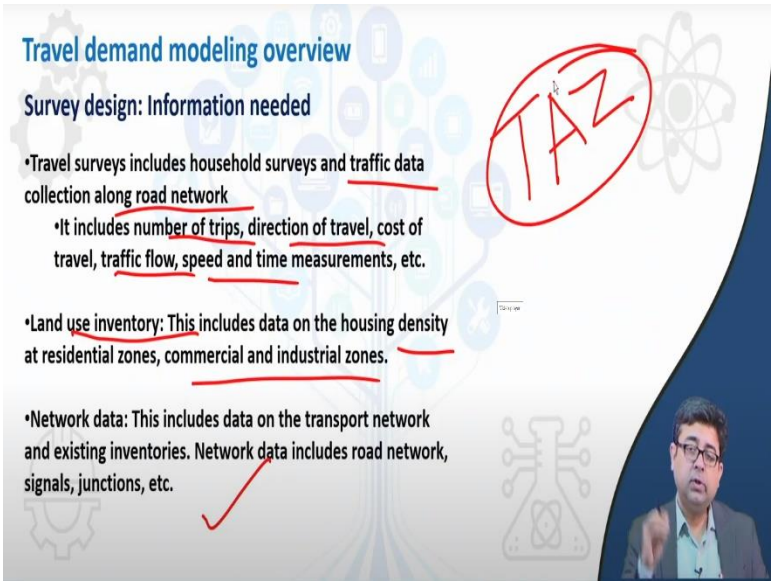
(Refer Slide Time 14:56)



Several types of surveys need to be conducted in order to get all this information. You have to conduct household surveys. So household survey, or household travel surveys, is very similar to your census survey that are done. A surveyor would come to your household and then ask you a certain number of questions, about typical trips that you take during a weekday or weekend.

So these are obviously are anonymized there is no information about, there is no data about, who you are, or what you are identification is; the data is just required for different categories of households, such as households by income, household by age group, households by number of cars you own. So the data is categorized in that manner without any of your personal information. So this is one type of survey that is conducted.

(Refer Slide Time 16:14)

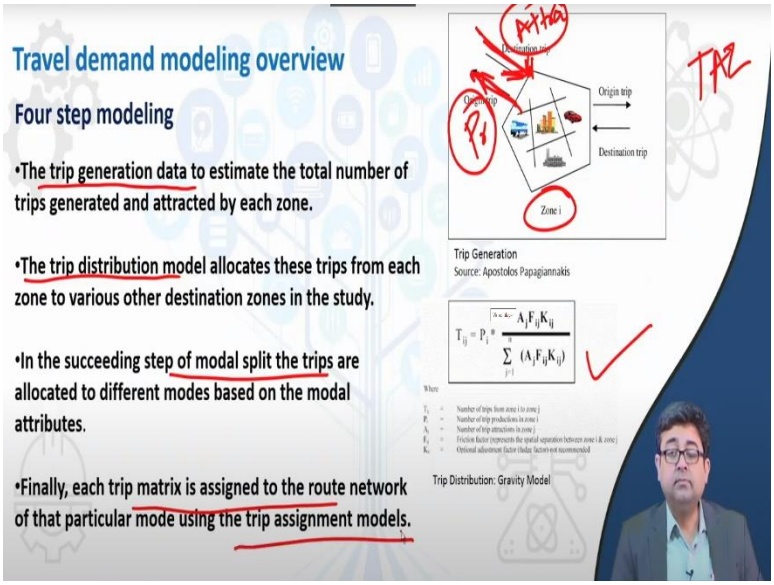


The other types of survey that are conducted include traffic data collection along roadway network. So you would have to have an information about what is the existing volume of traffic on your highways. So in order to do that, you have to collect data about the traffic volume on your roadway network. Nowadays, like I mentioned earlier, you have cameras throughout your transportation systems which makes it easier to at least gather this data.

So once you have gathered the information, you have to analyze it, you have to feed the data and convert it into information which will let you know the number of trips that have been taken. The direction of travel, the traffic flow, and its speed, all of these estimates can be made once you acquire or collect this kind of data. Along with it you have to have data on your land use inventory which can be collected from urban local bodies, the housing density, in commercial and industrial zones, that has to be also collected.

And of course you have to know your base skeleton network data about your highways, about your roads, and highways in the TAZ. So let us always remember that we are all collecting at a traffic analysis zone level. So once you divide your city into different analysis zones, for each of these zones, you will have to have this kind of information.

(Refer Slide Time 17:53)



Now what the four step model does is that in the first step it estimates how many trips are being generated at each of those TAZs. So this is zone 1, or zone i, meaning one of the traffic analysis zones. So what essentially it does is, it just counts the number of trips that are coming in and the number of trips that are going out. So in other ways you can say that these are production trips that are going out and these are attraction trips that are coming in.

So the trip is just a one way travel between point A to point B, it is not a round trip. It is just a one way trip. So any of this is one trip; this is the other trip; and if any trip being produced is an outward trip, it is called a production trip, or if anything is an inward trip to a zone, it is called an attraction trip. So the first step in the 4-step model only does this, i.e. it develops an estimate for the number of trips that are generated, meaning produced and attracted by any particular zone.

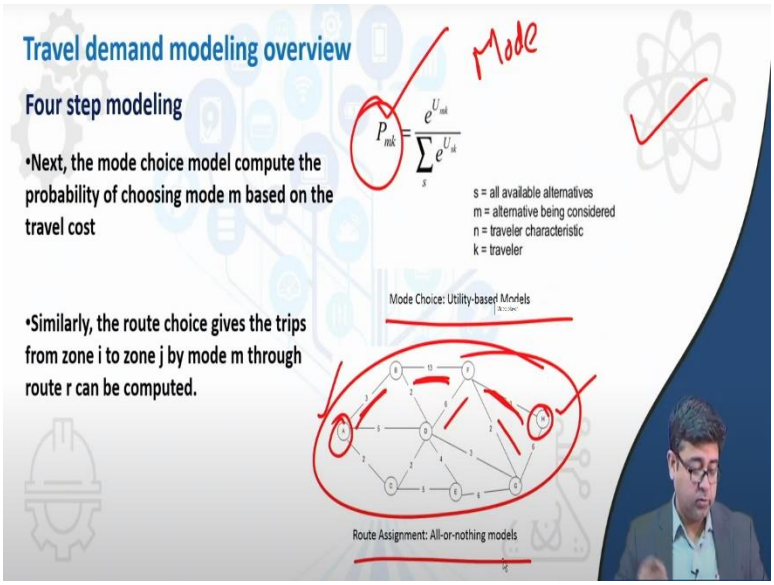
Then once you know that, in the second step or in the trip distribution step, where it says that now that we know how many trips are being generated, we have to assign those trips to other zones. Now if the trip is being produced from the zone i, it must be going to another zone. So which is that zone? So we need to assign it to that zone. Similarly if a trip is being attracted to this zone, it must have been produced in some other zone. So where is the trip is coming from? So the trip distribution model predicts that. It predicts where these trips that have been generated are coming from or going to. So usually the most common model that is developed is the gravity model. It says that the trips between 2 zone are directly dependent upon the attractions that are available in the other zone, and the distance or the travel time, between those two.

So if there are lot of attractions in the zone it is likely that trip that produced in one zone is attracted to that zone. So attractions mean, an attraction could be movie theatre, a park, a restaurant or number of restaurants, usually you want to say that residential zone are usually production zones in the morning and office area are normally the attraction zone in the morning. And whereas in the evening it is the reverse, so the office zone becomes the production zones where as the residential zone become the attractions zone.

So that is what trip generation and trip distribution model does. In the next step once you know where these trips are going to, i.e. between which zones the majority of the trips are going, it is essentially to understand how they are going there. So, are they going using 2 wheeler, using 4 wheeler, using metro rails, or are they walking to these zones, or are they using their bicycles?

So what is the choice of mode that they are taking up in order to travel from this zone to that zone? So this step is called modal choice and finally once you know the zones that they are going to and the mode that they are using you can assign that trips to the network that you already have. So you can say that, ok, to go from A to B there is no direct metro route. So it is likely that this person will take is or her private vehicle, and this is a road or the shortest route, shortest travel time route between these 2 zones. So let me assign this trip to that network. So essentially now you will know that of particular trip that was generate in one zone is being attracted by another zone, or is distributed to that zone, and it is using personal automobile then you can easily assign it on a network. So that is a last step in the 4-step modeling.

(Refer Slide Time 22:50)



Essentially, we have talk about this, the mode choice model, the most common model that are currently used are the utility based models. It calculates the probability of using a mode of transport. So in this case it is a discrete choice model so when we say it is a discrete choice model, what we mean to say is that everybody has their own choices. So we cannot say that another person's choice will affect my choice, we cannot say that. We say that their choice is discrete to my choice. How do we use this utility model is that, we way the different options that are available to us and whichever has the least negative utility or the highest positive utility, we use that mode. So different utility parameters could be time, cost, comfort, so on and so forth; so whatever we feel that are compelling factors for us to take that mode.

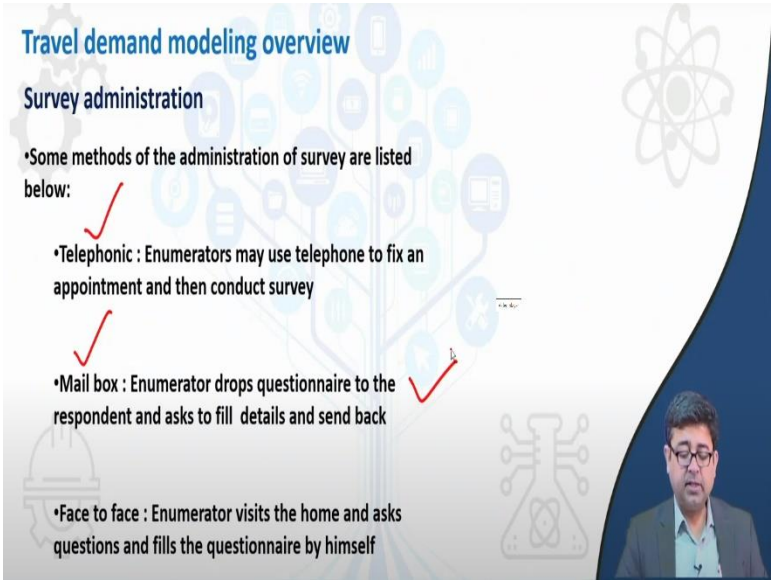
If I am a low income person, to me the compelling parameter could be the cost of travel from point A to point B. So I would look for the cheapest available mode of transport in order for me to go to my destination. Whereas if I am middle class or a upper class citizen then I would, may be give more weightage to comfort or travel time. So I want to get there early. So then I would may be pay a premium fee to take a mode that will ensure that I reach my destination on time and very quickly.

So all these things, all these factors, works in the background when you are trying to establish the probability of the mode that you are going to use. Finally, like I said, if this is your entire network of streets that is available and you are trying to go from zone A to zone H and you know that these are all the streets that are available to you, your trip would be assigned based on a your

origin zone and your destination zone and the mode of travel that you have chosen. It will be assigned to a network, which takes you to your destination in the shortest amount of time, for example.

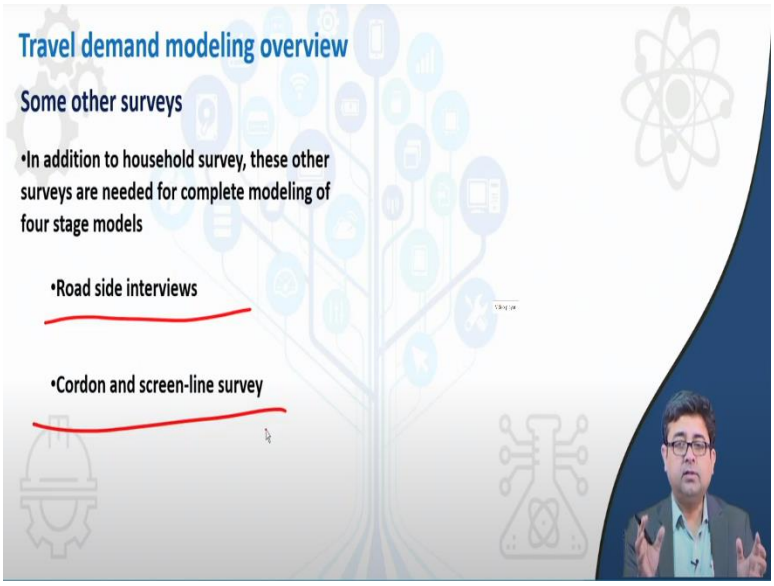
So this is a route assignment model, popularly called an "all or nothing" model. So like I said, in this class we are not going to go in detail about how we develop these models because there are other NPTEL courses on that. But however when you are talking about urban multimodal transportation system you have to be aware of the modeling that goes behind the development of these statistical models or mathematical models. How they are developed, what are the parameters, you have to at least have an idea about it otherwise you would not able to follow the next few lectures, the lectures throughout this class.

(Refer Slide Time 26:26)



Surveys, like I said most of the surveys are usually done via questionnaires and are household surveys. However you could also do telephonic surveys if you have enough funds. This again depends on how complex your transportation system is. How big your city is? If you really have funds to do it, you can do much more pinpointed telephonic survey. You could also use mailbox surveys, which is sending out the survey questionnaire via mail and requesting you the user to send it back. This is not much used nowadays but used to be used in the past. Face to face household surveys is something that is to be done.

(Refer Slide Time 27:18)

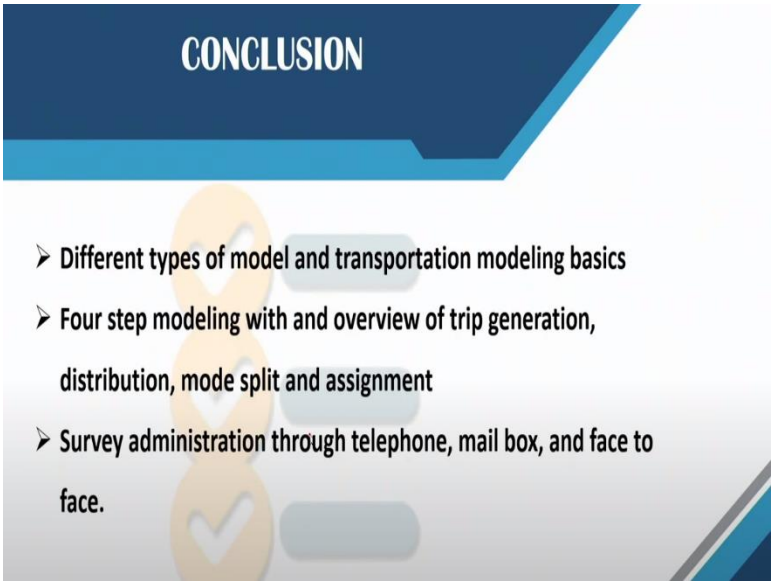


Very often, and in some cases you also do roadside interviews, where essentially you want to know the mode choice behavior. So what mode to use? What mode people do use for this particular trip. So it is sometime advisable to catch people on their way to a particular destination. So that they remember in mind exactly what trip and which mode they are using. So, many of the times you would see that people are conducting surveys at bus stops or a train station to just understand the behavior, to understand your travel behavior, or your mode choice behavior.

And cordon and screen line survey counts are done to determine the volume of the existing traffic on the network. So if you have a network, you draw a cordon around the network and you count the vehicle that is coming into the cordon and the number of vehicle that is going out of the cordon. So then you know essentially how many vehicles are there within the cordon at the given point of time.

So that tells you the existing volume of vehicles in your roadway network. So that kind of a survey is called a cordon and a screen line survey.

(Refer Slide Time 28:34)



So that was an overview of the transportation modeling, surveys, and travel demand modeling steps that are involves trip generation to trip assignment. And also how all these surveys are administered. So it is essential for you to at least to get an overview of these as we move along in this class we would be then able to follow as to how the capacity of different transportation system are calculated. Thank you very much for you time.