Urban Landuse and Transportation Planning
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Lecture - 48
Travel Demand Modeling Using CUBE and VISUM

Welcome back in lecture 48. In this lecture travel demand modeling has been covered using both CUBE and the VISUM software to explain trip generation, trip distribution, mode choice, and traffic assignment.

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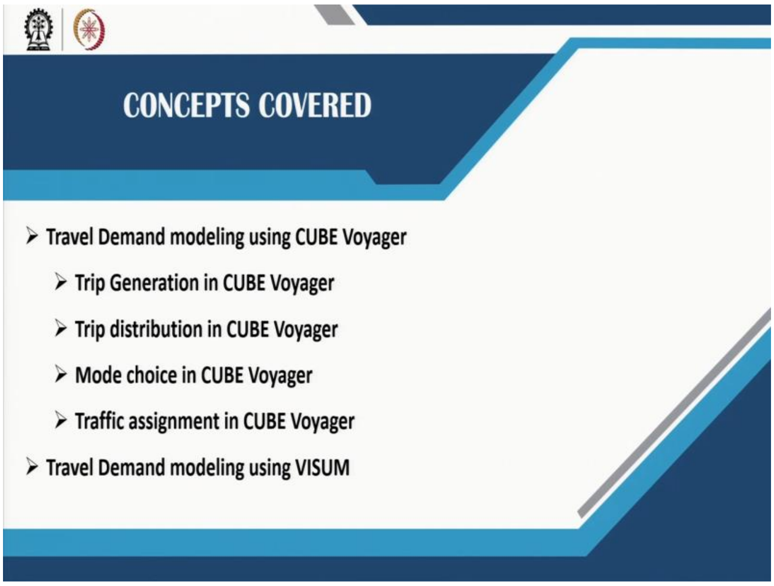

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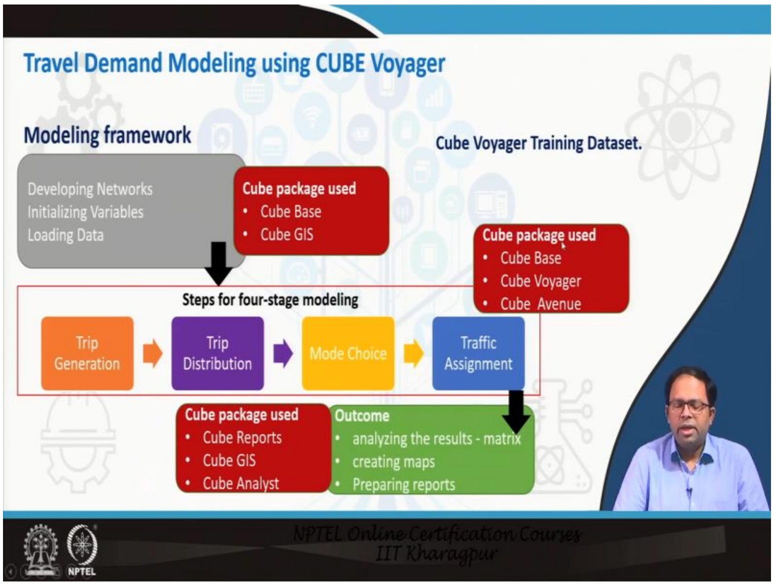

Travel Demand Modeling using CUBE Voyager

The basic structure of the cube software has been discussed in the previous lecture. Now, in this lecture, the focus will be on the cube voyager component. The modeling framework that is used in this particular software has been shown in the figure above. In the 4 stage travel demand model, there are 4 steps; trip generation, trip distribution, mode choice, and traffic assignment. Before starting with these 4 steps, we first need to deal with the basic data sets.

For example, there are data on different zones and different networks i.e. what kind of travel time it takes to reach one zone from another while travelling using cars along highways and roads or by public transit. So all these datasets have to be initialized first and after that, the actual 4 step travel demand modeling process can be started.

Initially cube base and cube GIS is used and then the 4 step model is developed using cube base, cube voyager as well as cube avenue. Finally, after completion of traffic assignment step reports can be generated and the different created matrices can be analyzed and for this cube reports, cube GIS and use cube analyst can be used. So this is how the different components of cubes can be used but cube voyager is the main component to complete the travel demand modeling process.

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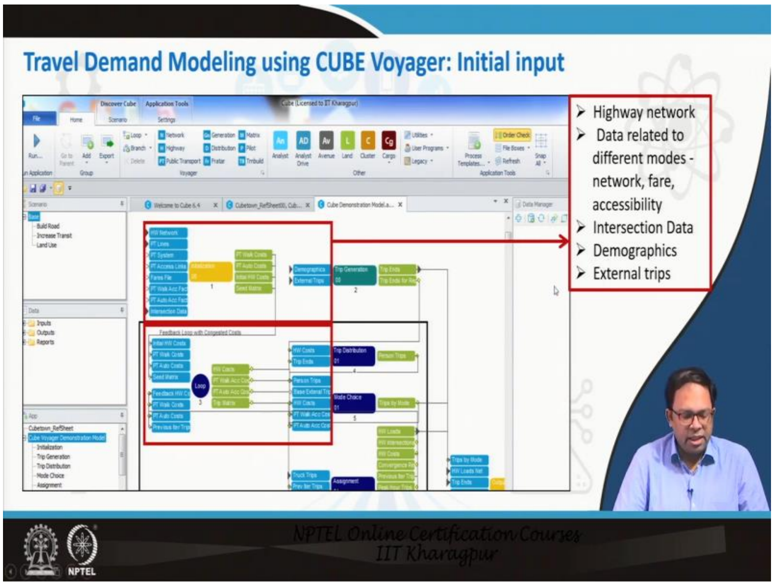

Travel Demand Modeling using CUBE Voyager: Initial input

The basic starting screen is shown in the above figure which shows the different initial inputs that have to be provided to the software. It has been already discussed about the way voyager presents its different components i.e. everything is organized in such a way so that it is easily understandable and legible. The blue boxes in the figure are the input and the green is the output.

The initialization is done i.e. it calculates the different cost of public transit, the cost of the highway and the seed matrix are prepared which is generated using different files, which includes data on public transit line, the highway network, the fares, walking access to public transit, etc. Similarly, data related to different modes, accessibility, intersection data to know the time taken during congestion, demographics and external trips data are required. Demographics and external trips are directly inputted into the trip generation model.

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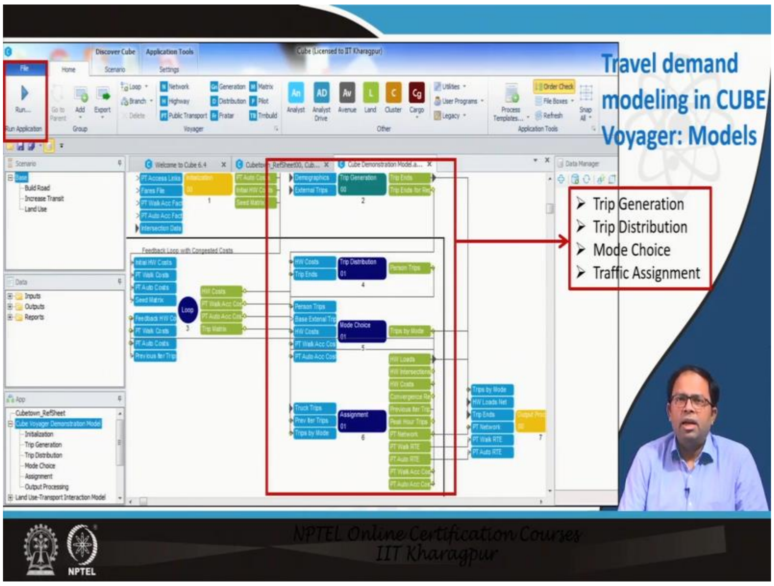

Travel demand modeling in CUBE Voyager: Models

In trip generation input is demographics and external trips, the network distances, network cost. The network scheme tables are required for trip distribution. After, trip distribution person trip matrix is generated that goes as input into the mode choice model. Finally trips by different modes can be assigned as per the different time of the day and as per different modes for this particular network.

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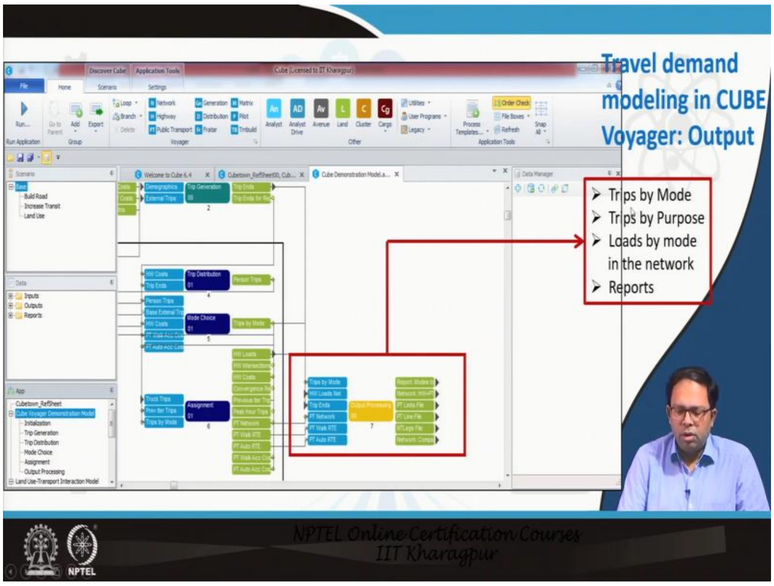

Travel demand modeling in CUBE Voyager: Output

Finally, after this process, trips by mode, purpose, and loads by mode in the network can be estimated and then reports can be generated from this model.

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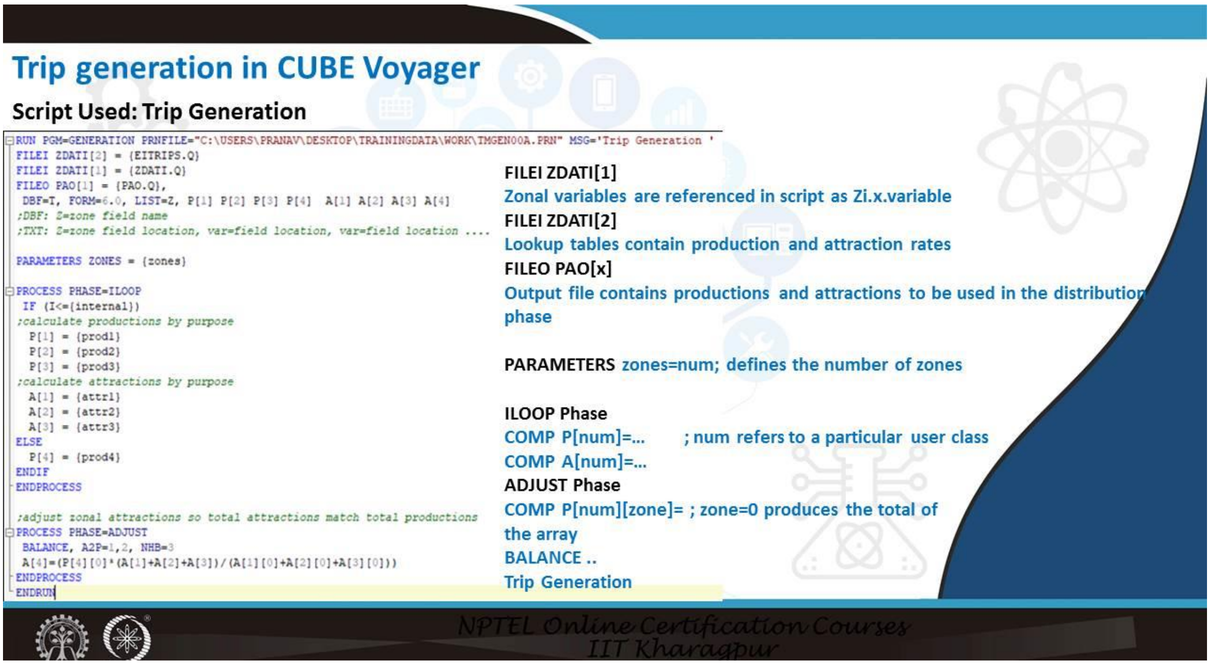

Trip generation in CUBE Voyager

Cube voyager or any cube software uses scripts. Scripts are instruction sets that are given and are executed. These are programs. So these programs can be customized. In this, the first program is for a trip generation. Like any program it has got inputs and then it does some processing and after that, it gives some output.

In the beginning, the initial files have to be entered. These zonal variables are referenced in the script as Zi.x variable in file ZDATI [1]. These zonal variables include data about the different zones and then look up tables contain production and attraction rates in ZDATI [2]. FILE PAO is the output file that contains production and attraction to be used in the distribution phase. Next, in parameters, the total numbers of zones are defined. In the Iloop the productions and attractions for different kinds of trips for all the zones are calculated by running it in a loop to execute it zone by zone. In this example, as there are 3 kinds of trips, 3 sets of productions, and 3 sets of attractions are found.

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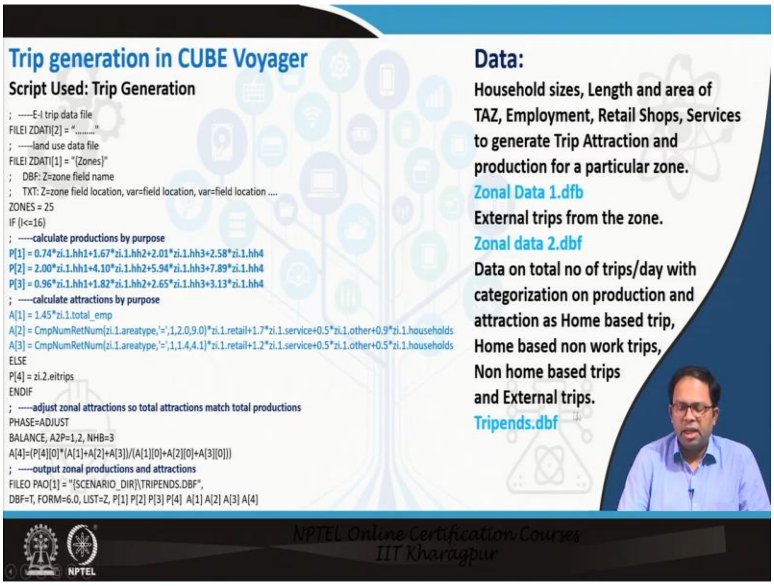

The equations that have been used are mentioned in the above figure. So, P1, P2, P3 are the 3 equations for predicting 3 kinds of trips productions for each zone, and A1, A2, A3 are 3 equations for predicting attractions for these different zones for these 3 kinds of trips. For example A1 is the home based trip.

In trip generation, data for each zone such as households of different sizes, area of TAZ, number of employments in TAZ, retail shops in TAZ etc. are used to generate trip attraction and production for a particular zone. Zonal data 2 dbf includes data on the external trips. Finally, total number of trips per day are stored in Tripend database. These are categorized as productions and attraction, home based trips and non-home-based trips, work trips and non-work trip and and external trips.

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The entire process of how it is done is shown in the attached video. After opening the cube 6.4.5 version the data has been imported. The training dot TPL file has been already created. A new template has to be added which is named as a training model. And finally, an application can be started within which voyager is set as group name team and group code because we are creating a voyager application.

The next step is to start with inputs to generation. A training model is created where the numbers of zones are entered and the equations are already given as the existing model is used for this video. Then the data need to be included which can be taken as input.

The unused files can be removed. There are the script file, the program file, the zonal data 1, and zonal data 2. After that, there are the print file and the results. The model can be run by clicking on 'model' to get the result.

There are 25 zones among which 16 are internal zones and the rest are external zones. So when one double clicks on the generation application box then the model is run and one can also click on the TRIPENDS DBF where all the data for production, the attraction is stored and the final results can be seen by clicking on that. Finally, attractions and productions for each zones are shown.

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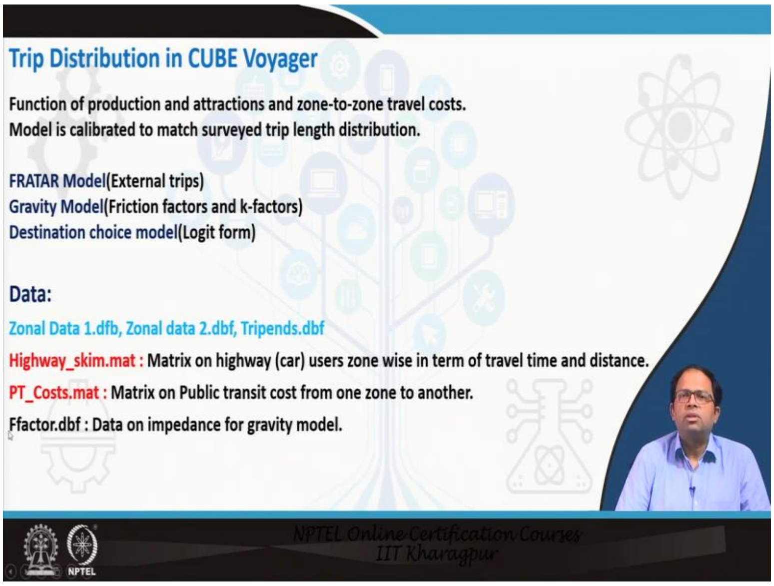

Trip Distribution in CUBE Voyager

The next step is the trip distribution. Trip distribution is a function of both production and attraction and zone to zone travel cost. So, the first step is to determine the zone to zone travel cost. The network, trip generation and the trip distribution programs are linked.

During running the distribution program certain other information has to be entered. For example, a gravity model has to be calibrated to match surveyed trip length distribution. The F factors and the K factors have to be determined. So either F factors are taken as input from external file or the model has to be calibrated. After that, the trip distribution model can be executed to get the final results. Trip distribution in cube voyager can be done with FARTAR model for external trips or using gravity model where friction factors and K factors are used. Additionally, complicated destination choice model in the logit form can also be applied.

In this example, the gravity model is used and the destination choice model will be shown in the next lecture during activity-based modeling. The entry data are zonal data 1, zonal data 2 like earlier and trip ends database which was generated in the previous step. The new data required are the highway scheme matrix and PT cost matrix. The highway scheme matrix gives zone-wise travel time and distance for car users, and the PT cost matrix includes cost from one zone to another. This can be public transit generalized cost or total travel time or distance, or impedance between the different zones. F factor dpf contains the data on impedance for gravity models which have been already prepared.

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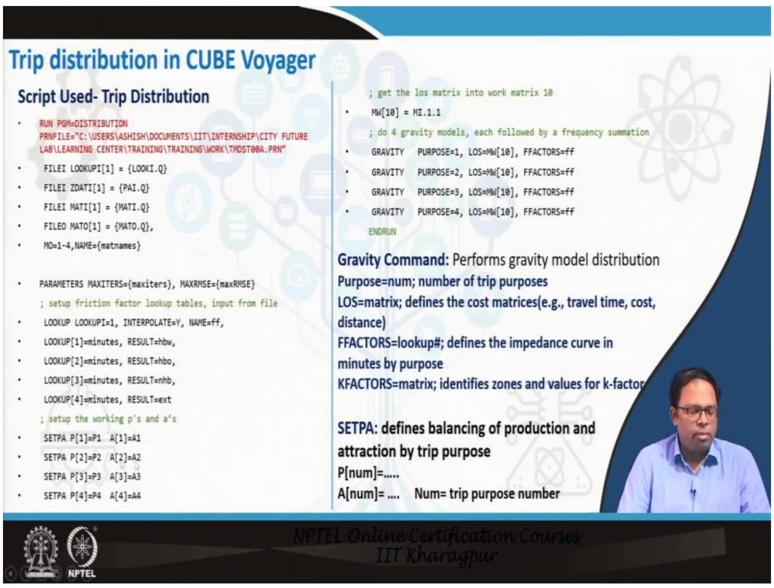

During running the model one will find the script like in the above figure with some variations maybe. There are 4 trip purposes and the 4th one is for returning trips. The matrices include the cost matrices, travel time etc. for running the gravity model. The friction factors define the impedance curve in minutes by purpose in form of an equation. K factors matrix is not here but it can be included. There are also zone-specific variables and adjusted variables. The total amount of production must be balanced with the total amount of attraction.

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At first, a network scheme has to be created and a file from the application has to be opened in voyagers. The successful run of highway files will show the different travel times. Similarly, it will be done for public transit. This data should be saved one by one. Some system files are also generated which can be cleaned up.

The trip distribution application is started and then the network scheme is included. Highway and public transit files are organized and some of these files are made public because that will be used directly later. Then one should go back to the parent mode where distribution will be done.

Different files are linked with generation as well as network. First trip ends and from matrix file 1 highway matrix is loaded. So, trip distribution starts with zonal data, the metrics file, and the script file. After running it the final result of trip distribution data will be saved in PERSONTRIPS.MAT which will be used in mode choice and assignment steps. By clicking on PERSONTRIPS.MAT it can be seen that the matrix is now populated with all the trip and interzonal volumes for different trips.

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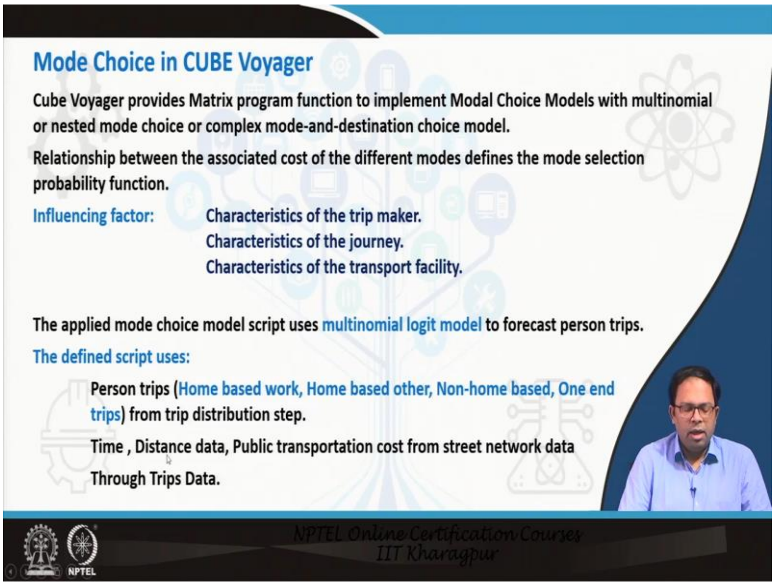

Mode Choice in CUBE Voyager

Mode choice in cube voyager can be done using multinomial logit model, a nested choice model and a mode and destination choice combined model. The matrix program function implements the mode choice models.

At first, the utility equations for the mode choice have to be developed and for that several characteristics or influencing factors such as characteristics of the trip maker, characteristics of the journey, characteristics of the transportation facility etc. can be included in a mode choice model. Trip generation and trip distribution data are already there which is also used.

In this particular example, a multinomial logit model has been used and the script has been defined by using person trips, home-based work, home base other, non-home-based and one end trips from trip distribution step, time distance data, public transportation costs from street network data and trips data.

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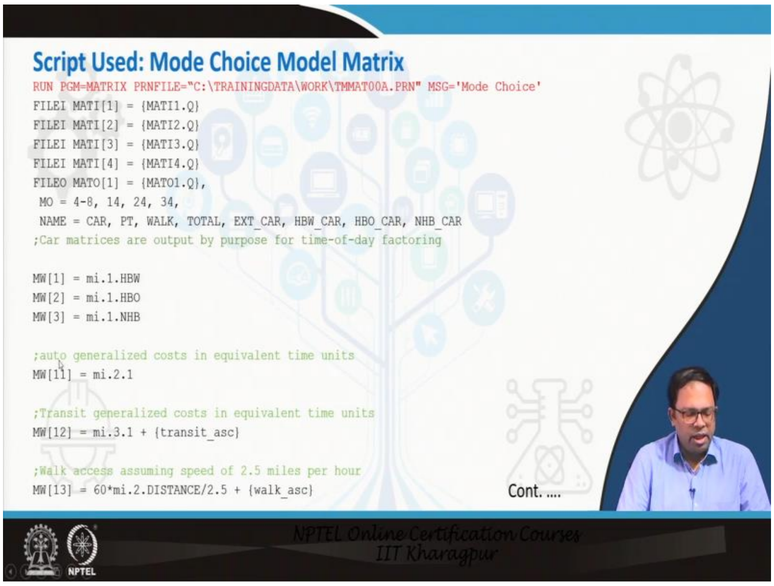

The above figure shows the script used in mode choice. The cost equivalent of time is generated for transit and walk.

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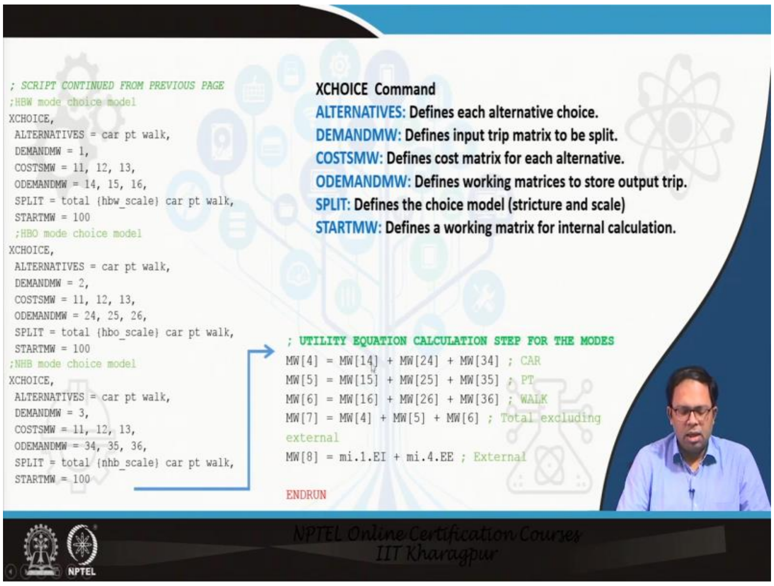

Time is converted to cost and XCHOICE is the mode choice command. The first part is defining alternatives where all choices are defined. This exercise is done 3 times as it is done for each trip purpose. DEMANDMW defines simple trip metrics to be split. The input trip matrix has to be divided into the costs of the different modes. MW defines a cost matrix for each alternative from zone to zone. ODEMANDMW defines working matrices to store output trips. Then split is the type of mode choice model.

For this example, 3 modes are considered like car, PT, walk for HBW. STARTMW defines a walking matrix for internal calculations. The utility for CAR, PT, WALK is defined in the utility equations, and using this, the mode choice model can be run.

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The next step is to run the mode choice model. Matrix from the cube voyager is clicked and mode choice for 3 purposes and 3 modes is selected. EXTERNAL.MAT from training data is for external trips. Next, the matrices are included. These can be arranged to look better and are linked. The matrix files from distribution, highway scheme matrix and PT matrix are added. The model is run by clicking on the matrix and the run report can be seen as well. MODETRIPS.MAT matrix contains all the data and all the mode choices are shown for the different inter zonal volumes.

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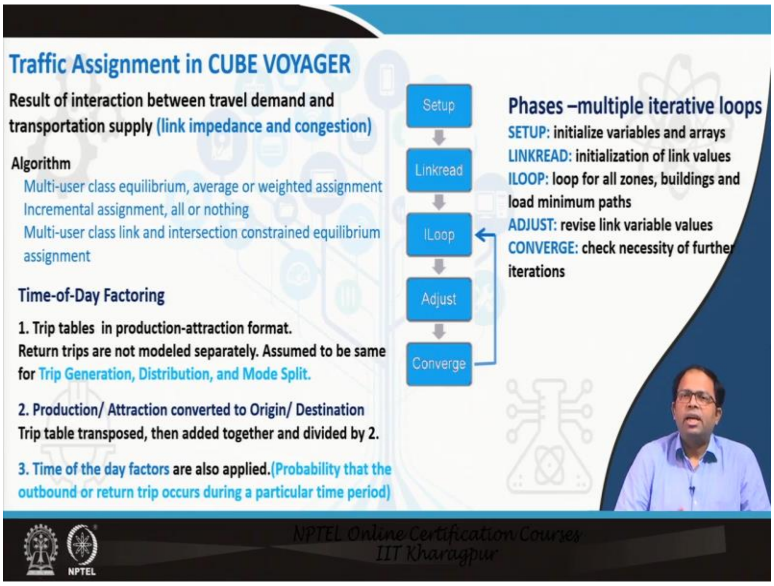

Traffic Assignment in CUBE Voyager

In the assignment model, different types of assignment algorithms can be used. In cube, there are different options like multi-use, average or weighted assignment, incremental assignment, all or nothing, multi-user class link and intersection constraint equilibrium assignments. Here constraint equilibrium assignment is done and intersection impedances are time spent at the intersection. Link costs are updated after each run. In any assignment, the data that gets updated are link impedance and condition.

In the first step variable arrays are initialized. There is a link read function where initialization of the link cost values is done for all zones and minimum paths in between every 2 zones are determined. The paths are created and link variable values i.e. impedance and congestion values are adjusted and then checking is done to confirm whether it has arrived at a convergence or not i.e. if the final error is within tolerance or final value is not changing much whichever is the convergence criteria. Iterations(Loops) are carried on till the convergence criteria is reached. The time of the day is also required to be considered.

Mode choice output is required to be split as per the different times of the day. Trip tables are in production and attraction format. Return trips are not modeled separately. The same sets of values are assumed for trip generation, distribution and mode split.Thus, production attraction is converted into origin-destination. So, the trip table and its transpose is added together and divided by 2. It helps us to create the total amount of travel between the different zones at different time points (24-hour format). Accordingly, time of the day factors are applied(following survey data) which is the probability that the outbound or return trip occurs during a particular time period. After that, hourly assignments in the network can be done.

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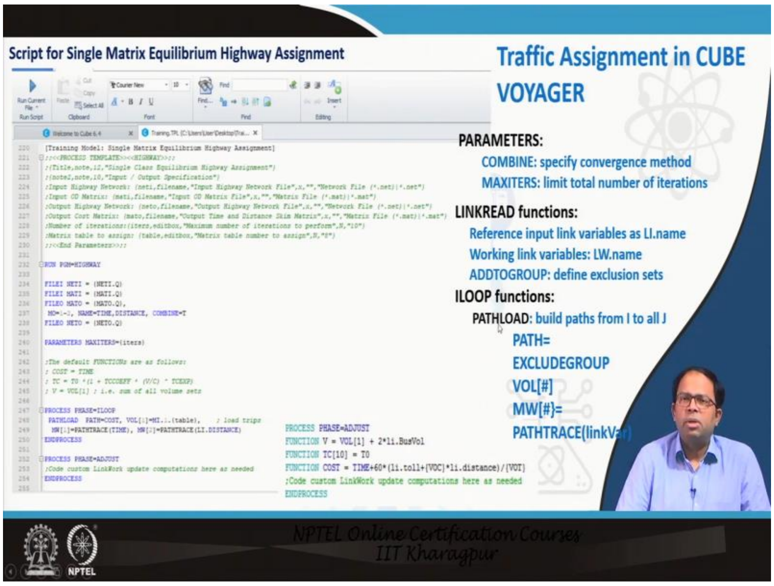

The script used is shown in the above figure. There are parameters and MAXITERS. Parameters show the convergence method which is COMBINE and in MAXITERS one can limit the total number of iterations. There are different functions like LINKREAD function and ILOOP function. In LINKREAD function input link variables are referred to as L1.name and working link variables as LW.names. ADDTOGROUP define exclusion sets. In Iloop convergence can be checked. At first, the paths for each shortest path from I to all J have to be built and then the assignment can be done followed by updating the impedance function. Then the next iteration/ loop is executed.

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At first, the network scheme are generated because this is the starting point for the iterations for assignment. The relevant files are linked with the mode choice file. The prerequisite models are the trip generation, distribution, and mode choice.

At first, the work folder is saved. Then occupancy adjustment by the hour and time of the day factor is considered. These factors are used to determine the hourly matrix and then this files are made public.

Next, the network file and matrixes are linked and the training model on single matrix equilibrium highway assignment is shown. The highway network file is given as input, the output highway network file is named as LODADED.NET and the output time and distance key matrix is named as CONGESTED.NET. Maximum iteration number is defined as 10 for this example. So, these are the parameters that we have to set for running the assignment (highway) model. Transit assignment is not done here. Next, by clicking on the assignment model we can get the final hourly outputs for this example.

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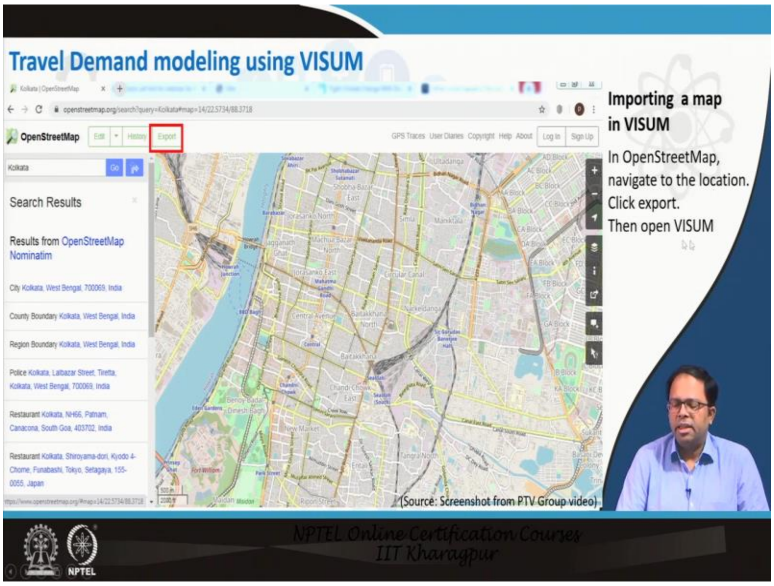

Travel Demand modeling using VISUM

The target of this particular lecture is to give an idea that, whatever theory is learned in the different steps starting from trip generation to distribution, mode choice and trip assignment can be seen in application by running this kind of software. The models are not made here, they have been just applied. Final outputs are received by linking all the models. However, the models have to be built using statistical software or using scripts and programming languages like python.

The models have to be built independently as it cannot be done inside the software. The software is just for doing the linkages i.e. the inputs and outputs are connected, and accordingly, the final results are found. As it is done for a bigger city one has to deal with many links and many kinds of modes. So, without the software, it becomes cumbersome to deal with that. So, that is how this software helps.

VISUM interface is a bit different compared to the cube. Map in VISUM can be imported directly by opening the OpenStreetMap and by clicking export followed by opening it in VISUM. OpenStreetMap includes open-source maps that are available on the net.

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In the VISUM interface, Openstreetmaps can be imported. The results can be found by selecting a particular saved OpenStreetMap file. The map will be distorted if the projection system is not right which can be corrected by opening the background map. After having the background map the nodes, links and the different zones can be drawn over this particular map, and our network with different nodes, links can be created.

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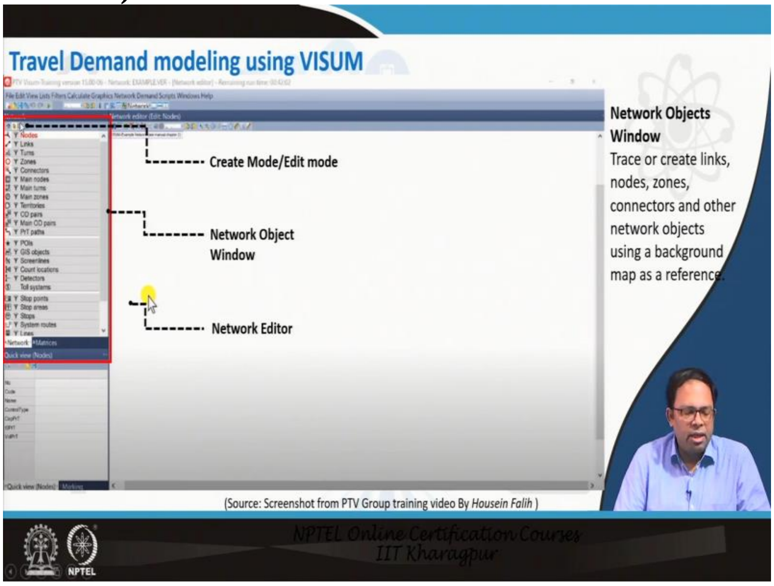

Using the network object window the different nodes, links, zones connectors, main nodes, maintenance, etc. can be created. Here new nodes can be created and the existing drawings can be edited as well.

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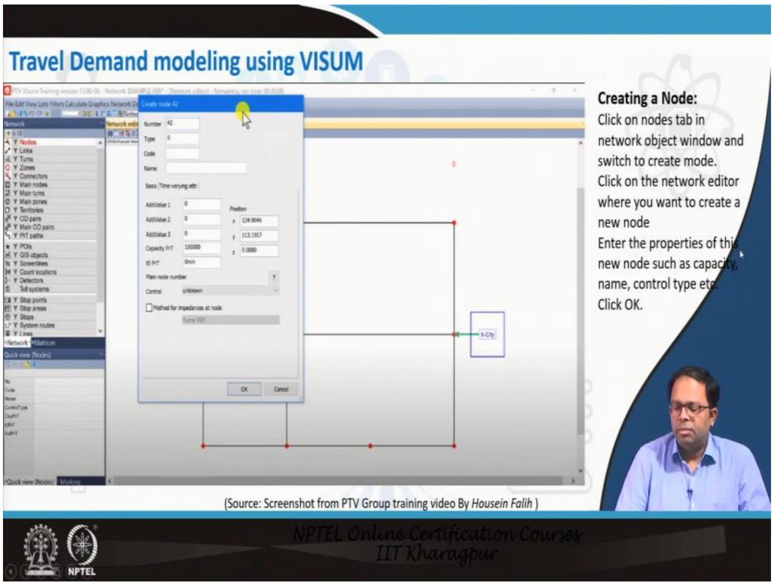

At first, a node is created by clicking on the nodes tab in the network object window. This is a part of the training module which is available online.It is similar to any kind of GIS or CAD software. The nodes, liks etc. can be created by using the 'create mode' option. The properties of this new node such as capacity, name, control type, etc. have to be entered as well.

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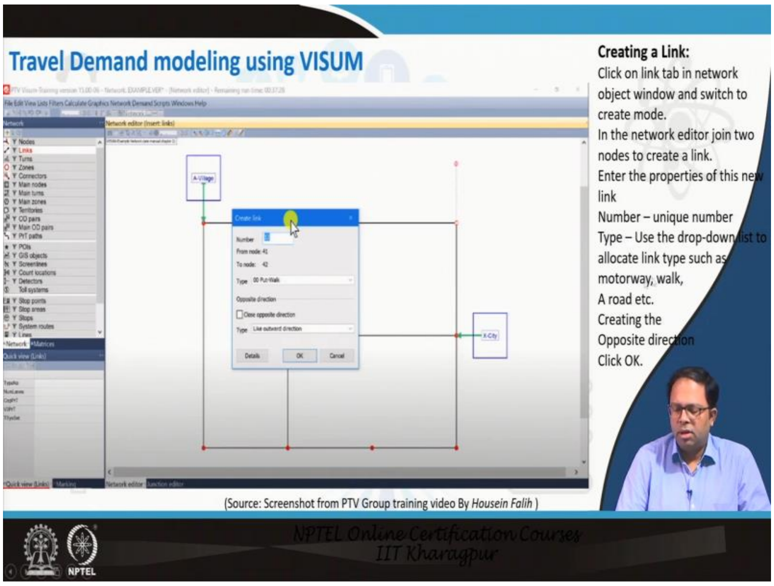

A link is created by dragging between 2 nodes in the network editor and the properties of this new link can be entered where a number is given to it and a drop-down list can be used to allocate link type whether it is a motorway or a walkway or road and so on. There will be a link in the opposite direction as well.

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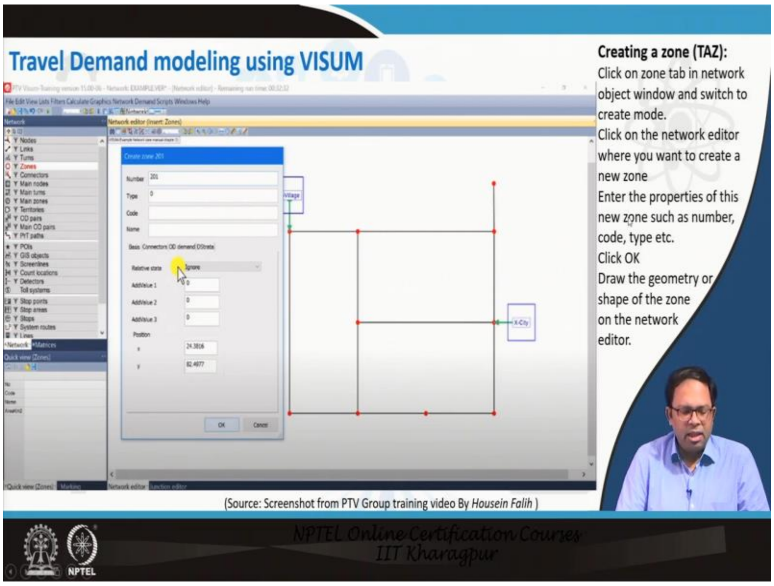

After that, a new zone can be created by using the zone tab from the network object window and the properties of that particular zone such as number, code, type, etc. can be given. Then the geometry or the shape of the zone can be drawn.

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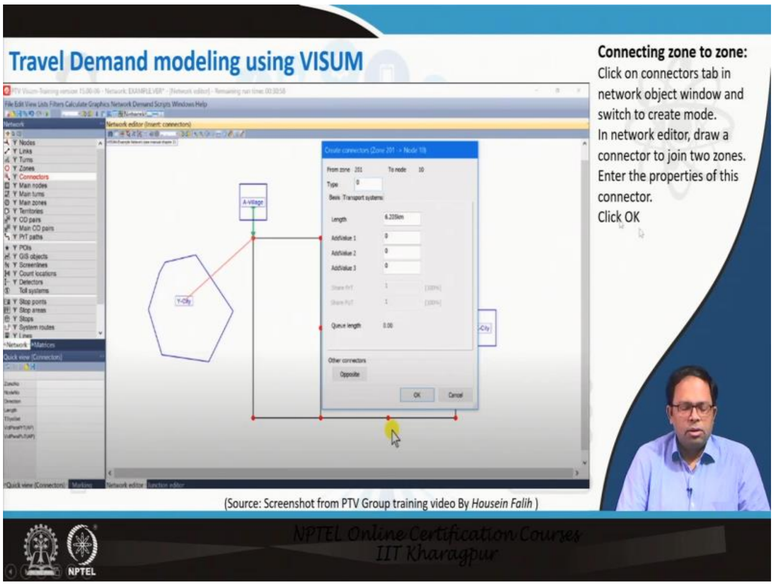

This zone can be connected with the network by using the connectors tab. A centroid zone can be connected to a network. That is how the basic editing of the network in VISUM can be done.

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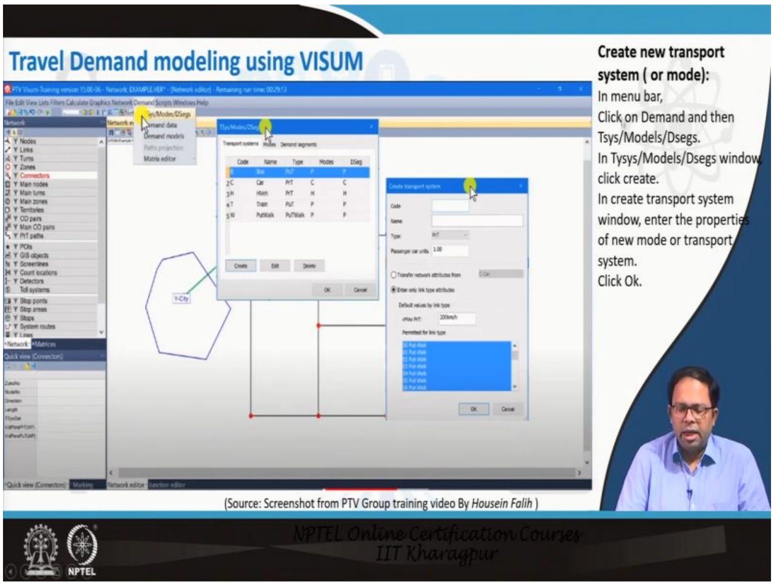

Next, some new transport system or modes can be set. Different modes like car, train, walk, heavy occupancy vehicles that are available in this zone can be added by clicking on demand and Tsys/models/Dsges.

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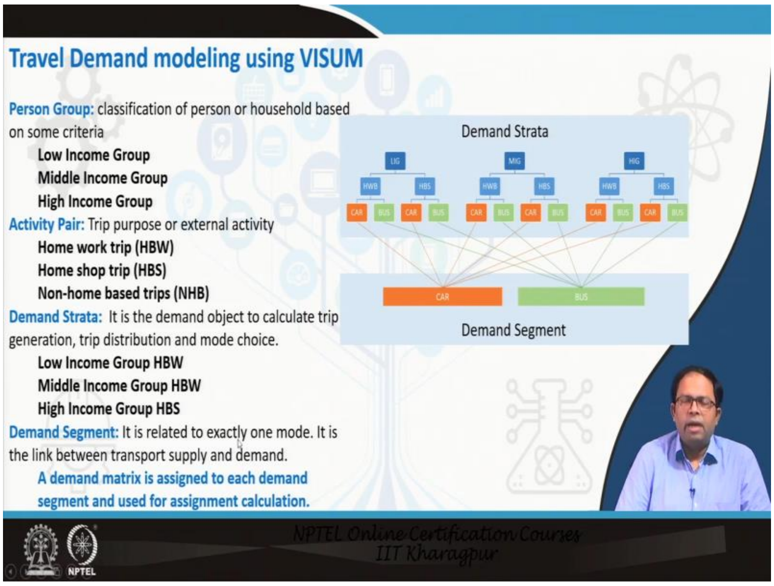

In VISUM there are certain concepts like person group which is the classification of a person or household based on some criteria. Different socio-economic groups like low income group, middle income group, high income group etc. can be modeled.

Next, there are activity pairs which are synonymous with trip purpose or external activity. It is called activity pair in this particular software. There may be a home-based work trip, home shop trip, non-home based trips, and so on. Demand strata is a demand object to calculate trip generation, trip distribution, and mode choice, and that is done for each group and each activity pair i.e. each social-economic group and each type of trip. This is how the total demand has been stratified and that is why it is called demand strata.

Next, there is a demand segment and each mode is 1 segment. This is the link between transport supply and demand. The demand matrix is assigned to each demand segment and used for assignment calculations.

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During the creation of demand strata, different activity appears first. Different demands can be created and added and new groups can be also added. For example, a new group called called university students and new activity i.e., they would be travelling to universities can be added. So, this would be university trips, and accordingly the demand strata can be created.

As the trip generation and attractions for all zones are not yet to be calculated, the trip generation model is run. Certain constants and the coefficient for initiating the calculations have to be defined. After the model initialization, the next step would be to run the 4 stage model. Before running the 4 stage model the sequence of steps has to be determined and the procedure sequence has to be defined. Procedure sequence can be calculated in the menu bar and finally, those files can be saved.

Within the procedure sequence, there are different steps. First, PUT schemes and network schemes can be calculated. Then trip generation, trip distribution, mode choice, and different matrices can be determined. Then assignment can be done in an iterative manner.

In this case, there is a need to modify the trip generation because a new activity pair is entered. So, the trip generation equations and trip attraction equations are being modified. In the next step, the trip distribution part can be modified by adding the new trips. In the trip distribution, the same impedance as other trips can be used for home university trips.

In the next step, the mode choice equations for the different demand strata are modified. For home shopping, there are 3 modes and 3 utility equations. We use the the same utility equations for the home university trip. Now the model is run. As can be seen in the video it is going in sequence and the loop for assignment continues until unless there is convergence.

The number of iterations can be seen. Finally, trips are now distributed between all zones, and assignment is done. In the zones table, all the trip production abnd attractions are now populated and other desired files can be also found as well.

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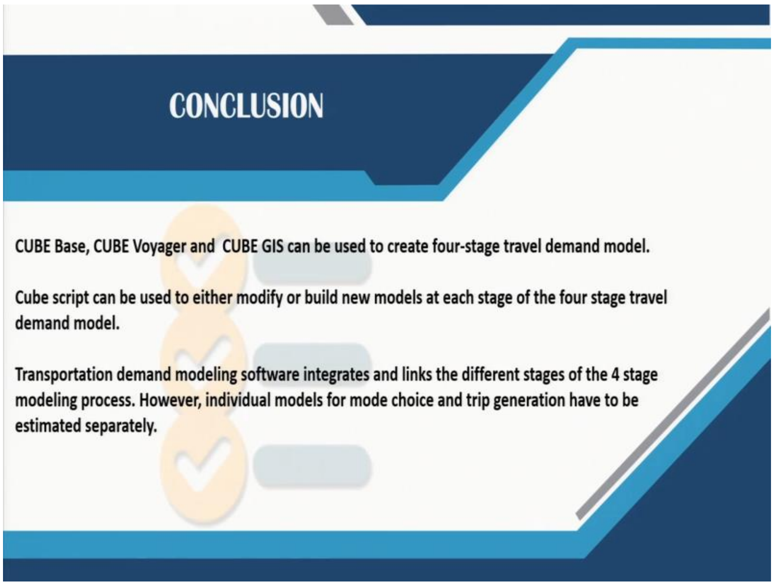

Conclusion

In this lecture, the application of the 4 stage travel demand model in both the software has been explained. Cube base, cube voyager, and cube GIS can be used to create the 4 step travel demand model. Cube script can be used to either modify or build new models at each stage of the 4 stage travel demand model.

Transportation demand modeling software integrates links and links are different stages of the four-stage modeling process. However individual models for mode choice and trip generation have to be estimated separately.

As primarily this helps to execute the modeling process much faster this software are required either for 4 stage models or even for building activity-based models which should be taken up in the next lecture.

Thank you.