Urban Land use and Transportation Planning
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Lecture - 49
Activity Based Modelling in Cube

Welcome back to lecture 49.

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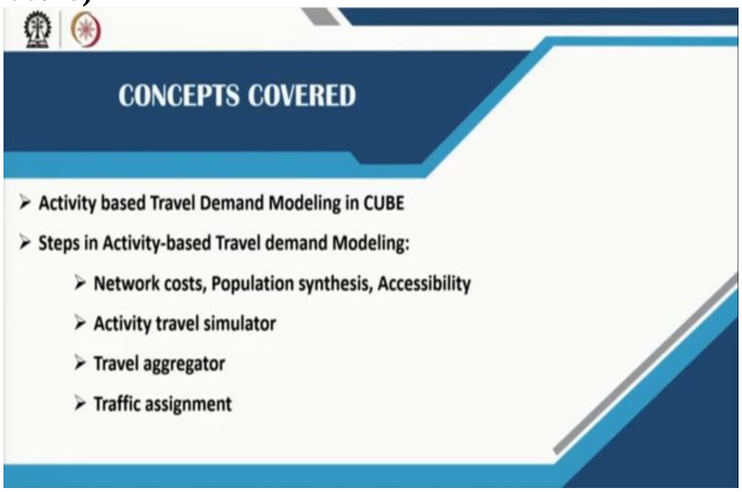

The different concepts that will be covered in this lecture are activity-based travel demand modeling in the cube and the different steps in the activity-based travel demand modeling such as network costs, population synthesis, accessibility, activity travel simulator, a travel aggregator, and traffic assignment.

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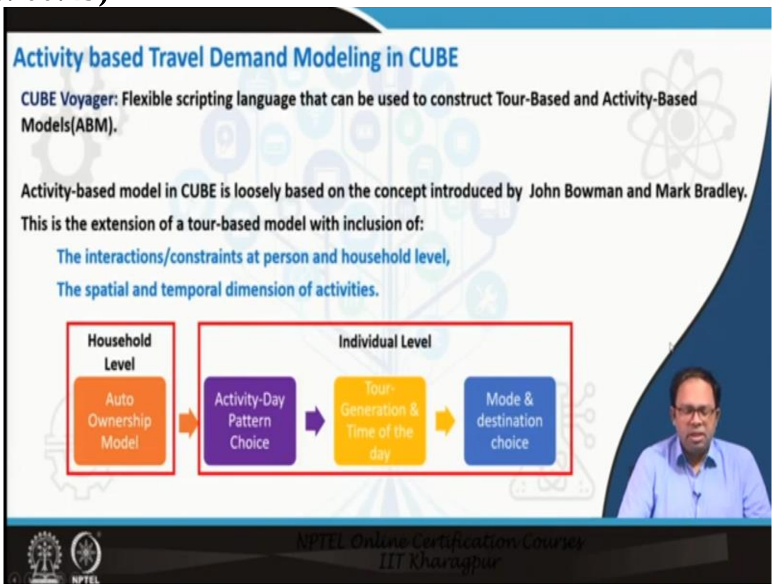

Activity-based model will be covered in module 12 in detail. Hence for better understanding, one may revisit this lecture after reading module 12.

Cube uses a flexible scripting language and can be used to construct and modify the basic 4stage model or to to develop a tour-based model or an activity-based model. Activity-based model involves activities of individual participants, when and where that activity is conducted and measures to support that particular activity. For example, at what time an activity will start and end, then how to organize activities throughout the day and what are the primary tasks. Travel is derived demand resulting from those particular activities. There are several frameworks for an activity-based model and there are different variations of it.

Activity-based modeling in CUBE is loosely based on the concept introduced by John Bowman and Mark Bradley which is relatively simple and is an extension of the tour based model. It includes the interactions and the constraints at person and household level i.e. how different individuals within a household interact i.e. do they share a ride or do they escort each other in a particular trip like a father taking a kid to the school and then going to his office. Other constraints are time constraint, destination constraints etc. For example, if one goes for a certain activity on a particular day, one cannot do something else. The number of intermediate stops depends on the available time.

The special and temporal dimensions of the activities like where it happens, how much or how long it happens are considered. So, at the individual level, an activity day pattern choice is created. However, household auto ownership is determined before that since, this is one of the primary reasons that determine what kind of activities one can participate and also determines mode choice.

From the activity pattern, one can detrmine what kinds of tours are generated, and at what time of the day those are generated. Finally when the tours are determined one can understand what kind of mode and destination choices are possible.

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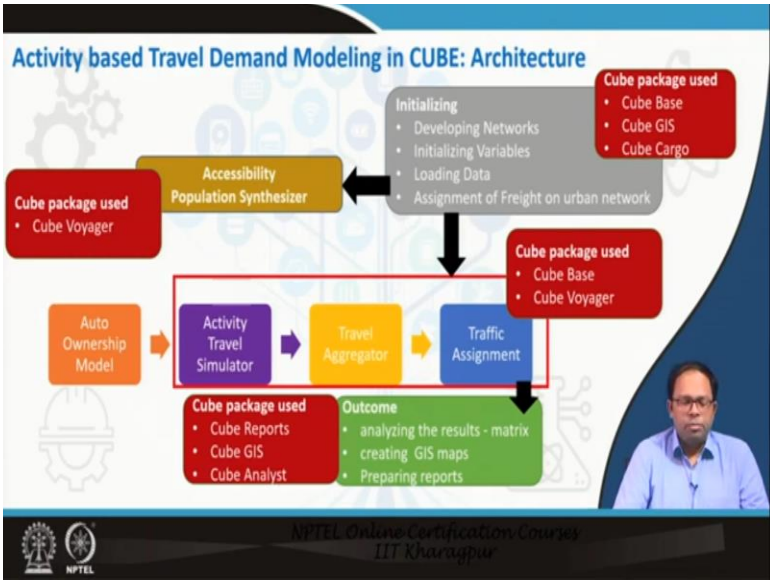

The figure shows the broad framework and the different components involved. The first task is to determine the total accessibility for a particular household. It can be done zone wise or can be also done individual wise using synthetic population.This could be done by using the cube Voyager package. The variables have to be initialized first and the network travel times have to be determined. Assignment of freight on urban network is also done. The basic data sets can be created using Cube Base, Cube GIS, and Cube Cargo and so on. This data is taken as input in the generation of the activity or in the activity-travel simulator, which based on auto ownership determines what kind of activities will be generated along with the time of the day choices, the destination choices etc. These are then aggregated for different zones, which is done by a travel aggregator. Zone to zone aggregated travels by different modes at different times of the day are finally assigned to the network. After segmentation, reports, maps and matrices can be generated which could be done by cube reports, cube GIS, and cube analyst. The activity-travel simulation is conducted using Cube Base and Cube Voyager.

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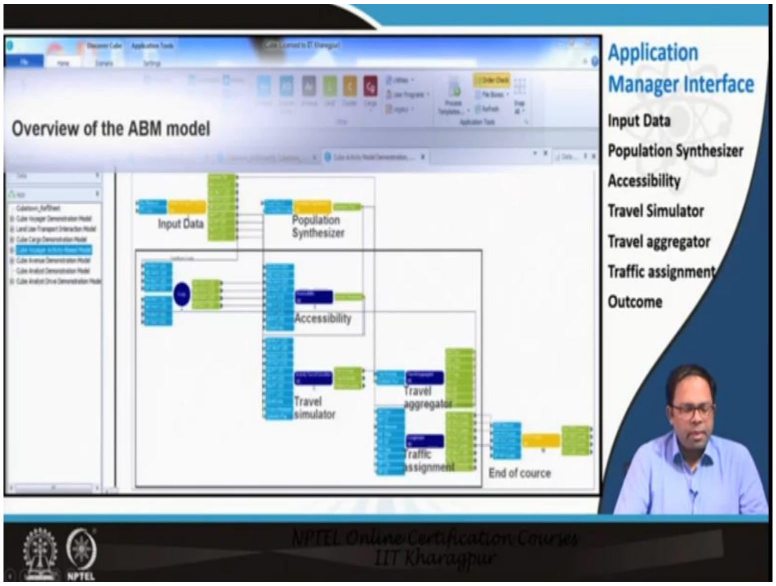

The above figure shows the demonstration model in cube. The activity based model form can be opened from cube catalog. The first step is the network. Next, there are input data, population synthesizer, accessibility estimator, travel simulator and travel aggregators. Each of these has got inputs in form of data sets or matrices and outputs as well. Once the activities are simulated, the time of the day, the tour patterns and travel are aggregated. Once travel is aggregated, reports can be generated.

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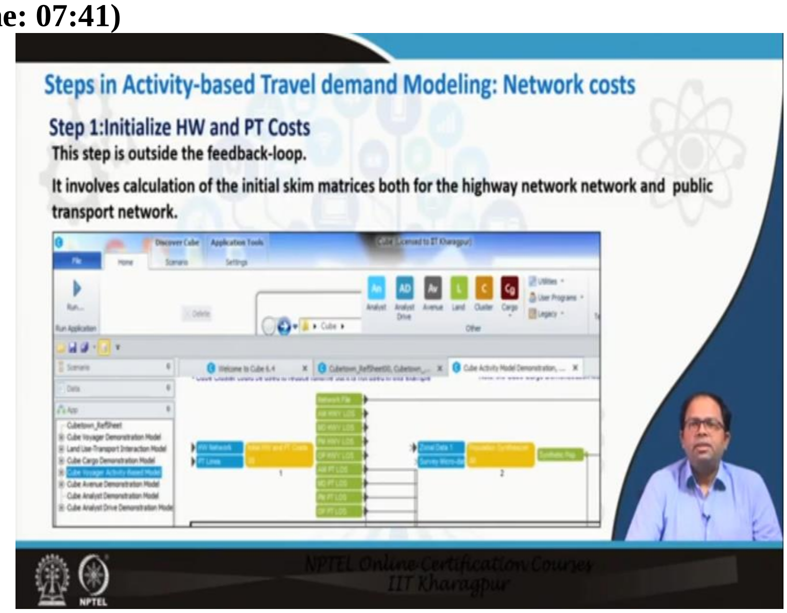

The first step is to initialize highway and PT costs. Before starting any kind of modeling, various data such as travel time between different zones(highway or the road network) or different stops(transit), travel distances, travel cost etc. are required. This is kept outside the feedback loop and not within the iterative process.This is used to calculate the initial skim matrices for highway network and public transport network. During iteration these values are updated and at one point these values become stable and results are determined.

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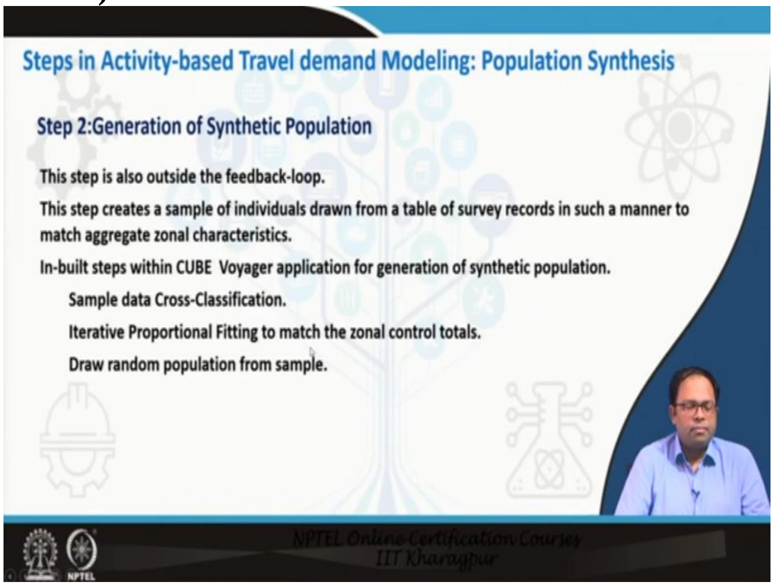

The next step is the generation of synthetic population which is also outside the feedback loop. This step creates a sample of individuals drawn from a table of survey records in such a manner to match aggregate zonal characteristics which have been discussed in module 4 in detail. At first, cross-classification data for different zones are required.

Different kinds of cross-classification can be done based on the sample data and the population can be segregated. Then, iterative proportional fitting can be used to match the zonal control totals with the survey data. Finally, a random population can be drawn from the sample which can be added to create the synthetic population till the zonal total matches. This process has been detailed out in earlier lectures. There is an in-built step in cube Voyager which can be used to generate synthetic population for activity-based models.

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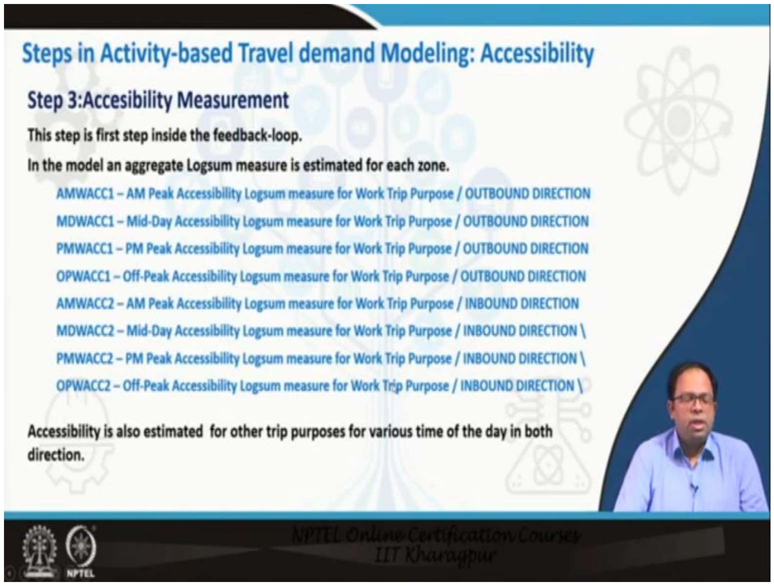

The next step is to determine accessibility. Again, accessibility can be determined in different ways. Accessibility for different kinds of trip purposes, for various times of the day and in both directions have to be determined i.e. accessibility will vary depending on the direction, as per the trip purposes and also for different times of the day. Accessibility is measured using various data such as highway schemes, the public transit schemes, and the zonal data.In this particular case, a log sum is used, but any other measure can be also used. A log sum is a composite measure which includes the travel time by different modes. In this particular case, it determines how accessible a particular zone is. The above figure shows the different accessible measures for work trip purposes. Similarly,other trip purposes are also considered.

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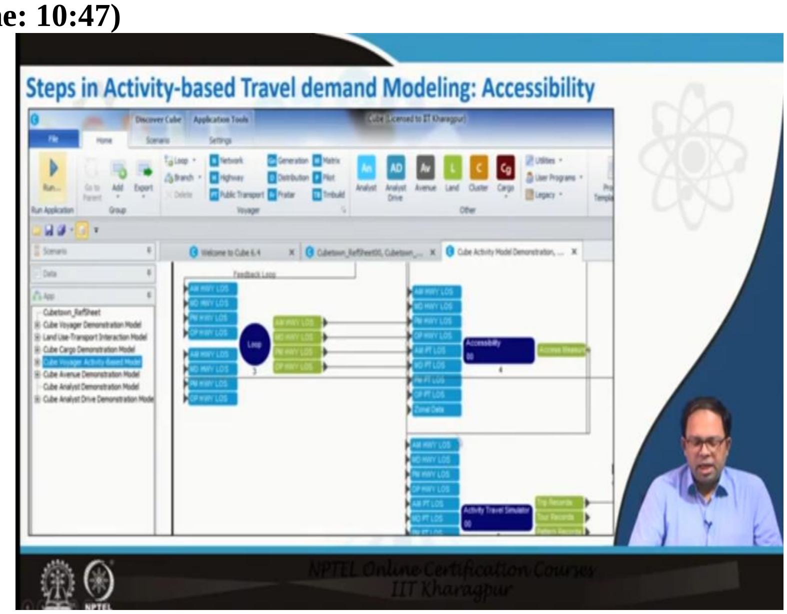

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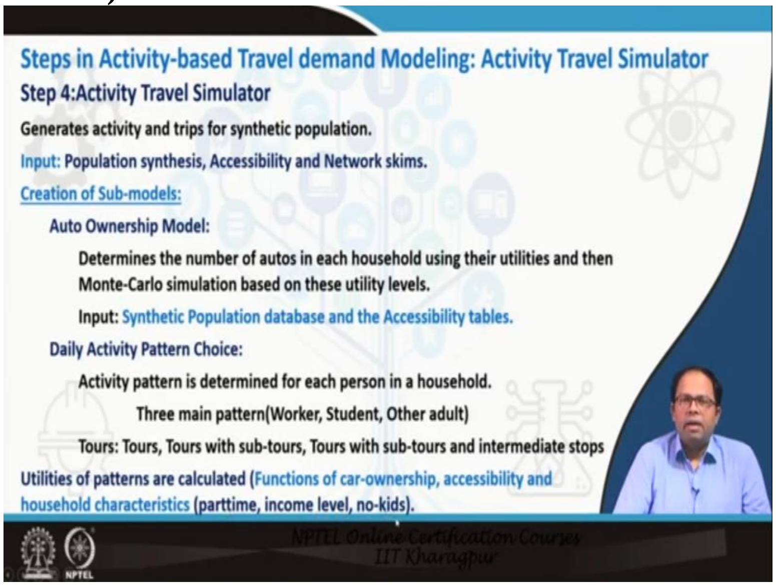

The main step is the activity travel simulator. This step generates activities and trips for the synthetic population. So, the inputs to this step are the synthetic population, accessibility values and the network schemes.

The first step is to create an auto ownership model based on the logit model. The number of autos in each household is determined using the utilities and Monte Carlo simulation based on these utility levels. In Monte Carlo simulation a random number is picked up and matched with the cumulative probability which is estimated using the utilities of those particular modes.Based on the match, a particular choice(number of vehicles) is assigned to this particular household. The input to this step is a synthetic population database and the accessibility tables which are the explanatory variables to determine the utility equation for auto ownership or vehicle ownership.

In the activity pattern choice, another set of utility equations are developed to determine the activity pattern. In this example, there are 3 main patterns and the activity pattern is chosen for each person in the household. The pattern is either he is a worker, student or adult and based on this, types of tours, sub tours, and intermediate stops are determined. Depending upon the combination several options of tours are generated for a particular individual and a particular activity pattern. Thus, utilities of these patterns will be calculated based on again explanatory variables or functions of car ownership, accessibility and household characteristics such as part-time worker, income level, having kids or not etc.

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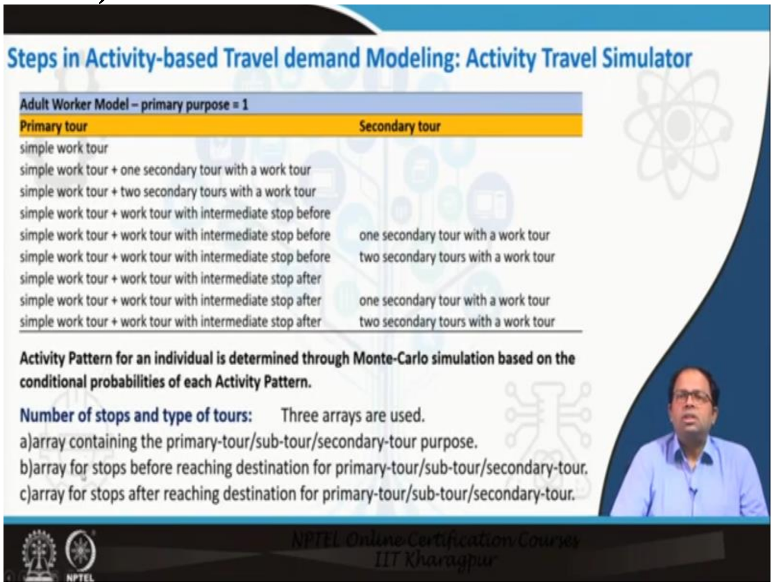

The pattern for that particular household is chosen using Monte Carlo simulation. For primary tour, there may be several options. For example, for an adult worker and for primary purpose, there are many ways a tour pattern can be generated like he can just do a simple work tour or he can do a simple work tour plus one secondary tour with a work tour. For better understandings of primary and secondary tour concepts, the reader may go through module 12.

Usually, a person does a primary activity and then there are discretionary activities and secondary activities during an entire day. One can also do like simple work tour, plus a work tour with intermediate stops plus 1 secondary tour with the work tour, and so on. Different combinations are possible and each of these alternatives has got a utility which can be used to calculate probability. Then using Monte Carlo simulation, it can be determined what pattern or tour a particular person will choose. Next, this data is stored in 3 arrrays. One array contains the primary tour, sub tour or secondary tour, the second array contains the stops before reaching the destination for each of these tours and the third array contains stops after reaching the destination for primary tours. Thus, there can be a primary destination and a secondary destination and in between different stops can be chosen. So, this choice of stops is modeled similar to choice of pattern or tour based on different utilities for different kinds of individual.

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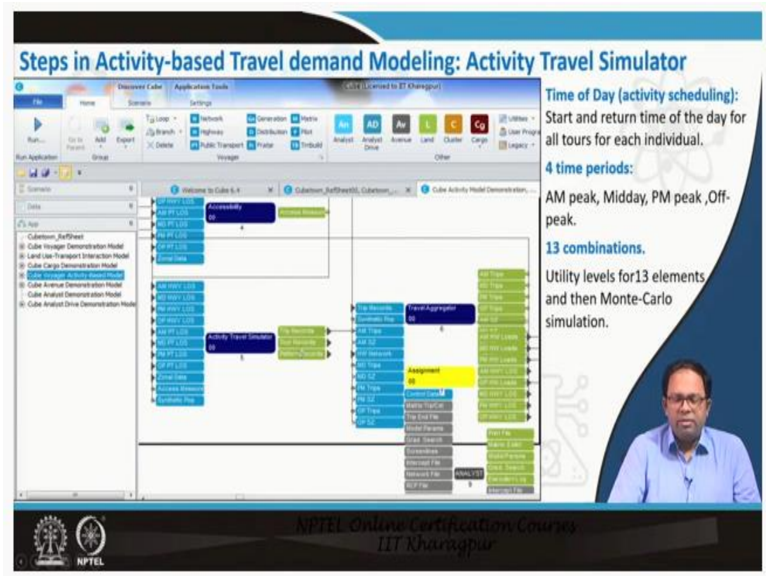

The output from the activity-travel simulator are trip records, tour records, and pattern records. This output goes into the travel aggregator where all these data sets are aggregated. After determining the tours it is important to determine at what time of the day that tour starts and ends. There may be different time periods, like 4 time periods as in this particular example, like AM peak, midday, PM peak, off-peak or it could be even time periods of every five minutes or every 30 minutes. Depending on this activities start at a certain time and end at a certain time. Thus, if both of them are taken together, i.e., a combination of start and end periods, there will be 13 combinations. So, each of these combinations has got a utility for a particular individual. Then again using Monte Carlo simulation, the start and end period or rather the combination of start and end period for a particular tour for this particular individual can be found.

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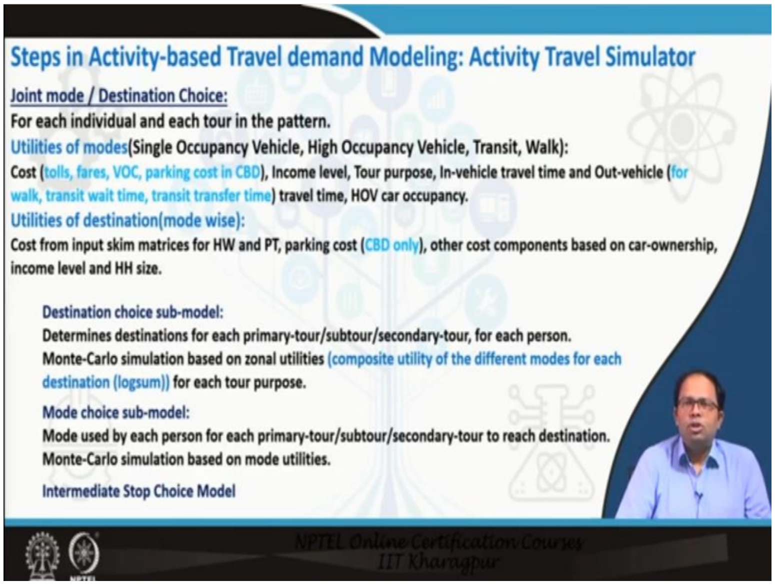

The next step is to determine the joint mode and destination choice i.e. the mode used by each person for each primary tour, sub tour, or secondary tour to reach a particular destination. This choice of mode is conditional on what tour one is doing and this is again determined using Monte Carlo simulation. Similarly, destination can be determined as a choice as well.

Destination choice is determined for different kinds of tours, sub tours, secondary tours, and so on using Monte Carlo simulation. Zonal utilities are used where the composite utility of the different modes for each destination log sum are considered. Hence, this is a nested choice model. So, the log sum measured from the mode choice is used in the destination choice model. This is conditional and the mode choice is conditional upon that destination choice.

For each individual and each tour pattern utilities for different modes are considered such as a single-occupancy vehicle, high occupancy vehicle, transit, walk etc. and the different utilities are measured using the cost for tolls, fares, parking costs, income level, tour purpose, in-vehicle travel time, out of extra travel time and so on. Utilities of destination choice can be determined based on costs estimated for input skim matrices for highway and public transit trips, parking cost, and other cost components based on car ownership, income level, and household size. Next, is the intermediate stop choice model.

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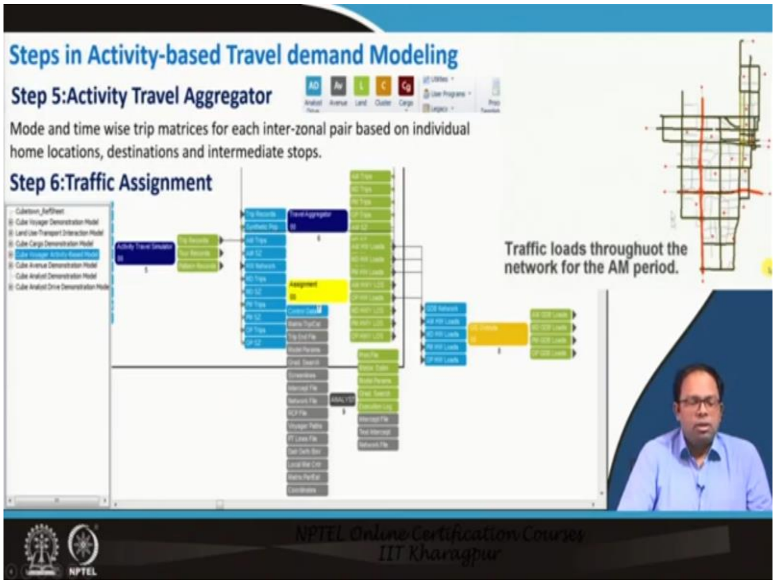

The next step is to aggregate all this which is done by an activity-travel aggregator. All the inputs such as trip records, synthetic population, AM trips, AM highway networks, PM trips are used to do traffic assignment.

The data is divided as per the different time periods and different car occupancies. Traffic loads are determined throughout the network for the AM period, PM period, and so on.

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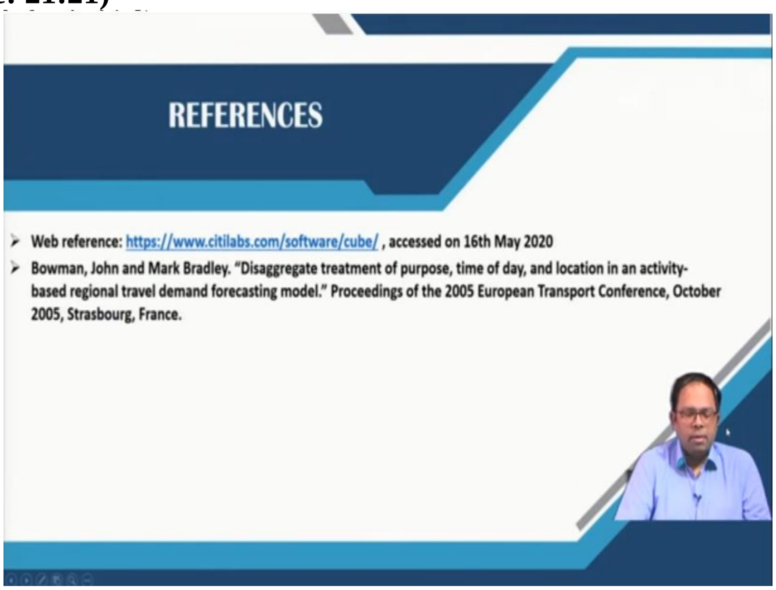

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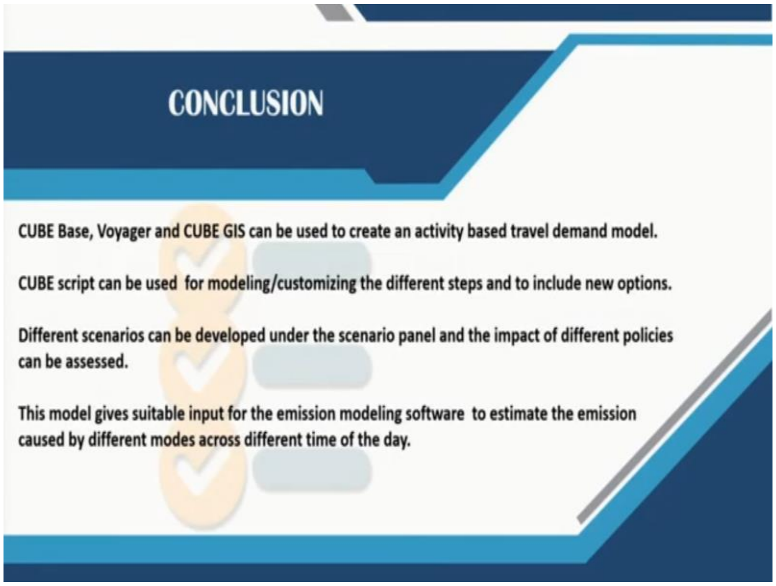

The references are mentioned in the above figure.

Conclusion

Cube base, Voyager, and cube GIS can be used to create an activity-based travel demand model.

Cube script can be used for customizing the different steps and to include new options.

Different scenarios can be developed under the scenario panel and the impact of different policies can be assessed.

This model gives suitable input for emission modeling software to estimate emissions caused by different modes across different times of the day.

Thank you.