Urban Landuse and Transportation Planning
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Lecture - 47
CUBE Overview

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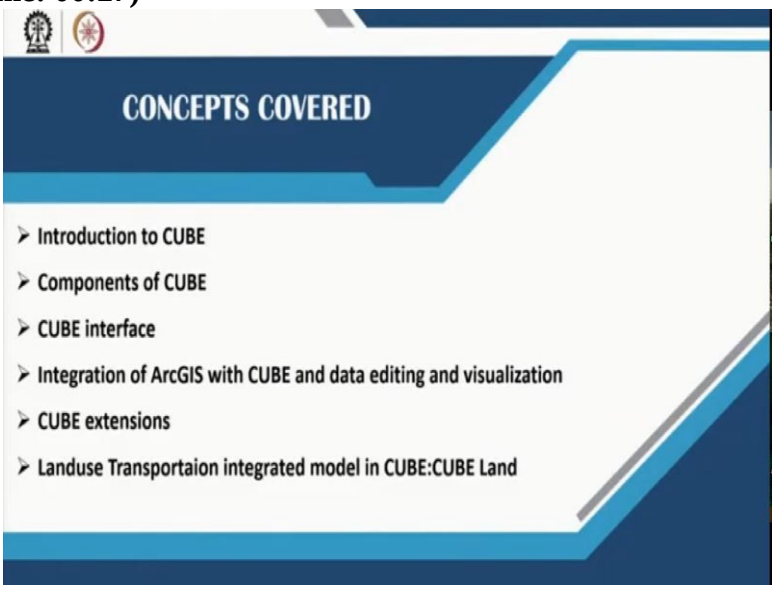

Welcome back. In lecture 47, the contents that will be covered include introduction to the cube software, components of the cube software, CUBE interface, integration of ArcGIS with CUBE, CUBE extensions and Landuse transportation integrated model in cube using CUBE land.

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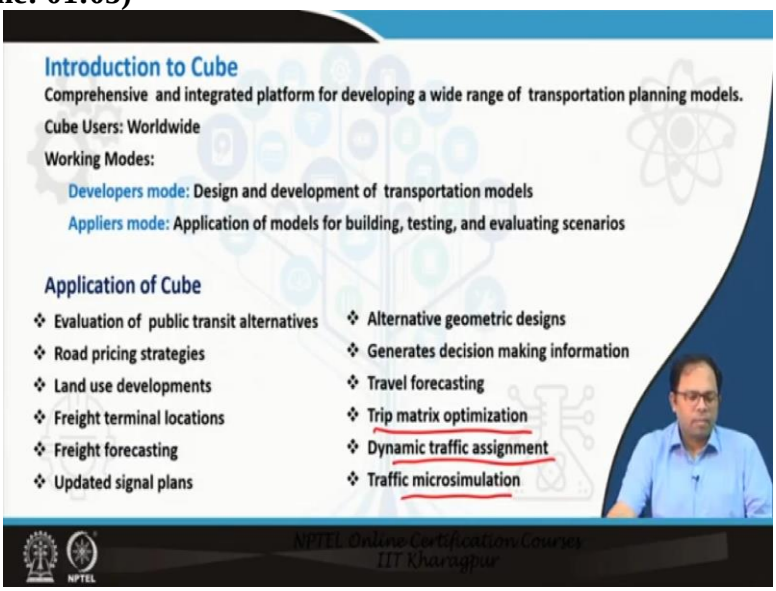

Introduction to CUBE

CUBE is a comprehensive and integrated platform for developing wide range of transportation planning models. It consists of many components and different types of analysis required for overall transportation planning work can be undertaken. It is a popular model which is used worldwide and is used in India as well.

There are 2 working modes in which we can work such as:

- Developer mode
- Applier mode.

Developer mode is where one can design as well as develop the transportation model. Appliers mode is where the model can be applied for building, testing and evaluating different scenarios and eliminates the need for everyone to build a model. People who are capable of developing models or calibrating models can use the developer's mode, whereas people who want to apply a specific model to test some scenarios or understand the effect of a certain temporary restriction etc., can adopt the applier's mode.

Application of CUBE

Evaluation of different public transit alternatives.

Road pricing strategies – CUBE can be used to decide on different strategies.

Land use developments - can be tested to know its effect.

Location of freight terminals - For example, if a freight terminal is relocated, what effect will it have. Freight terminal location actually determines the cost incurred to a particular company based on the distribution of different retail outlets in that particular area. If there are 3 alternatives identified for terminal location and if one alternative has to be identified as the most beneficial one, it can only be done if the distribution happening from those terminal locations could be modeled by the software. For instance, consider a vehicle distributing soft drinks from a bottling plant, a restocking tour would probably be adopted to explain movement from one retail store to another and has to be modeled in one go. So, location of terminals or warehouses or industries plays a role in the trips that would be generated.

Freight forecasting – Different models could be used in CUBE such as the commodity based model, truck based model etc. which is similar to passenger travel demand model. Truck

travel demand model considers trucks serving different locations, whereas, commodity flow model considers how commodities come in and go out of different zones which eventually generate the truck flows etc.

Updated signal plans - One can update signal plans based on its effect.

Alternative geometric designs

Generate decision making information - Policy valuation tools can be used to understand the impacts.

Travel forecasting

Trip matrix optimization.

Dynamic traffic assignment and

Traffic micro simulation could be also undertaken using cube.

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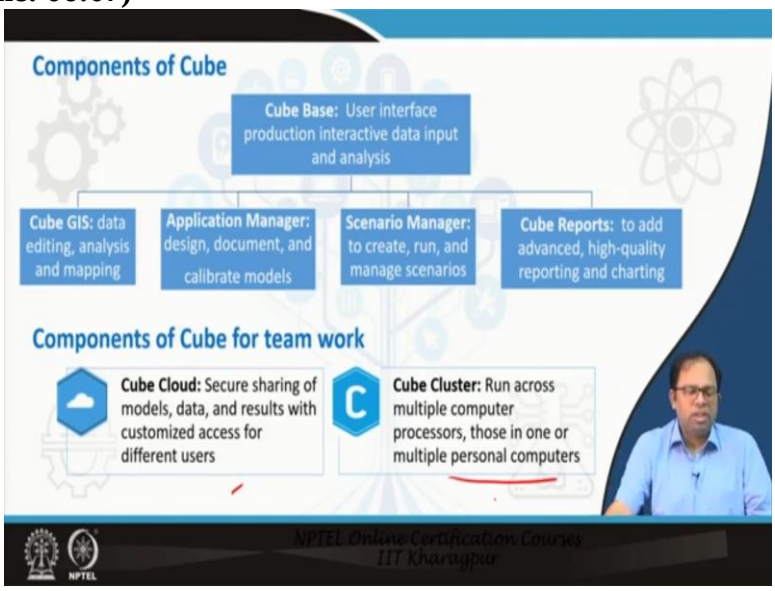

Components of CUBE

The basic component of cube is CUBE base. It has a user interface through which detailed data editing and analysis can be done. It can call *CUBE GIS* using which data editing, mapping, development of the networks etc. are possible. *Application manager* can be used to design and calibrate the model, that is, to do necessary changes to the model which are already there based on the requirement. *Scenario manager* helps to create, run and manage

different scenarios. There is *CUBE reports* to add advanced, high quality reporting and charting.

Components of CUBE for teamwork

Cube cloud - Models can be shared using CUBE Cloud where different users can have different level of access

Cluster based model - *C*luster actually helps to increase the simulation or the computational capacity by running across multiple computers and thus reduces the cost.

These features are not available in many other software.

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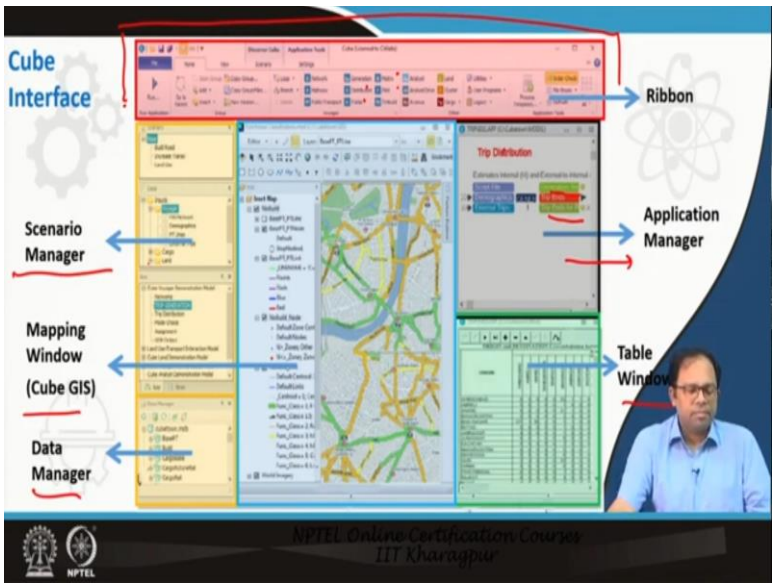

CUBE Interface

Ribbon - The topmost part from where different things are controlled, consisting of Generation, Distribution, Fratar, Matrix etc.

Application manager - *S*hows the framework that is used, the different components currently in use and how these are linked, the different scripts that are being utilized, the trip generation and trip end details, as well as the trip distribution component.

Mapping window - This window shows the data that is shown in the map.

Data manager - Connects the data and databases.

Scenario manager

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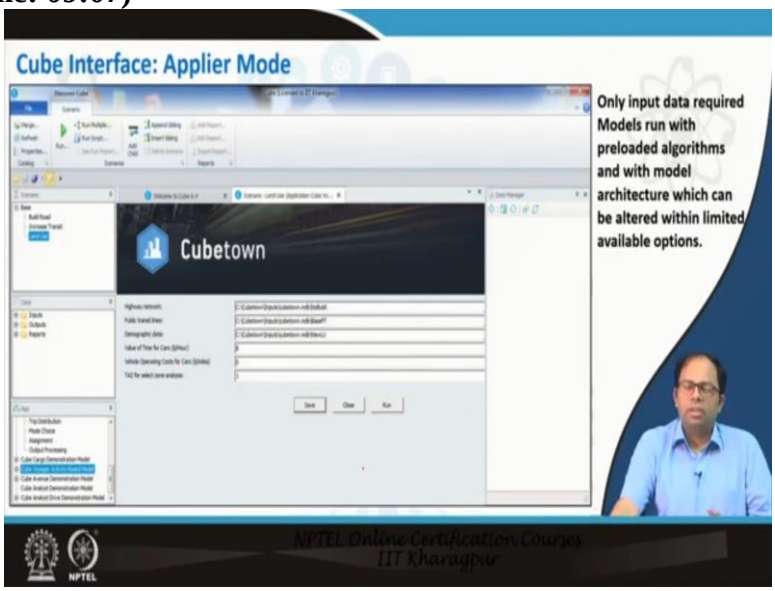

CUBE Interface – Applier mode

In the the applier mode, the data required can be input and the models can be run with pre-loaded algorithms and allows limited alterations within the same model architecture. The input data includes the highway networks, public transit lines, demographic data etc. Thus, running CUBE in applier mode uses the existing model system that is already developed.

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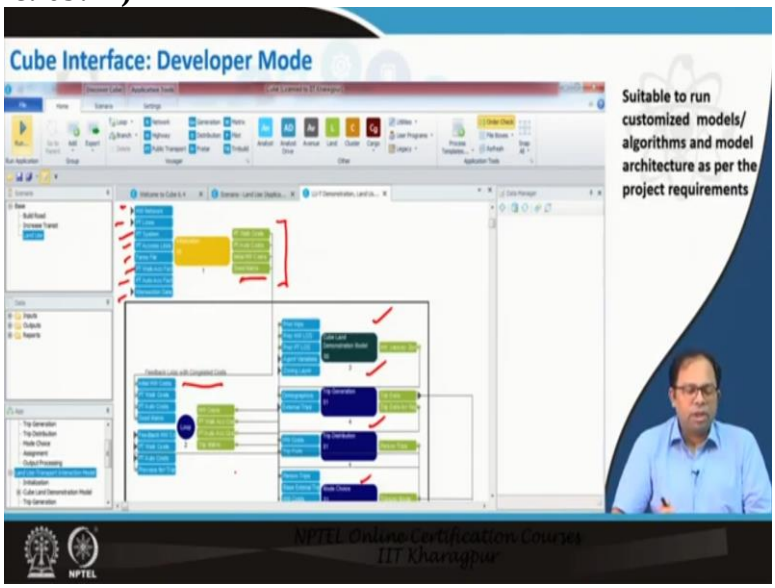

CUBE Interface –Developer mode

When it is run in developer mode, the entire framework is visible including the data such as the highway network data, PT lines, public transit lines, public transit system, public transit access links, access to the different stations, fares, public transit walk access, public transit

auto access, intersection data etc. The impedance files on public transit, walk, auto, highway cost and seed matrix are also considered. Then, there is the Feedback loop which considers different parameters like congestion cost based on which values are updated. So, using all these, CUBE land, trip generation, trip distribution, mode choice etc. can be modelled. As the entire framework is visible, one can understand how different data are connected, which data is used for what, and also enables easy modification. One can click on each of them and can get details, modify corresponding parameters and model structure. So, this is suitable to run customized models, algorithms and model architecture as per the project requirements.

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CUBE Interface –CUBE Catalog

This contains the help files and resources to learn the system.

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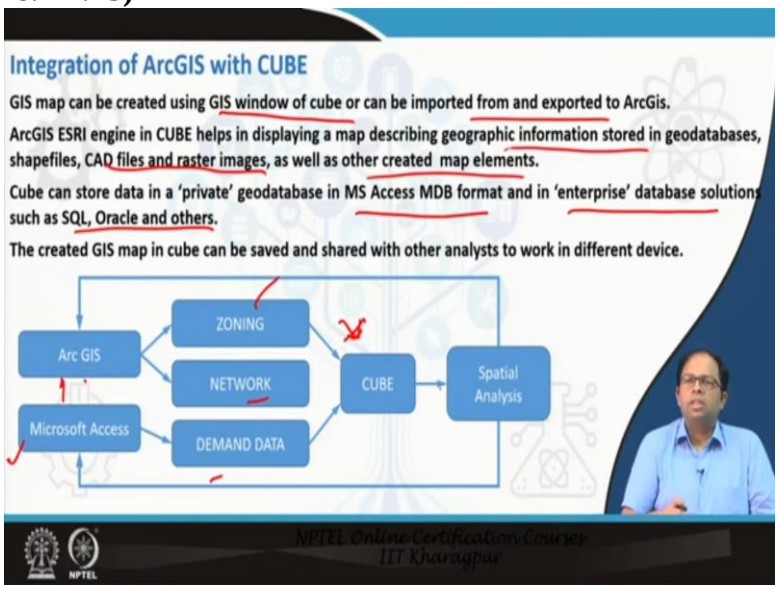

Integration of ArcGIS with CUBE

CUBE uses the ArcGIS engine for mapping. Shape file or a map can be prepared in ArcGIS and then imported back to cube and vice versa using the GIS window of cube. ArcGIS ESRI engine in CUBE helps in displaying the map describing geographic information stored in geo databases, shape files, CAD files, raster images, as well as other created map elements. Hence, most of the capabilities of ArcGIS are available in CUBE.

In addition to the GIS integration, CUBE can also store data in 'private' geodatabase in MS Access MDB format and in 'enterprise' database solutions such as SQL, Oracle and others. So, when there is a need to handle large amount of data, relational database management systems (RDBMS) can be relied upon. The created GIS map in CUBE can be saved and shared with other analysts to work in different devices. MS Access is a full-fledged database and can link different tables for complex query search. For example, the different tables could involve the list of households, list of individuals, etc. linked with an ID. This can enable complicated query; for example, searching a person whose income belongs to a particular category or categorizing different socio economic groups in different complicated ways. So, once the related tables are prepared in MS Access, it could be linked with ArcGIS. So, all these together form the database for spatial representation. Data on travel demand and socio economic characteristics, etc. can be stored in Microsoft access whereas the data on the administrative zones, the network data, nodes etc. can be stored in ArcGIS. Different CUBE platforms such as the CUBE base, CUBE Voyager etc. can use all the data from the different software. Spatial analysis can be done and then the models can be run to get results of travel demand, vehicle flows in different corridors or links etc.

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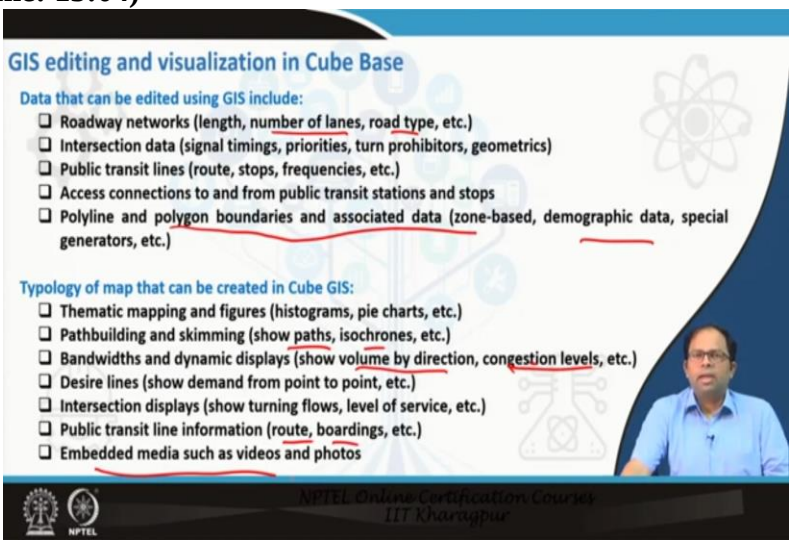

GIS editing and visualization in CUBE Base

Data that can be edited in GIS include:

- *Roadway network data* - including length of the roadways, number of lanes, road types etc. *Intersection data* – which involves signal timings, priorities, turn prohibitors, geometry of the intersection etc.
- *Public transit lines* - the route, the stops, frequencies of public transit buses
- *Access connection to and from public transit station and stops*
- *Polygon boundaries, polyline boundaries and associated data* – zone-based, demographic data, special generators etc.

Typology of maps that can be created in cube GIS includes

- *Thematic mapping and figures* - using histograms, pie charts, etc.
- *Path building and skimming* - show paths, isochrones etc.
- *Bandwidths and dynamic displays* - show volume of by direction, congestion levels, etc. Different levels of volume can be represented by increasing the width of the link, similarly, congestion levels can also be represented.
- *Desire lines* – show demand from point to point etc.
- *Intersection displays* – shows turning flows, level of service etc.
- *Public transit line information* - route, the number of boarding etc.
- *Embedded media such as videos and photos*

So, it not only allows creation of data, using data from shape files, or from sub databases, but also, does the analysis of data. After analysis, the findings can be represented using thematic maps, histograms etc.

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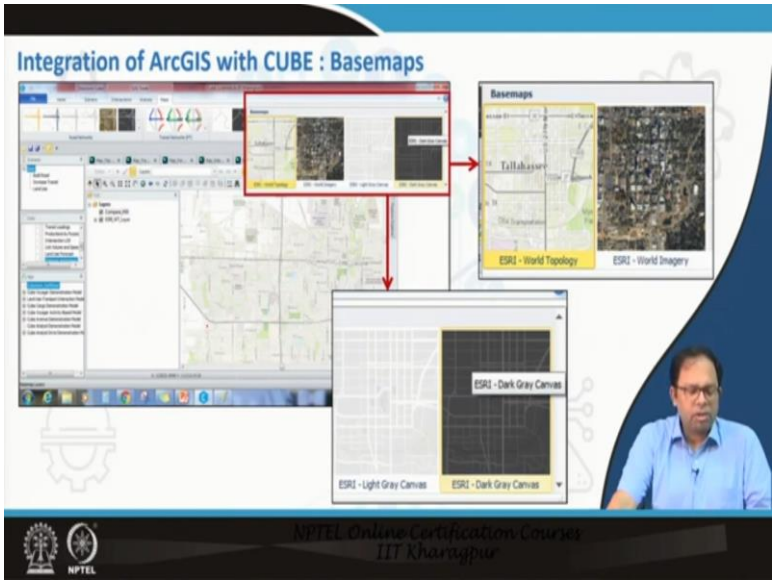

Integration of ArcGIS with CUBE - Basemaps

As shown in the above figure, base maps, satellite imagery, street maps, etc can be imported directly to the software.

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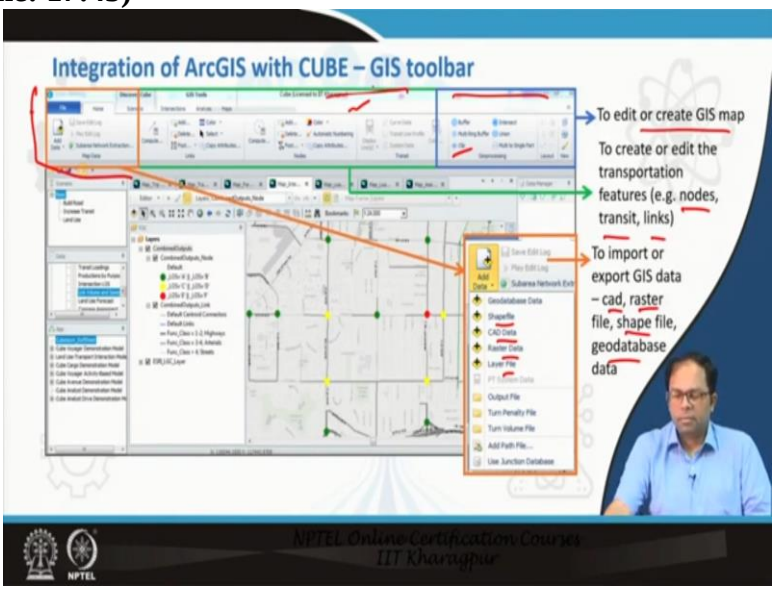

Integration of ArcGIS with CUBE – GIS toolbar

In the above figure, the left top rectangle drawn indicates the provision for import and export of GIS data, CAD files, raster files, shape files, geodatabase data, etc and enables direct import to CUBE. One can create and edit the transportation features like nodes, transit links, etc. Also, GIS maps can be created as well as edited in CUBE.

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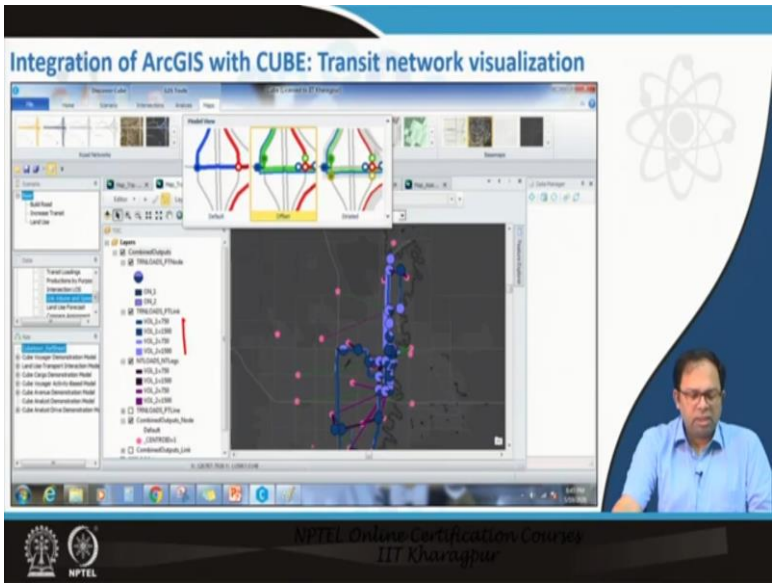
Integration of ArcGIS with CUBE – Transit network visualisation

So, the following figure shows how transit network can be visualized. The volumes, the total loads at different points etc. can be visualised by different representations.



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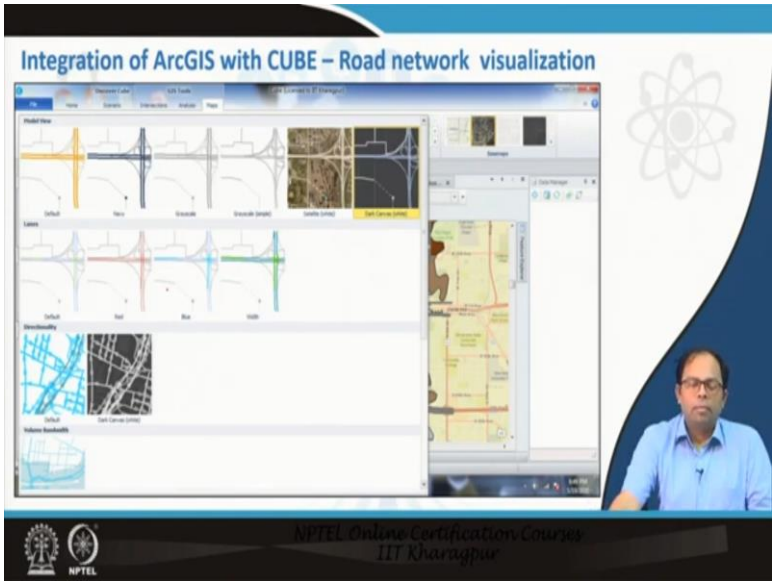
Integration of ArcGIS with CUBE – Road network visualization



The above figure shows how visualizing of the different roads can be achieved by indicating volume bandwidth, directions, etc.

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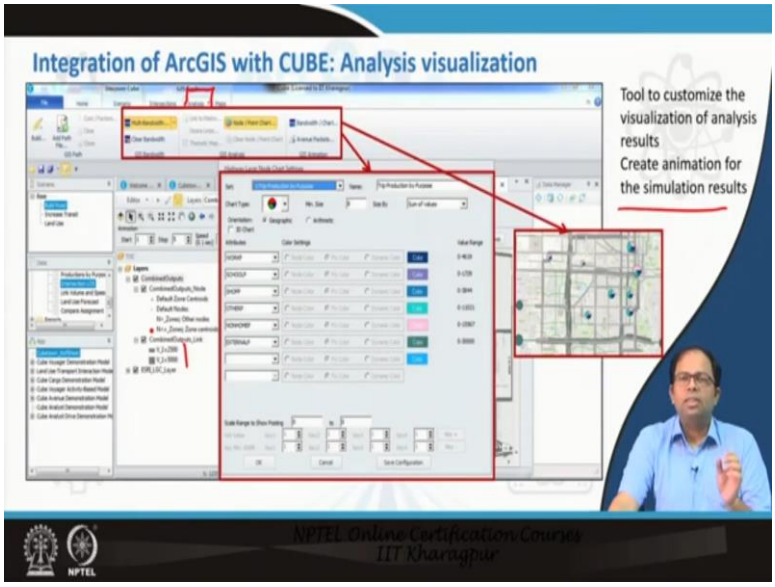
Integration of ArcGIS with CUBE – Analysis visualization



Thematic maps can be generated based on analysis and findings. In the above figure, different widths are indicative of different volumes, as you can see over here. Along with that, the the percentage share of different kinds of trips like walk trip, school trips, can be shown for the different links. One can create animation for the simulation results as well.

The scope of the lecture is to introduce the capabilities of the interface rather than addressing each of the features in detail.

Integration of ArcGIS with CUBE – Other features

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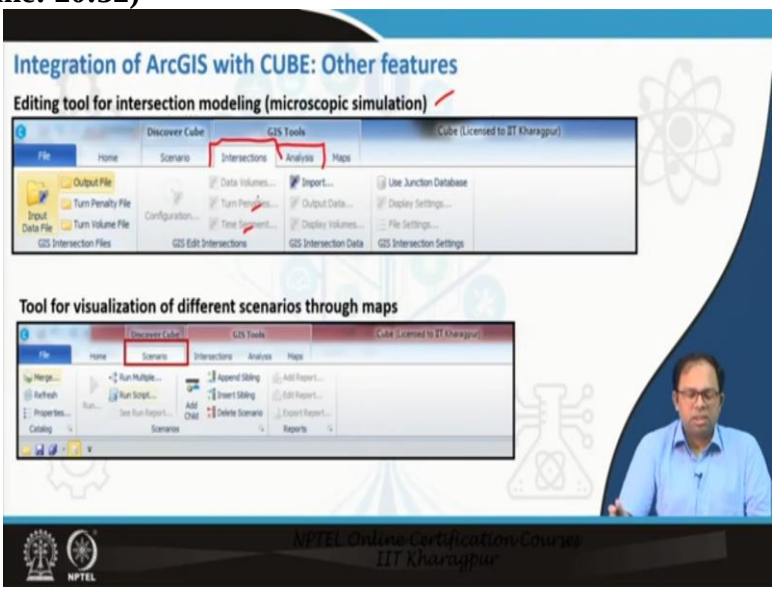

There are editing tools for intersection modeling corresponding to microscopic simulation, using which data such as volume, turn penalties, time segments, etc can be input. Different scenarios could also be modelled.

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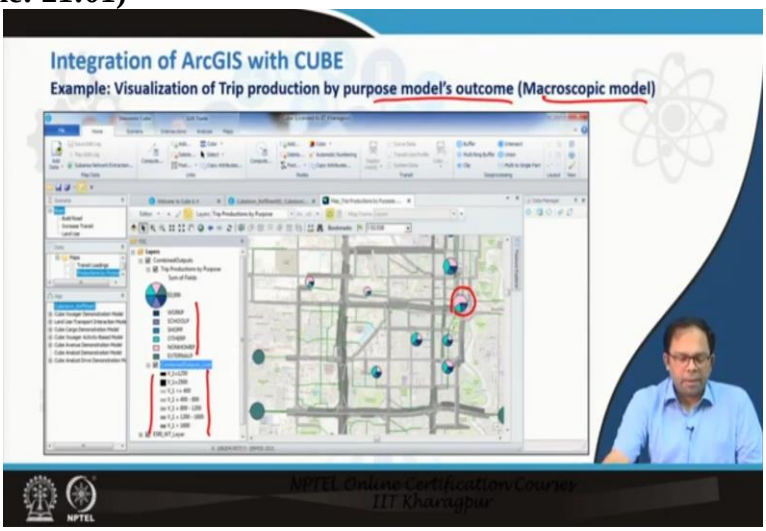

Integration of ArcGIS with CUBE – Examples

The above figure shows the visualization of trip production by purpose based on the macroscopic model. Different trip purposes and its share including the school trips are seen in the image. Different volumes are indicated using different color gradients.

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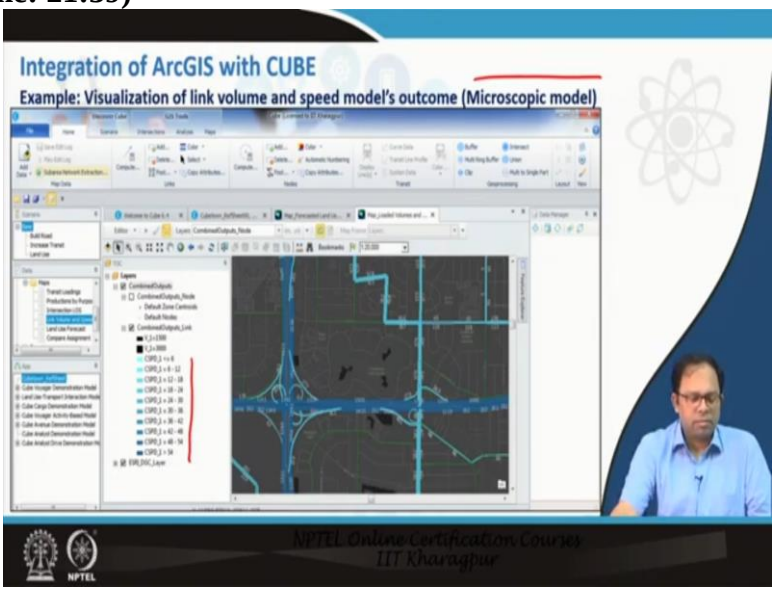

The above figure shows how one can visualize the link volume and speed corresponding to a microscopic model. This shows the varying congestion levels on different road links easily.

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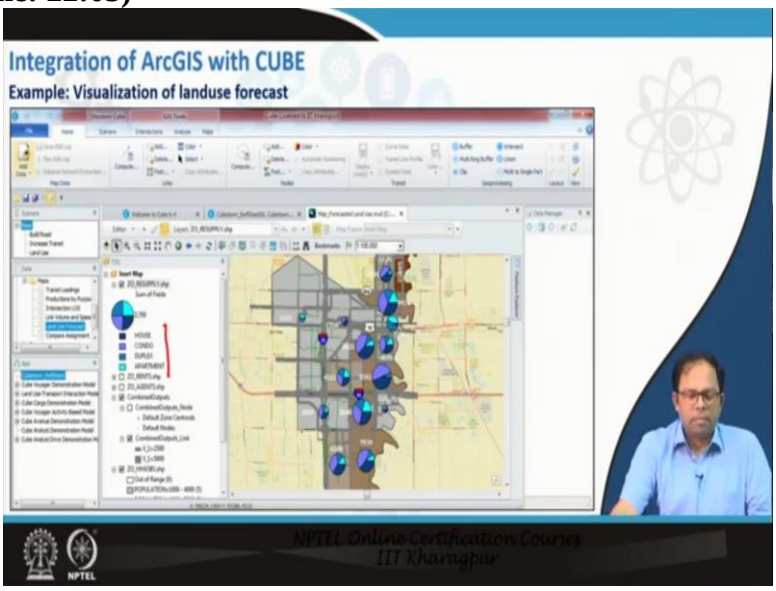

The above figure shows the visualization of the land use forecast. It shows the share of houses, duplex and apartment in those different zones.

CUBE Extensions

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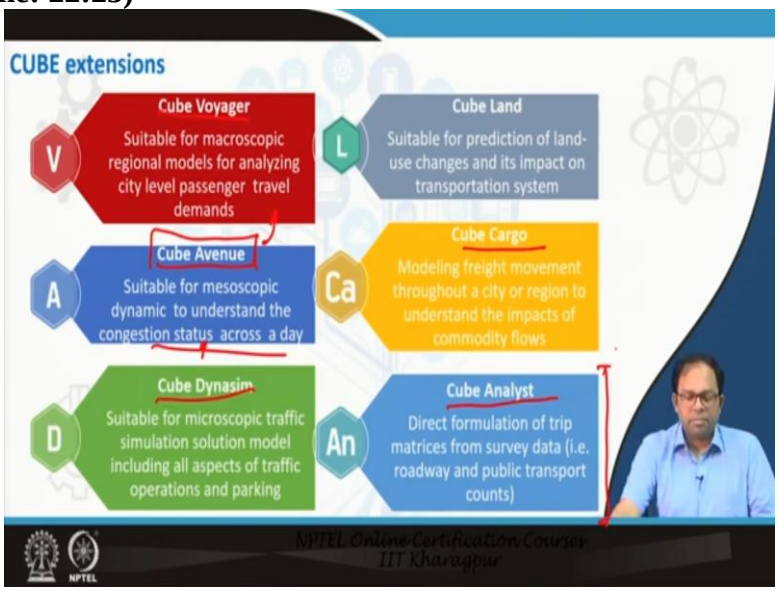

Apart from cube base, there are different components.

CUBE Voyager - It is suitable for macroscopic regional models for analyzing, city level passenger travel demands.

CUBE dynasim - for the microscopic traffic simulation.

CUBE avenue - which is the mesoscopic model and helps to understand the congestion status across a day. Cube avenue is very detailed. Many of the features of a microscopic model could also be done using cube avenue. It can be used for dynamic assignment. It also helps to generate specific data, which goes as a feedback to the cube voyager model.

CUBE land - is suitable for prediction of land use changes and its impact on transportation systems

CUBE cargo - which enables modelling of freight movements throughout a city or region and to understand the impacts of commodity flows.

CUBE analyst - which is a direct formulation of trip matrices from survey data, i.e., roadway and public transport counts. So, if it is not possible to do travel demand surveys or travel diary surveys and an existing model is already present, based on data corresponding to the surveys done earlier, there is provision to update the model. This can be done by getting data related to a limited number of road stretches and putting it in the data sets in the CUBE analysts.

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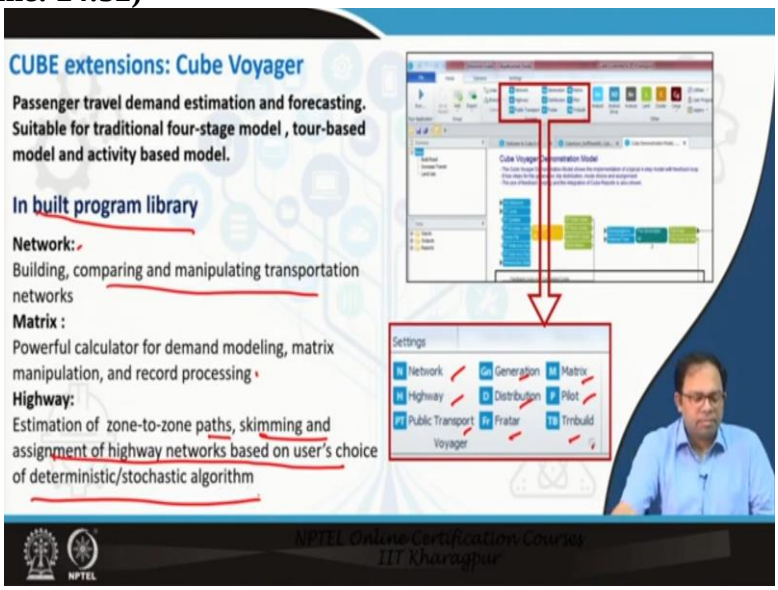

CUBE Extensions – CUBE voyager

One can do travel demand estimation and forecasting using CUBE voyager using 4 stage model, tour based model and activity based models.

In built program library:

It consists of network, highways, public transport, generation, distribution, fratar, matrix, plot, turn build. Other associated features can be accessed by clicking on the mentioned ones. So, these are the different inbuilt program libraries for the CUBE voyager. Different components can be build using this.

Network – building, comparing and manipulating the transportation networks.

Matrix - powerful calculator for demand modeling, matrix manipulation and record processing.

Highway - which estimates zone to zone paths, skimming and assignment of highway networks based on users choice of deterministic and stochastic algorithms. Using this, assignment is done to the highways.

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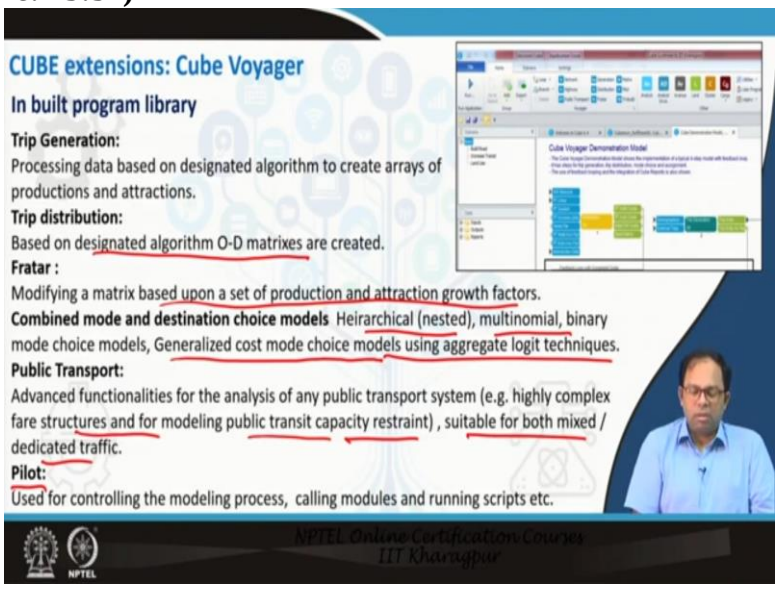

Trip generation – for processing data using algorithms to create arrays of productions and attractions for different zones.

Trip distribution - based on the designated algorithms, OD matrices can be created.
Fratar - modifying a matrix based on a set of production, and attraction growth factors. Based on these factors iterative modification can be done to arrive at an OD matrix.

Combined mode and destination choice models - Hierarchical (nested), multinomial, binary mode choice models, generalized cost mode choice models using aggregate logit techniques.

Public transport - Advanced functionalities for the analysis of any public transport system (eg: highly complex fare structures for modeling public transit capacity, different capacity restraints based on the public transit capacity restraint), suitable for both mixed and dedicated traffic.

Pilot - Used for controlling the modeling process, calling models and running scripts. As mentioned earlier, while discussing land use transport frameworks, a central controller controls and gives instructions related to their sequence of running for different models such as the real estate model, location choice model, traffic model etc. A pilot controls the modelling process. It helps in linking up the different modules or the components and how the data flows between these particular components.

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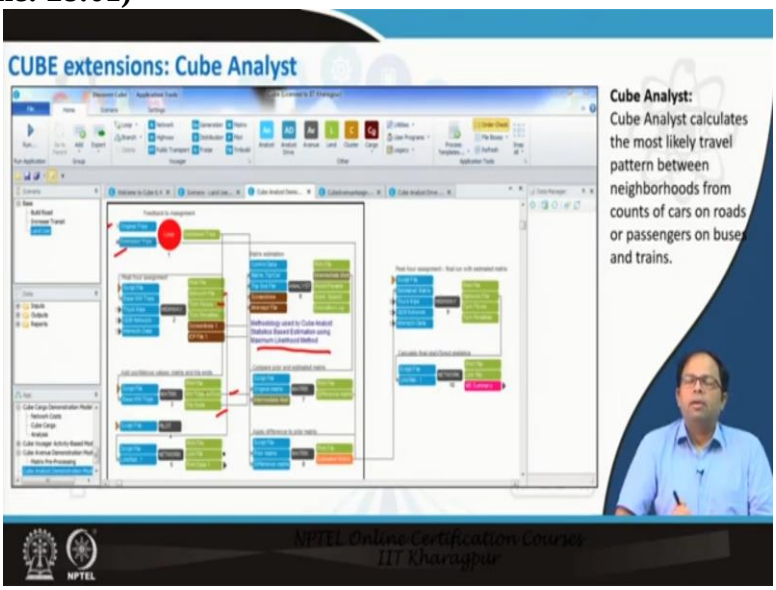

CUBE Extensions – CUBE analyst

Cube Analyst calculates the most likely travel patterns between neighborhoods from count of cars on roads or passengers on buses and trains. Thus, if such data are available and loaded, then, the travel pattern from one neighborhood to another or from one zone to another is given automatically. In order to achieve this, different data such as a network file, original trips, estimated trips etc. have to be loaded. Different methods such as a static method or a maximum likelihood method is utilized. Based on flows, generation at different zones etc. can be determined. This is done based on probabilities.

In order to generate the OD matrices, different data have to be entered involving the turn flows at different intersections, network flows, highway trips, trip ends, etc. Trip ends can refer to a shopping mall or any other facility; surveys of such facilities can be done to understand how many trips lead to those locations. Highway flows can be obtained by surveying at screen points.

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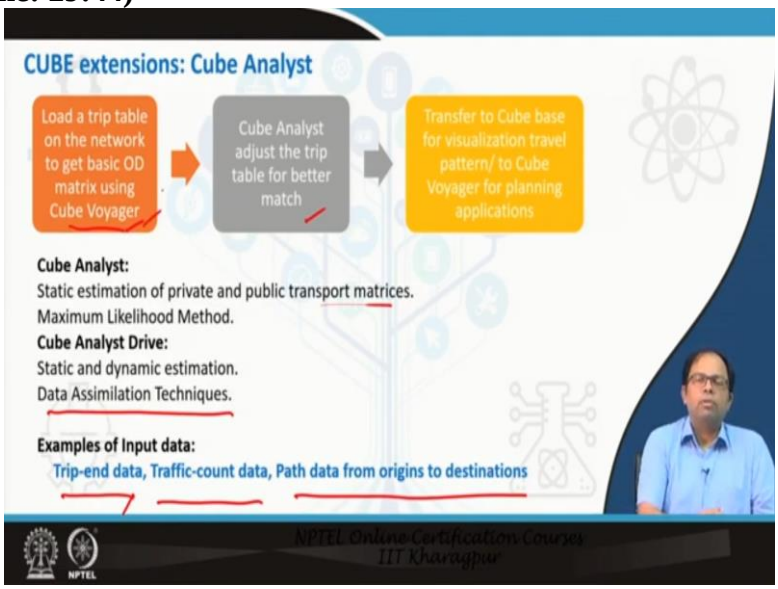

The first step is to load a trip table on the network to get basic OD matrix using CUBE voyager. If this is done, then CUBE analyst can adjust the trip table for better match with the actual observed values. Then, the data can be again transferred to CUBE base for visualization of travel pattern or to CUBE voyager for planning applications.

CUBE analyst does static estimation of private and public transport matrixes using maximum likelihood method whereas, using *CUBE analyst drive*, both static and dynamic estimation can be done using data assimilation techniques. These are the 2 techniques that are being used.

The input data required for modifying OD matrices involve trip end data, traffic count data, and path data from origins and destinations. These modified OD matrices, could be integrated with the forecast to make the model more robust and to match the condition that is observed in the network.

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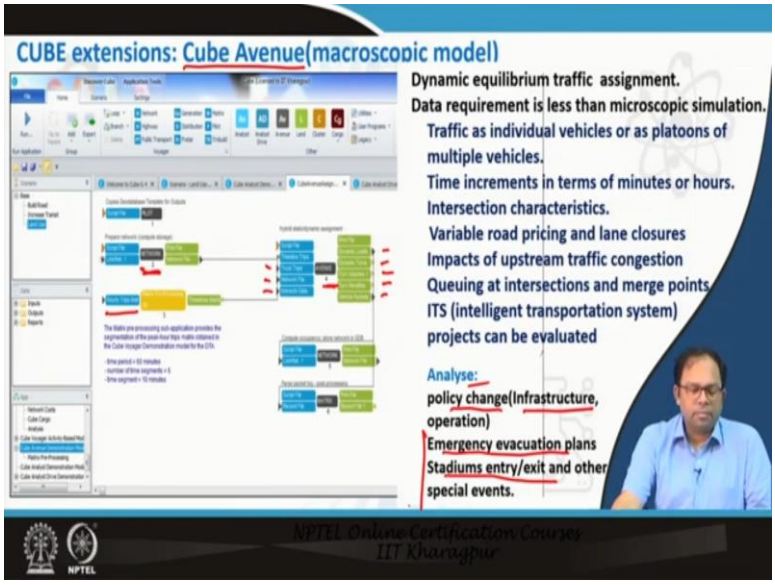

CUBE Extensions – CUBE avenue

This is for doing the macroscopic model for cube. However it has many capabilities almost similar to a microscopic model. CUBE avenue is essential to undertake dynamic traffic assignment.

Data requirement is less than microscopic simulation. Traffic can be considered as both individual vehicles and platoons of multiple vehicles and time increments can be considered in terms of minutes or hours. Change in the traffic conditions over minutes or hours can be known. Intersection characteristics, variable road pricing, lane closures can also be modeled, Impact of upstream traffic congestion, queuing at intersections and merge points if there is upstream traffic congestion etc. can be modelled. Shockwave can be modeled, to indicate the decrease in speeds in the downstream corridors. ITS components can also be incorporated.

In the interface, truck trips, intersection data, network file, etc. can be put in. Dynamic loads, dynamic turns, turn volumes, etc. can be predicted and based on that hourly trip matrix is estimated which is further used for assignment based on network, impedance, feedback etc.

Analysis

- *Policy change analysis* – For example, if there are certain change with respect to infrastructure, its effect can be understood.
- *Emergency evacuation plans* - Emergency evacuation plan and its effect can be predicted using models.

- *Stadium entry/exit and other special events* - cn be also modeled for its effect on the network.

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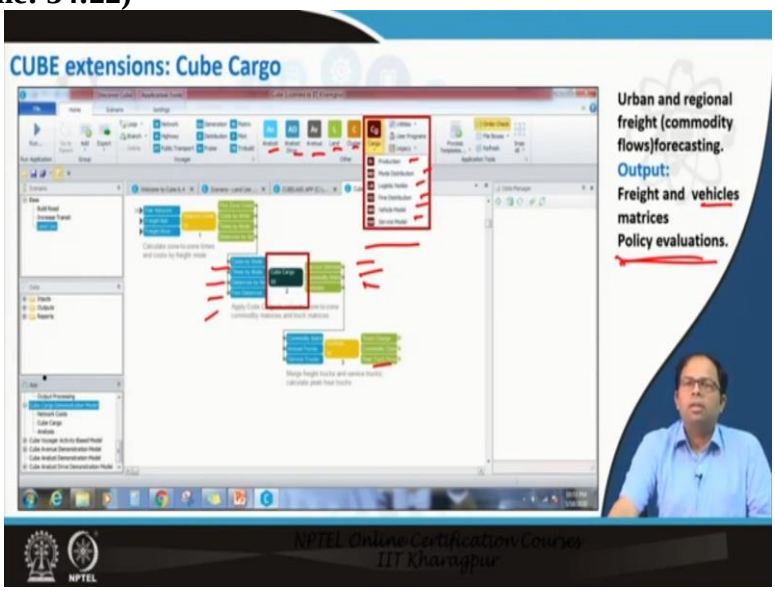

CUBE Extensions – CUBE cargo

Production Mode distribution, Logistic nodes, Fine distribution, Vehicle model and Service model are the different components of the CUBE cargo. Cost by modes, times by modes, distances by modes, and fine distances are considered and then, service vehicles, commodity matrix and vehicles are considered. The commodity matrix can be used to determine the total peak truck flows and the vehicles that can be used for this distribution. Urban and regional freight (commodity flows) can also be forecasted using CUBE cargo. The output involves the freight and vehicles matrices and policy evaluations. Freight refers to the total amount of commodity that flows between different zones and the total vehicle matrices shows the vehicles resulting from freight flows. So, commodity is not same as vehicles because the commodity has to be converted into both vehicles as well as the number of trips undertaken by a vehicle and also based on the number of zones.

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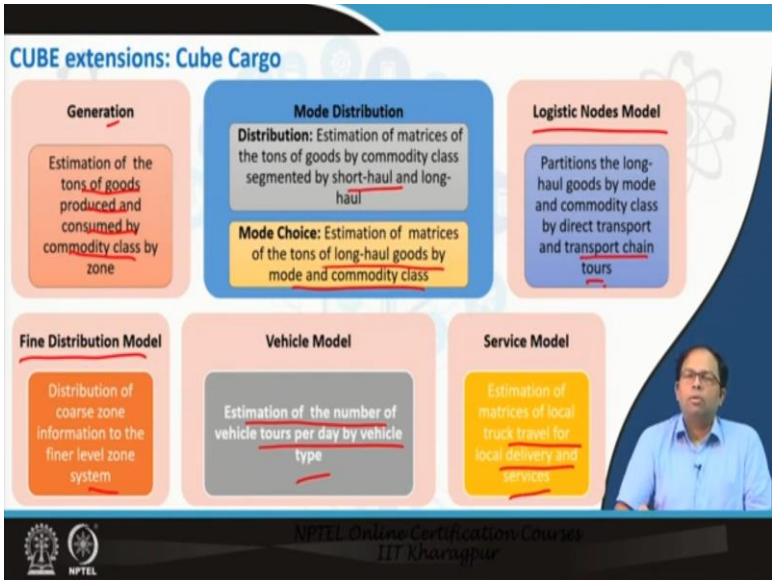

Different components of the CUBE Cargo

Cargo generation – Estimation of the tons of goods produced and consumed by commodity class for each zone. For each zone, there is production of certain commodities and consumption of certain commodities which has to be modelled. Thus truck flows are not modeled but the commodity flows. However, truck flow models can also be done.

More distribution - Estimation of matrices of the tons of goods by commodity class segmented by short haul and long haul is done corresponding to distribution. The reason why short haul and long haul are segmented is because different logistics apply for each of them. Mode choice also varies accordingly. Estimation of matrices of the tons of long haul goods by mode and commodity is done considering mode choice.

Logistic nodes model - Partitions the long haul goods by mode and commodity class by direct transport and transport chain tours. Direct trips consider trips from one point to another point such as coal or steel being delivered from one point to another. When an item such as refrigerator are to be given to multiple distribution centers from the industry, then, the vehicle will go to the different distribution centers one after another resulting in a transport chain tour. These has to be modelled based on the specific logistic decision that is undertaken.

Fine distribution model - This is for distribution of coarse zones information to the final level zone system and this is for micro level modeling, i.e., how movement is carried out within a zone and so on.

Vehicle model - Estimation of the number of vehicle tours per day by vehicle type.

Service model - Estimation of matrices of local truck travel for local delivery and services.

CUBE Extensions –Others

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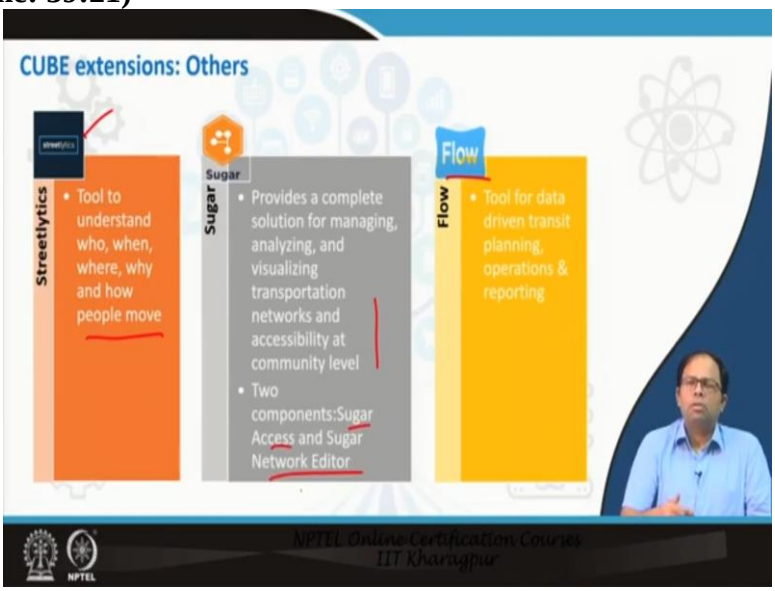

Cube Flow- where one can plan for the transit operations

Cube Street Analytics - who, when, where, why and how people move can be understood

Cube Sugar - provide complete solution for managing analyzing and visualizing transportation networks and accessibility at community level. The two components includes sugar access and sugar network editor.

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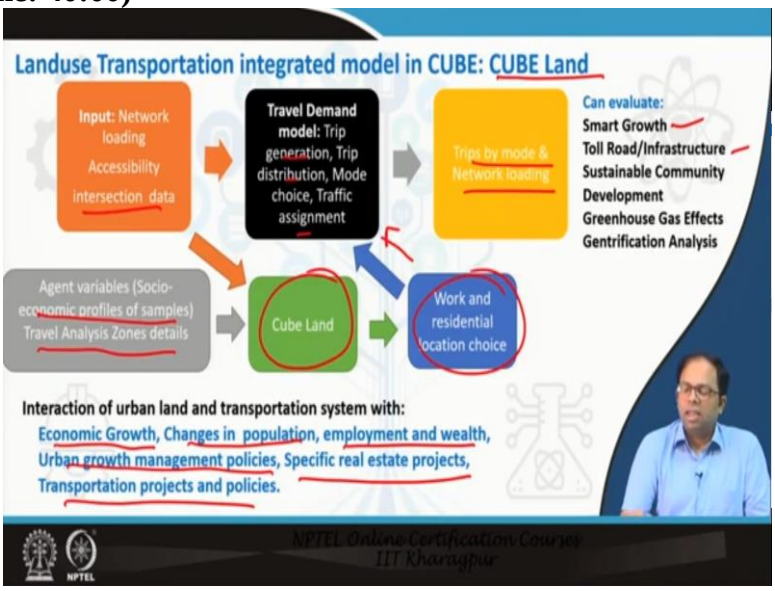

Land use transportation integrated model in CUBE – CUBE Land

CUBE land is used for modeling real estate development. Network loading, accessibility, and intersection data forms the input similar to any kind of land use transportation model. In the travel demand model component, trip generation, trip distribution, mode choice and traffic assignment is done. This gives trips by mode and network loading. Traffic assignment results in the trip load in the network, which can be visualized. Network loading, accessibility, intersection details, can be also taken as input along with agent variables, that includes socio-economic profiles of samples, details of travel analysis zones etc. Based on real estate developments, work and residential location choice model predicts where people will redistribute themselves or the updated total household in each zone which go as input to the travel demand model and this eventually helps us to determine what kind of flows are there in different corridors. CUBE land explains the interaction of urban land and transportation with economic growth, changes in population, employment and wealth, growth management policies, specific real estate projects, transportation projects and policies. It can evaluate smart growth principles, toll road/ infrastructure, sustainable community development, greenhouse gas effects and gentrification analysis as well.

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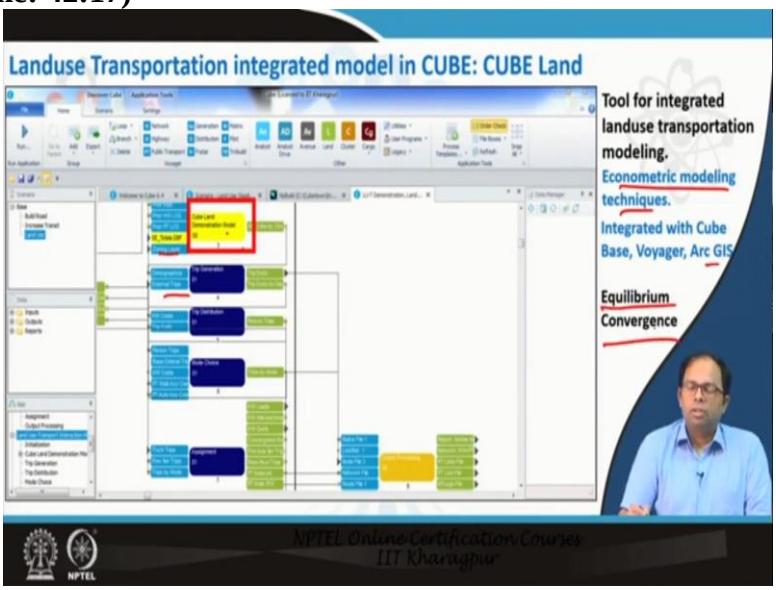

The above figure shows the overall framework. Here, inputs from CUBE land goes into the trip generation model and then subsequently the trip distribution. It can be observed that these are connected to the mode choice and all these models consider feedback from each other.

This is a tool for integrated land use transportation modeling. Different econometric modeling techniques are applied in CUBE land and this is integrated with CUBE base, voyager, ArcGIS and other components. Equilibrium convergence is considered.

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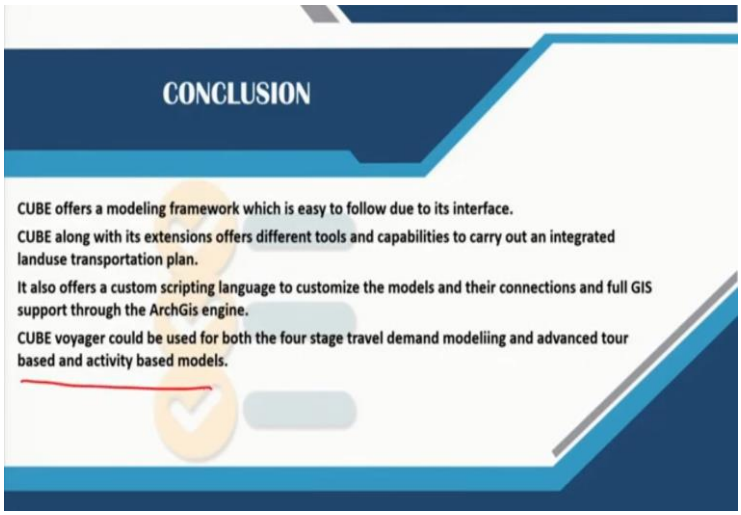

Conclusion

Cube offers a modeling framework which is easy to follow due to its interface.

Cube along with it extensions offer different tools and capabilities to carry out an integrated landuse transportation plan.

It also offers a custom scripting language to customize the models and their connections and full GIS support through ArcGIS engine.

Cube voyager can be used for both four stage travel demand modeling and advance tour based and activity based model.

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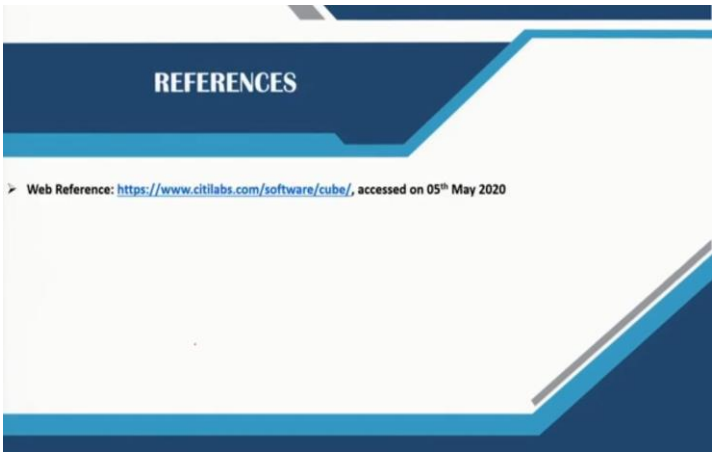
References



Citilabs website can be accessed to understand more about the topic. Thank you.