Urban Landuse and Transportation Planning
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Lecture – 09
Existing Integrated Land Use Transportation Models

Welcome back. Lecture 9 will cover the existing integrated land use transportation models which are already used in different urban planning areas.

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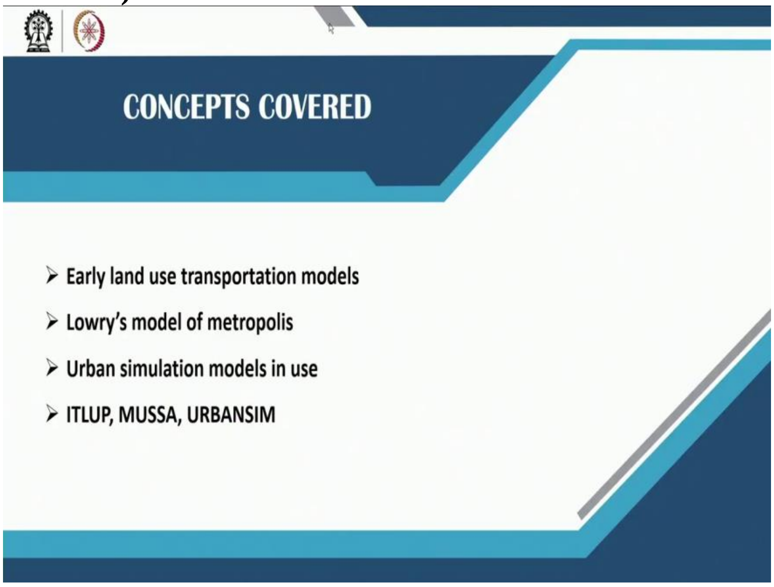

The different concepts that will be covered are; early land use transportation models, Lowry's model of Metropolis which was partly covered earlier, Urban simulation models which are currently in use, and details of 3 urban simulation models with these are ITLUP, MUSSA and URBANSIM.

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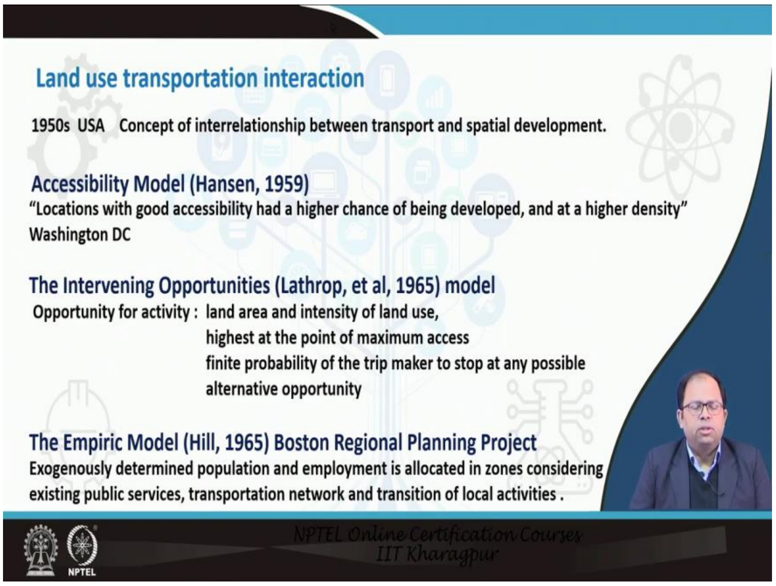

Land use transportation interaction

The concept of the interrelationship between transport and spatial development was initiated during the 1950s in the USA and the first model that came out was the Accessibility model by Hansen which was applied in the Washington DC area. This model stated that locations with good accessibility have a higher chance of being developed and at higher density. This was the first model that talked about how transportation in the form of accessibility to different land areas is related to land use.

Next, was the Intervening Opportunities model by Lathrop in 1965 where, the opportunity for an activity was determined based on the land area, the intensity of land use, etc. Even though opportunity was highest at the point of maximum accessibility, there is a finite probability of the trip maker to stop at any possible alternative opportunity along the way. This was called an intervening opportunity. Thus, the final choice can be a lower order of choice as well.

Next, was the Empiric model made by Hill which was applied in the Boston Regional Planning project. In this model, the population and employment are exogenously determined and are allocated in zones considering the existing levels of service of public services, transportation networks, and transitions or changes in local activities. This means that exogenous projections of population and employment are taken and then allocated as per the potential of different areas. Potential is estimated not only based on transportation but also based on other factors such as public services and transitions of local activities within that area.

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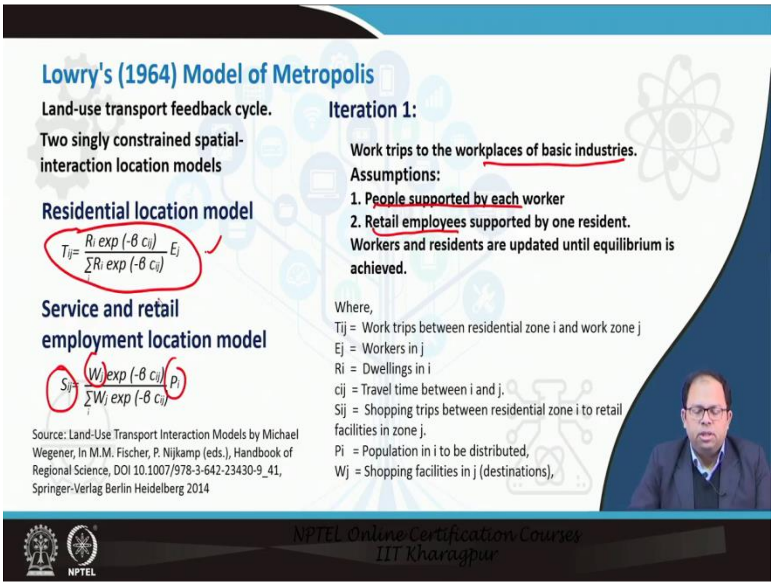

Lowry's model of metropolis

Lowry's model of Metropolis is the most famous land-use transportation model and is still applied in many areas. Currently, various modifications and modifications of this model exist and are applied in many developed countries as well. This is the first major model that started the process of land-use transportation interaction modeling. The model incorporates the land use transport feedback cycle and two singly constrained spatial interaction location models namely, the residential location model and the service and retail employment location model.

The first model determines residential location based on the location of the different industries or jobs and could be determined from the equation given in the slide. For example, if Tij are work trips between residential zone i and work zone j, Ej the workers in j, Ri are dwellings in i and cij the ravel time between i and j then, this particular equation has to be iterated and balanced to get to estimates of Ri. This shows us the spread of residences in an urban area for a particular location of jobs.

Next, two assumptions are made. First, for each job, there are a certain number of people who are supported and the first model predicts where these people are going to reside. Next, the number of retail employees supported by each resident is estimated which enables the estimation of the second model i.e., the service and retail employment location model.

The location of retail facilities/jobs can be estimated iterating the second model where, Sij are the shopping trips between residential zone i to retail facilities in zone j, Pi the population in i and Wj are the shopping facilities/jobs in j (destinations). These retail jobs also support more population whose location has to be estimated using the first model and the total number of workers and population and their location is updated till equilibrium is reached. Sij and Tij values give the transportation estimates. Thus both location/land use and number of trips/transportation can be determined using these two equations.

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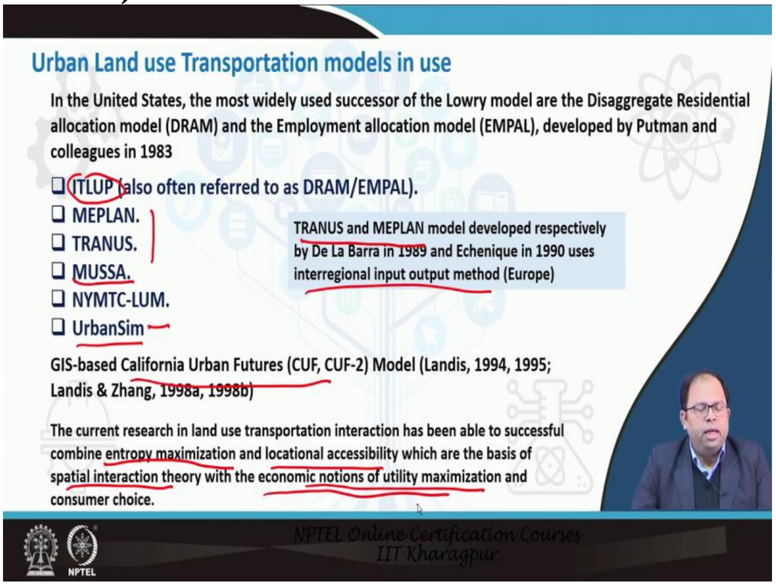

Urban land use transportation models in use

The most widely use successor of the Lowry model is the Disaggregate Residential Allocation model called DRAM and Employment Allocation model EMPAL. These two models are used together in the form of a model system also known as ITLUP. This was developed by Putman and colleagues in 1983.

TRANUS developed by De La and MEPLAN by Echenique is another model system developed following the same lines of the Lowry model. This model system uses interregional exogenous input to determine the final output which is the amount of flow following the principles of spatial allocation. and is widely used in Europe.

Another model is MUSSA which uses the bid rent theory. URBANSIM and California Urban Futures are other popular models that have been also discussed. URBANSIM is one of the latest models which involve multiple agents and micro-simulation. Thus, the current research in land use transportation interaction has been able to successfully combine entropy maximization and locational accessibility, which are the basis of spatial interaction theory and the economic notions of utility maximization. This has resulted in the development of robust choice models which can be used for determining land use for an urban area.

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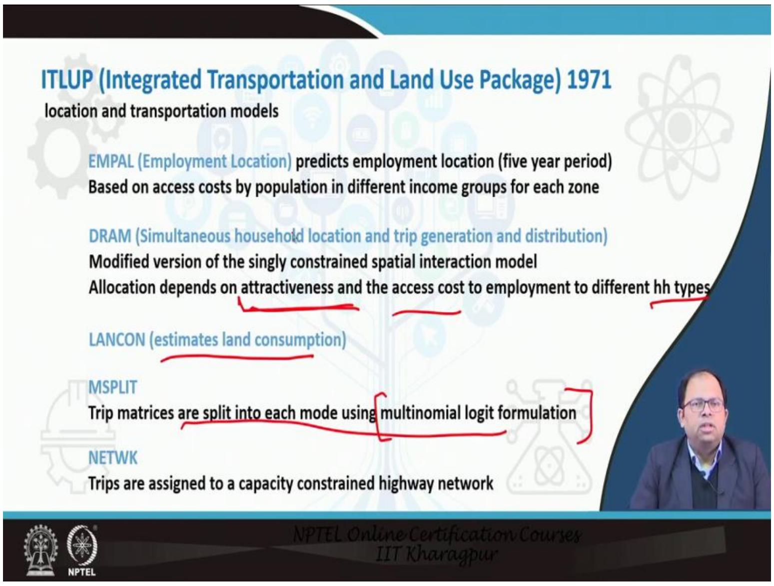

ITLUP

The ITLUP model system includes different components. The full form of ITLUP is Integrated Transportation and Land Use Package and was made in 1971. It includes both the location and transportation models, and there are 5 major components.

The first component is EMPAL which predicts the employment location for different income groups and every zone in the planning area for every 5 year period. The prediction is based on the access cost of the population. While the EMPAL part takes care of the only land, the DRAM component predicts trip distribution, trip generation, and household location simultaneously. This model is a modified version of the singly constrained spatial interaction model and is similar to the Lowry model to some extent. Residential allocation depends on the utility of each zone in terms of its attractiveness and access cost to employment for different household types. The next component is LANCON which is used to estimate the land consumption part. Next using the MSPLIT component trip matrices are split into different mode choices using multinomial logit formulations which will be explained in later lectures.

The final component is NETWK which assigns trips to capacity-constrained highway networks. Thus all the four stages of trip generation, distribution, and model split as well as network assignment is taken care of along with household and employment allocation, which completes the entire land use transportation modeling package.

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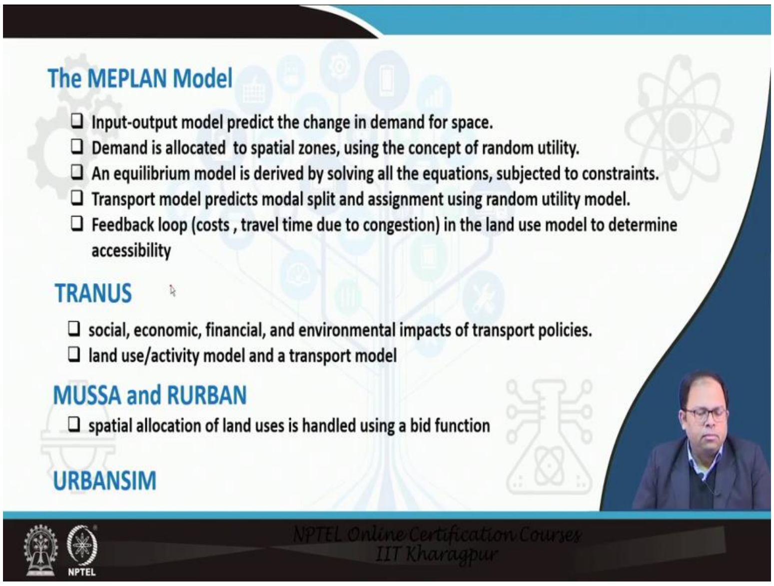

MEPLAN

MEPLAN is similar to ITLUP in many aspects. However, it uses the input-output model to predict the changes in demand for space. Then, demand is allocated to spatial zones using the concept of random utility. An equilibrium model is derived by solving all the equations subjected to constraints. Next, is the transport model which predicts model split and assignment using the random utility model, and finally, there is the feedback loop involving cost, travel time, etc.(changes with traffic condition/congestion) which is connected to the land use model. This cost and travel time influence accessibility which determines allocation.

TRANUS

TRANUS is similar to MEPLAN. However, unlike MEPLAN, social, economic, financial, and environmental impacts of transport policies can be evaluated using the TRANUS model. TRANUS also includes a land use activity model along with the transport model.

Both TRANUS and MEPLAN is used widely in Europe. MUSSA and RURBAN are two model systems where bid functions are incorporated for spatial allocation of different land uses. And finally, URBANSIM is also covered in this lecture.

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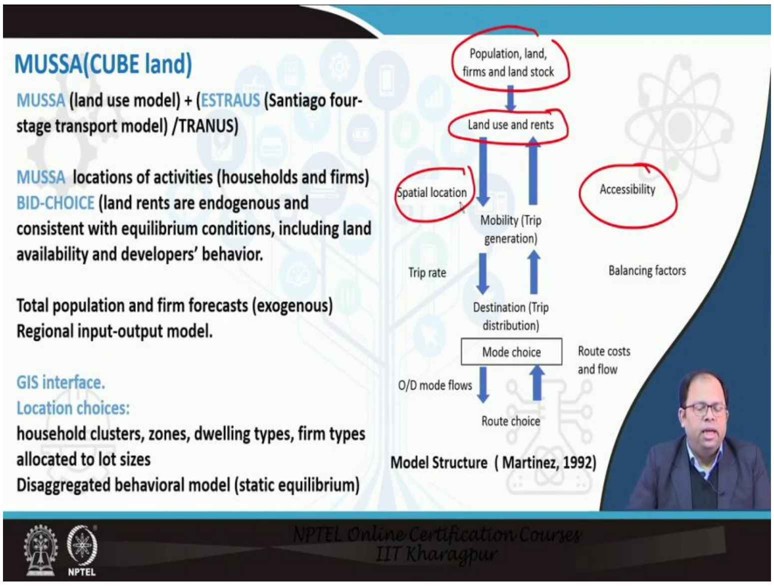

MUSSA

MUSSA is the land use part only and it is used along with other software that provides the transportation part. Currently it is, found in the CUBE software and is called CUBE land. CUBE is a popular software for transportation planning and modeling and CUBE land is the component that takes care of land use in CUBE software package. The MUSSA land use model was initially combined with ESTRAUS and was made by Martinez for Santiago, Chile. ESTRAUS is a 4 stage transportation model. MUSSA can be also combined with TRANUS as well.

MUSSA can be used to predict the location of activities i.e., households and firms. It uses the bid rent theory to determine the allocation of houses and firms in an urban area. Land rent prediction is endogenous to the model and is consistent with equilibrium conditions including land availability and developers' behavior. The total population and firm forecast is taken as exogenous input from the regional input-output model. Location choices are predicted for household clusters, zones, dwelling types, firm types, and each unit is allocated to different types of lots as per size and as per the most suitable choice using a disaggregated behavioral model. The model includes a GIS interface and connects to a basic transport model that covers the trip generation, destination, mode choice, and route choice. The inclusion of land rent in this model makes it different from the other models discussed earlier.

Land use is determined based on rents. Rent is determined endogenously based on exogenous input of population and number of jobs/firms. This helps in determining the developer's choices which finally helps in determining land use for a particular area. Spatial location and accessibility are the two criteria which connect the choice models and the transportation model.

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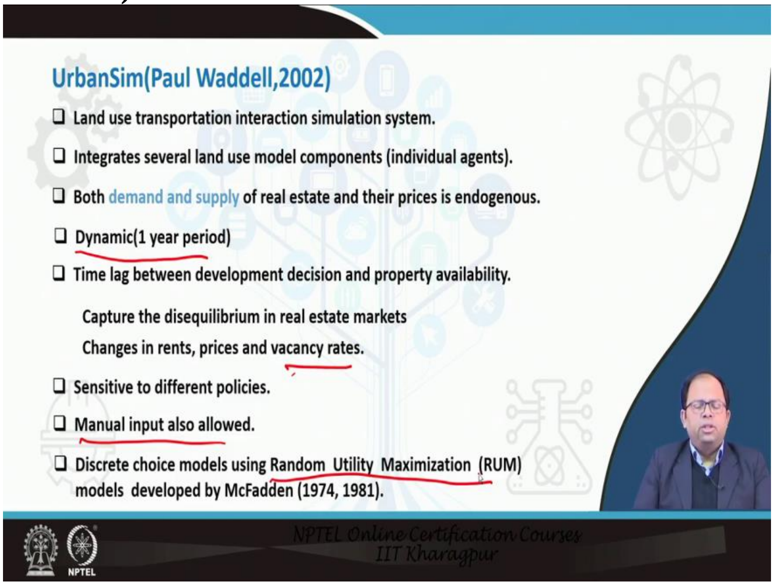

URBANSIM

URBANSIM model is developed by Paul Waddell in 2002. Instead of land use transportation model we can also call this model a land use transportation interaction simulation system or an urban simulation system. This is because; this model has got several components and the entire urban land use and its changes along with transportation can be modeled or simulated.

Several land use components are included and are known as individual agents. Both demand and supply of real estate and their prices are endogenous to the model. Thus, demand for real estate i.e., the number of households or firms choosing to locate somewhere is modeled along with the supply part i.e., developers' choice to build. Thus, the model can determine the kinds of development developers are willing to build, their location, etc. along with the choice of a firm or households to move from one area to another, which generates this demand in the first place. URBANSIM is dynamic with updates at every 1 year. Output at the end of the first year period goes as input for the next iteration. Thus, the time lag between development decision and property availability is also captured.

Developers decide to build at a particular location based on different criteria such as market demand, available land, land price, etc. and the property eventually becomes available at the end of a certain time period. This leads to a sort of disequilibrium in the real estate market which influences rental prices and vacancy rates which are also modeled in URBANSIM. Current rent, current price, current vacancy rate are used by a household to choose a particular location for moving in.

URBANSIM is also sensitive to different policies like urban growth boundaries, high density development, etc. The model also allows manual input to accommodate changes in law or to test certain policies. Discrete choice models using the random utility maximization framework are used for determining probabilities of different choice alternatives.

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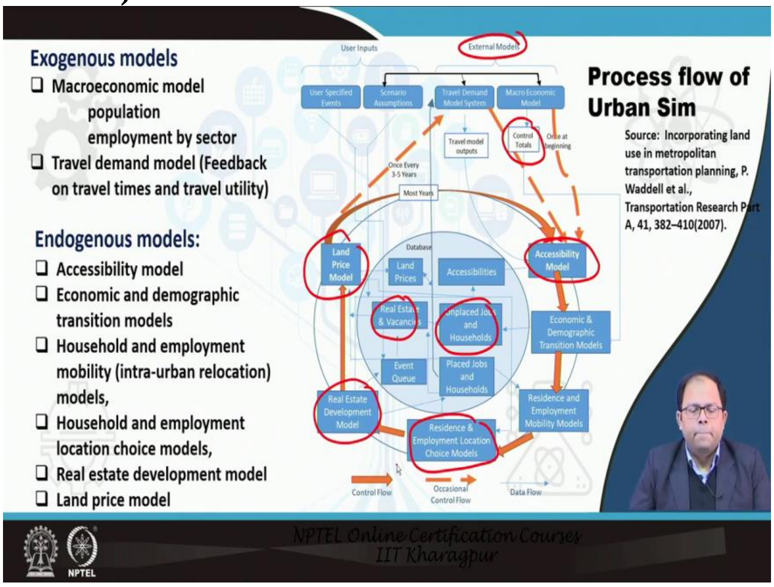

The URBANSIM model structure as shown in the image includes an exogenous macroeconomic model for population forecast and sector-wise employment forecast for different job types. Similarly, the travel demand model is also exogenous. Output from the land use components is taken as input to the travel demand model which results in feedback in the form of travel times between different origin and destinations and also the travel utilities between them. These two feedbacks go back and forth between the land use and the transportation models/components. The different endogenous model systems are the accessibility model, economic and demographic transition models, household and employment mobility models, and intra-urban relocation model, household and employment location choice models, real estate development model, and land price model. These models will be explained in detail in the next lecture.

Each of these different model components are linked with each other through several variables or parameters. For example, the land price model depends on several attributes, but the land price itself influences real estate development, and real estate development influences the household and employment location choices. These linkages are illustrated in the figure showing the process flow of URBANSIM. The accessibility model takes input from the travel demand model. The macroeconomic model provides the population and employment forecast for this urban area and can also influence the outcome of the accessibility model. As shown in the image, the accessibility model leads to the economic and demographic transition model which predicts the change in jobs and demographic distribution in different areas. Next, are the residential and employment mobility models. Mobility models predict if a household or a firm will change its location from one part of the city to another. This result in a vacancy in both residential and commercial building and locations and the buildings become available in the market. Mobility in jobs i.e. people changing jobs are also modeled.

Next, are the different location choice models. For example, unplaced households are allocated using a residential location choice model. The real estate development model also works along with the land price model. While these models are linked in a framework, these need to be run in a sequence. This is taken care of through the software architecture of this particular model, which will be discussed in subsequent chapters. All these models are linked together and they give feedback to each other and they form an overall modeling system or a simulation system for the entire urban area.

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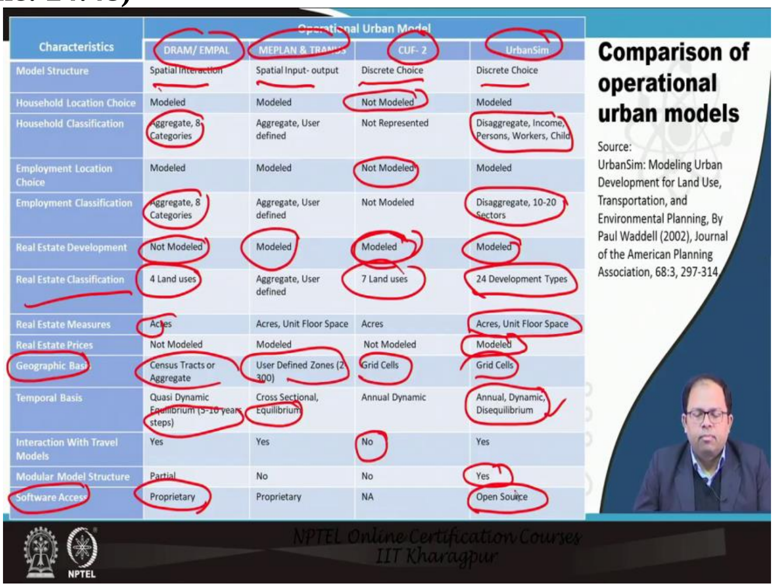

Characteristics	Operational Urban Model			
	DRAM/ EMPAL	MEPLAN & TRANUS	CUF- 2	UrbanSim
Model Structure	Spatial Interaction	Spatial Input- output	Discrete Choice	Discrete Choice
Household Location Choice	Modeled	Modeled	Not Modeled	Modeled
Household Classification	Aggregate, 8 Categories	Aggregate, User defined	Not Represented	Disaggregate, Income, Persons, Workers, Child
Employment Location Choice	Modeled	Modeled	Not Modeled	Modeled
Employment Classification	Aggregate, 8 Categories	Aggregate, User defined	Not Modeled	Disaggregate, 10-20 Sectors
Real Estate Development	Not Modeled	Modeled	Modeled	Modeled
Real Estate Classification	4 Land uses	Aggregate, User defined	7 Land uses	24 Development Types
Real Estate Measures	Acres	Acres, Unit Floor Space	Acres	Acres, Unit Floor Space
Real Estate Prices	Not Modeled	Modeled	Not Modeled	Modeled
Geographic Basis	Census Tracts or Aggregate	User Defined Zones (2-300)	Grid Cells	Grid Cells
Temporal Basis	Quasi Dynamic Equilibrium (5-10 years steps)	Cross Sectional, Equilibrium	Annual Dynamic	Annual, Dynamic, Disequilibrium
Interaction With Travel Models	Yes	Yes	No	Yes
Modular Model Structure	Partial	No	No	Yes
Software Access	Proprietary	Proprietary	NA	Open Source

<u>Comparison of operational urban models</u>

Several model systems namely, DRAM/EMPAL, MEPLAN /TRANUS, California urban futures, and URBANISM are compared in this section. The model structure shows that, California urban futures and URBANISM follows the discrete choice theory, whereas MEPLAN and DRAM, EMPAL, follows spatial allocation theory. Household location choice is modeled in all the models except for the California urban futures. While DRAM/EMPAL shows 8 categories of household classification, URBANSIM uses a full disaggregate approach. This is because it is a microsimulation model and individual households possess different combinations of characteristics which determine their different choices. Employment location choice is modeled in most of the models except for the California urban futures model. The number of employment classification considered in the URBANISM model is 10 to 20 sectors, whereas, in DRAM/EMPAL, 8 sectors are considered. Real estate development is not modeled in DRAM/EMPAL whereas, it is modeled in the other models. For example, in the California urban futures, a list of developable lands is created and then the most profitable lands are accordingly allocated development. Considering, real estate classification, 24 development types such as commercial development of different kinds, residential developments of different kinds etc. are considered in URBANSIM, whereas, other models support different categories of land use. While real estate development is considered

in acres, URBANSIM considers both acres and unit floor space. Thus, both land use and building space are both considered. Real estate prices are not modeled in any of the models except for URBANSIM. Considering the geographic basis, i.e. the macro and micro debate, the initial models are based on zones or census tracts whereas; the later models are based on grids.

While URBANSIM is a dynamic disequilibrium model which is run annually, the other models are run considering a 5 to 10 year equilibrium period. All the models are connected to a travel model except for the California urban futures model which is a pure land use model. While most of these are proprietary software that has to be bought, URBANSIM is open source software that is available freely.

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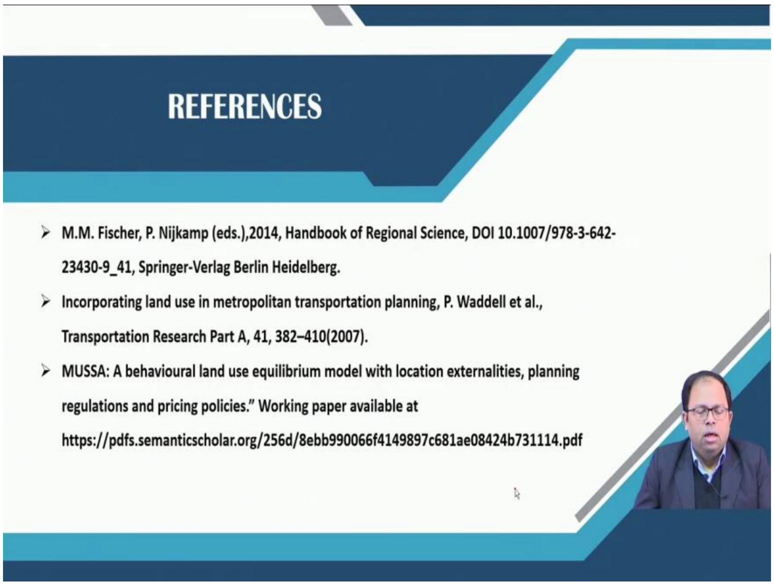

References
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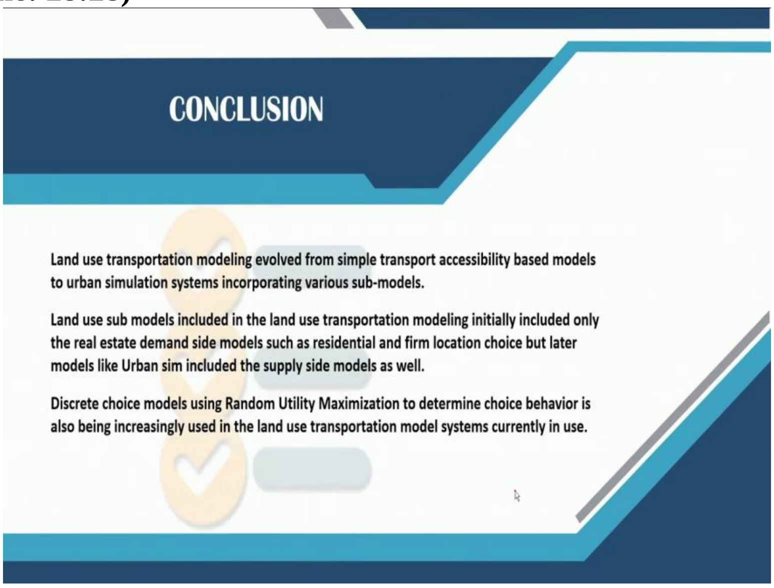

In conclusion, we can say;

Land use transportation modeling evolved from simple transport accessibility based models to urban simulation systems incorporating various sub-models.

Land use sub-models included in the land use transportation modeling initially included only the real estate demand side models such as residential and firm location choice, but later models like URBANSIM have included the supply side models as well as real estate development models, land price models, and so on.

Discrete choice models using random utility maximization to determine choice behavior are also being increasingly used in the land use transportation model systems currently in use.

Thank you.