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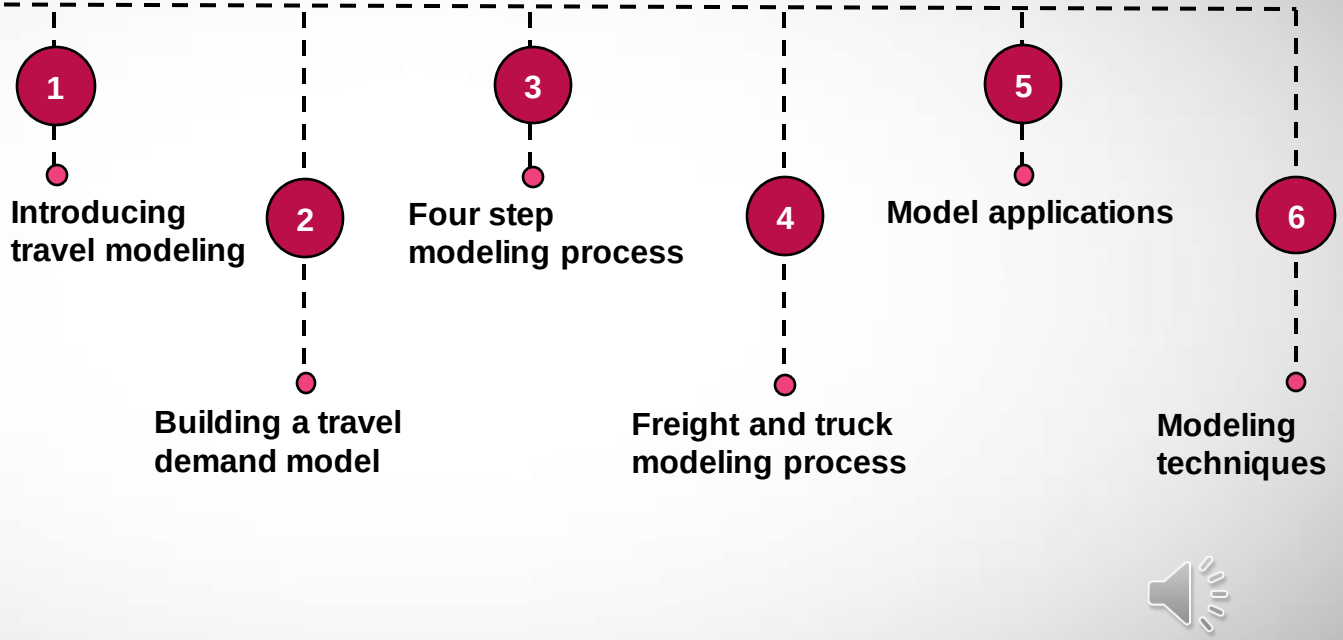
Introduction to Travel Demand Modeling

January 2024

Agenda


1
Introducing travel modeling
2
Building a travel demand model
3
Four step modeling process
4
Freight and truck modeling process
5
Model applications
6
Modeling techniques

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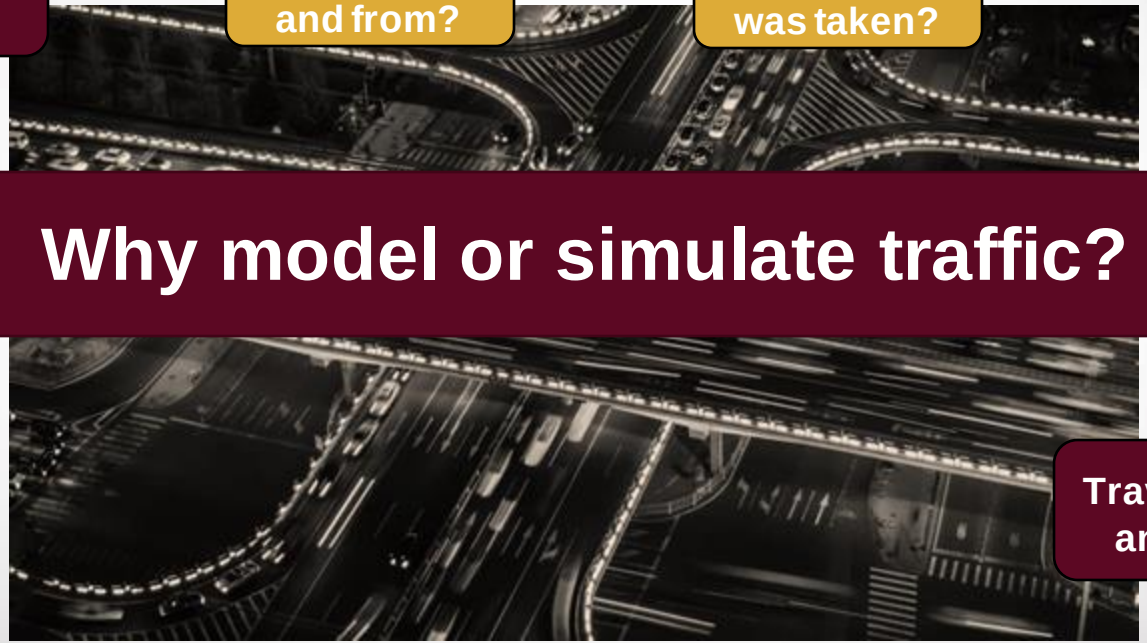
Introduction to Transportation Modeling

Transportation Modeling

Forecast of future travel

Traveling to and from?

Which route was taken?

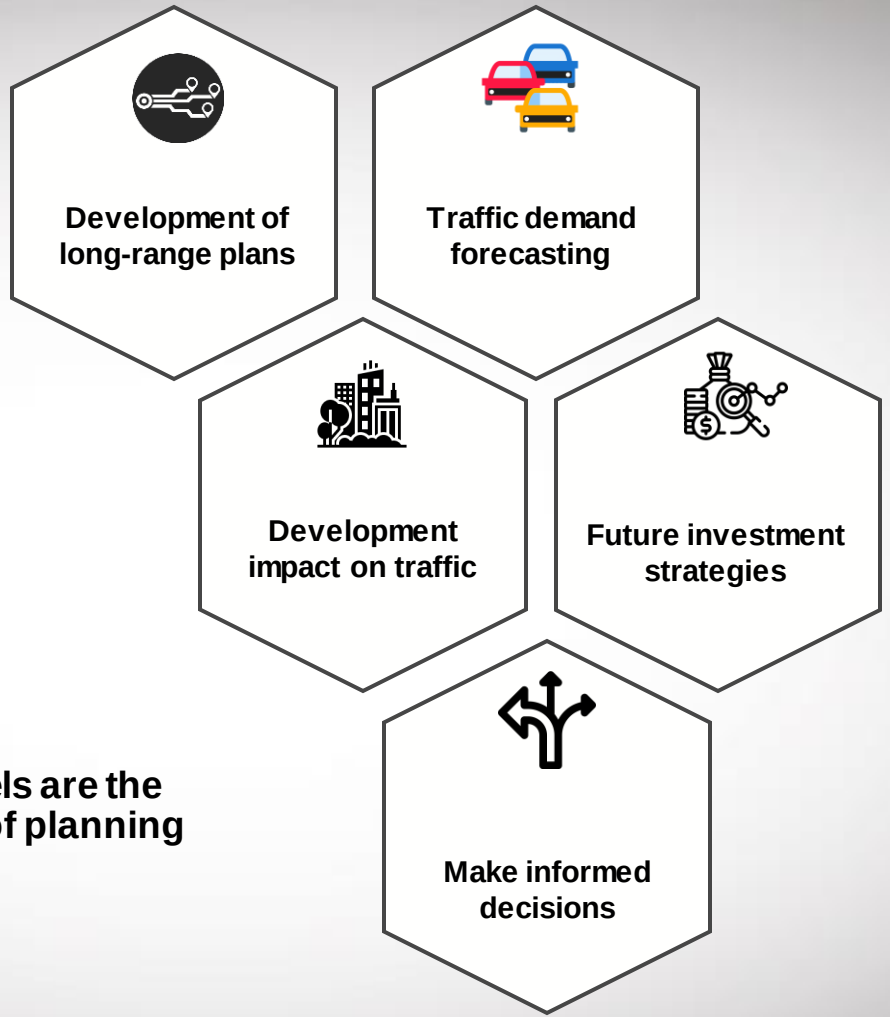


Why model or simulate traffic?

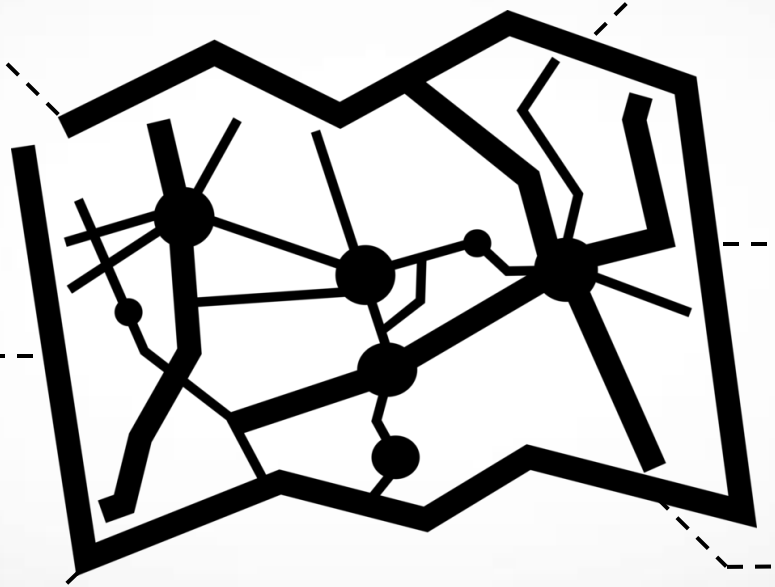
Travel demand and supply

Importance of Transportation Models

Models are the heart of planning



Travel Demand Models



Provide information about future needs

Analyze multiple scenarios (What ifs?)

How many lanes are needed?

Where congestion occurs in the future?

Land use change impact on traffic

Which projects can reduce congestion?

Types of Travel Demand Models

Sketch Planning

Low	Low	Low	Low	Low

Strategic Planning

Low-Moderate	Low-High	Moderate-High	Low	Low

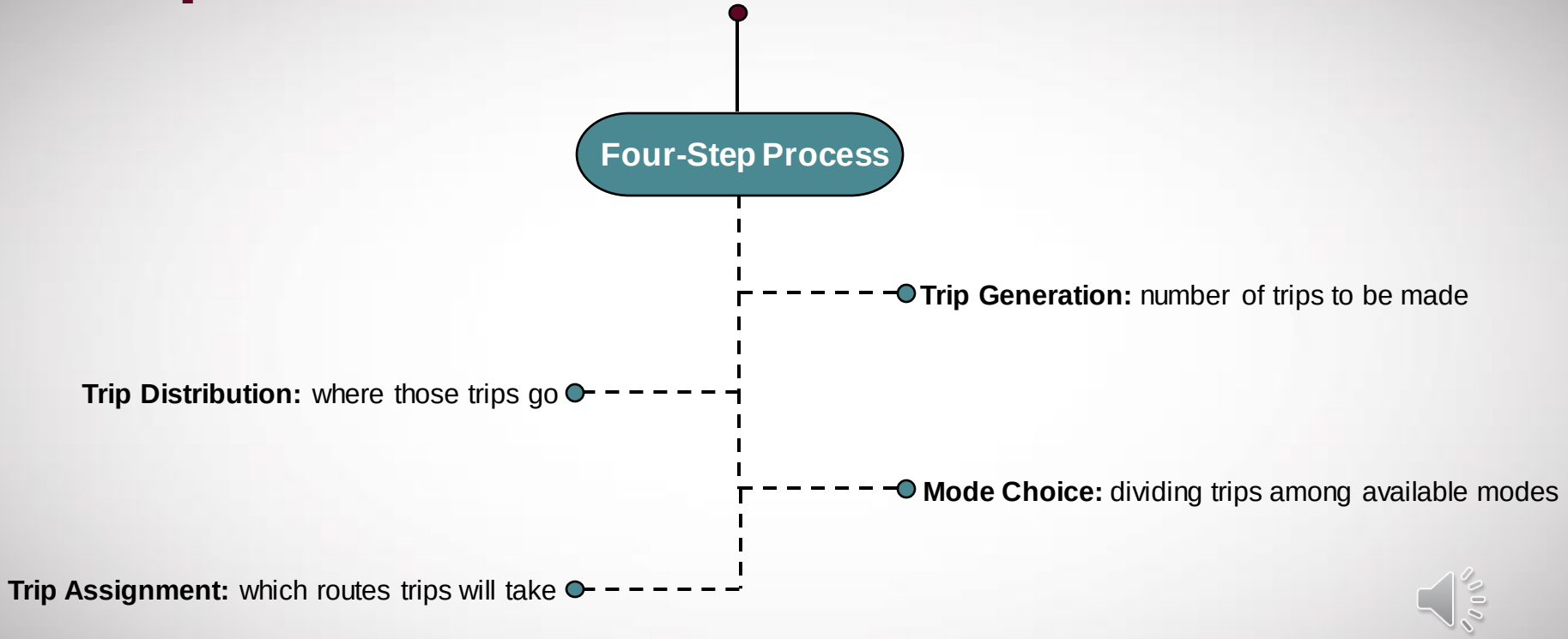
Trip-Based

Low-Moderate	Moderate	Moderate	Moderate	Moderate

Activity-Based

Moderate-High	High	Moderate-High	Moderate	Moderate

Trip-Based Travel Demand Model



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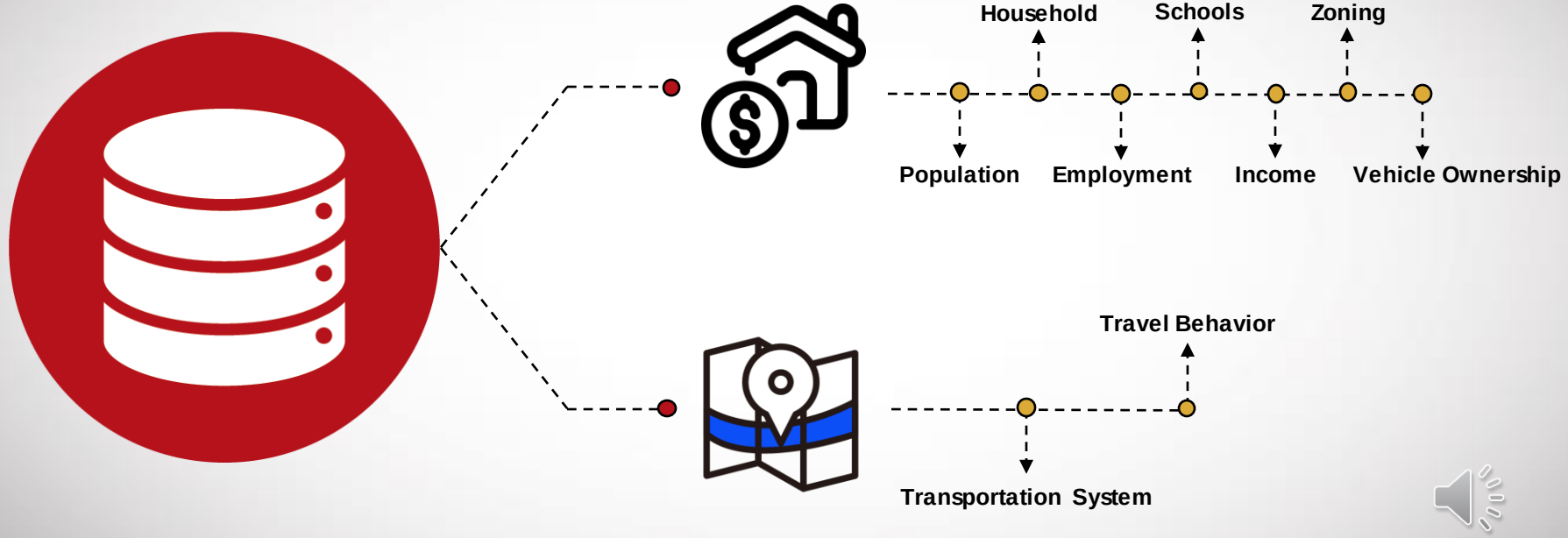
How to build a model?

Before Modeling: Collect Input Data



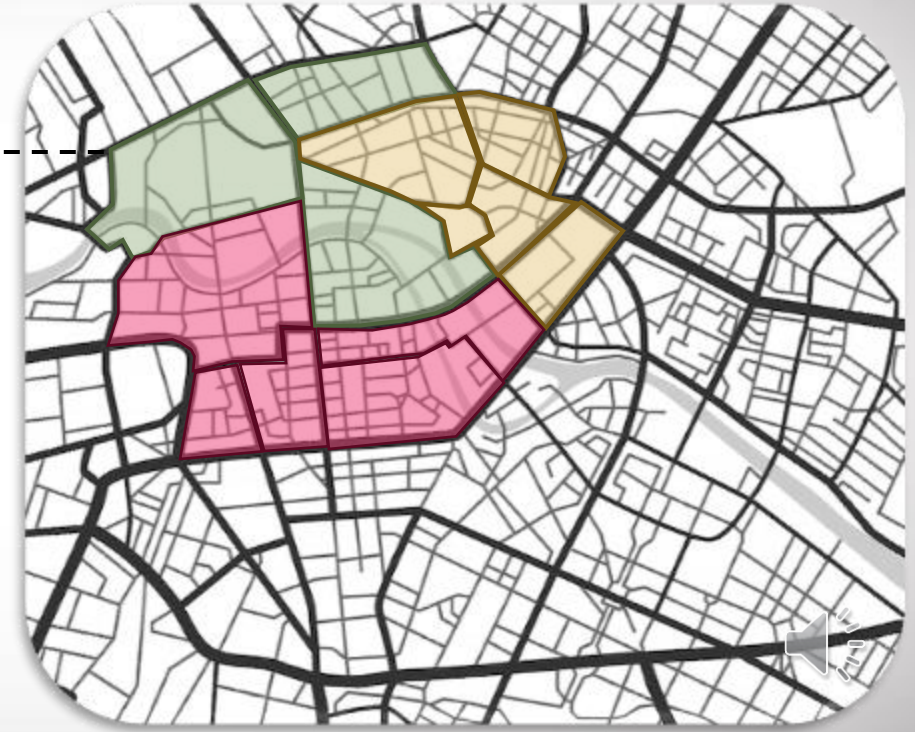
Data Organization is Critical!

Traffic Analysis Zones

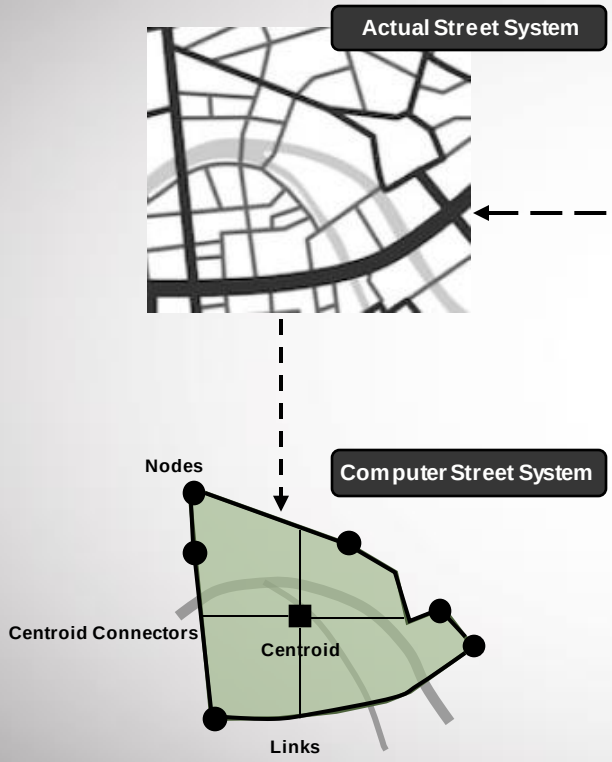
Geographic area
- Census geography
- Socioeconomic data
- Approximately equal in size

Homogeneous land use

Boundaries (roadway/physical barrier)



Understanding Roadway Network



Network Attributes

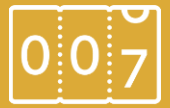
Capacity

Speed

Direction

Travel Time

Classification



Traffic Counts

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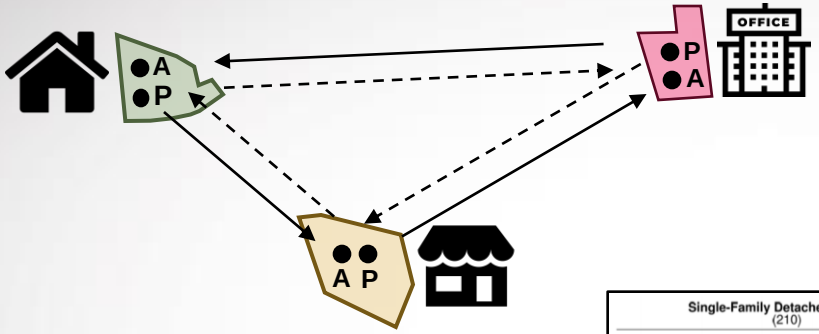
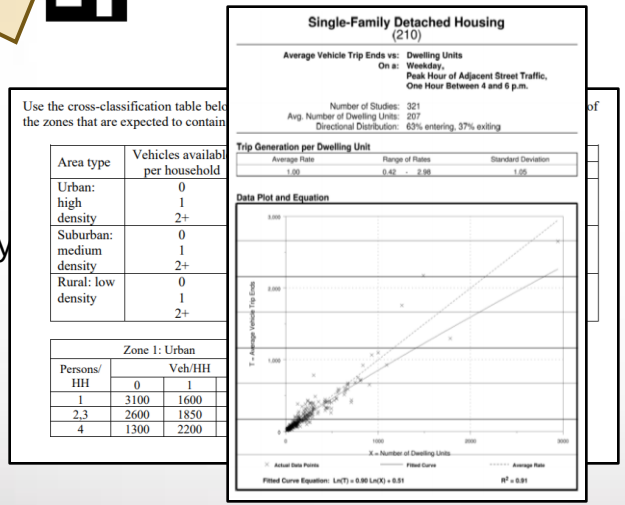
Four Step Model

- How many trips are being **produced** from and **attracted** to each TAZ?



- Trip generation methods:
  - Rates based on activity
  - Cross classification


Use the cross-classification table belo
the zones that are expected to contain

Area type	Vehicles availabl per household
Urban: high density	0 1 2+
Suburban: medium density	0 1 2+
Rural: low density	0 1 2+

	Zone 1: Urban	
Persons/ HH	Veh/HH	
	0	1
1	3100	1600
2,3	2600	1850
4	1300	2200

Single-Family Detached Housing
(210)

Average Vehicle Trip Ends vs: Dwelling Units
On a: Weekday,
Peak Hour of Adjacent Street Traffic,
One Hour Between 4 and 6 p.m.

Number of Studies: 321
Avg. Number of Dwelling Units: 207
Directional Distribution: 63% entering, 37% exiting

Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
1.00	0.42 - 2.98	1.05

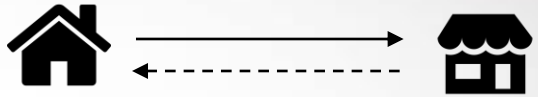
Data Plot and Equation

Step 1: Trip Generation

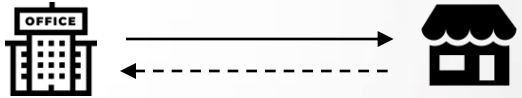
Trip Purpose

- Home-Based Work

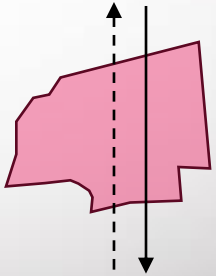
- Home-Based Other



- Non-Home Based

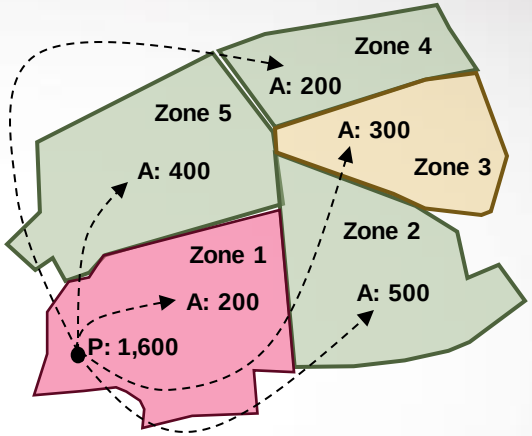


- External Trips



Step 2: Trip Distribution

- Determine where trips are **going to** and **coming from**



- Trip distribution methods:
  - Gravity model

$$T_{ij} = P_i \times \frac{A_j F_{ij} K_{ij}}{\sum_{i=1}^{n} (A_j F_{ij} K_{ij})}$$

T_{ij}: Number of trips from zone *i* to *j*

P_i: Number of trip productions in zone *i*

A_j: Number of trip attractions in zone *j*

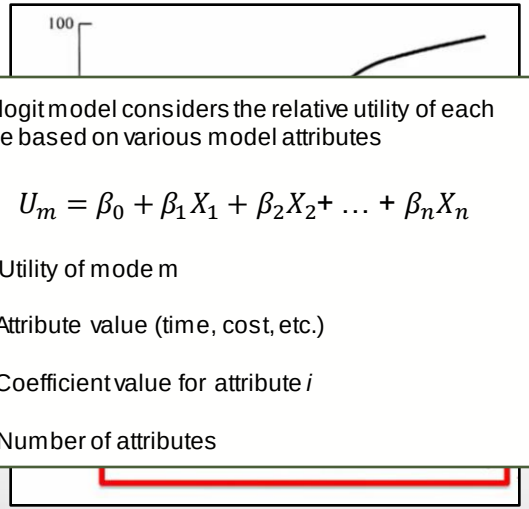
F_{ij}: Travel time friction factor

K_{ij}: Zone to zone adjustment factor

Step 3: Mode Choice

- Which transportation **modes** will be used to complete the trip?

- Mode choice methods:
  - Direct generation
  - Trip end models
  - Logit models



The logit model considers the relative utility of each mode based on various model attributes

$$U_m = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n$$

U_m: Utility of mode m

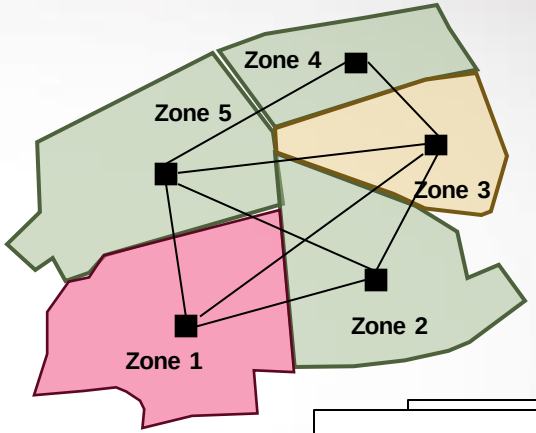
X_i: Attribute value (time, cost, etc.)

β_i: Coefficient value for attribute *i*

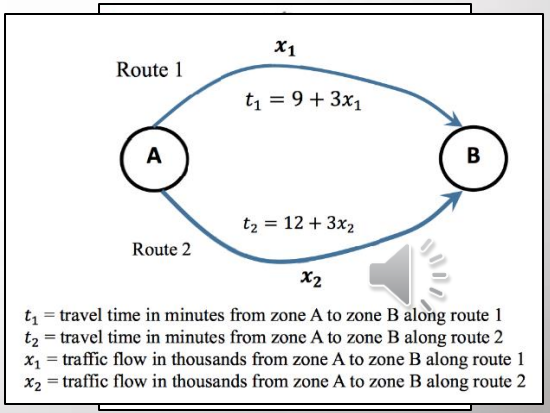
n: Number of attributes

Step 4:
Trip Assignment

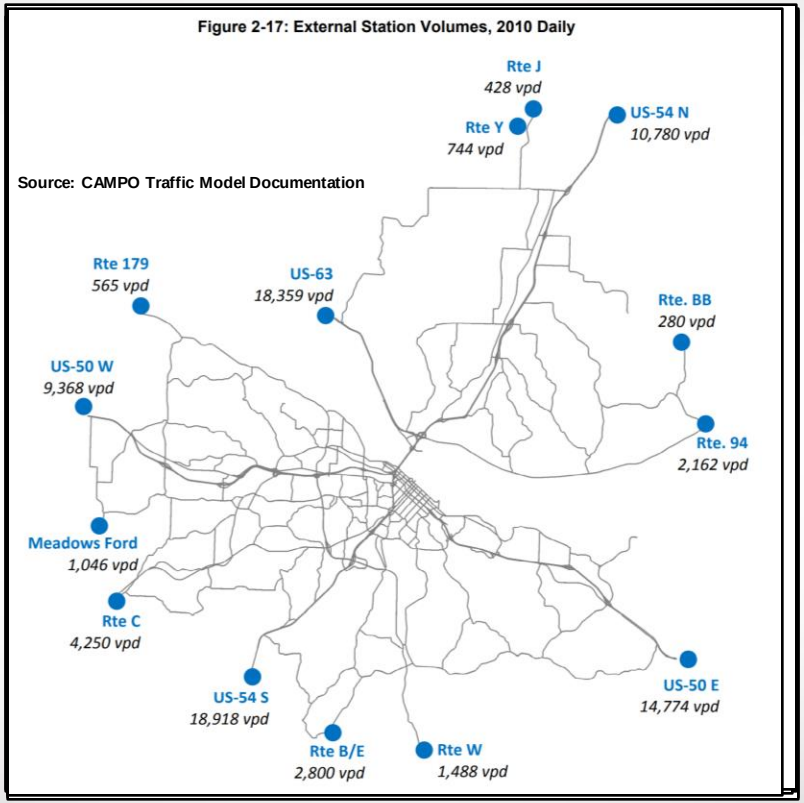
- Determine the **path** a trip will take between the origin and destination TAZ



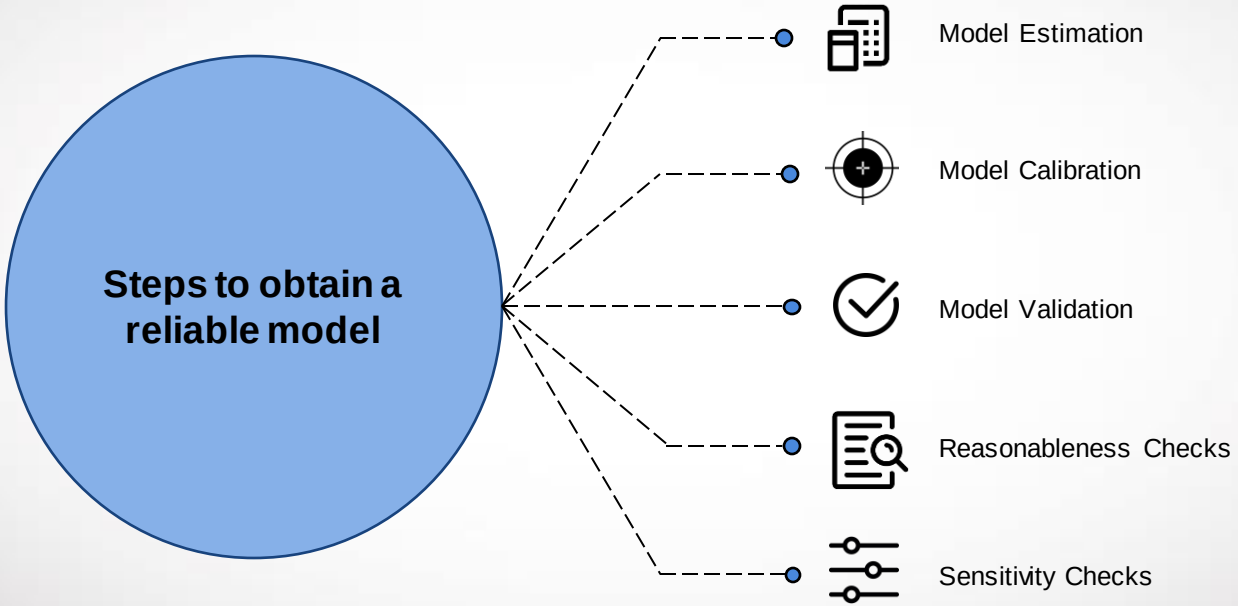
- Trip distribution methods:
  - Capacity restraint method
  - User equilibrium
  - System optimization



Model Outputs



Model Reliability



Acceptable Ranges of Error

Volume-to-Count Ratios and Percent Error [3]

Statistic	Standards	
	Acceptable	Preferable
Freeway Volume-to-Count	+/-7%	+/-6%
Arterial Volume-to-Count	+/-15%	+/-10%
Collector Volume-to-Count	+/-25%	+/-20%
One way/Frontage Road Volume-to-Count	+/-25%	+/-20%

- External model cordon lines should achieve +/-1 percent
- Screenlines with greater than 70,000 AADT should achieve +/-10 percent
- Screenlines with 35,000 to 70,000 AADT should achieve +/-15 percent
- Screenlines with less than 35,000 AADT should achieve +/-20 percent
- Cutlines +/-15 percent

Source: Florida Department of Transportation System Planning Office

Root Mean Square Error (RMSE) By Volume Group [3]

Statistic	Standards	
	Acceptable	Preferable
RMSE: LT 5,000 VPD	100%	45%
RMSE: 5,000-9,999 VPD	45%	35%
RMSE: 10,000-14,999 VPD	35%	27%
RMSE: 15,000-19,999 VPD	30%	25%
RMSE: 20,000-29,999 VPD	27%	15%
RMSE: 30,000-49,999 VPD	25%	15%
RMSE: 50,000-59,999 VPD	20%	10%
RMSE: 60,000+ VPD	19%	10%
RMSE Areawide	45%	35%

Source: Florida Department of Transportation System Planning Office

Percent Error by Volume Group and Roadway Designs [3]

Statistic	Standards	
	Acceptable	Preferable
Percent Error: LT 10,000 Volume (2L road)	50%	25%
Percent Error: 10,000-30,000 (4L road)	30%	20%
Percent Error: 30,000-50,000 (6L road)	25%	15%
Percent Error: 50,000-65,000 (4-6L freeway)	20%	10%
Percent Error: 65,000-75,000 (6L freeway)	15%	5%
Percent Error: GT 75,000 (8+L freeway)	10%	5%

Source: Florida Department of Transportation System Planning Office

Root Mean Square Error (RMSE) By Functional Class [13]

Functional Type	Small Regions	Large Regions*
Freeways	20%	20%
Principal Arterials	30%	35%
Minor Arterials	40%	50%
Collectors	70%	60%

Source: Virginia Department of Transportation

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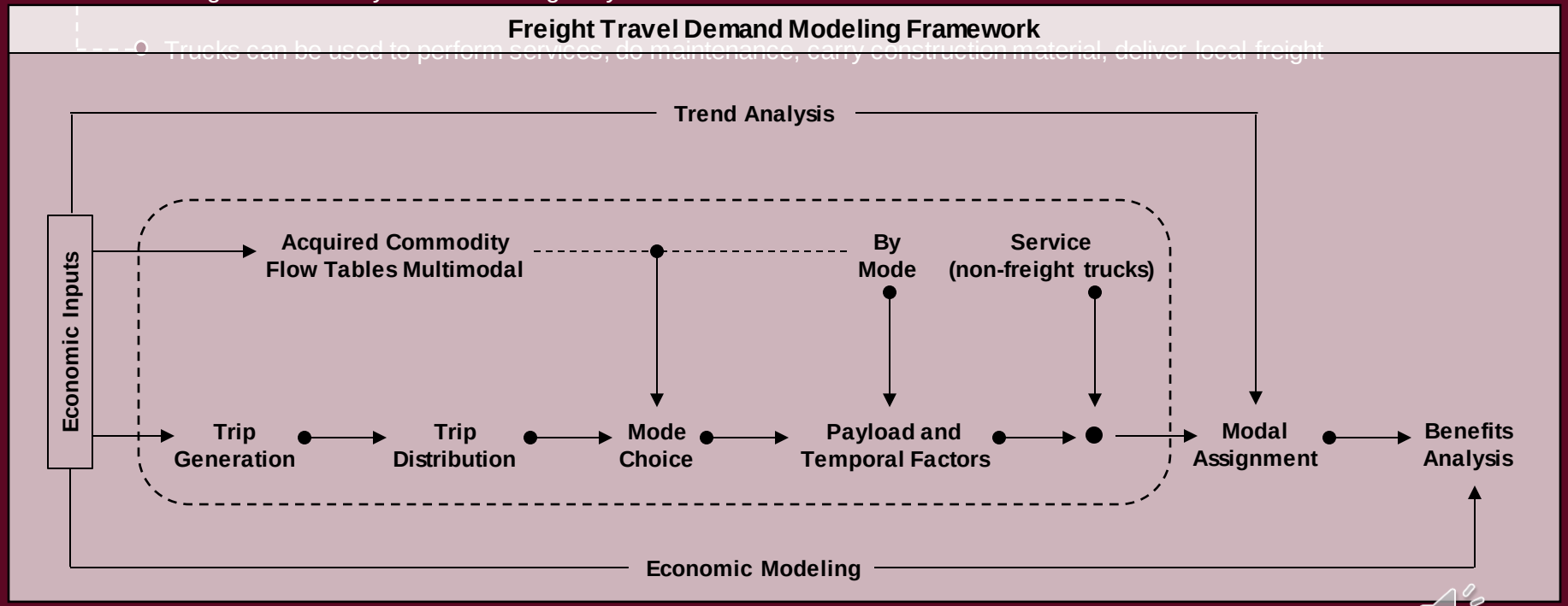
Truck and Freight Modeling

- **MPOs should consider freight to be distinct from trucks in their transportation planning**
  - Freight models may include non-highway modes
  - Trucks can be used to perform services, do maintenance, carry construction material, deliver local freight



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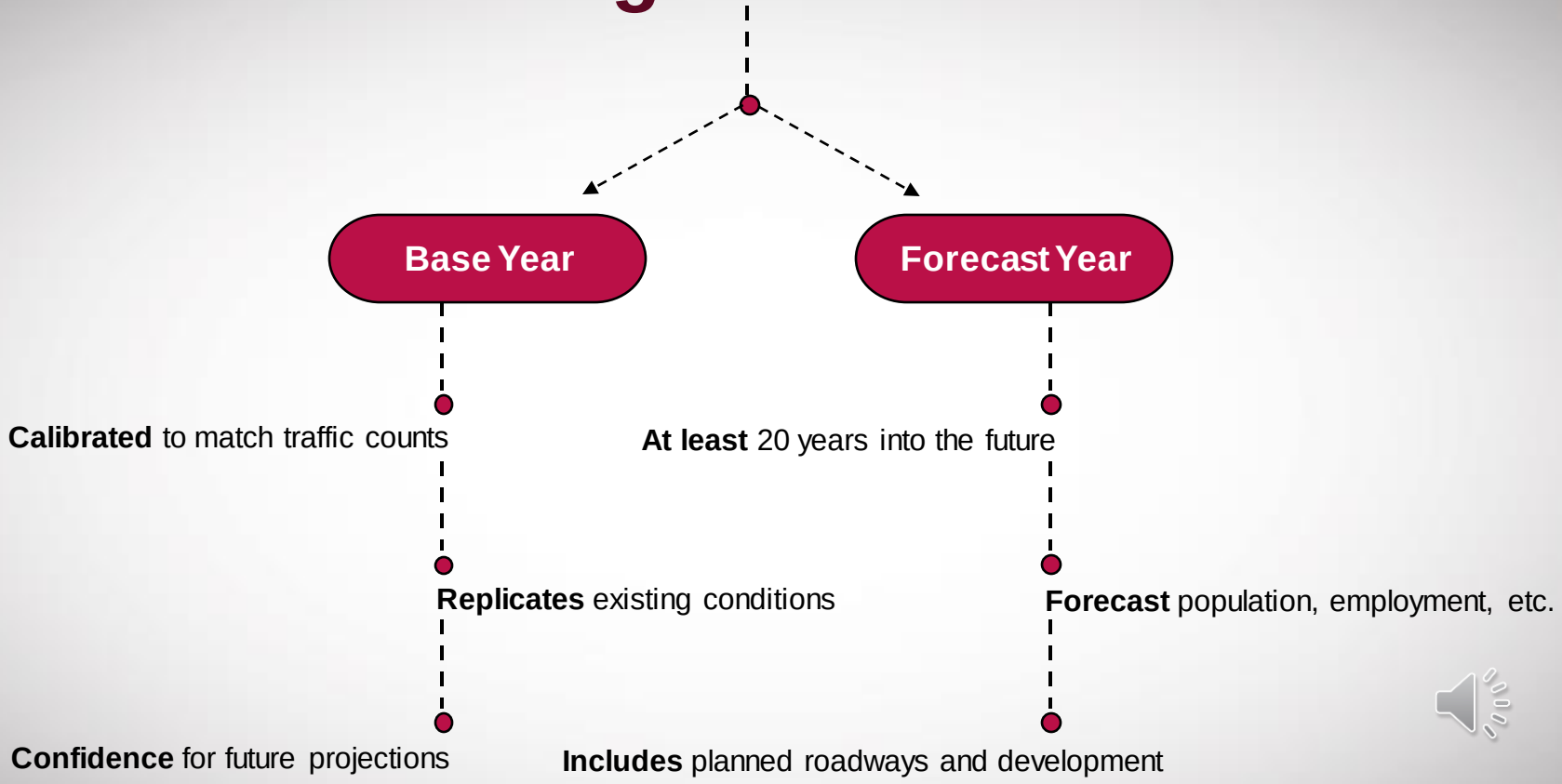
Model Applications

Modeling Time Frames

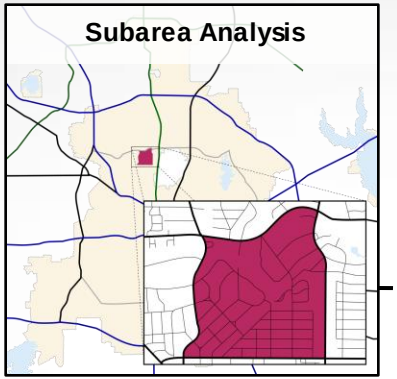


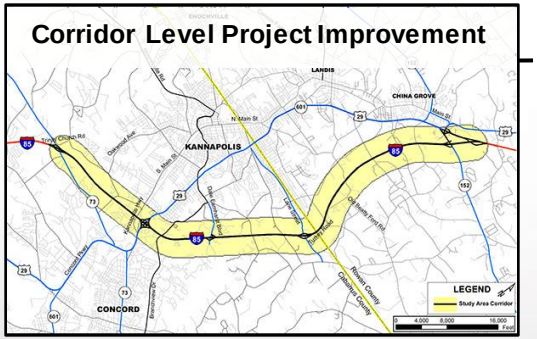
Model Applications

- Evaluation of transportation system performance
- Long- and short-term transportation planning
- Air quality conformity analysis
- Evaluation of transportation improvements and infrastructure investments
- Evaluation of the effects of transportation and planning policies

Subarea and Corridor Analysis

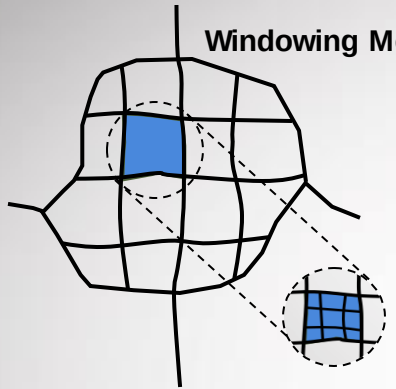
Regional Travel Demand Models

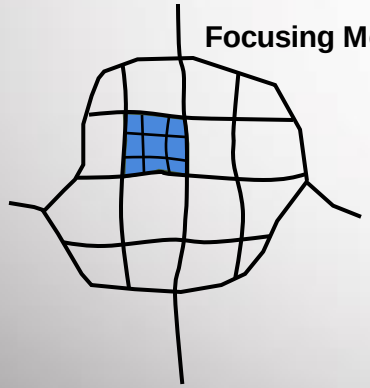




- Guidance on analytical methods
- Use cases

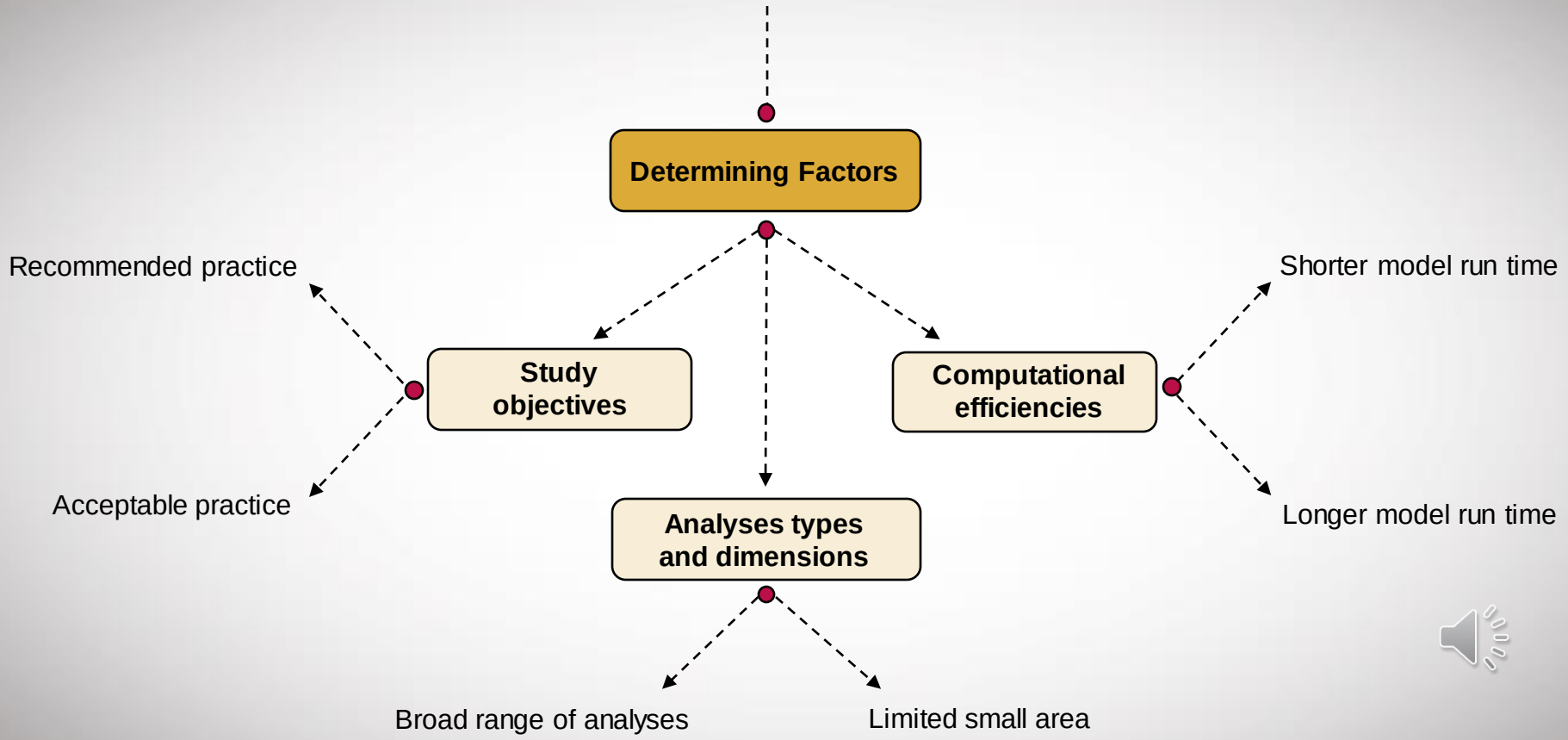
Analytical Methods





Features	Analytical Method	
	Focusing	Windowing
Spatial dimension	Focus area varies	Small area
Temporal dimension	Short, intermediate and long	Short
Spatial detail	Enhanced	Enhanced
Temporal detail	Time periods of day	Peak hours
Extraction	No	Yes
OD trip table	Regional	Separate OD trip tables for subarea
Traffic operational characteristics	Limited	More flexible to add
Interaction between subarea and rest of region	Maintained	No/Limited
Consistency with regional model in traffic assignment method	Maintained	Preferred but not necessary
Model run time	Like regional model	Much shorter

Use Cases (Applicability Situations)



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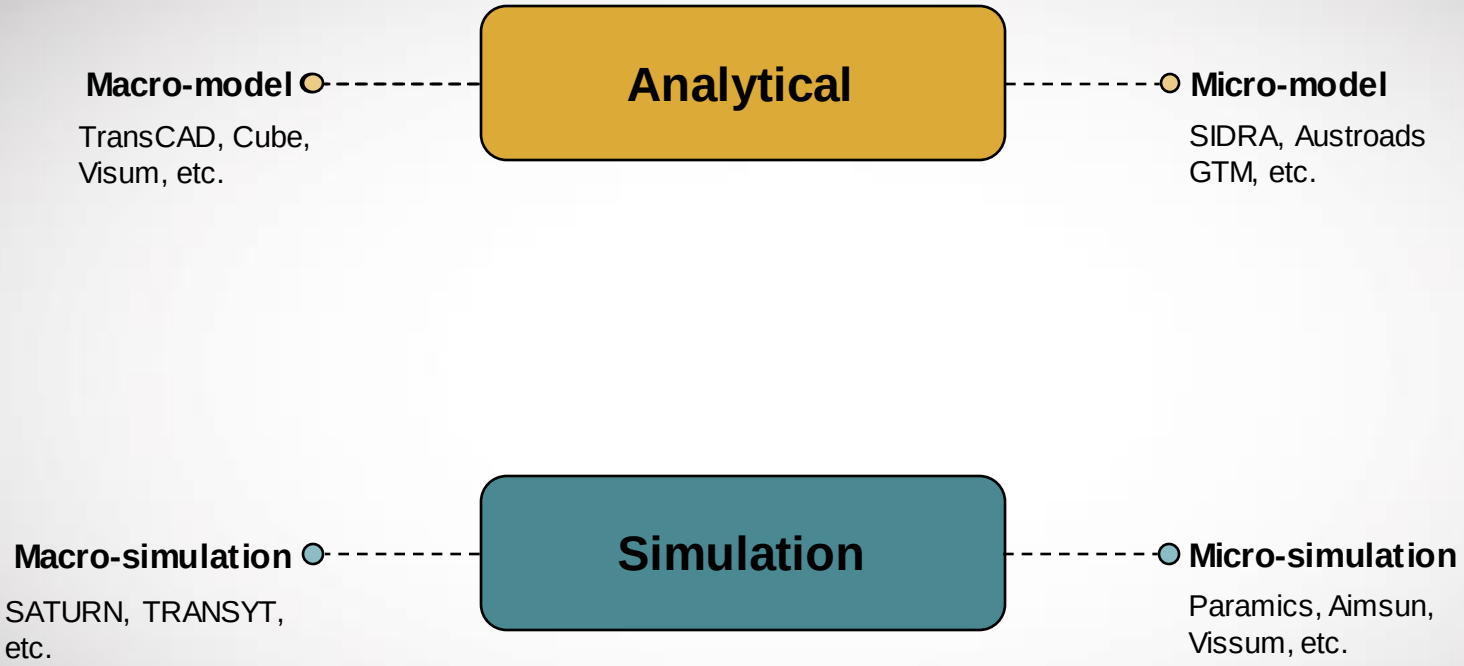
Modeling Techniques


Macro-model
TransCAD, Cube, Visum, etc.
Analytical
Micro-model
SIDRA, Austroads GTM, etc.
Macro-simulation
SATURN, TRANSYT, etc.
Simulation
Micro-simulation
Paramics, Aimsun, Vissum, etc.

Frequently Asked Questions

- **How much time does it take to build a travel demand model?**
  - Small or medium-sized city: several months to a year
    Large metropolitan area: several years
- **How often are MPOs updating their network?**
  - TDMs are updated every five years (it is part of the federally mandated RTP planning process)
- **If 2020 and 2025 TDMs are available, what can MPOs do if they want to model 2023 scenario?**
  - MPOs can use 2025 model but input 2023 demographic data

Questions?

Contributors:

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- Laura Norton

- Georges Bou-Saab
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