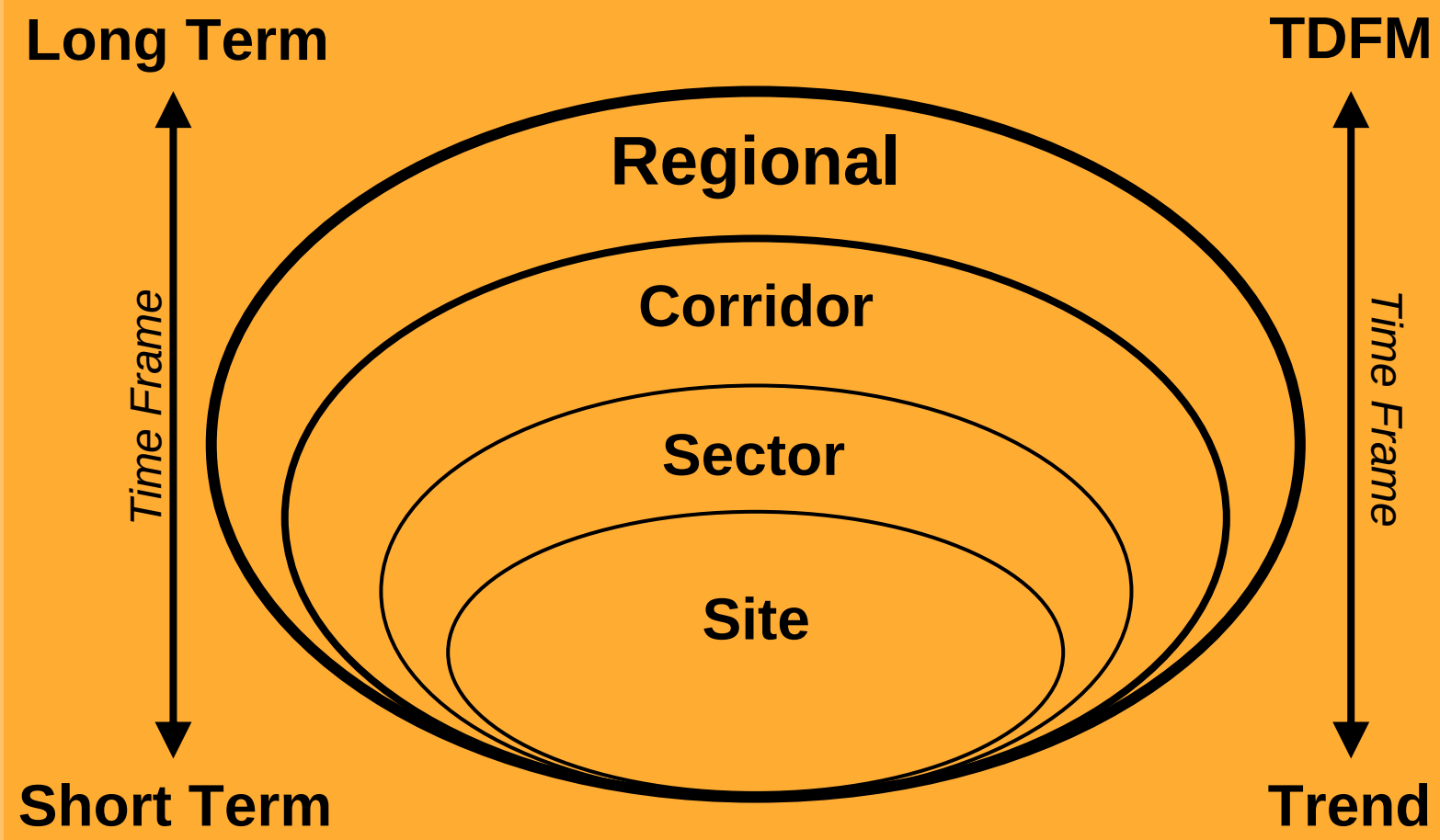
Travel Demand Forecasting Overview

March 17, 2009

Tysons Task Force Transportation Subcommittee

Levels of Transportation Planning Studies



What is a Model

- Mathematical Representation

$$P(k) = \frac{e^{U_k}}{\sum_x e^{U_x}}$$

- Evaluate Scenario
  - Land Use
  - Network Improvements
  - Social-Economic Policies → Pricing

Travel Demand Forecast Models

- Proposed Land Use
- Proposed Highway and Transit Facilities
- Impact of Land Use on the Transportation System

Role of TDFMs

- Develop Potential Travel Demand
- Project Evaluation
- Design
- Economic Analysis
- Environmental Impacts

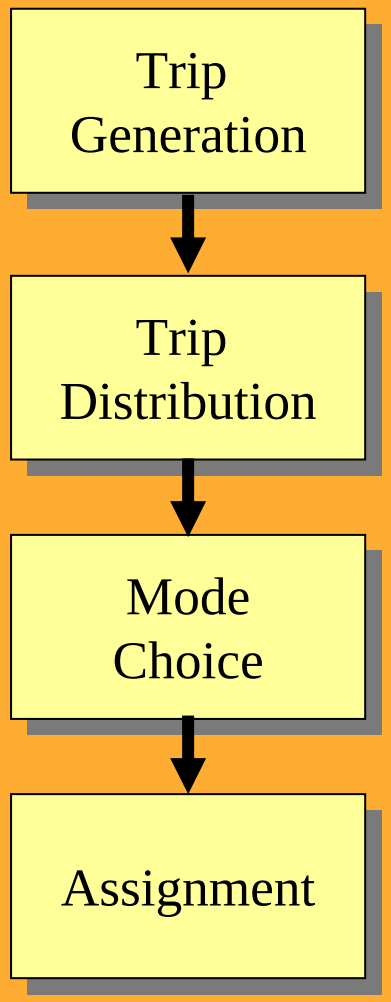
General Limitations of TDFMs

- Not Traffic Operations
- Aggregate Level
- Non Motorized Travel
- Linking of Trips
- Freight and Commercial Movements
- Time-of-Day Issues

TDFMs State-of-Practice

- TRB Survey 381 MPO's
- Four-Step Model
- Trip End Models – P & A
- Aggregate Person Level Travel
- Purposes: HBW, HBS, HBSc, HBO, NHB
- Gravity Model
- Mode Choice Logit Model
- Assignment Highway - Equilibrium

Four-Step Model Process



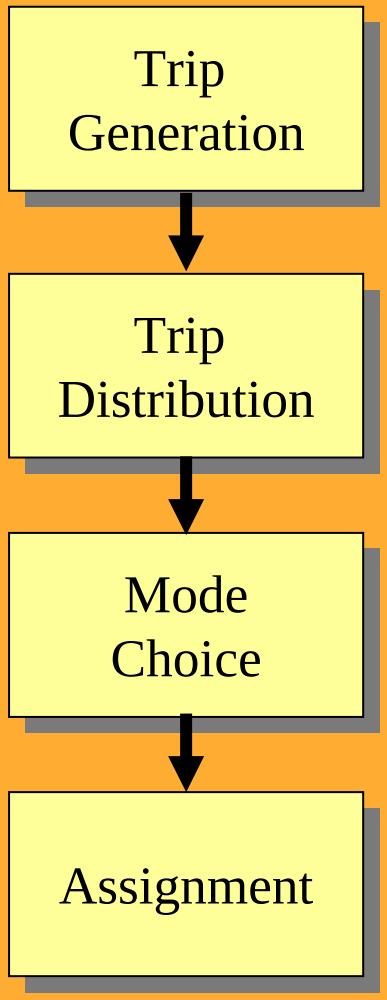
Why

Where

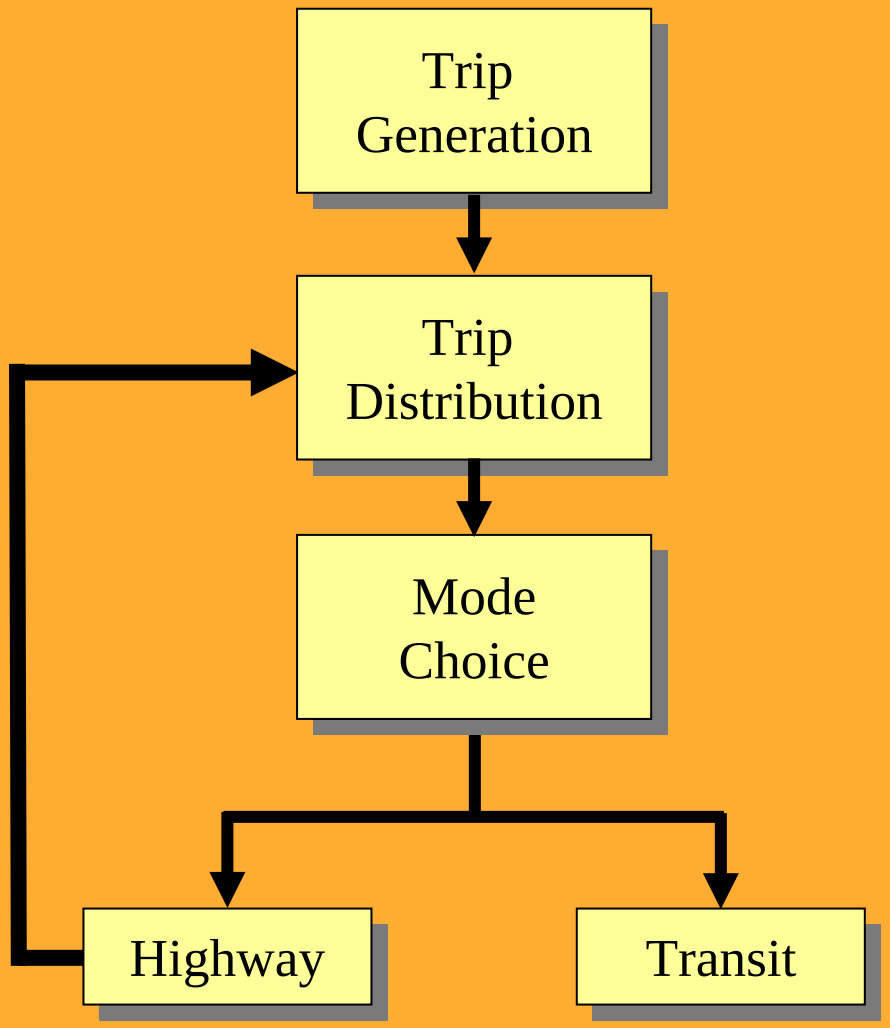
How

Which

Four-Step Model Process

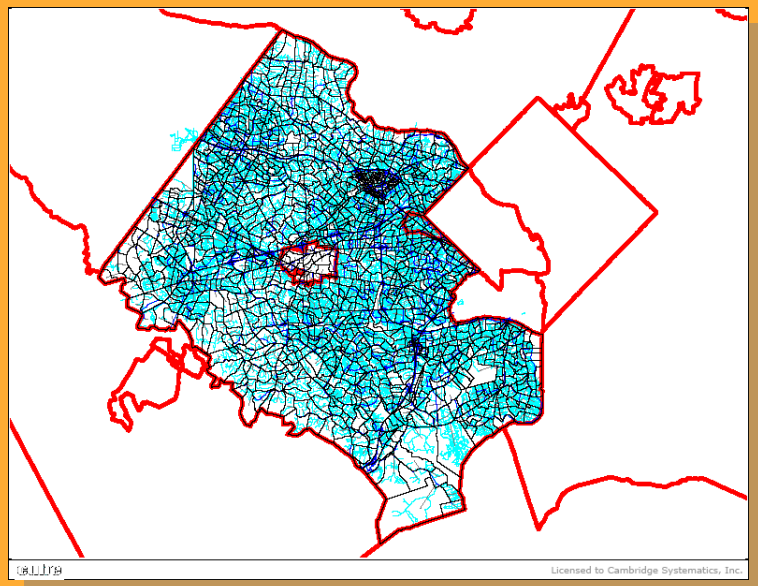


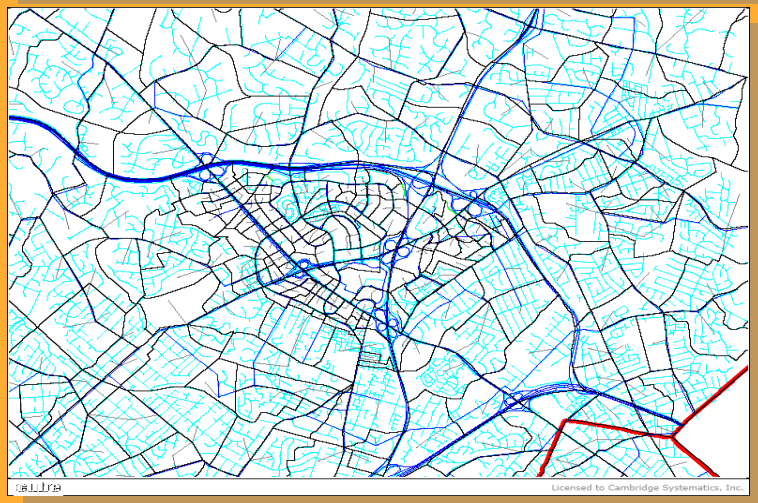
Four-Step Model Process



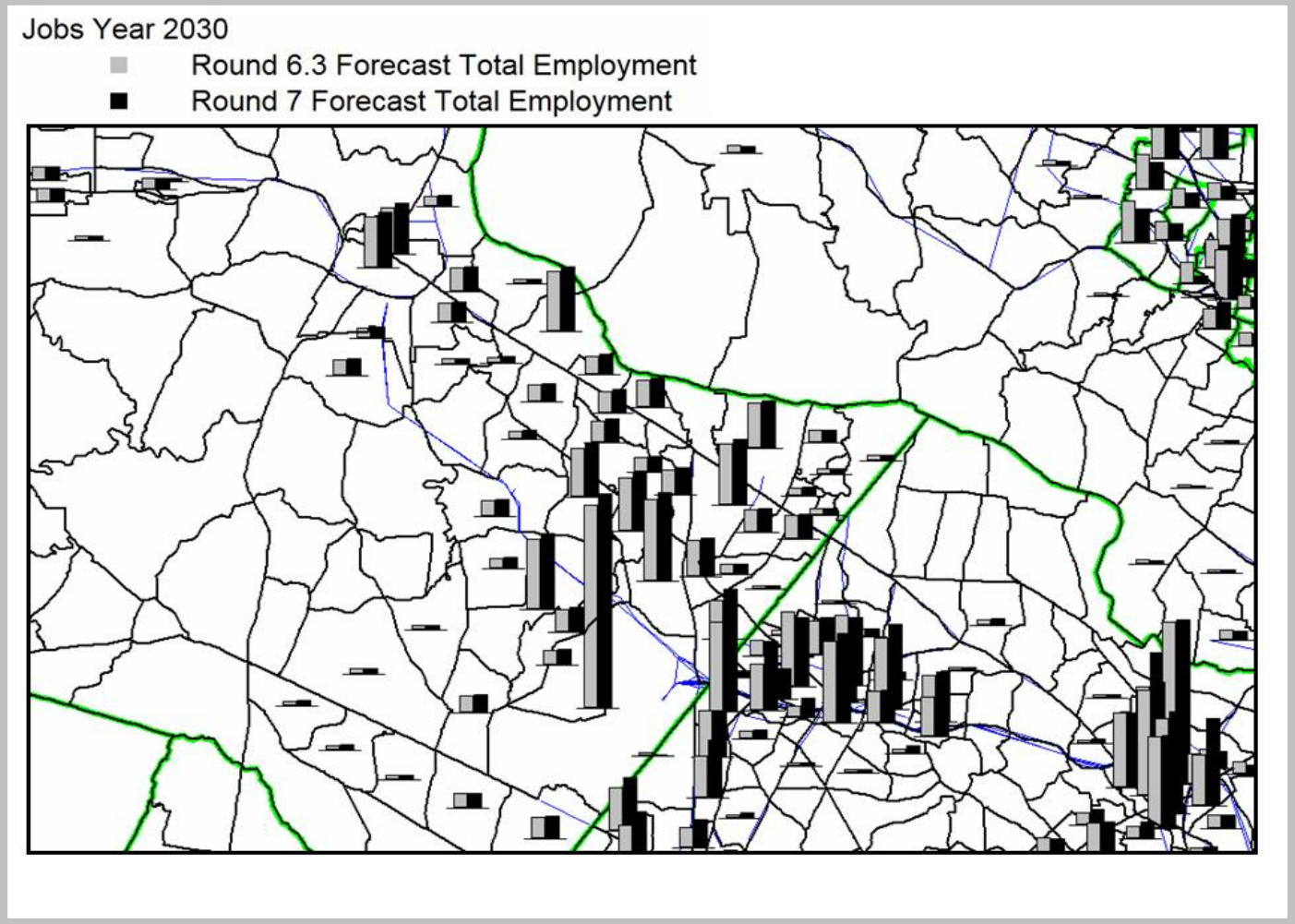
Four-Step Model Process

- Basic Inputs
  - Land-Use
    - Employment Type
    - Households
  - Aggregated TAZ
    - Major Highway Facilities
    - Homogenous Land Use



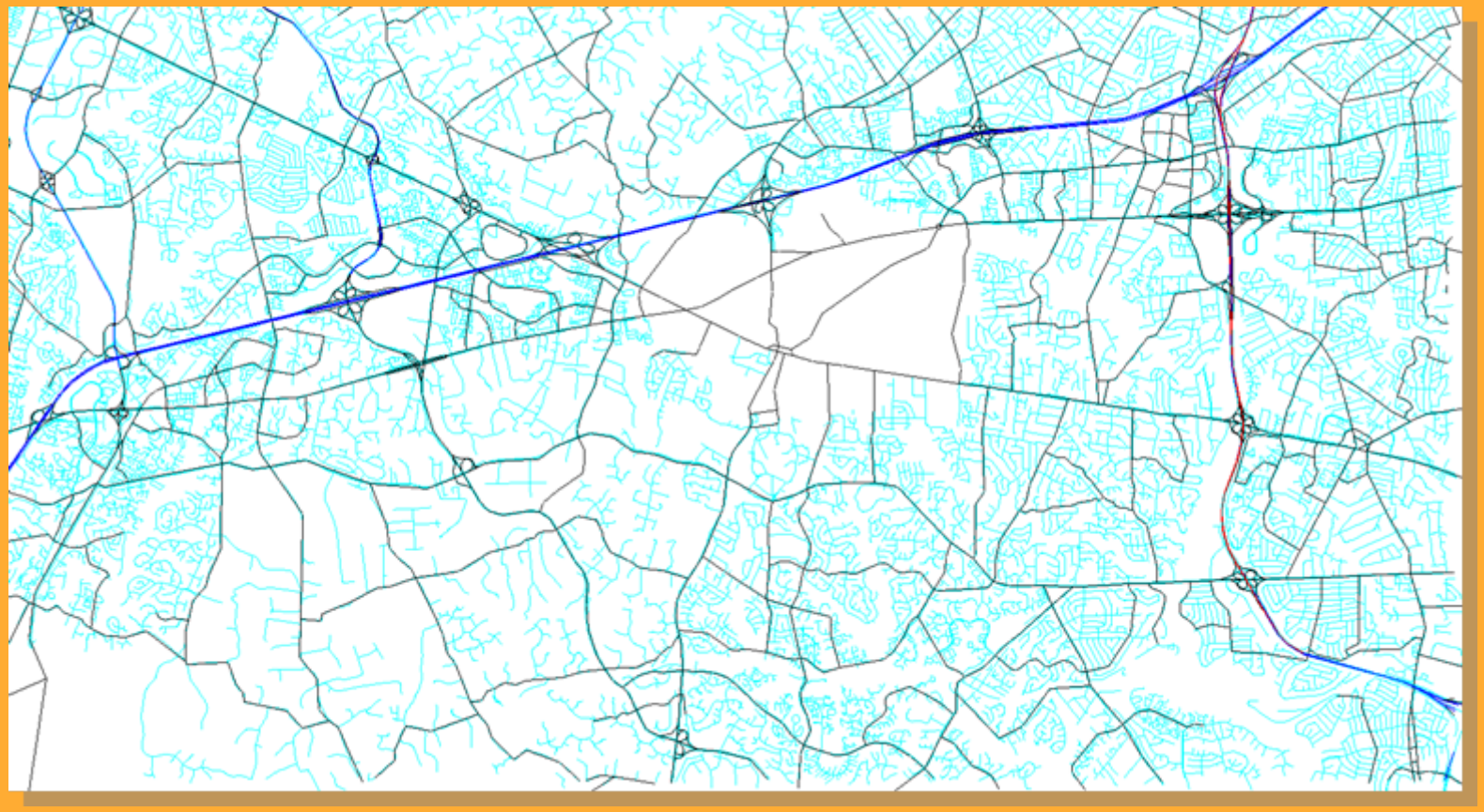


Four-Step Model Process



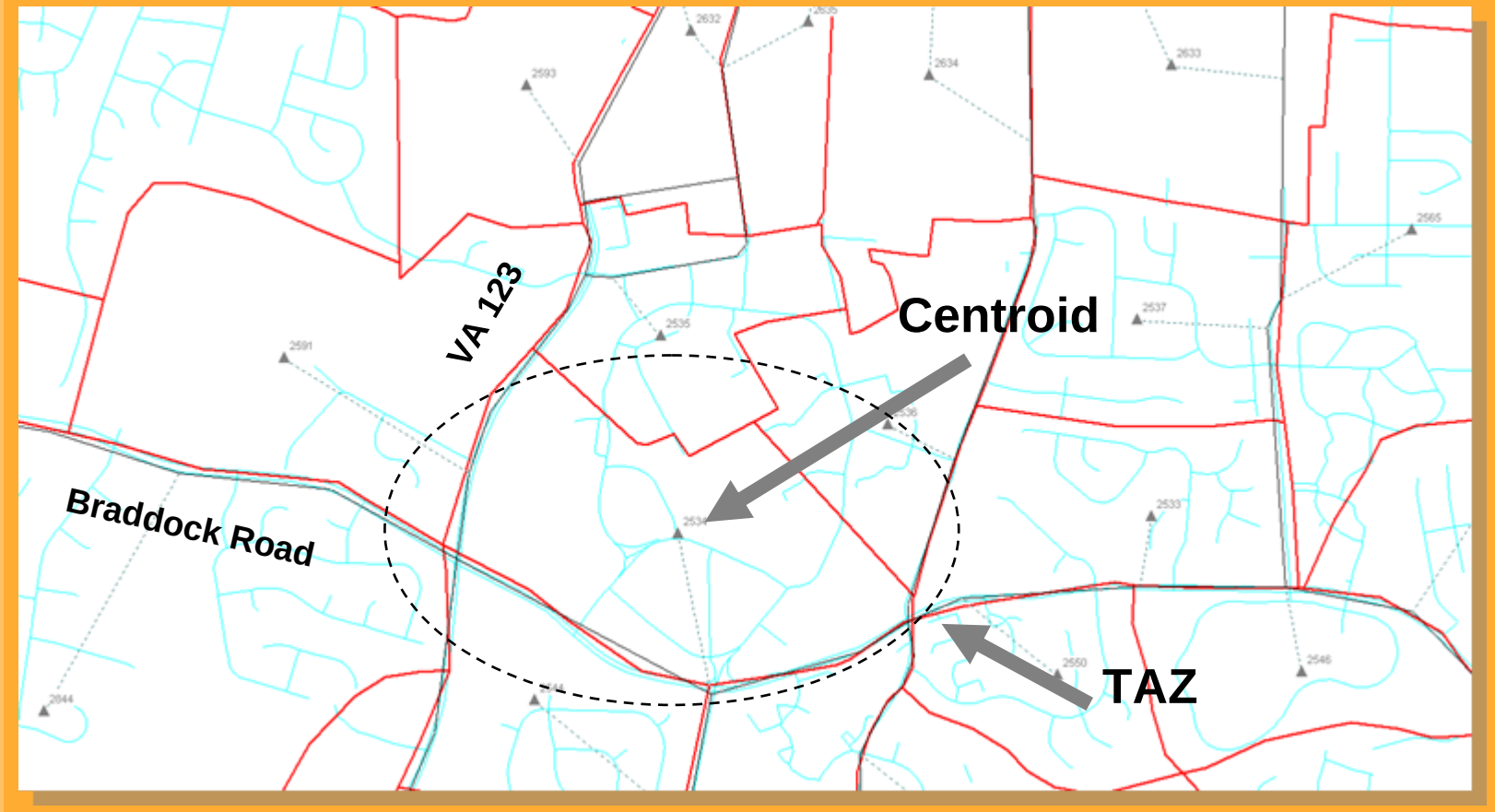
Four-Step Model Process

Network

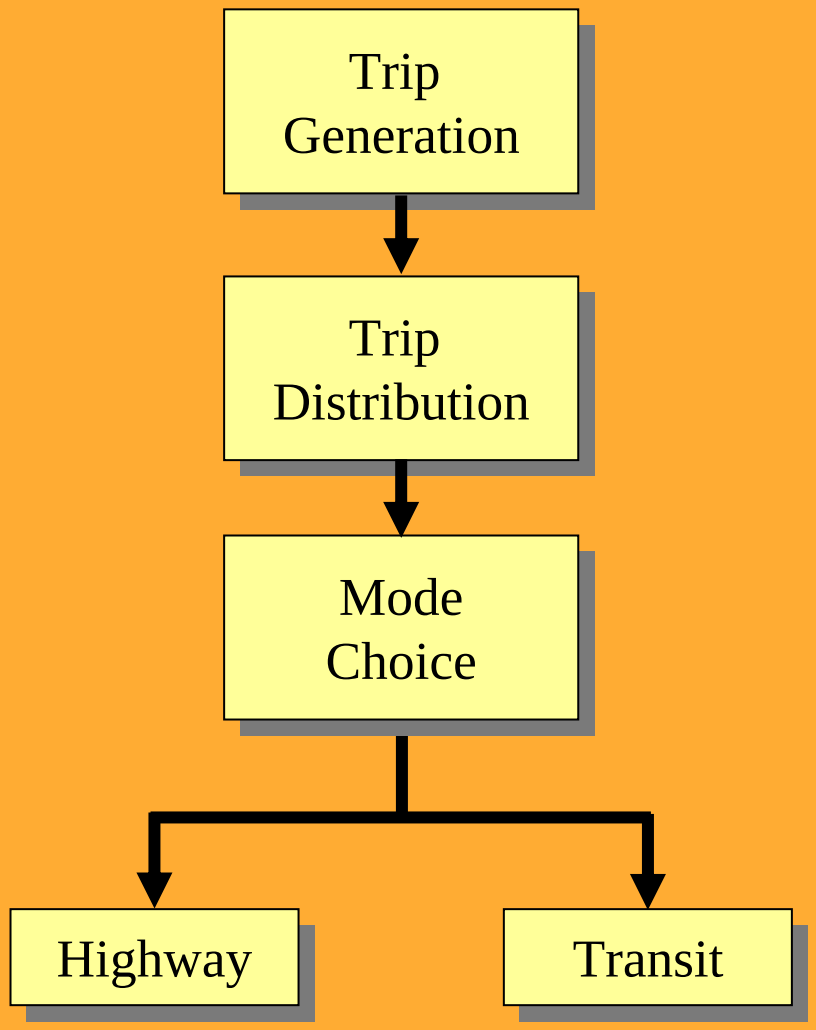


Four-Step Model Process

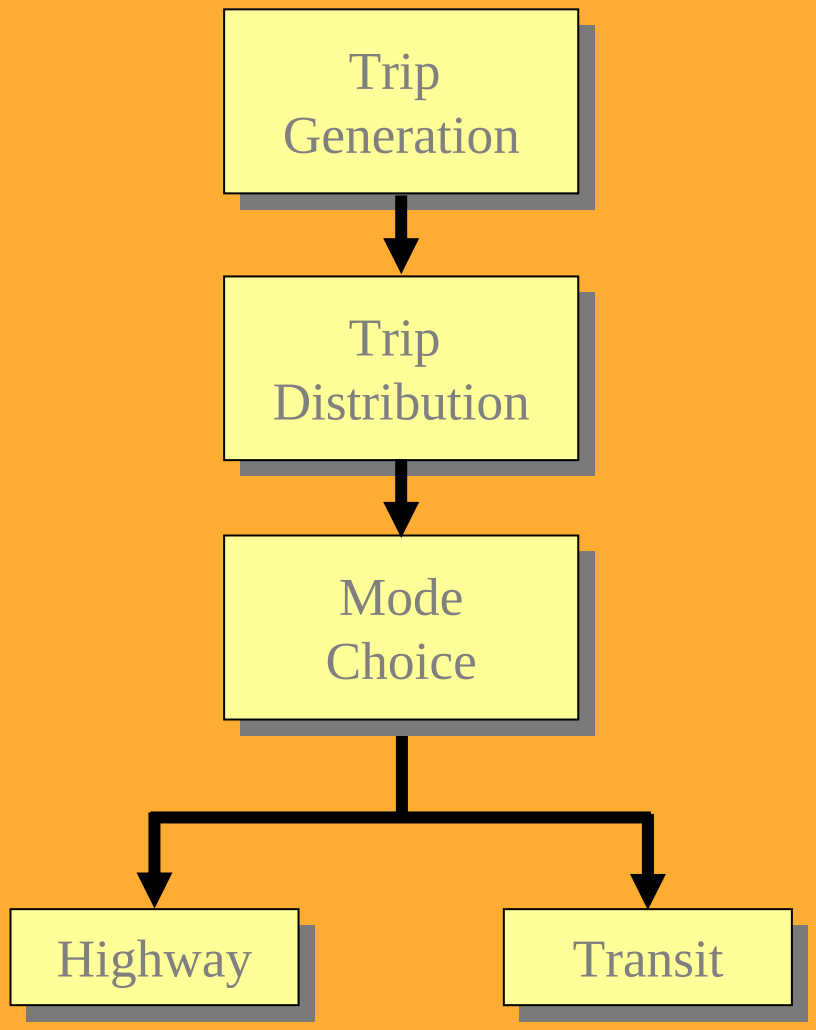
Network



Four-Step Model Process

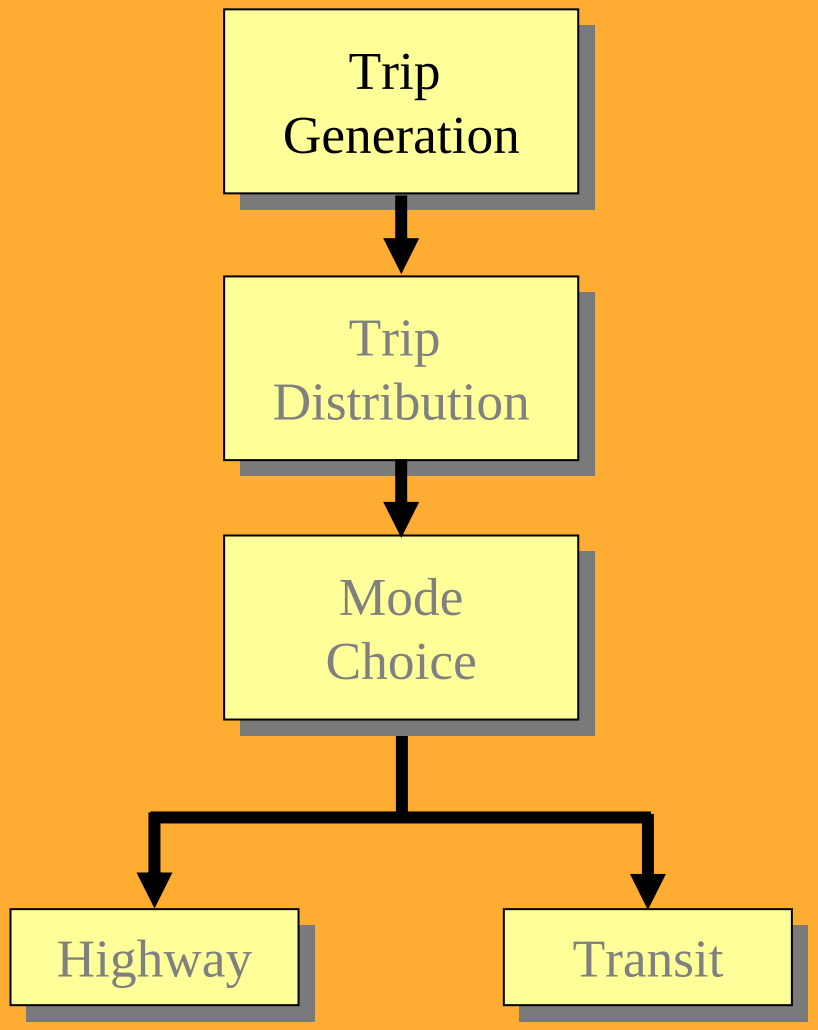


Four-Step Model Process



Four-Step Model Process

- Input ➔ Land Use
- Output ➔ Trip Ends
  - Production
  - Attractions
- Regression Equations
- Cross-Classification
- Balance on Productions

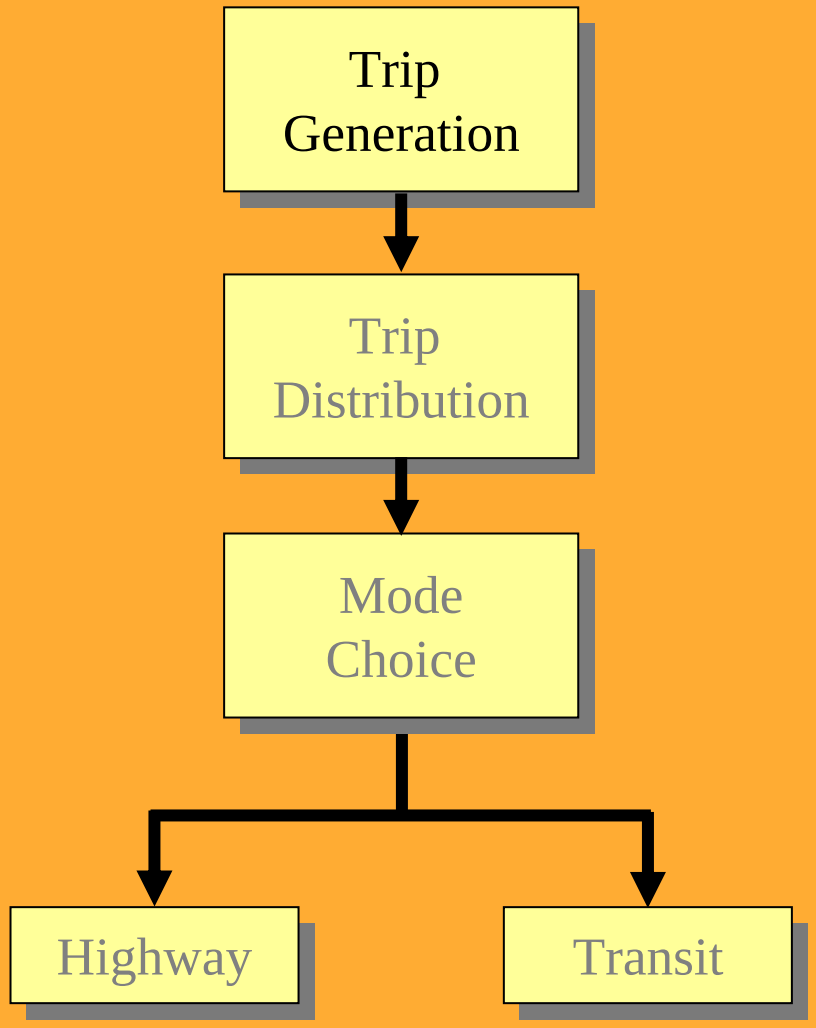


Four-Step Model Process

Production Trip Rates

Purpose	Workers or Persons	Income 1	2	3	4	Sub-Total
HBW (Workers)	0					
	1	0.945	1.209	1.235	1.335	1.260
	2	1.816	2.097	2.575	2.575	2.533
	3+	3.300	3.500	4.000	4.020	4.012
	Sub-Total	0.315	0.832	1.215	2.050	**1.522**
SCH (Persons)	1	0.000	0.000	0.000	0.000	0.000
	2	0.070	0.070	0.084	0.084	0.081
	3	0.487	0.522	0.522	0.581	0.561
	4	1.416	1.416	1.416	1.454	1.444
	5+	1.450	1.860	1.884	2.757	2.543
	Sub-Total	0.201	0.273	0.357	0.762	**0.550**
HBS (Persons)	1	0.758	0.890	0.890	0.900	0.859
	2	1.251	1.930	1.990	1.990	1.927
	3	2.000	2.100	2.100	2.240	2.191
	4	2.640	2.670	2.700	2.773	2.748
	5+	2.700	2.780	2.780	3.274	3.157
	Sub-Total	1.150	1.593	1.711	2.228	**1.917**
HBO (Persons)	1	0.880	0.890	0.890	0.890	0.888
	2	1.121	1.702	1.920	1.920	1.832
	3	2.650	2.734	3.050	3.050	2.996
	4	2.950	3.850	3.958	4.441	4.241
	5+	3.500	4.800	5.808	7.225	6.783
	Sub-Total	1.277	1.783	2.117	3.156	**2.549**
JTW (Workers)	0					
	1	0.200	0.308	0.361	0.404	0.363
	2	0.350	0.384	0.510	0.672	0.629
	3+	0.400	0.500	0.741	0.743	0.740
	Sub-Total	0.065	0.188	0.300	0.524	**0.381**
JAW (Workers)	0					
	1	0.126	0.163	0.305	0.305	0.272
	2	0.229	0.233	0.385	0.614	0.556
	3+	0.300	0.400	0.500	0.774	0.742
	Sub-Total	0.041	0.104	0.242	0.466	**0.324**

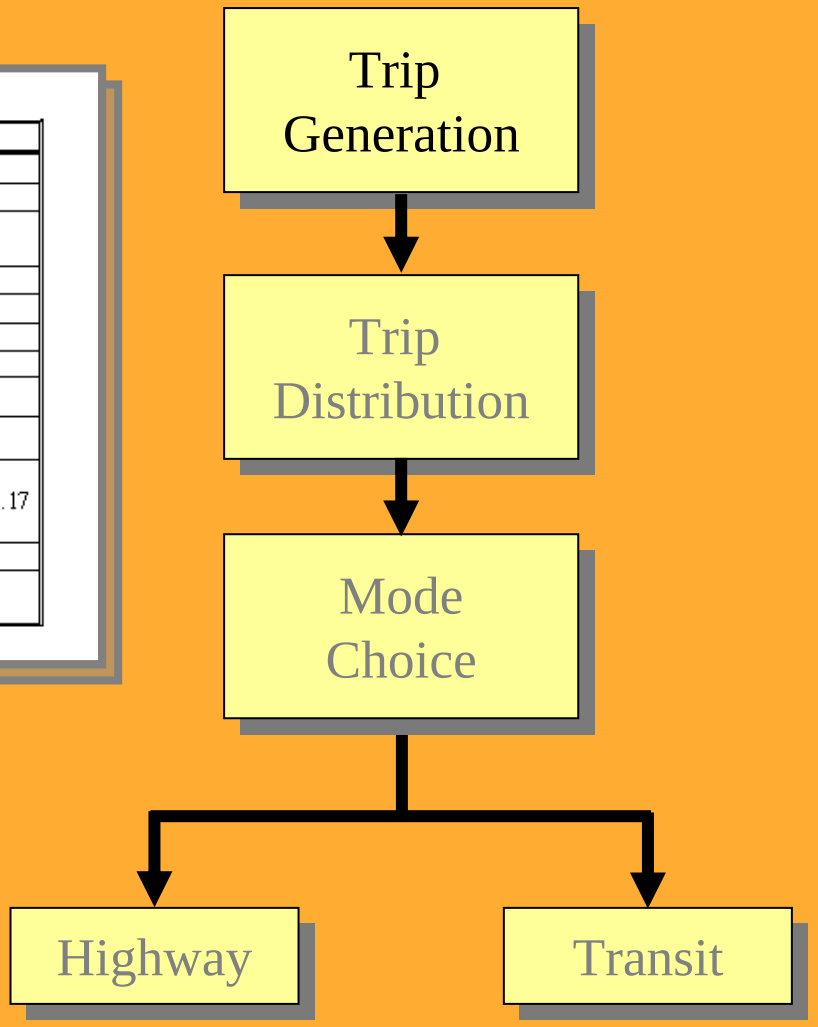
Source: Hampton Roads TDFM



Four-Step Model Process

Person Trip Attraction Equations

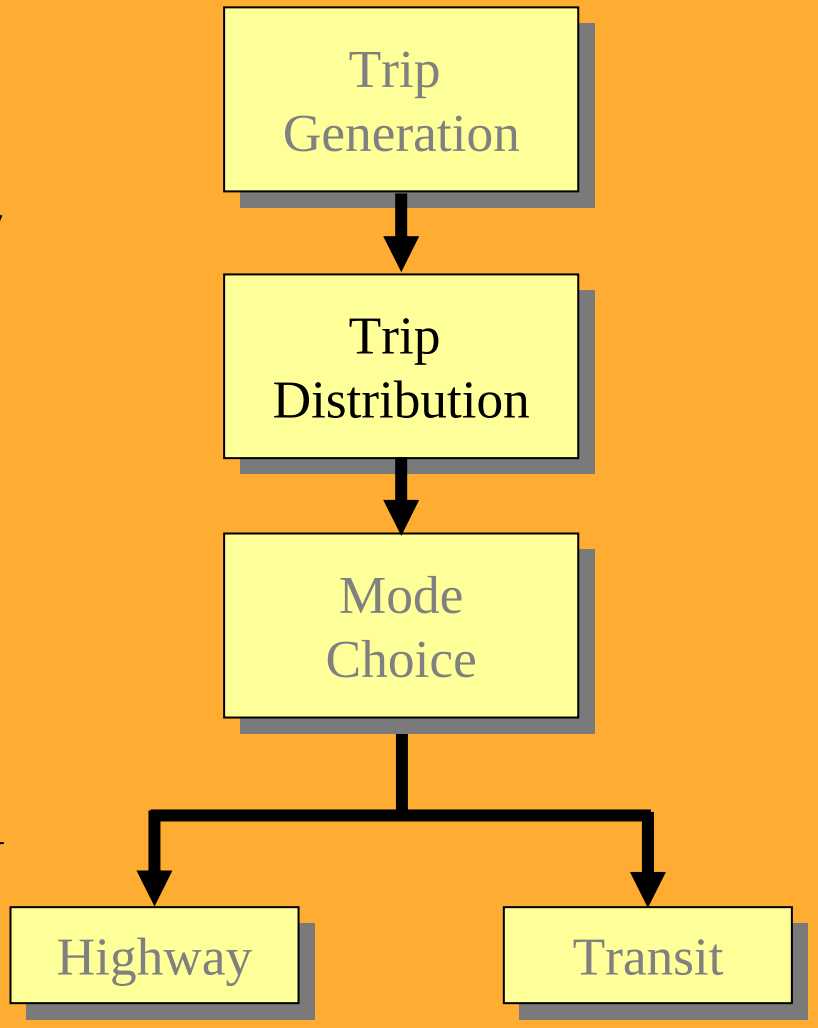
Purpose	Attraction Equation
Home-Based Work	Balt: 0.82 * TE – 564
	Wash: 0.83 * TE + 396
Home-Based School	Balt: 1.08 * ENROLL
	Wash: 1.18 * ENROLL
Home-Based Shop	Balt: 2.38 * RE + 1.66 * HH – 5215
	Wash: 1.74 * RE + 0.45 * HH – 533
Home-Based Other	Balt: 1.32 * OTH + 2.21 * HH – 2553
	Wash: 1.86 * RE + 1.13 * OTH + 1.29 * HH + 947
Non-Home-Based Journey to Work	Balt: 0.66 * RE + 0.80 * OTH + 0.27 * HH – 1870
	Wash: 1.76 * RE + 0.38 * NRE + 0.40 * HH – 836
Non-Home-Based Journey At Work	Balt: 0.35 * RE + 1.22 * OTH – 1245
	Wash: 0.90 * OFF + 0.64 * OTH + 0.40 * CBDEMP + 0.17 * HH + 275
Non-Home-Based Other-Based Other	Balt: 3.03 * RE + 2.09 * HH – 6728
	Wash: 3.02 * RE + 0.99 * HH + 503



Four-Step Model Process

- Gravity Model
- Input ➔ Person Trips by Purpose
- Output ➔ Origins and Destinations

$$\text{Trips}_{ij} = P_i \times \frac{A_j \times FF_{ij} \times K_{ij}}{\Sigma(A_j \times FF_{ij} \times K_{ij})}$$



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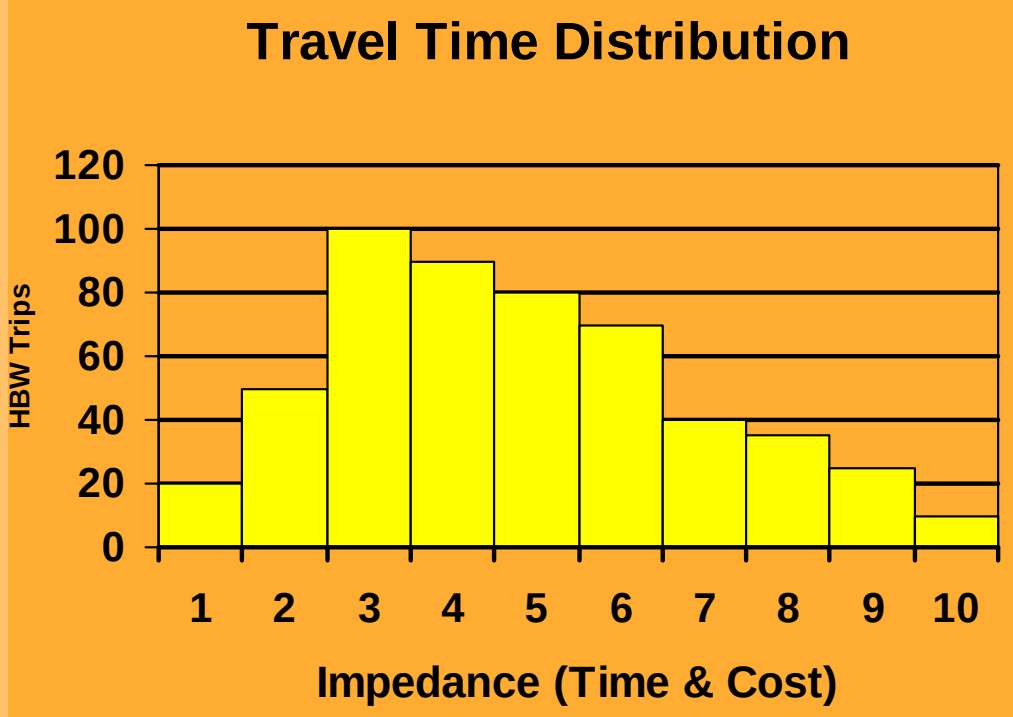
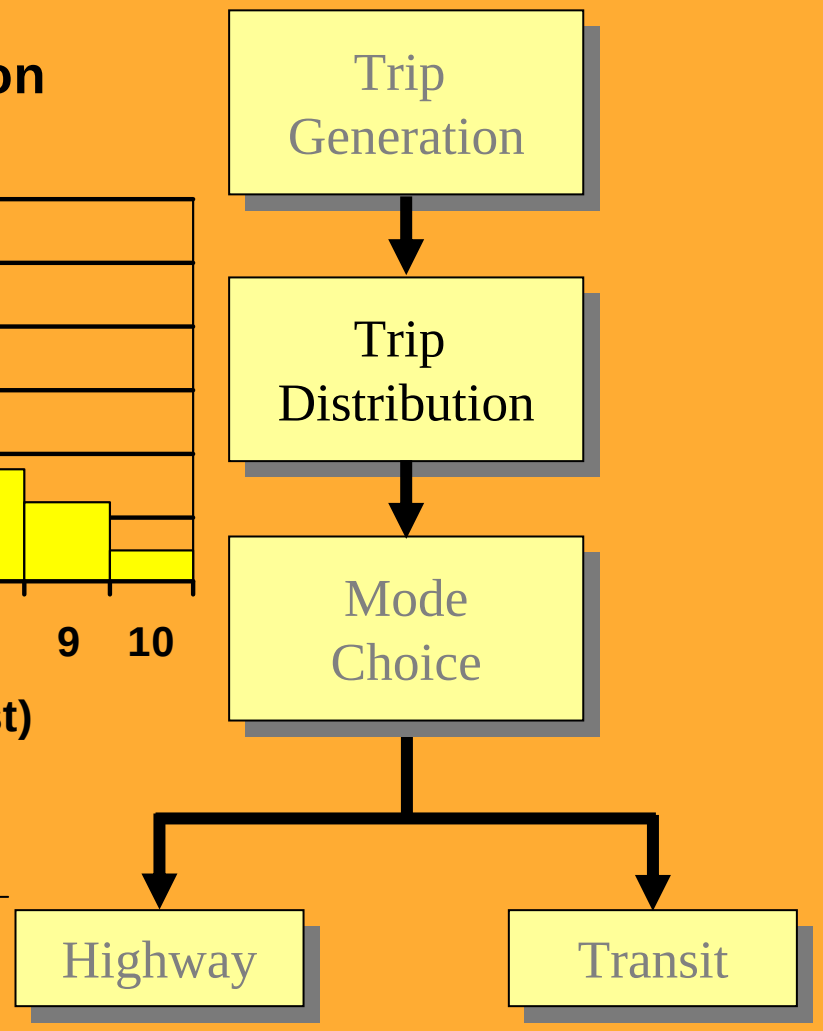
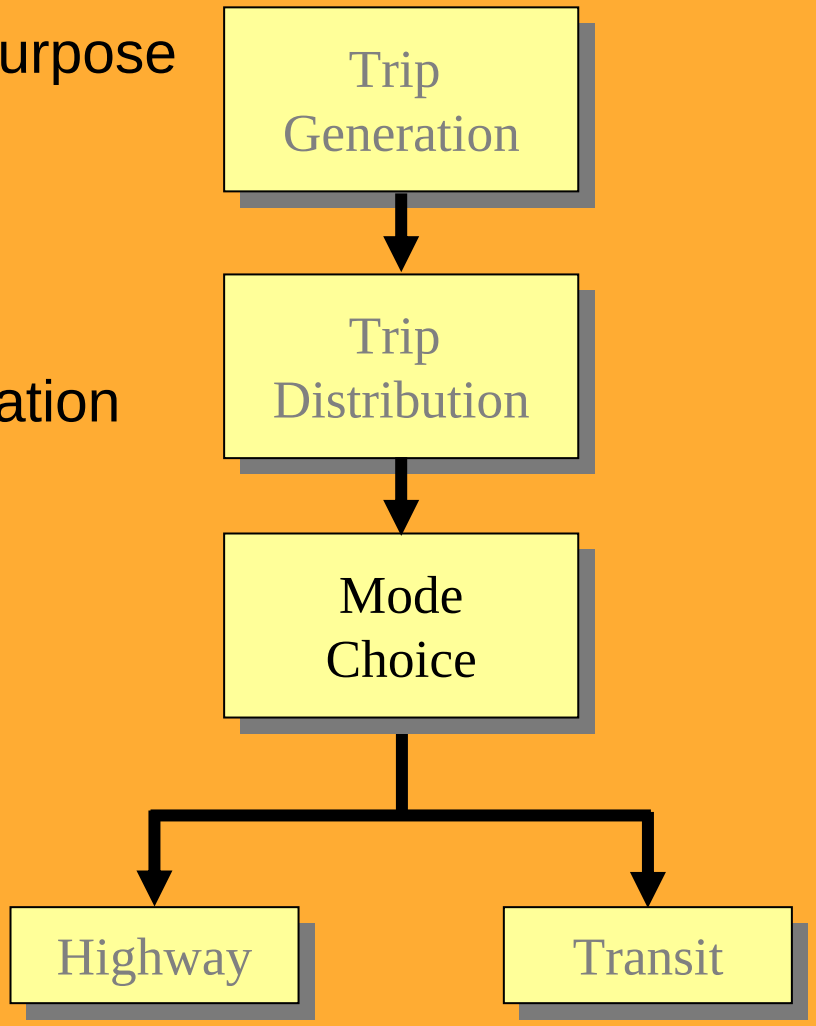




$$\text{Trips}_{ij} = P_i \times \frac{A_j \times FF_{ij} \times K_{ij}}{\Sigma(A_j \times FF_{ij} \times K_{ij})}$$

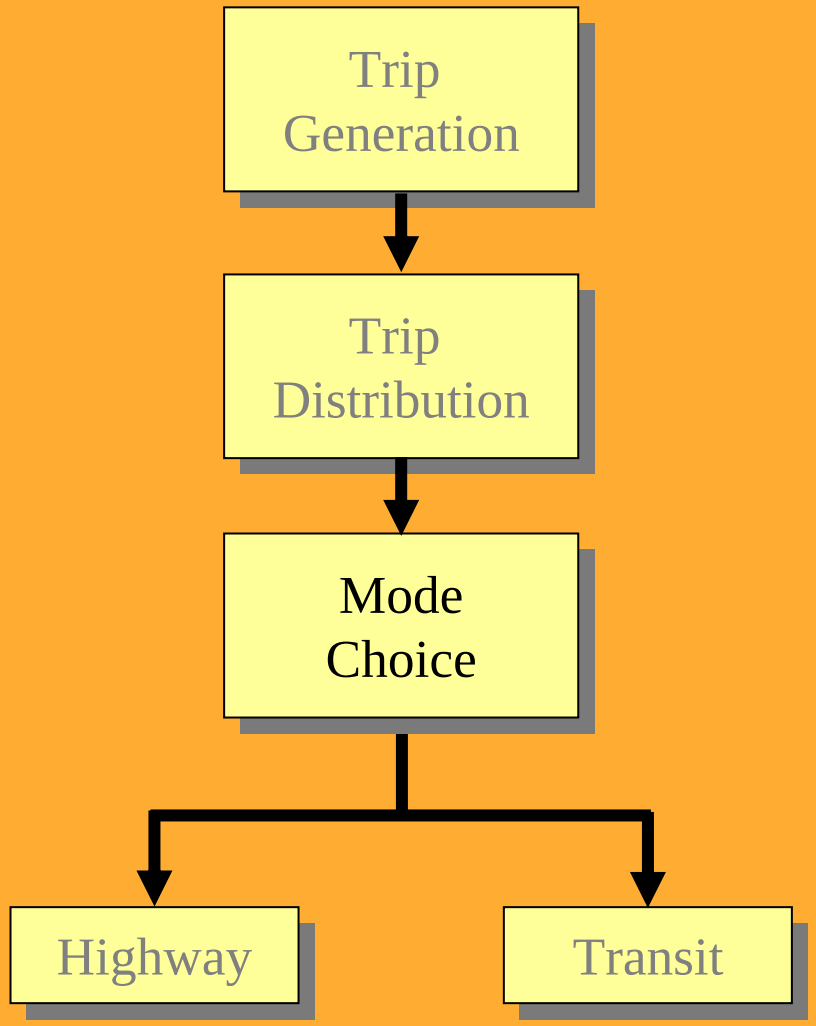
Four-Step Model Process

- Input ➔ Person Trips by Purpose and Origin/Destination
- Output ➔ Person Trips by Purpose and Origin/Destination and <u>Mode</u>
- Zonal Level
- Logit Model
- Probability



Four-Step Model Process

- Parameters
  - Destination
  - Cost
  - Travel Time



Travel Time Components

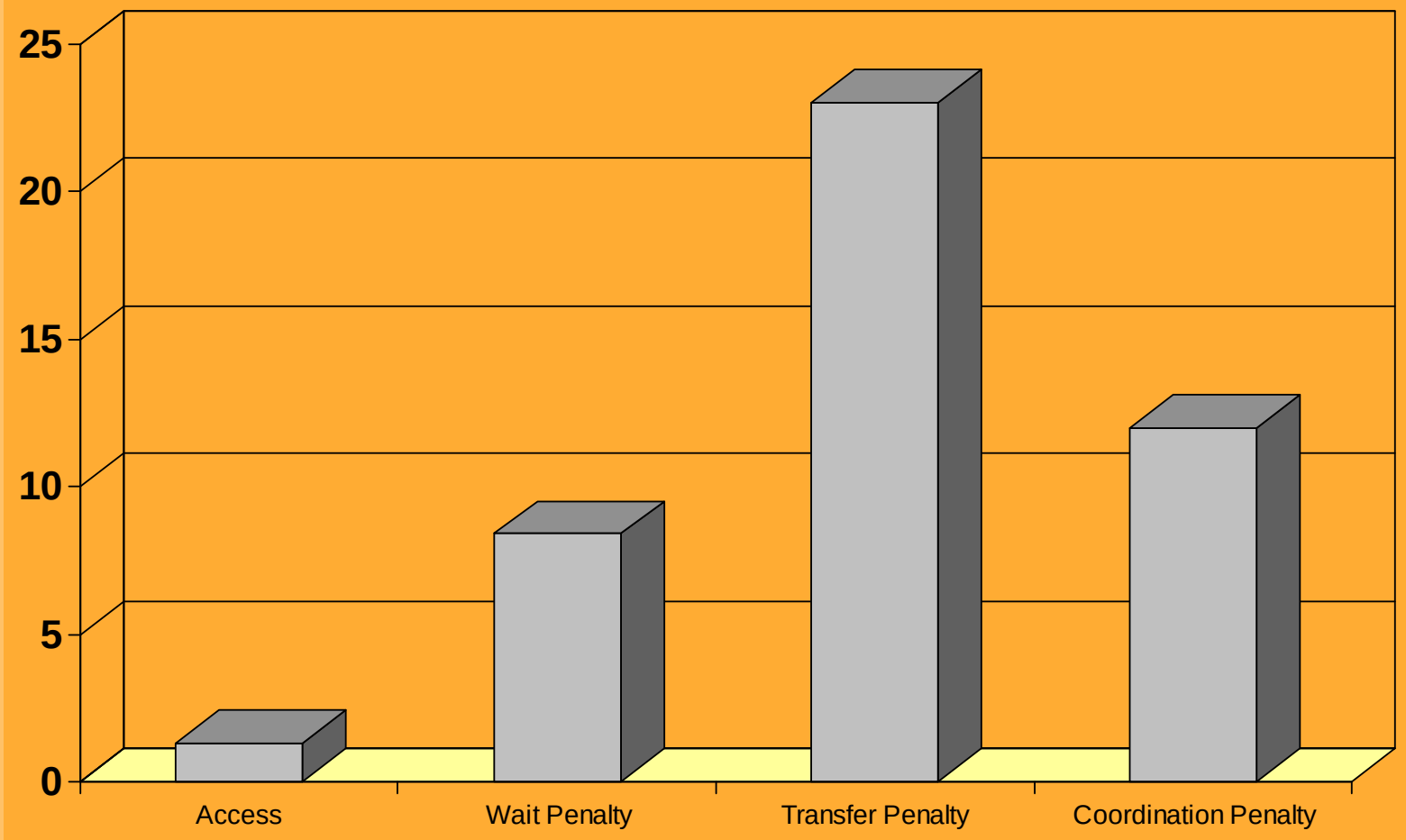
$$P(k) = \frac{e^{U_k}}{\sum_x e^{U_x}}$$

$$U = a_o + a_1q_1 + a_1q_1 + a_2q_2 + \ldots\ldots + a_xq_x$$

$$\begin{aligned} TRAN = {} & 0.0583 \times WT + 0.0583 \times IWT + 0.637 \times TT \\ & + 0.0173 \times TIVT + 0.0173 \times TOVT \\ & + 0.0044 \times F + Abias + 0.0173 \times ACONN \end{aligned}$$

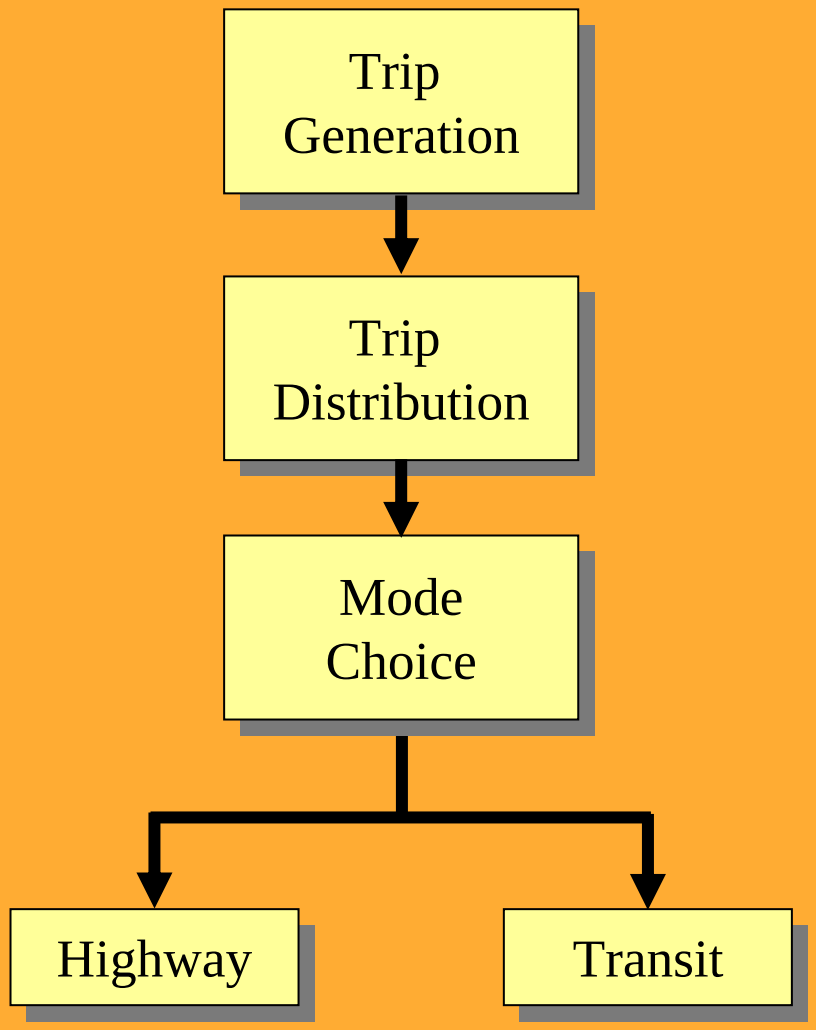
- In-Vehicle Time
- Out of-Vehicle Time
  - Access Time
  - Initial Wait Time
  - Transfer Wait
  - Egress Time

Wait Time Disutility



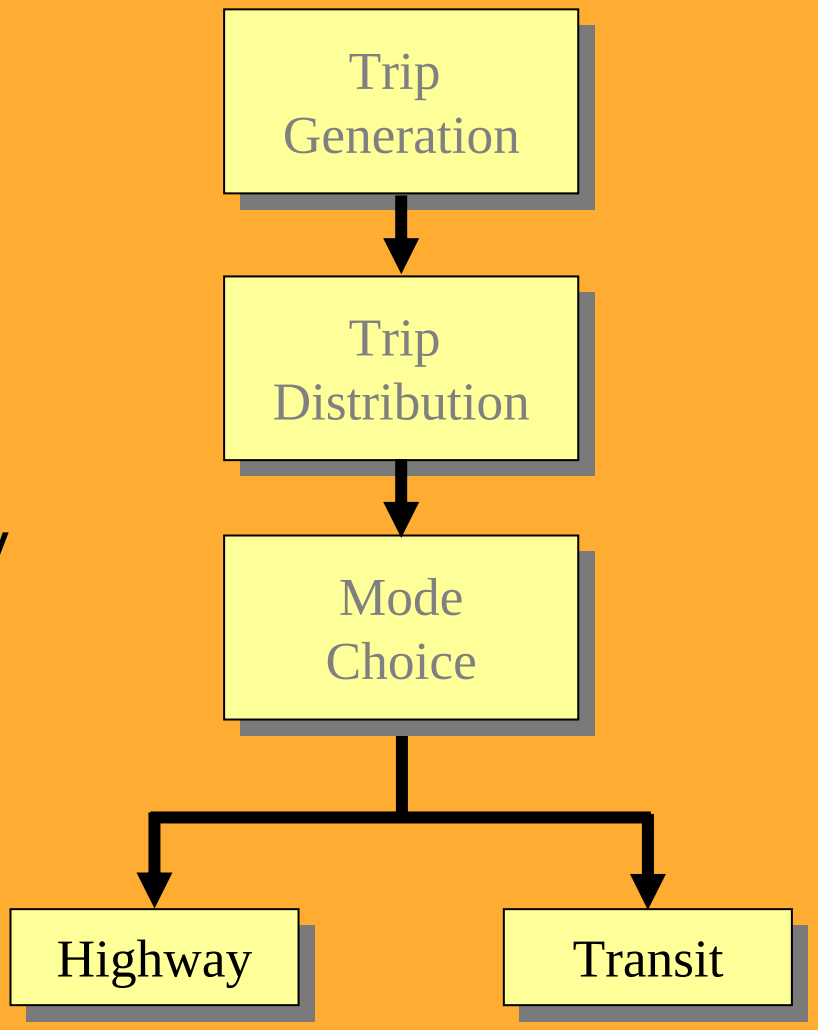
Mode Choice Elasticity

Four-Step Model Process

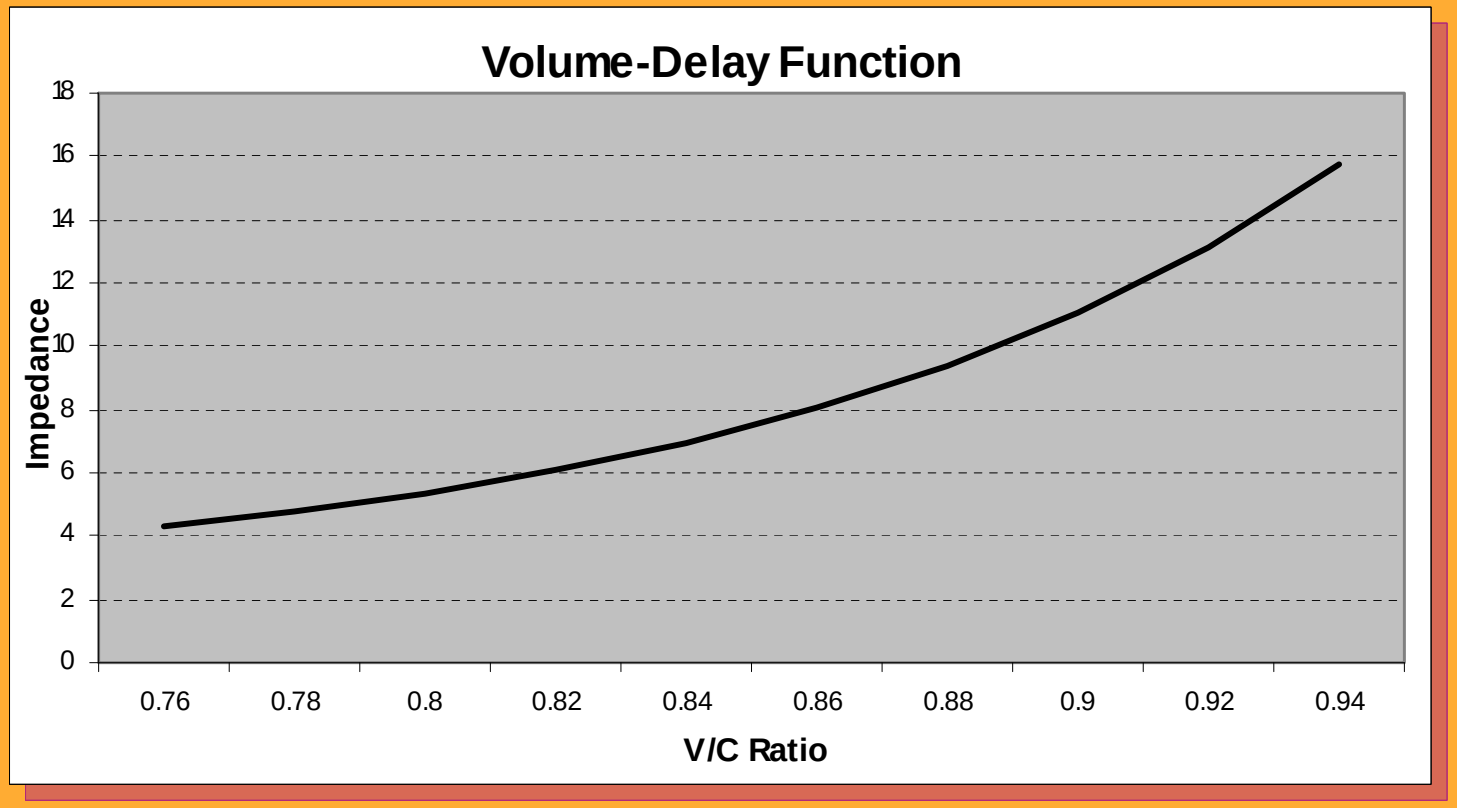


Four-Step Model Process

- Input ➔Trip Tables
- Output ➔ Loaded Network
- Highway
  - Incremental Capacity Constraint
  - Equilibrium
- Transit
  - All-or-Nothing (AON)



Impedance Equation



$$T_c = t_o \times \left[1 + \alpha \left(\frac{v}{c}\right)^{\beta}\right]$$

Historical Applications of TDFMs

- Urban Transportation Planning
- Geometric Design
- Pavement Design

Current Applications of TDFMs

- Air Quality
- TDM Programs
- TSM Programs
- Social Policy (Environmental Justice)

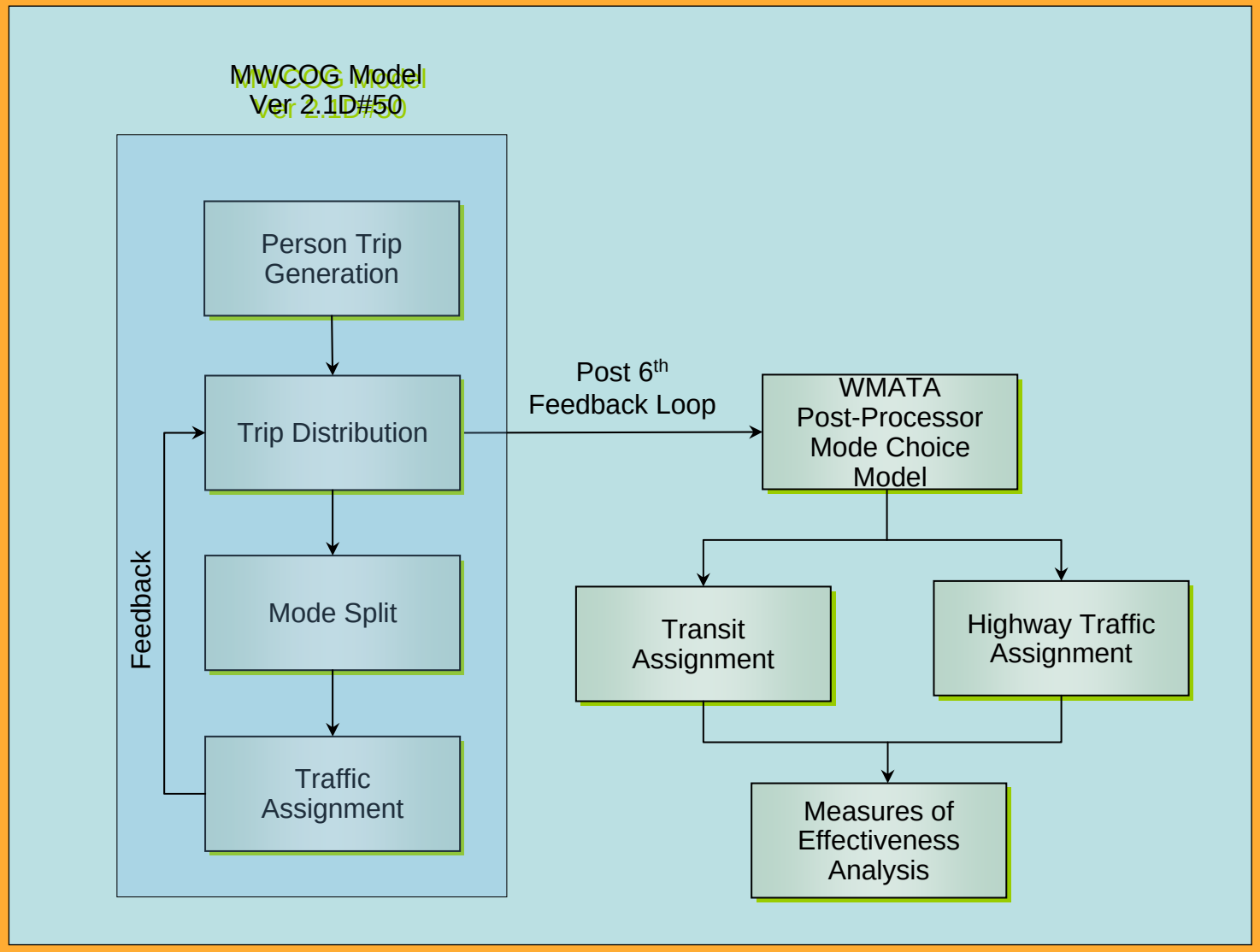
MWCOG TDFM

- Series of Sequential Models
- State of the Practice
- Validation
  - Regional
  - Study Area

Forecasting Application

WMATA Post-Processor provides enhanced transit forecasting capabilities.

Fairfax County submodel provides enhanced highway assignment capabilities.



Questions