# Activity-Based Models
# 1993-2012
# One Developer's Perspective

**UC Berkeley**
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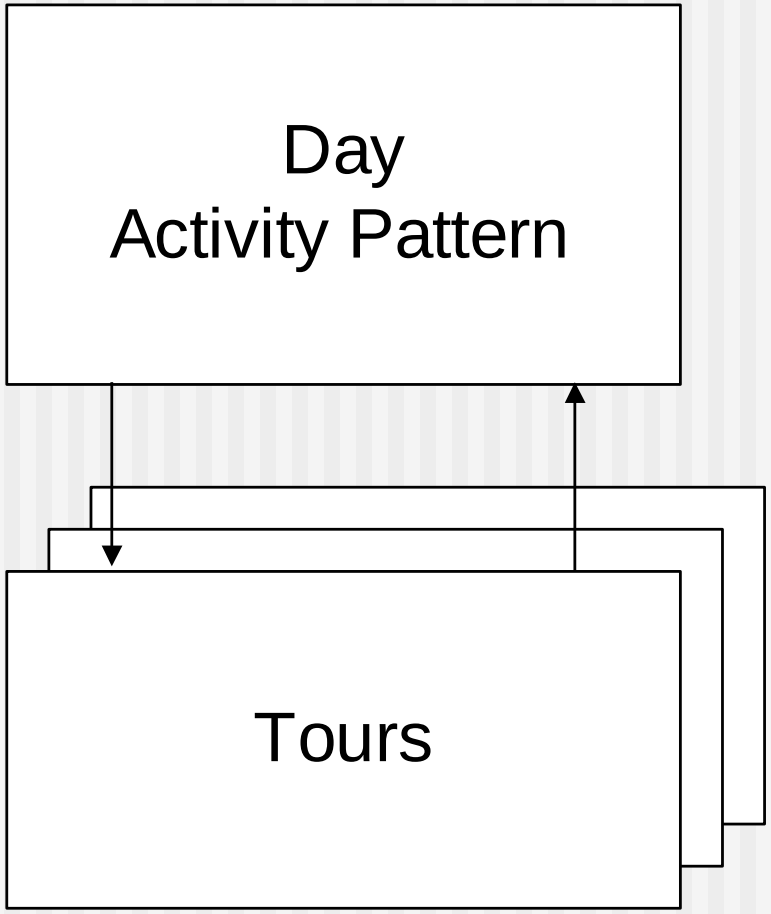
# Acknowledgments


- Moshe Ben-Akiva (1993-1998)
- Keith Lawton at Metro (1995-2000)
- Mark Bradley (since 1996)
- Gordon Garry & Bruce Griesenbeck at SACOG (since 2001)
- John Gibb & DKS (since 2005)
- Joe Castiglione (since 2007)
- Resource Systems Group (since 2008)
- Peter Vovsha & Parsons Brinckerhoff (since 2001)

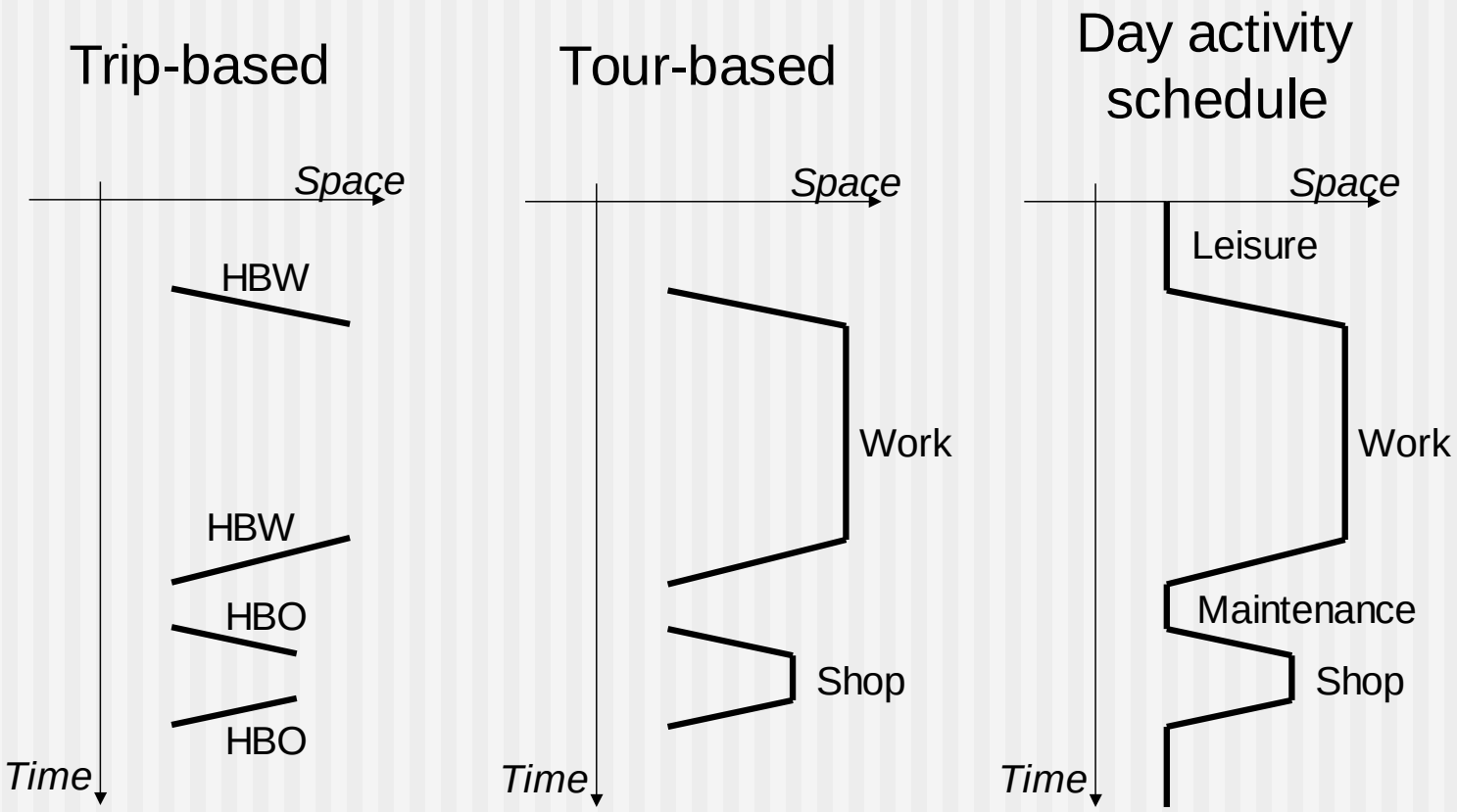
# Activity-Based Models
## 1993-2012

- Early history in the U.S.
- Basics of the "Activity-Based" model systems
- Advanced features

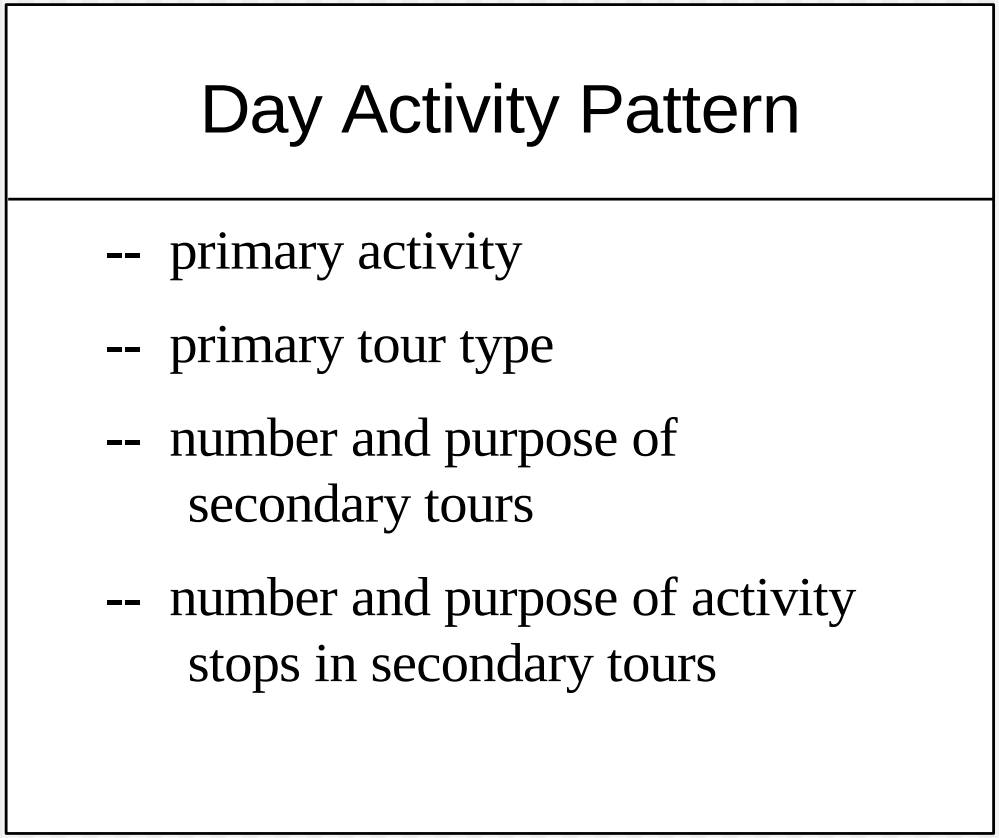
# The Day Activity Schedule (TRB January 1994)



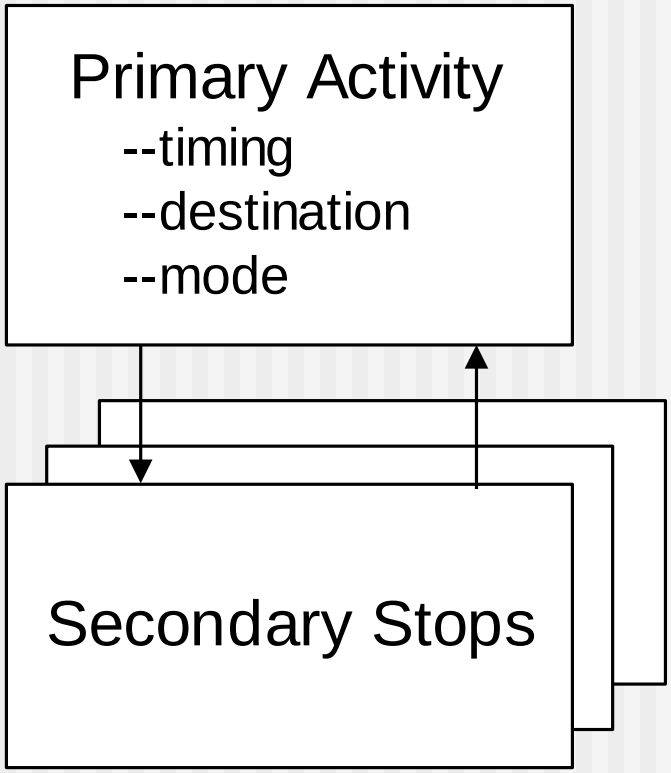
# Discrete Choice Approaches



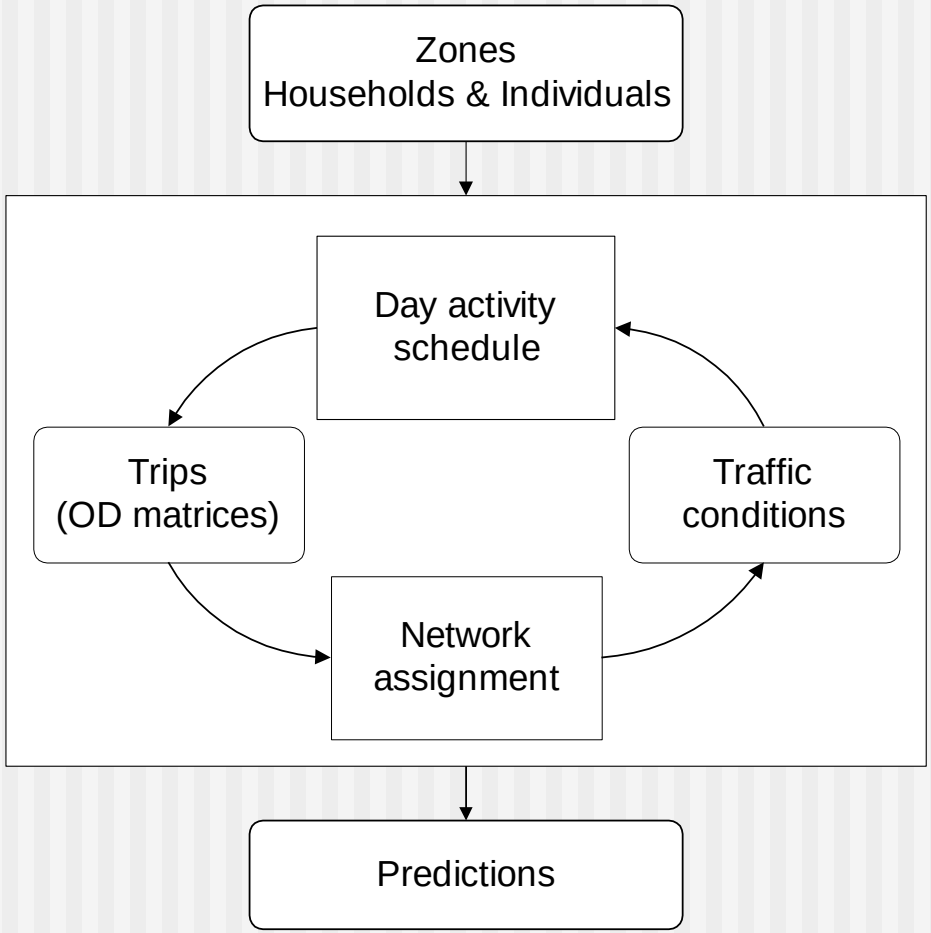
# Day Activity Pattern



# Tours


Primary Activity
--timing
--destination
--mode
Secondary Stops

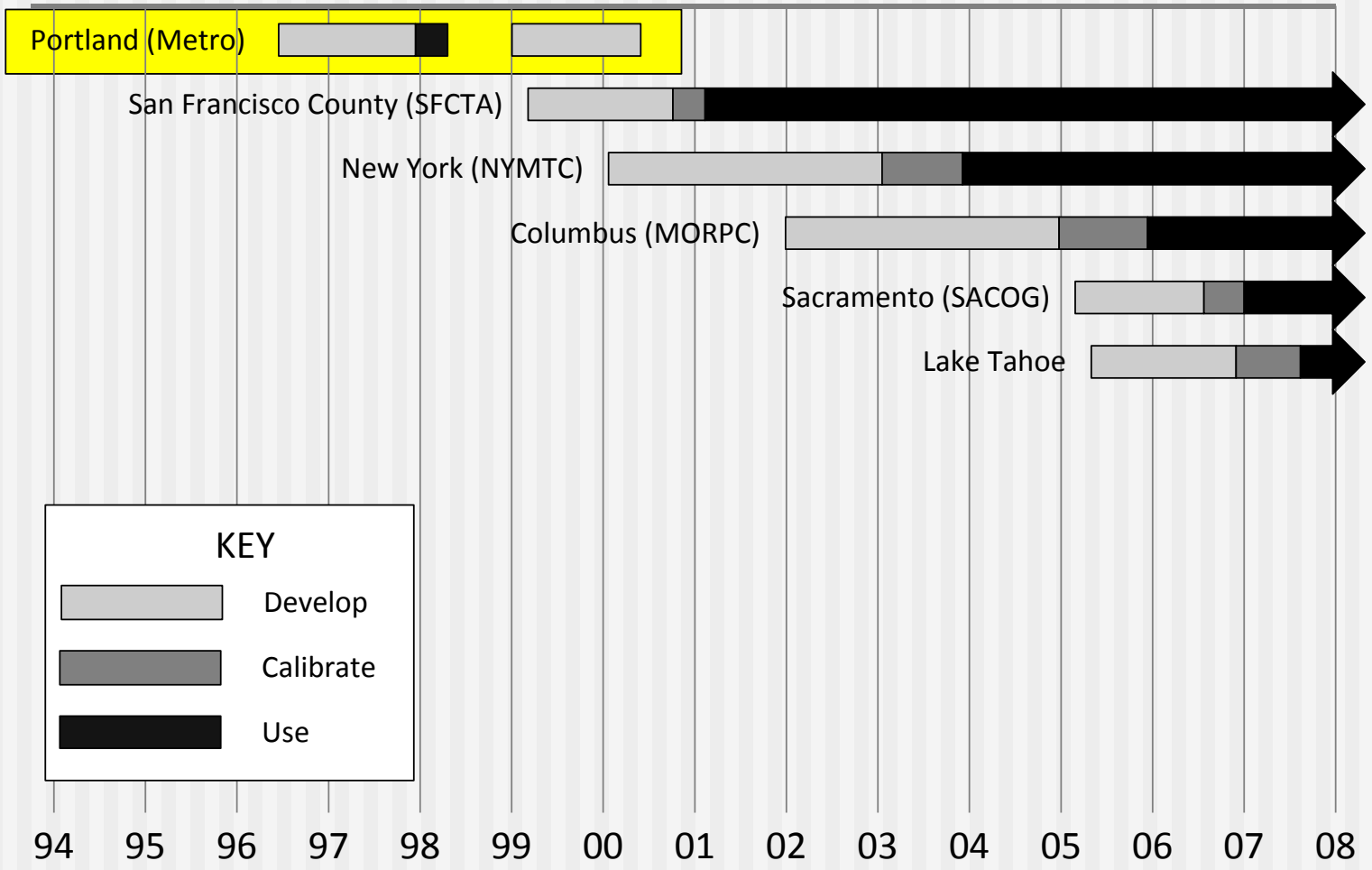
# Model Application



# Jan 1995: MIT Prototype

- 😐 operational for forecasting and policy analysis
- ☺ available data and discrete choice methods
- ☺ integrated system of daily activity and travel choices
  - ☺ tours in a daily activity pattern
  - 😐 activity time of day

# Early U.S. Projects



# 1996-1998: Portland Metro

- Features not in MIT prototype
  - Usual work and school location
  - Intermediate stops on tours
  - Detailed activity purposes (8)
  - Detailed spatial resolution (block face)
  - Work-based subtours
  - At-home activities
  - Integration with assignment models
- Used model for policy analysis

# Early Application Results (Portland 1998)

| Effect of Change in Auto Variable Costs (AVC) | | | Double AVC all times of day | | Double AVC in peak periods | |
|---|---|---|---|---|---|---|
| **Purp** | **Mode** | **Time of day** | **% chg Tours** | **% chg Miles** | **% chg Tours** | **% chg Miles** |
| Work | | | | | | |
| | All | All | -0.8 | -9.4 | -0.6 | -5.5 |
| | SOV | All | -5.8 | -14.6 | | |
| | | AM peak | | | -5.9 | -13.1 |
| | | Off-peak | | | +1.0 | 0.0 |
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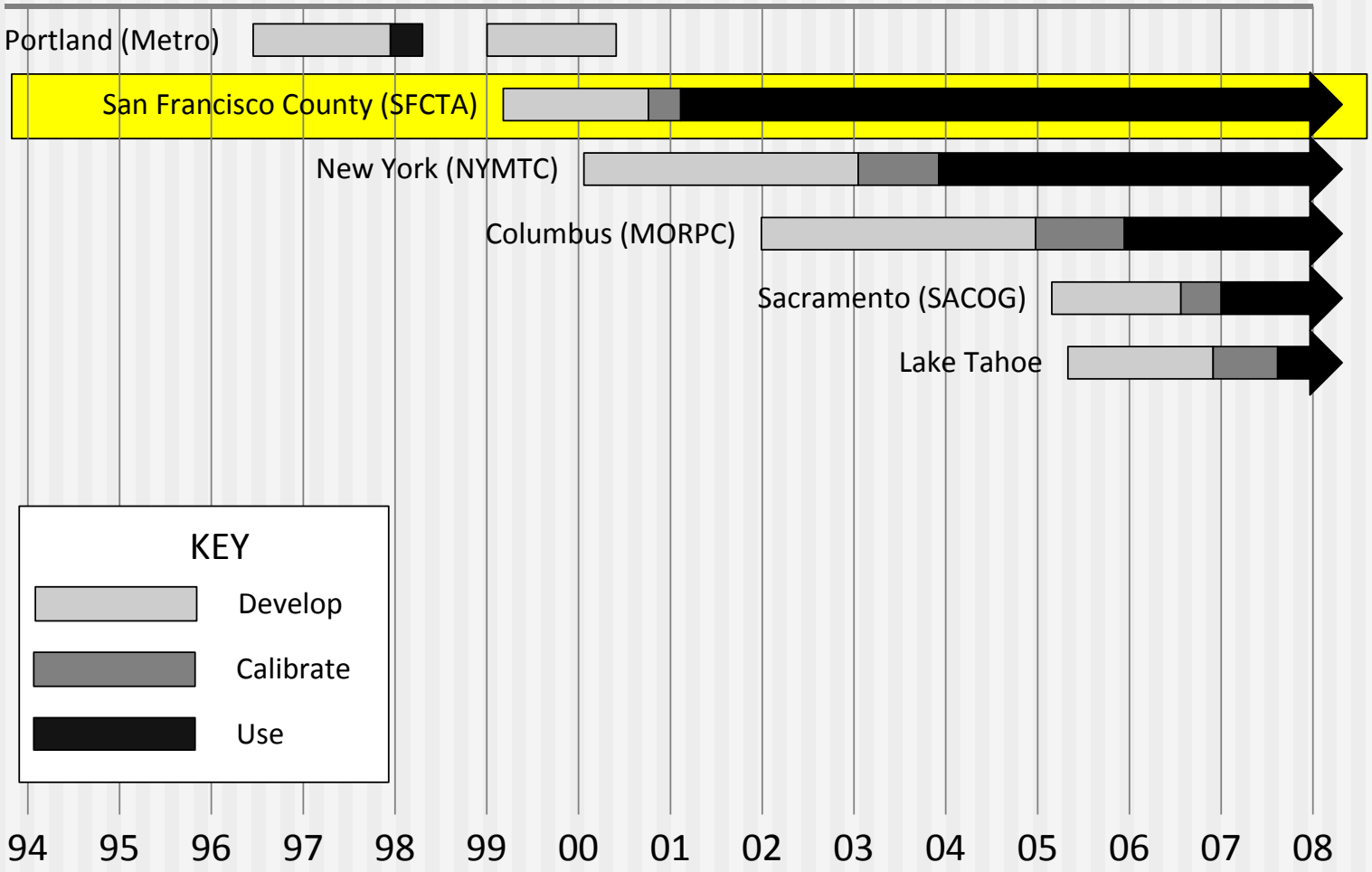

# 1999-2012: SFCTA

- 1999
  - Ongoing use for policy analysis
  - User benefits calculation for New Starts (SUMMIT) analysis
- 2007
  - Mode choice using tolled versus free paths and distributed values of time
- 2011
  - Bicycle route choice

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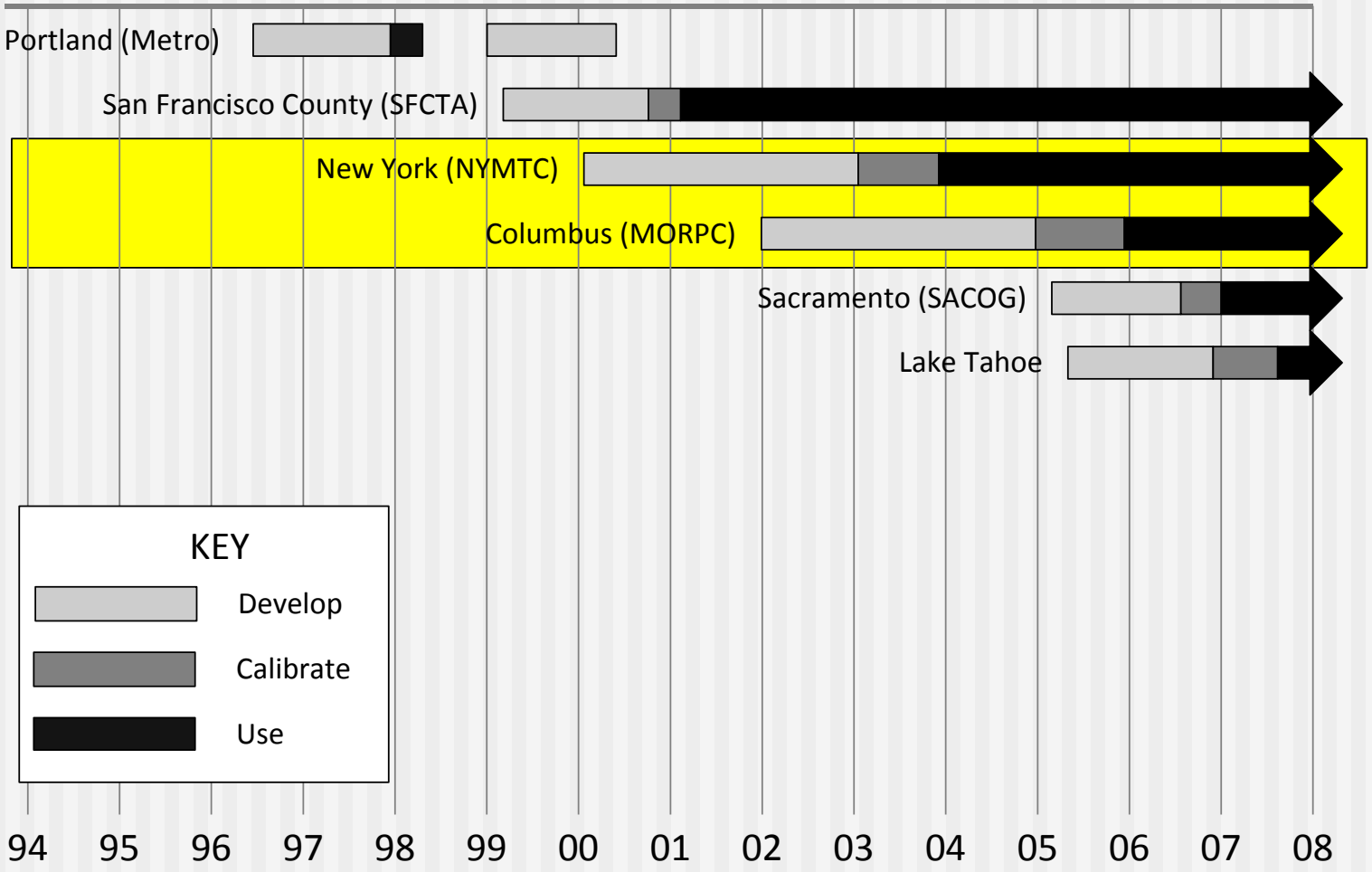

# 2004: MORPC Innovations

- Intra-household interactions
  - HH activity pattern
  - joint tours
  - HH maintenance activities
- Detailed time resolution (1 hr)
- Multithreaded software
- Parking choice sub-model
- Free-parking eligibility model

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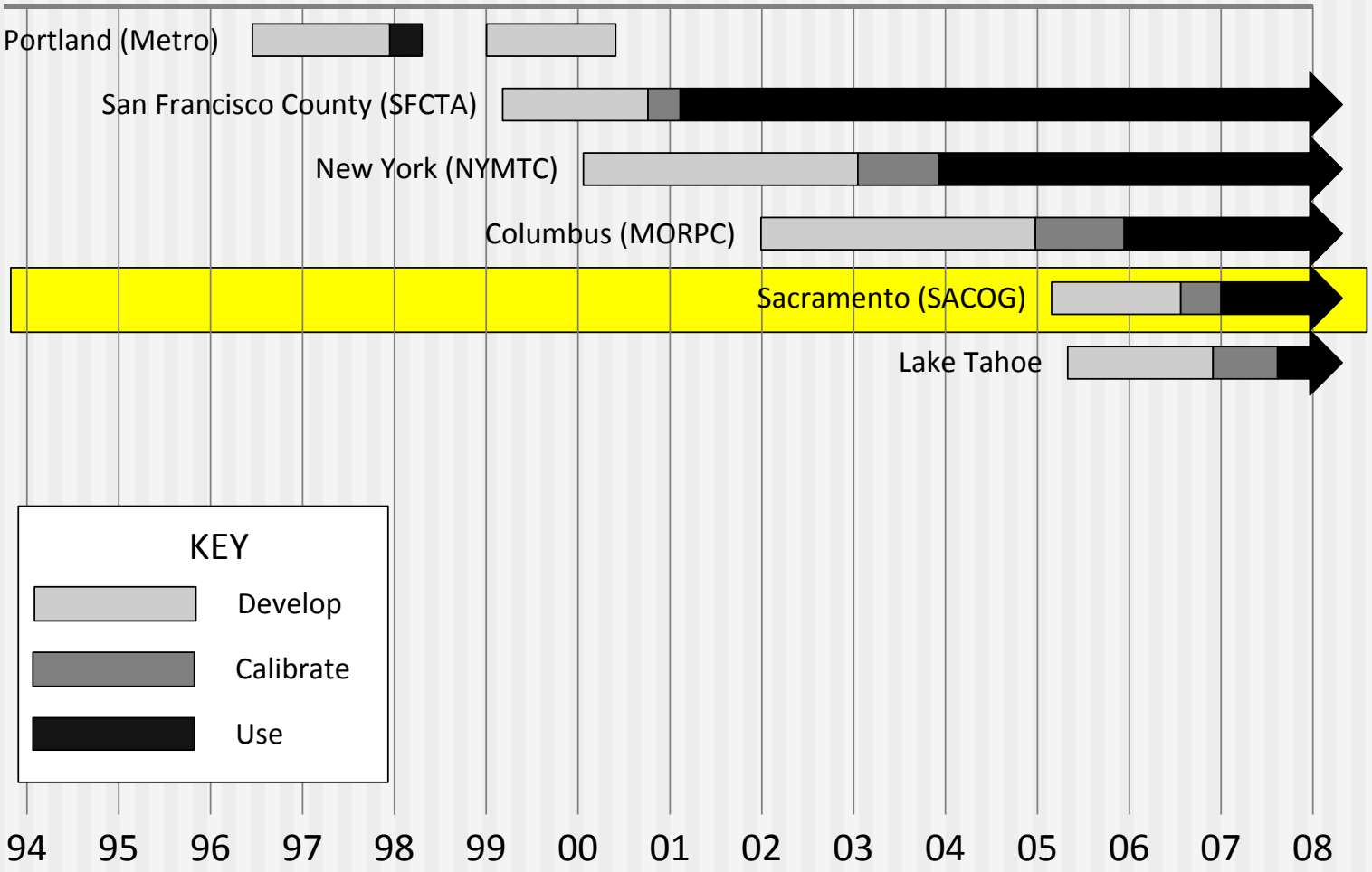


# 2005-2012: SACOG

- Respecified day activity pattern
- High resolution
  - purpose (7)
  - time (1/2 hr)
  - space (parcel)
- Improved integration
- Equilibration techniques

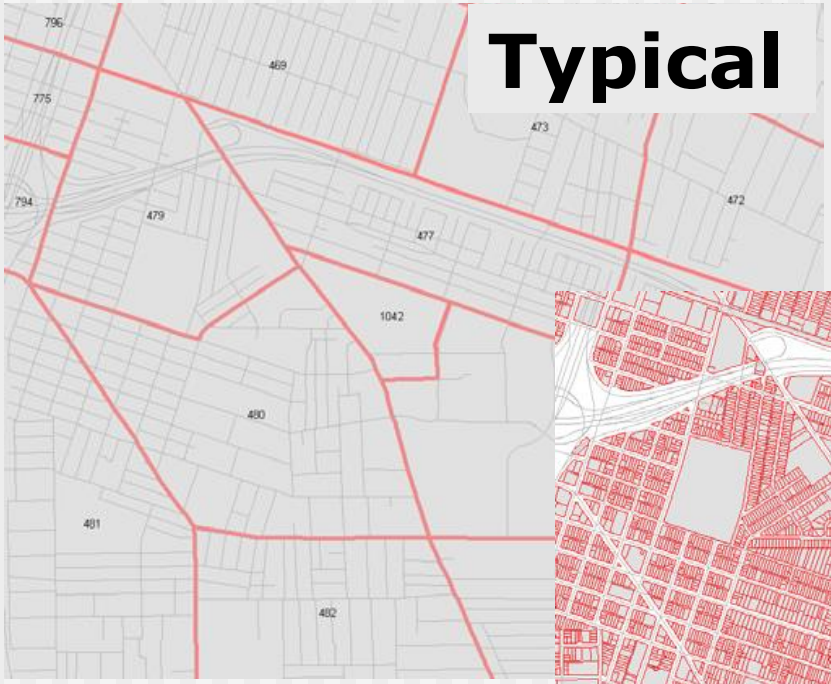
# Disaggregating Purpose

| Typical | SACOG |
|---|---|
| Work | Work |
| School | School |
| Maintenance | Escort |
| | Personal Business |
| | Shopping |
| Discretionary | Meal |
| | Social/recreation |

# Disaggregating Time

| Typical | SACOG |
| --- | --- |
| AM peak<br>Midday<br>PM peak<br>evening<br>night & early AM | 48 half-hour periods |

# Disaggregating Location—750,000 parcels



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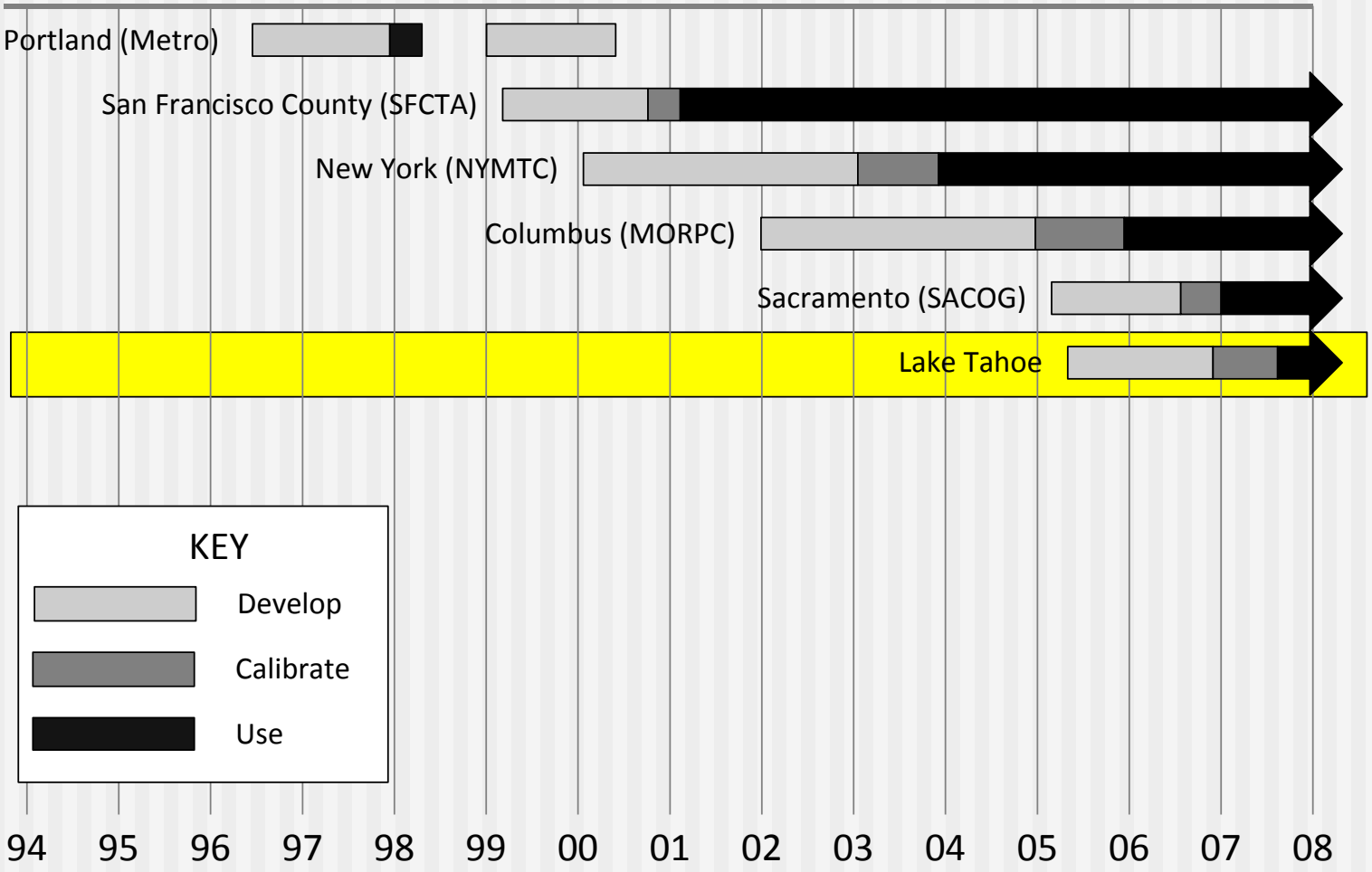


# 2007-2008 Political Impetus

- Issues
  - land use
  - road pricing
  - energy
  - environment

# TRB Special Report 288 (2007)

- committee formed by FHWA, FTA, Secretary of Transportation, and TRB
- to **evaluate** the state of practice in metropolitan travel forecasting, and **recommend** improvements
- report:
  "METROPOLITAN TRAVEL FORECASTING: Current Practice and Future Direction"

# TRB Special Report 288
## Evaluation

- "The basic modeling approach at most MPOs remains a sequential four step process... "
- "The demands on forecasting models have grown significantly in recent years... Existing models are inadequate to address many of these new concerns."
- "...the processes...in the four-step model are not behavioral in nature; ... and are not well suited to representing travelers' responses to the complex range of policies typically of interest to today's planners and politicians."

# TRB Special Report 288
## Recommendation

"The committee recommends that the USDOT, the FHWA, and FTA take the (seven) steps outlined below to assist in the needed improvements in practice.

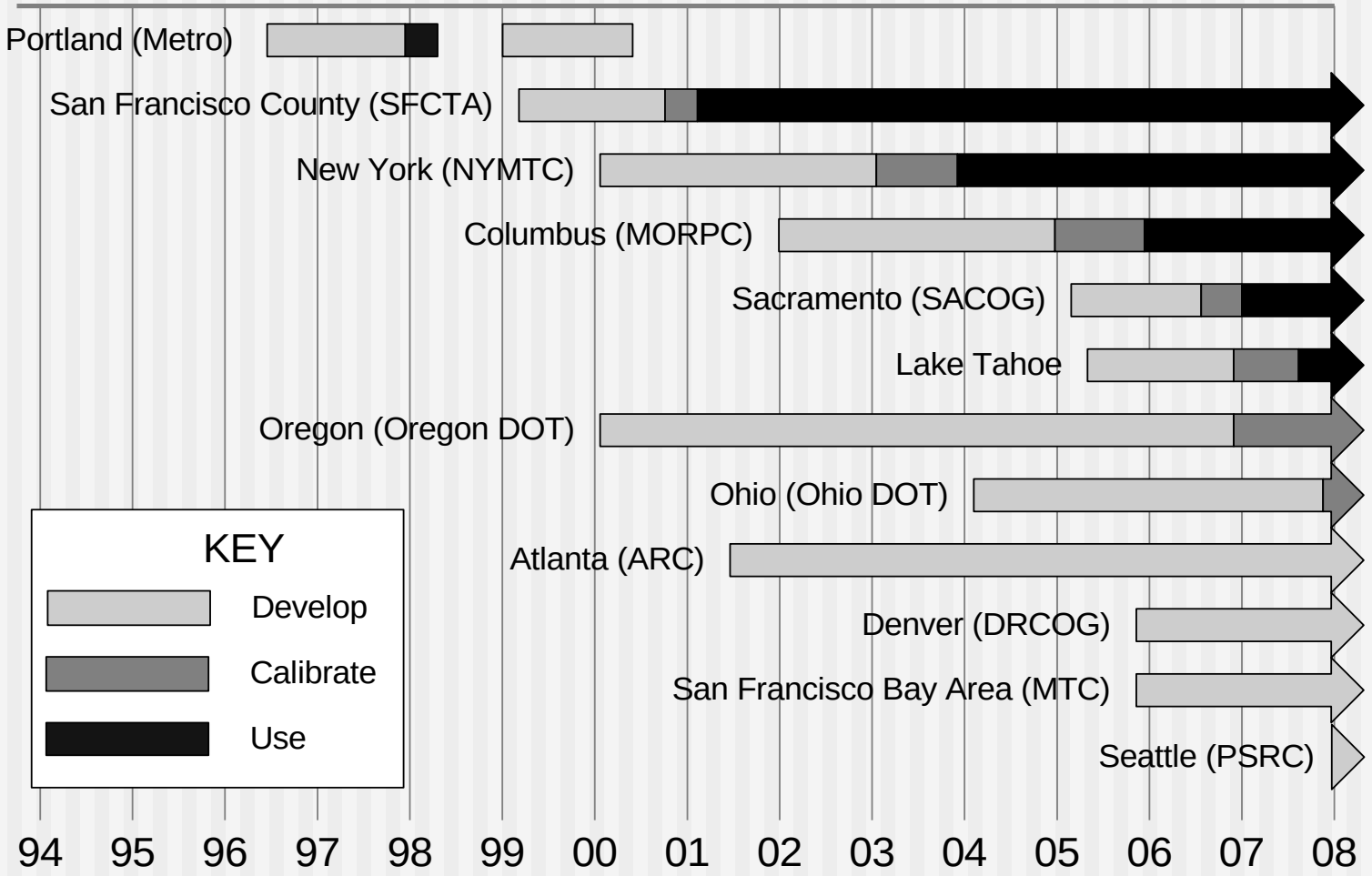
2. Support and provide funding for the continued development, demonstration, and implementation of advanced modeling approaches, including **activity-based models**.

4. Continue support for the implementation of **activity-based modeling** and other advanced practices; considerably expand this support through deployment efforts in multiple urban areas."

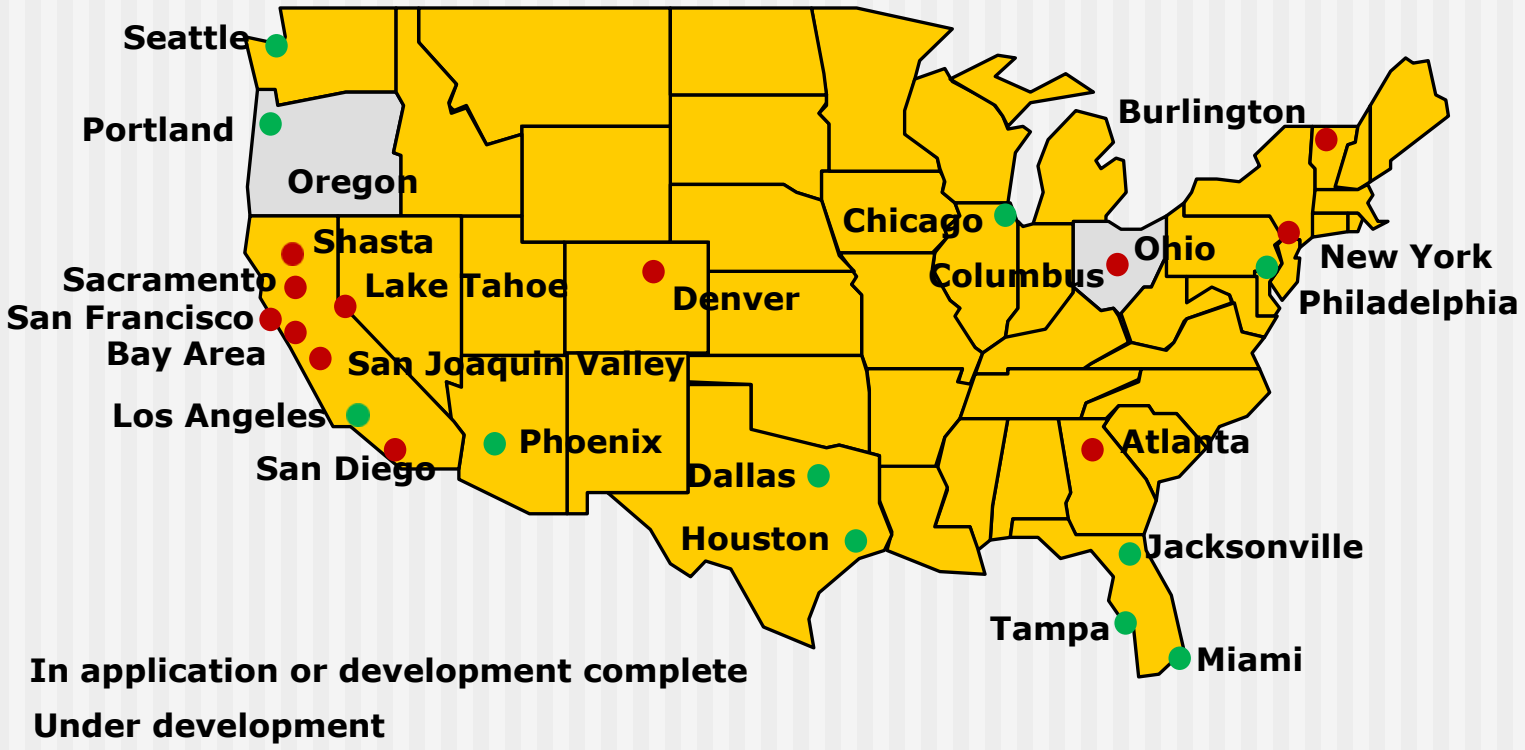
# California

- Senate Bill 375 (Sep 2008)
  requires the California Transportation Commission to maintain guidelines for travel demand models
- CTC Guidelines (May 2008)
  The largest four MPOs and other COGs and RTPAs with rapid growth and established transit systems "should develop tour-based travel models in the short term and **activity-based travel models** within a few years."

# The Projects



# U.S. AB Models in 2012



# Pending additions?

- Pending in United States?
  - Boston
  - Nashville
  - Cincinnati
- International developments
  - Tel Aviv and Jerusalem
  - Copenhagen
  - Beijing?

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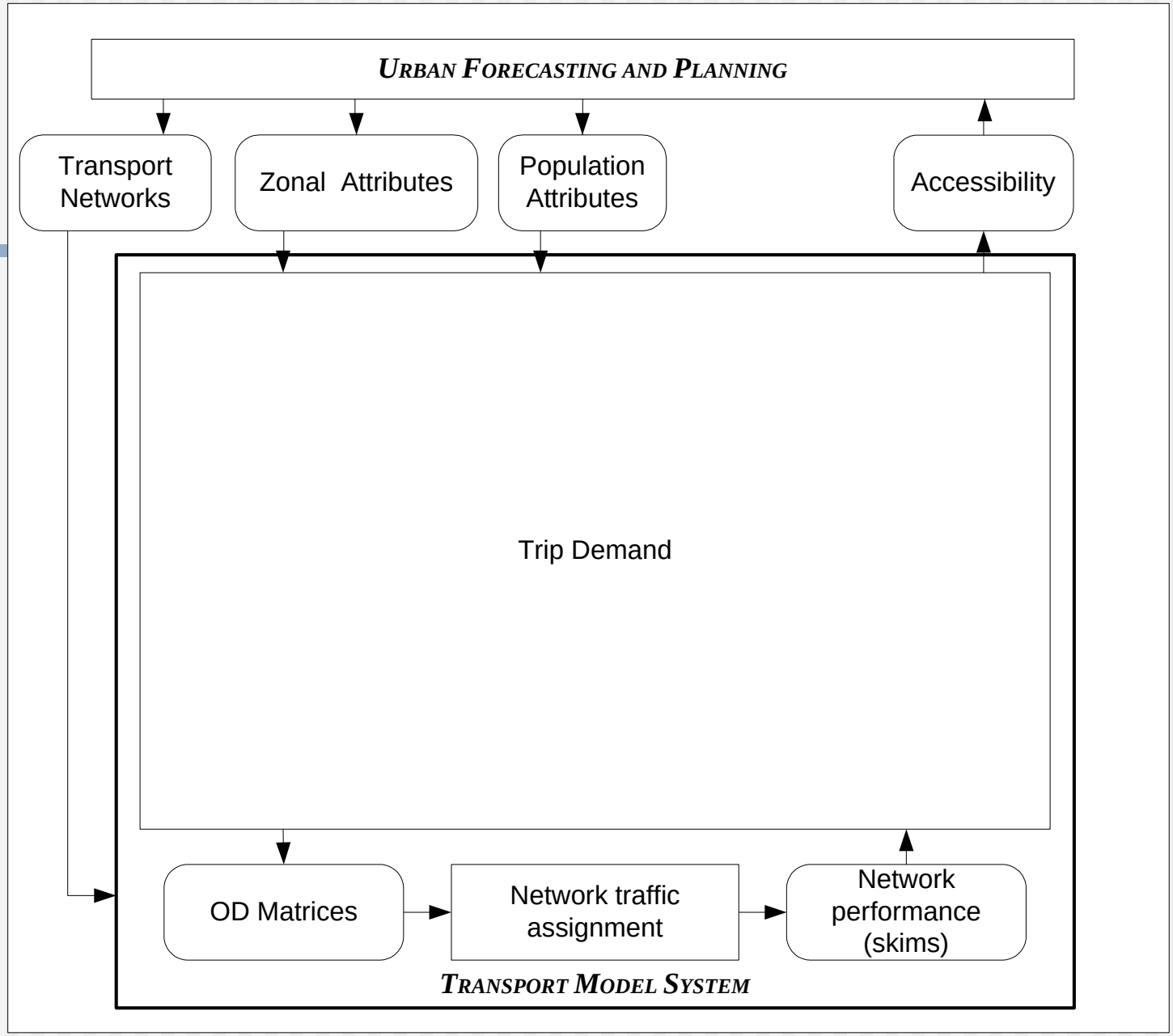
- **Basics of the "Activity-Based" model systems**
- Advanced features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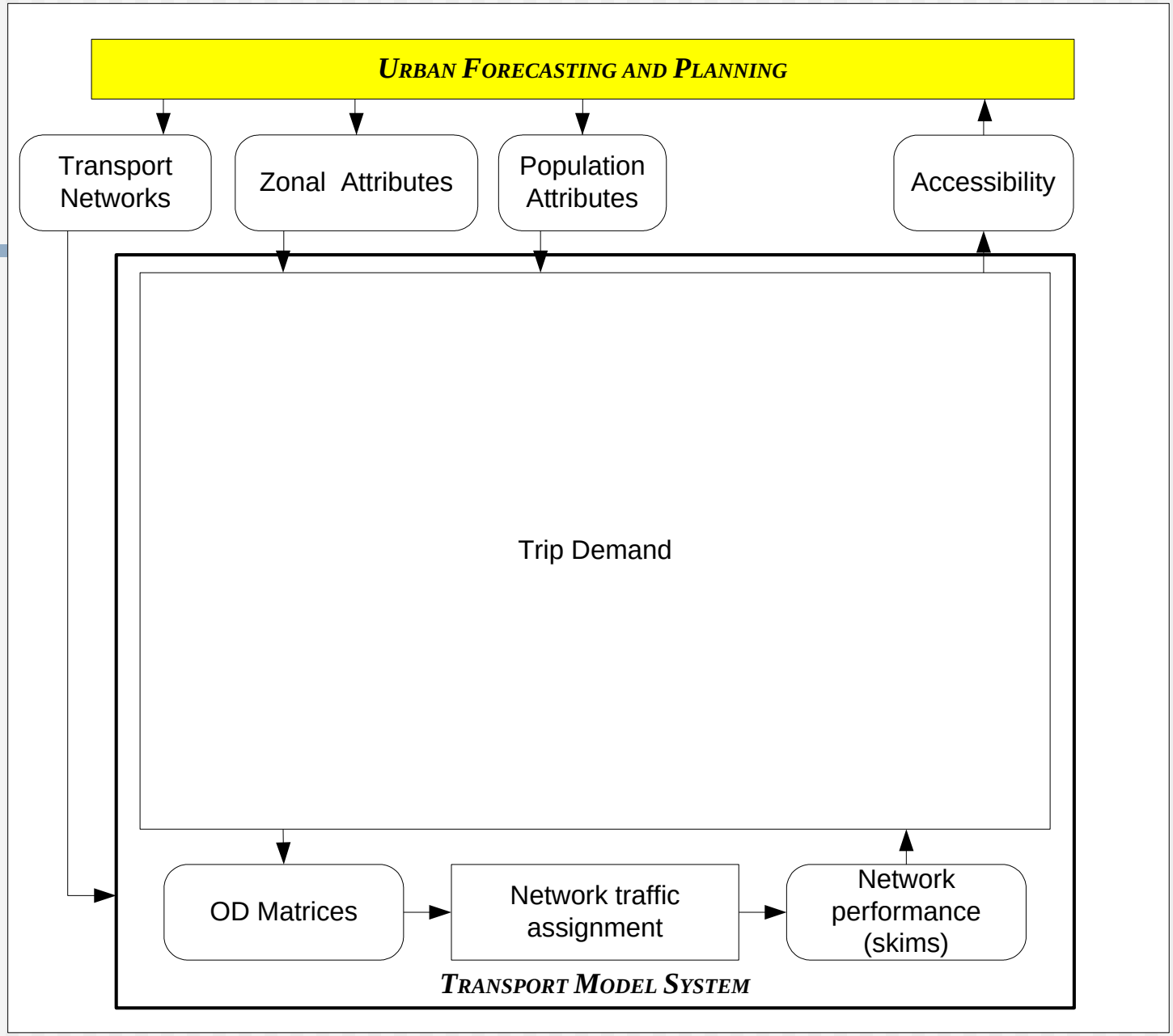
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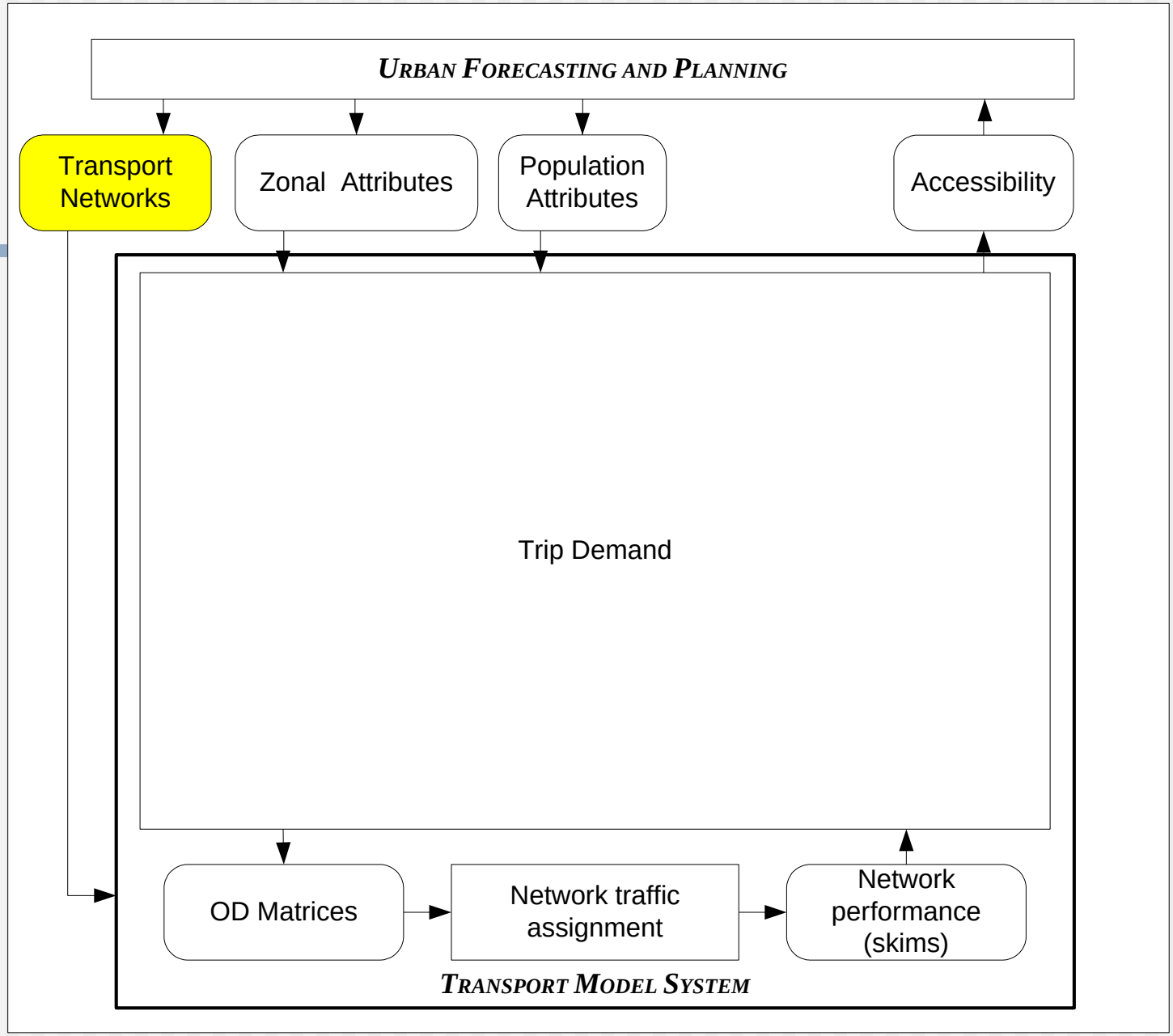
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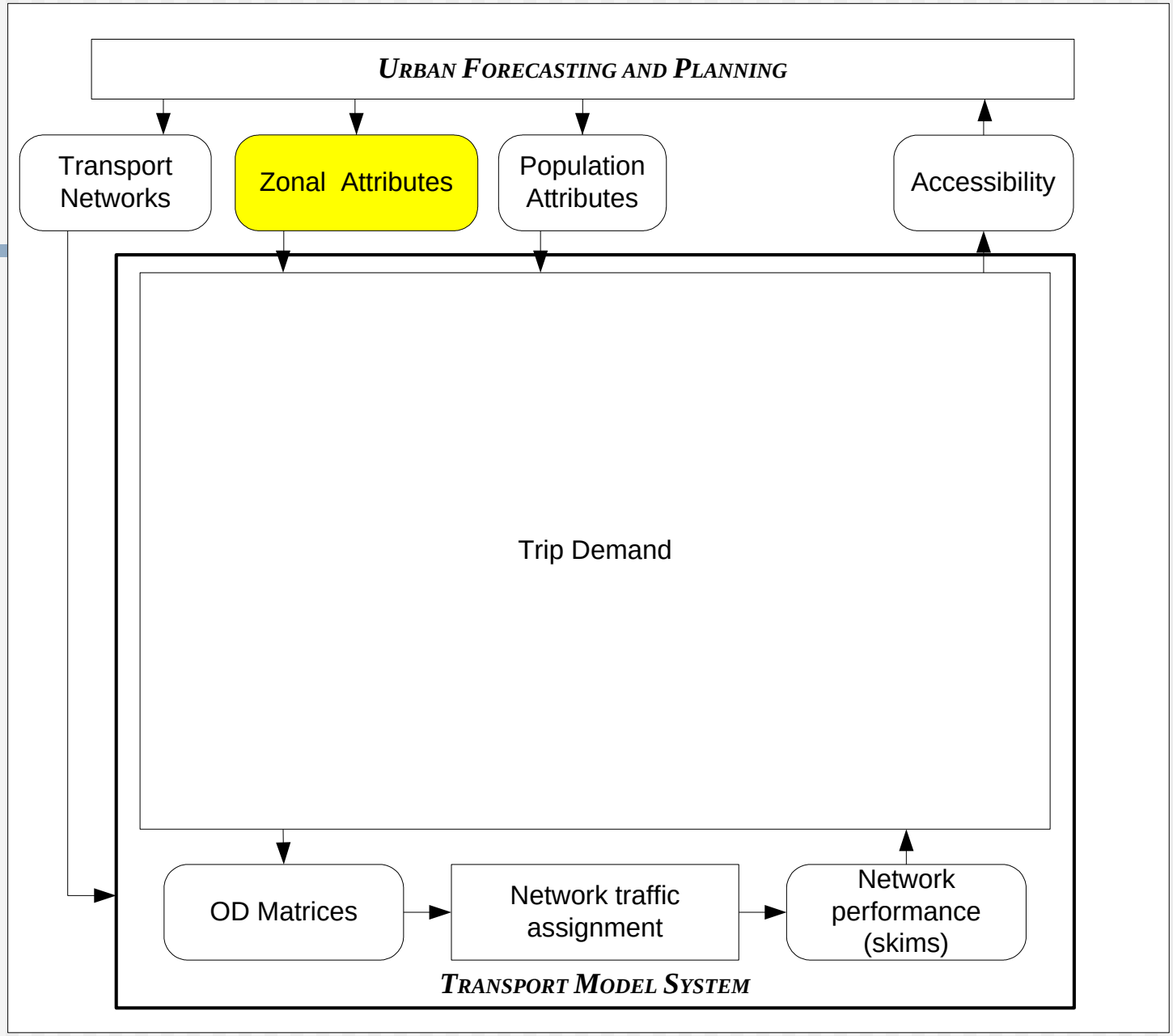
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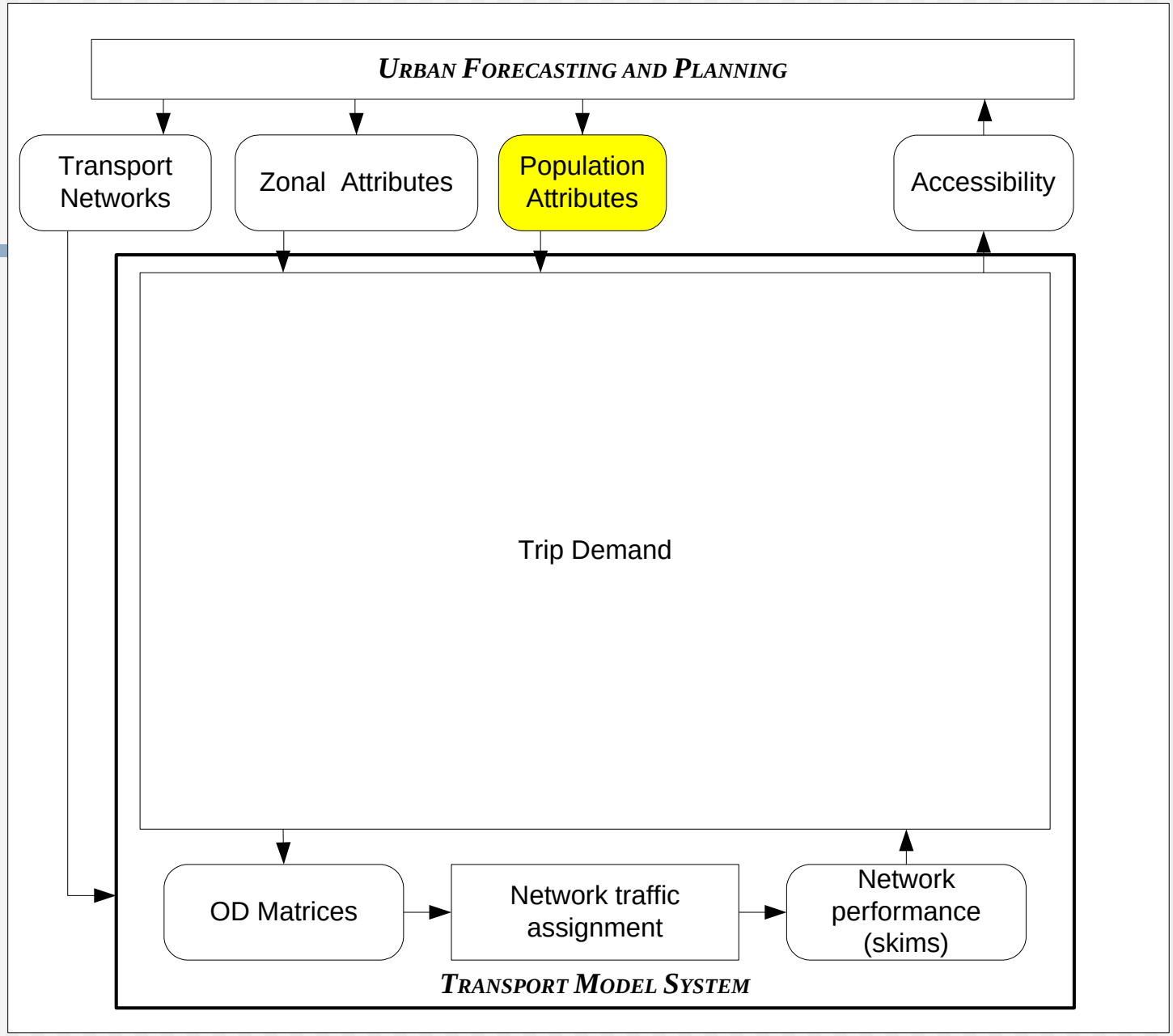
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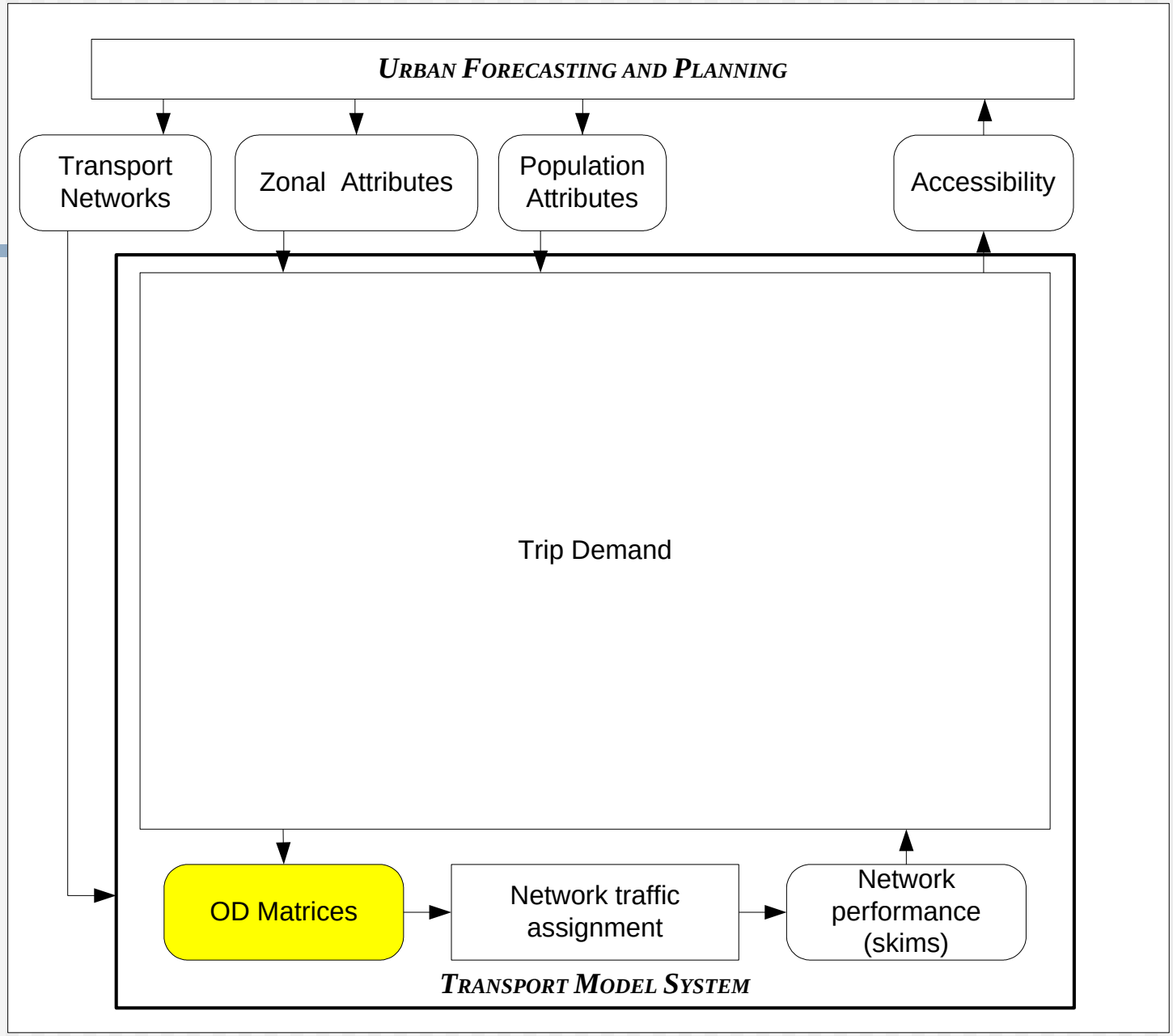
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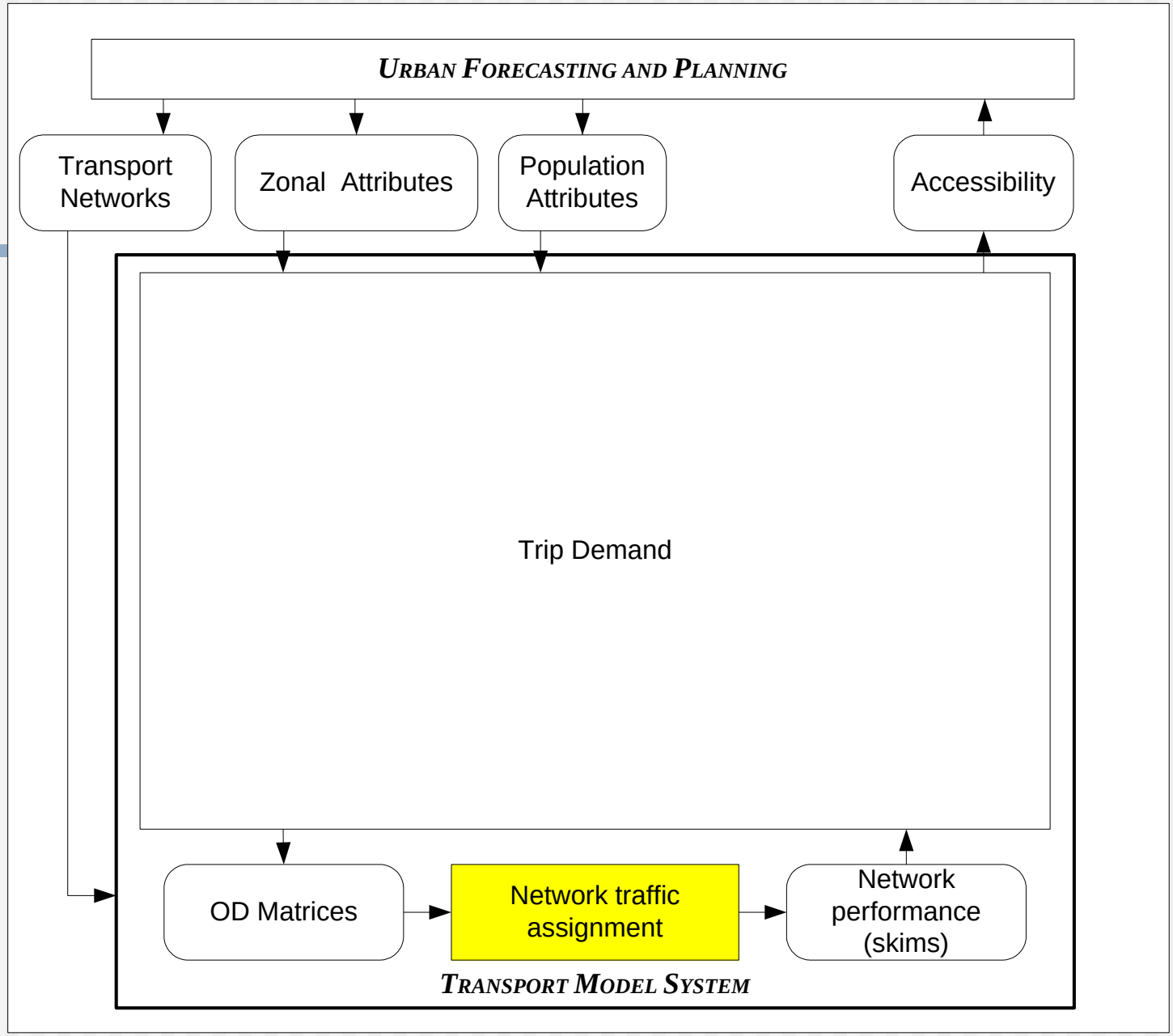
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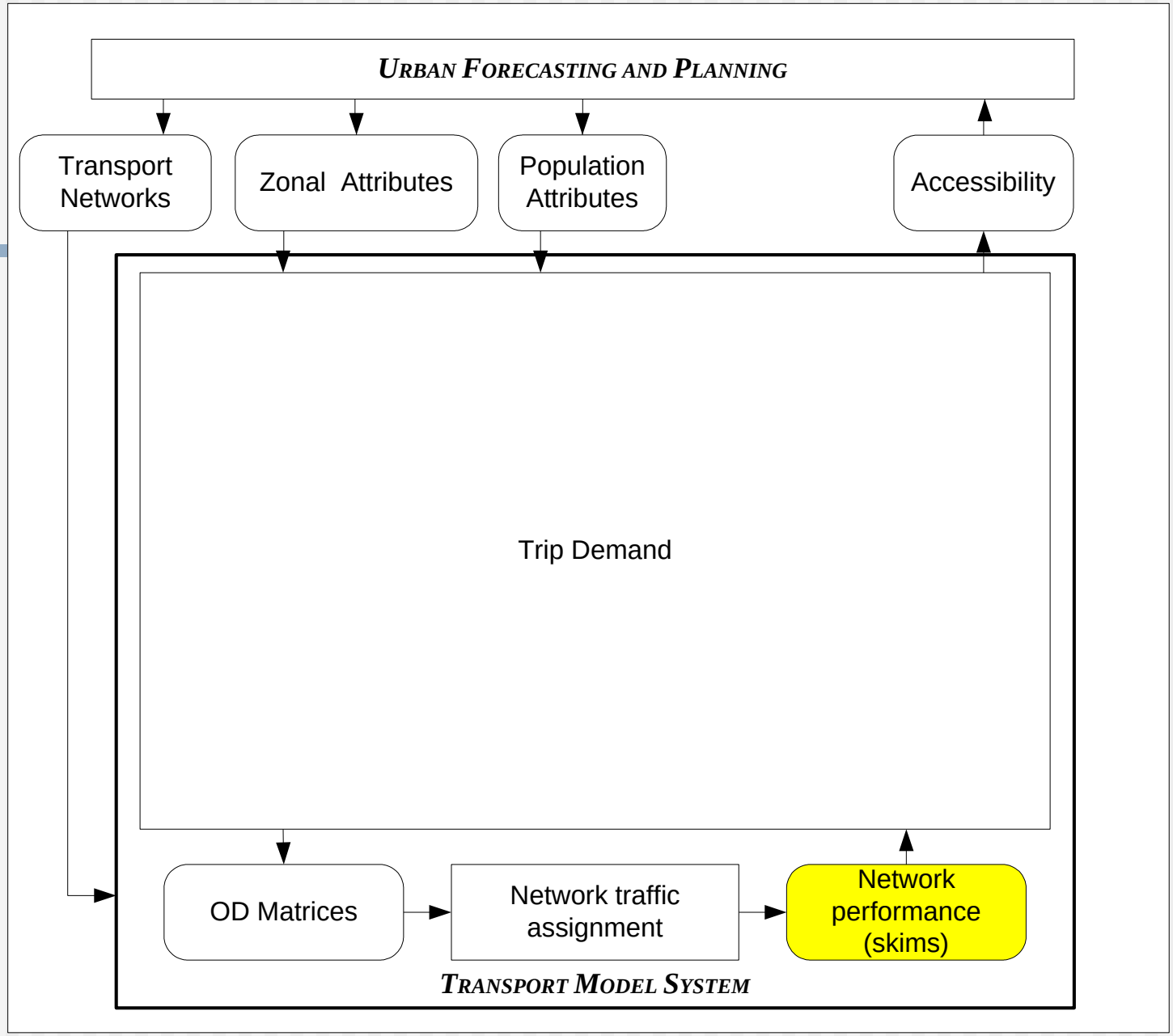
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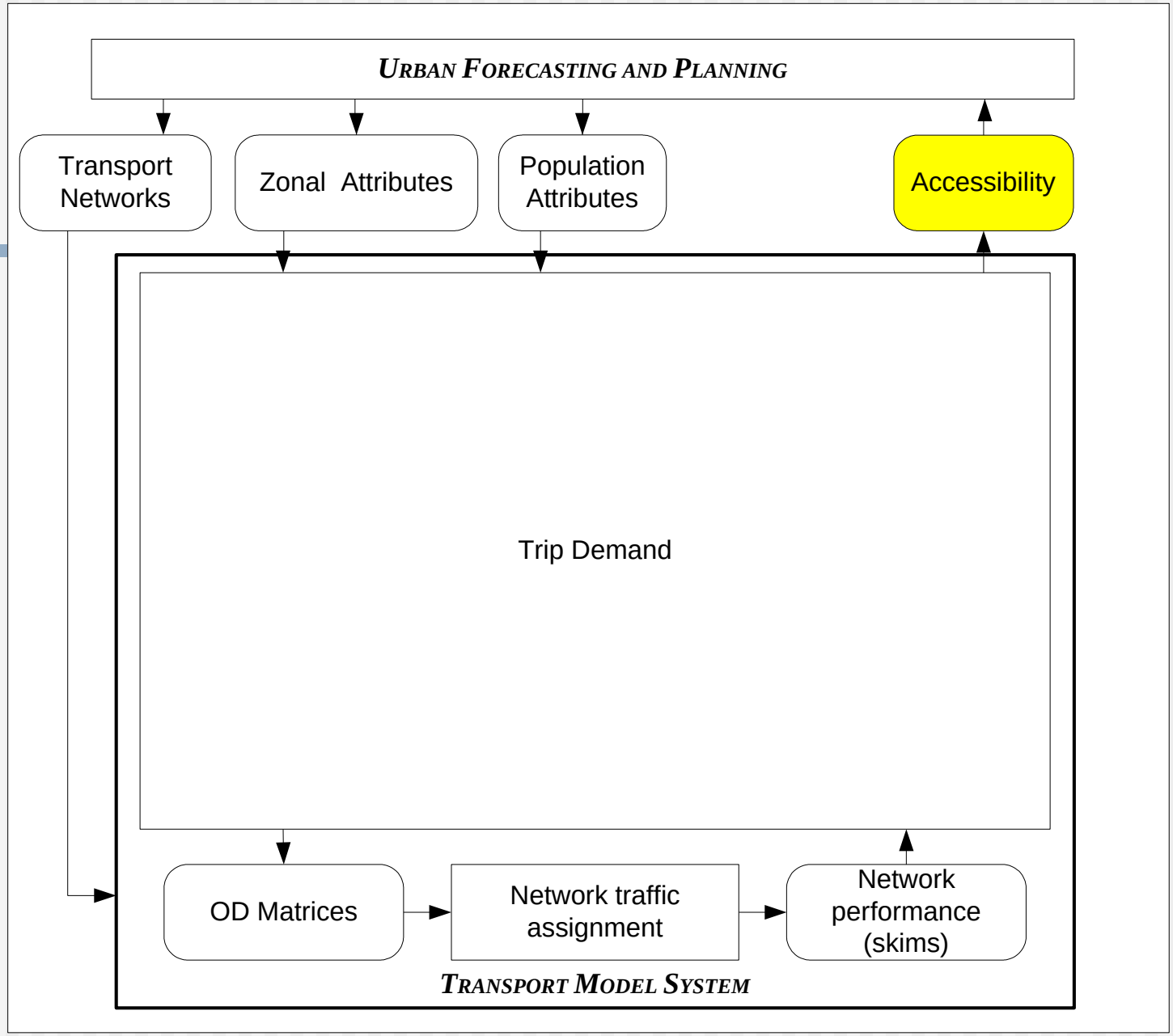
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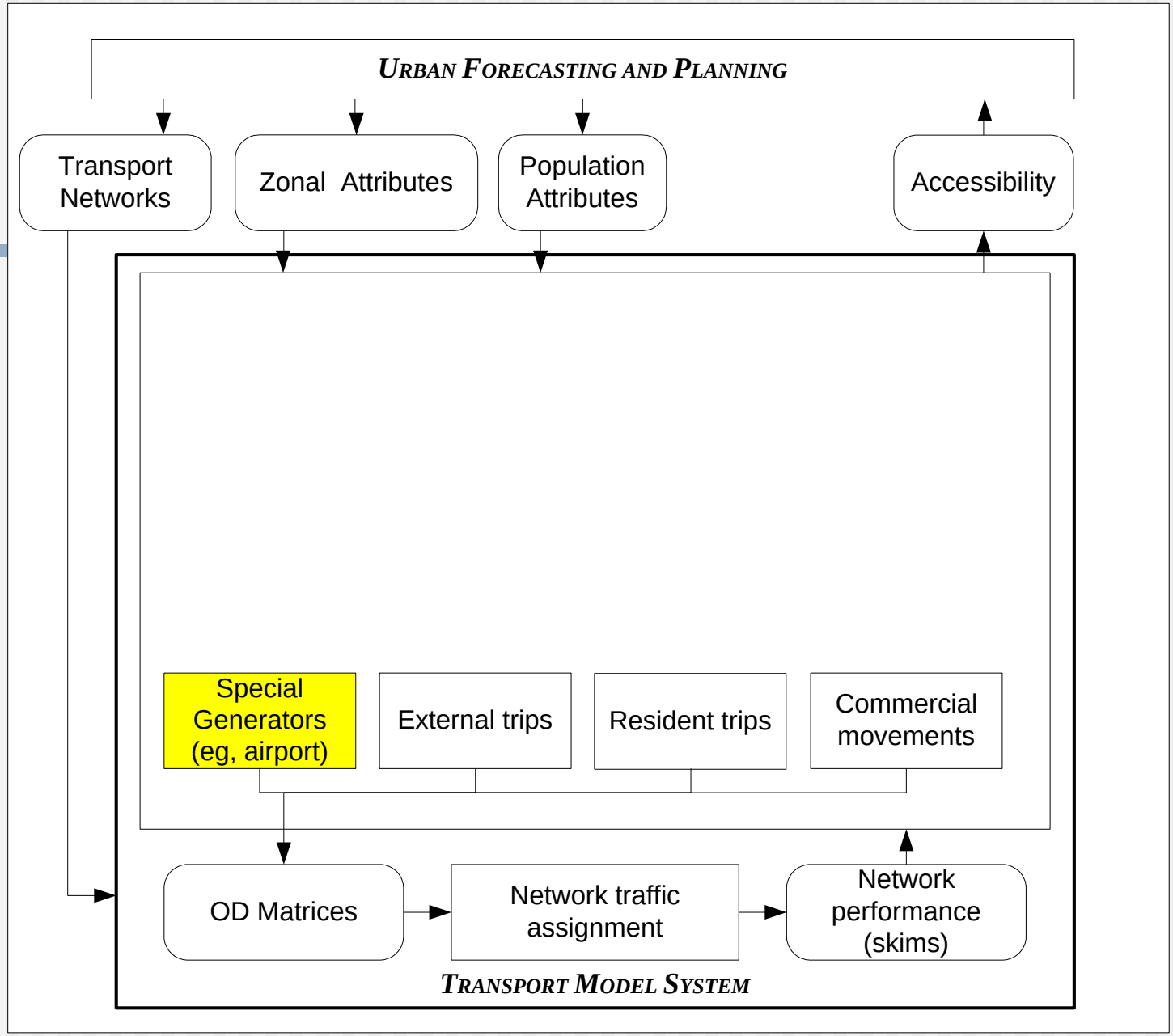
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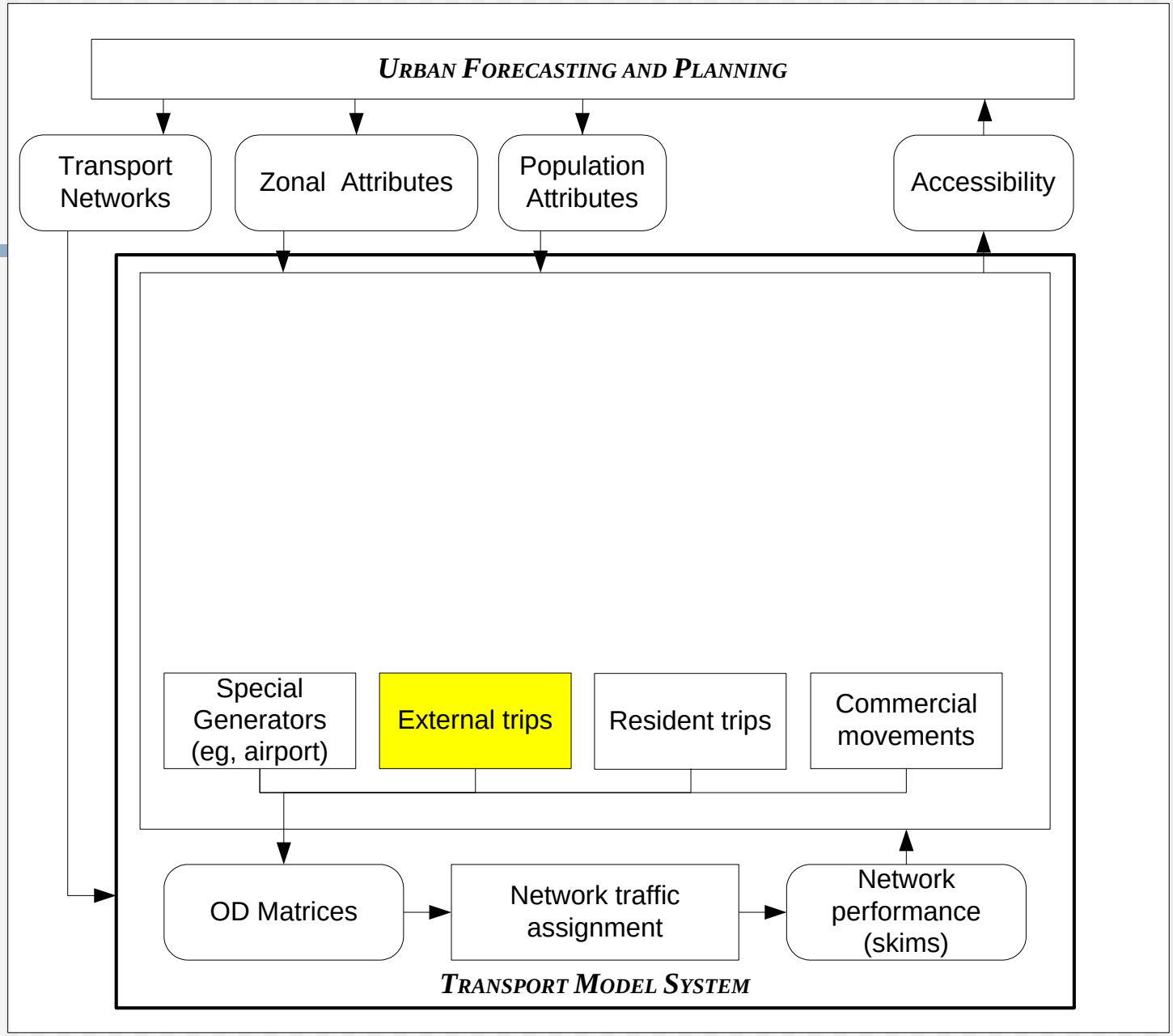
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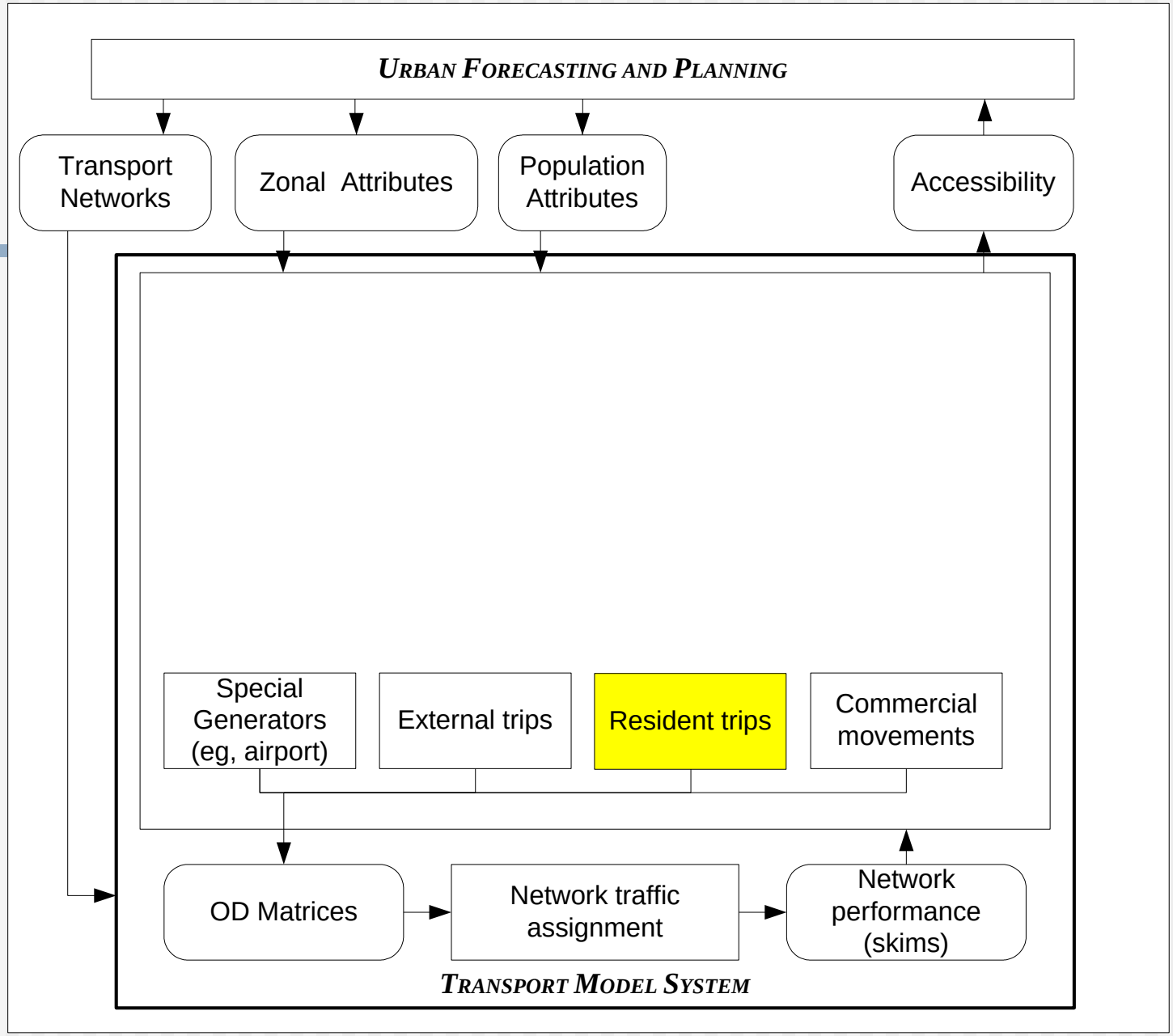
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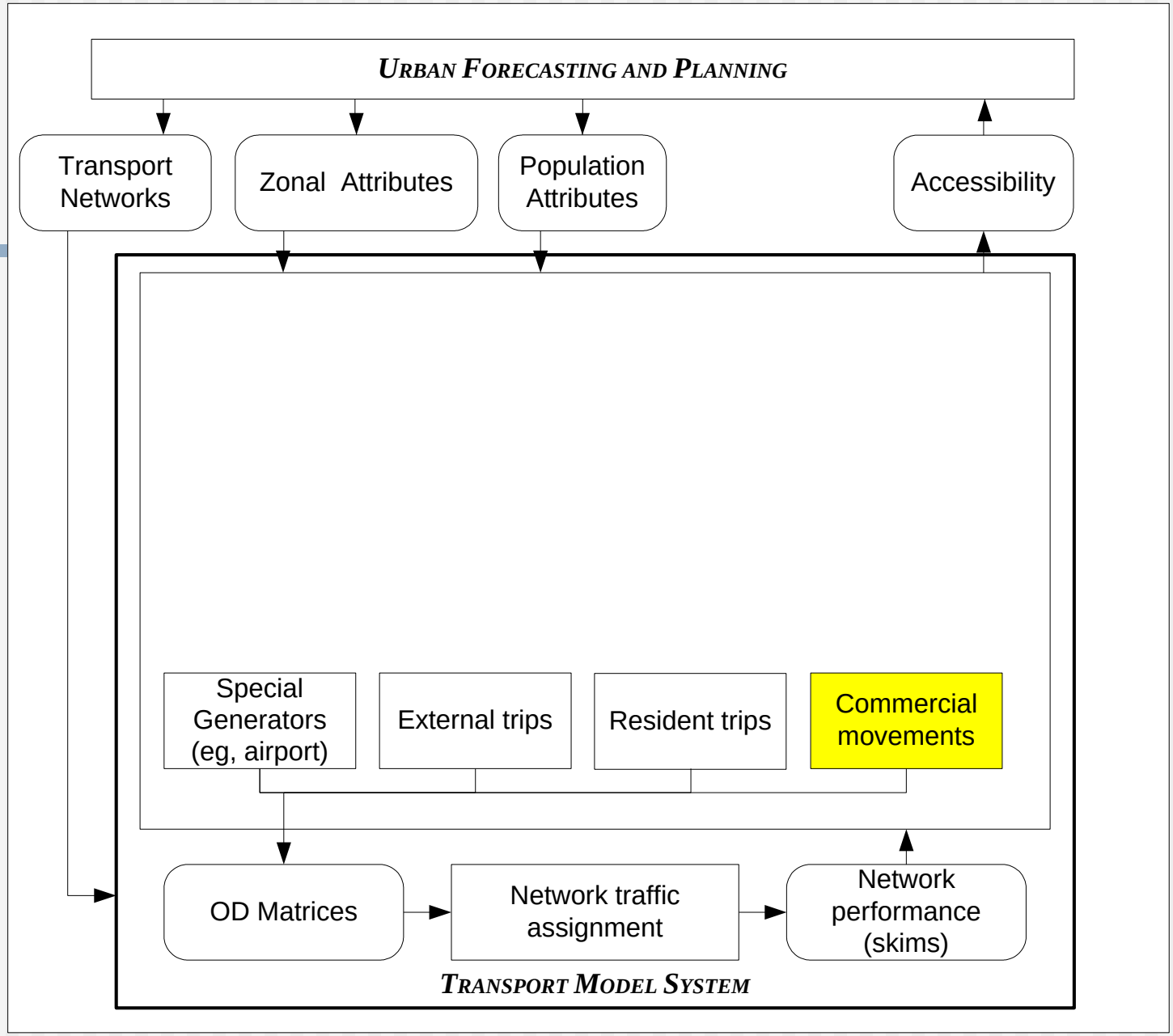
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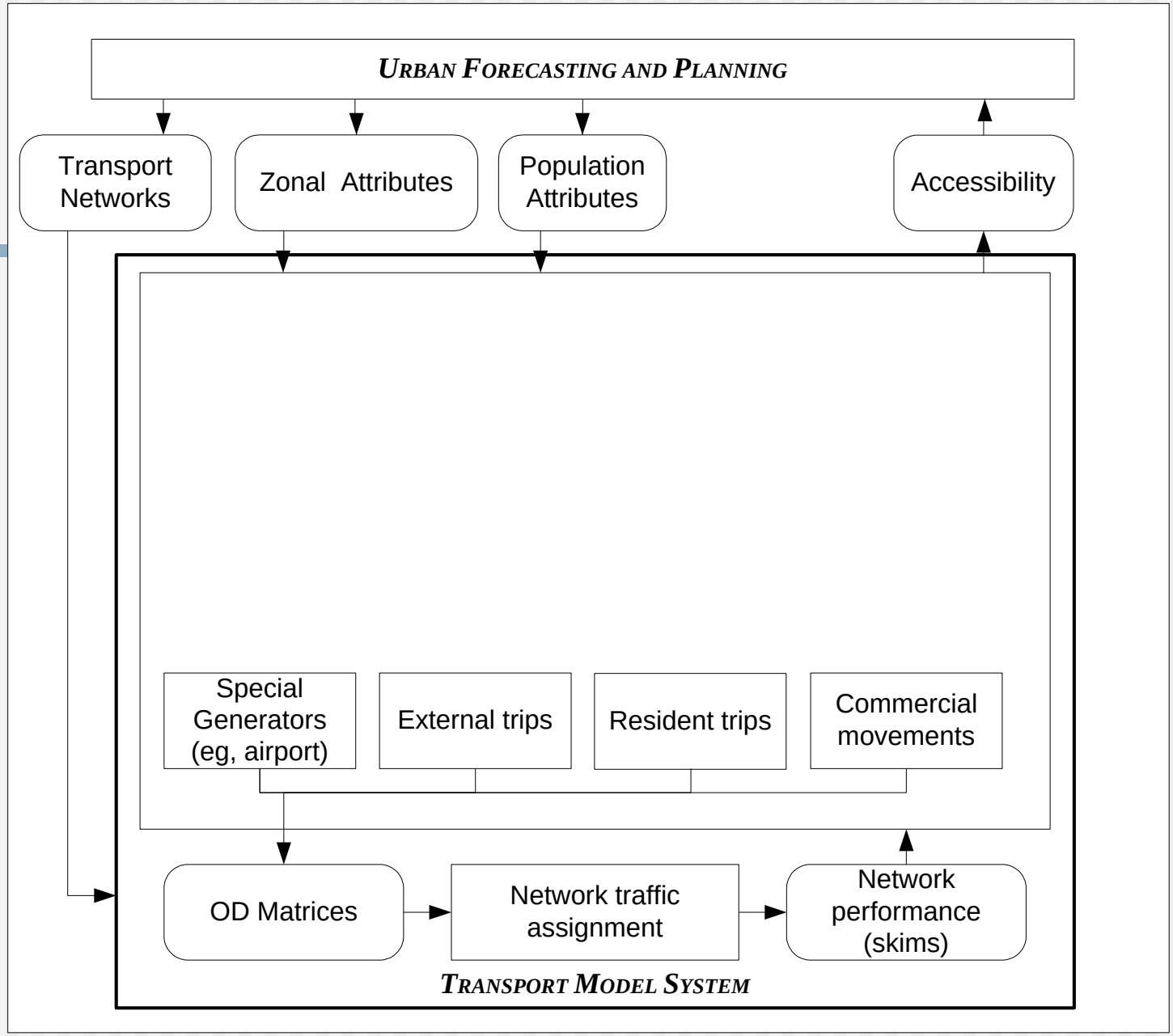
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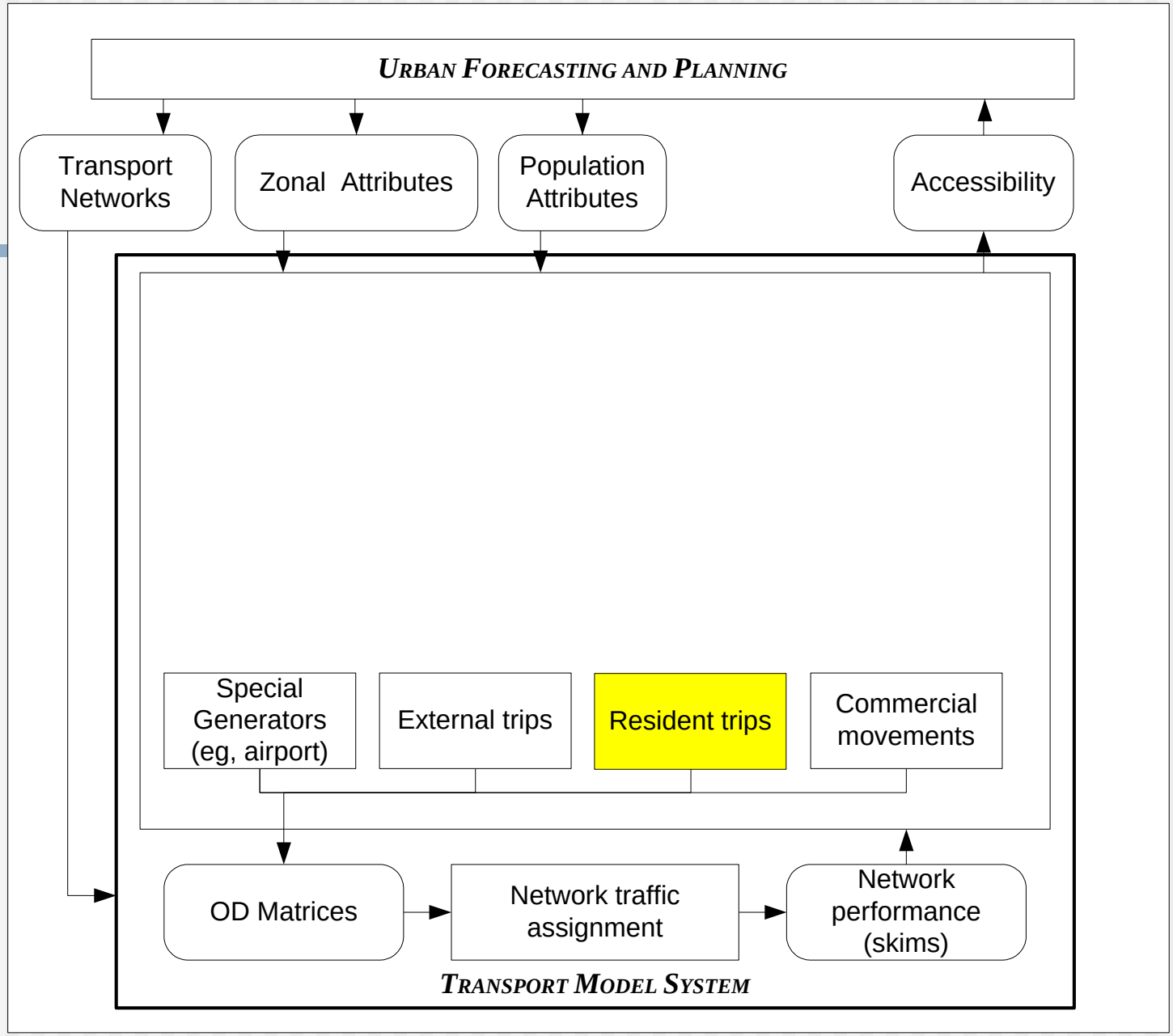
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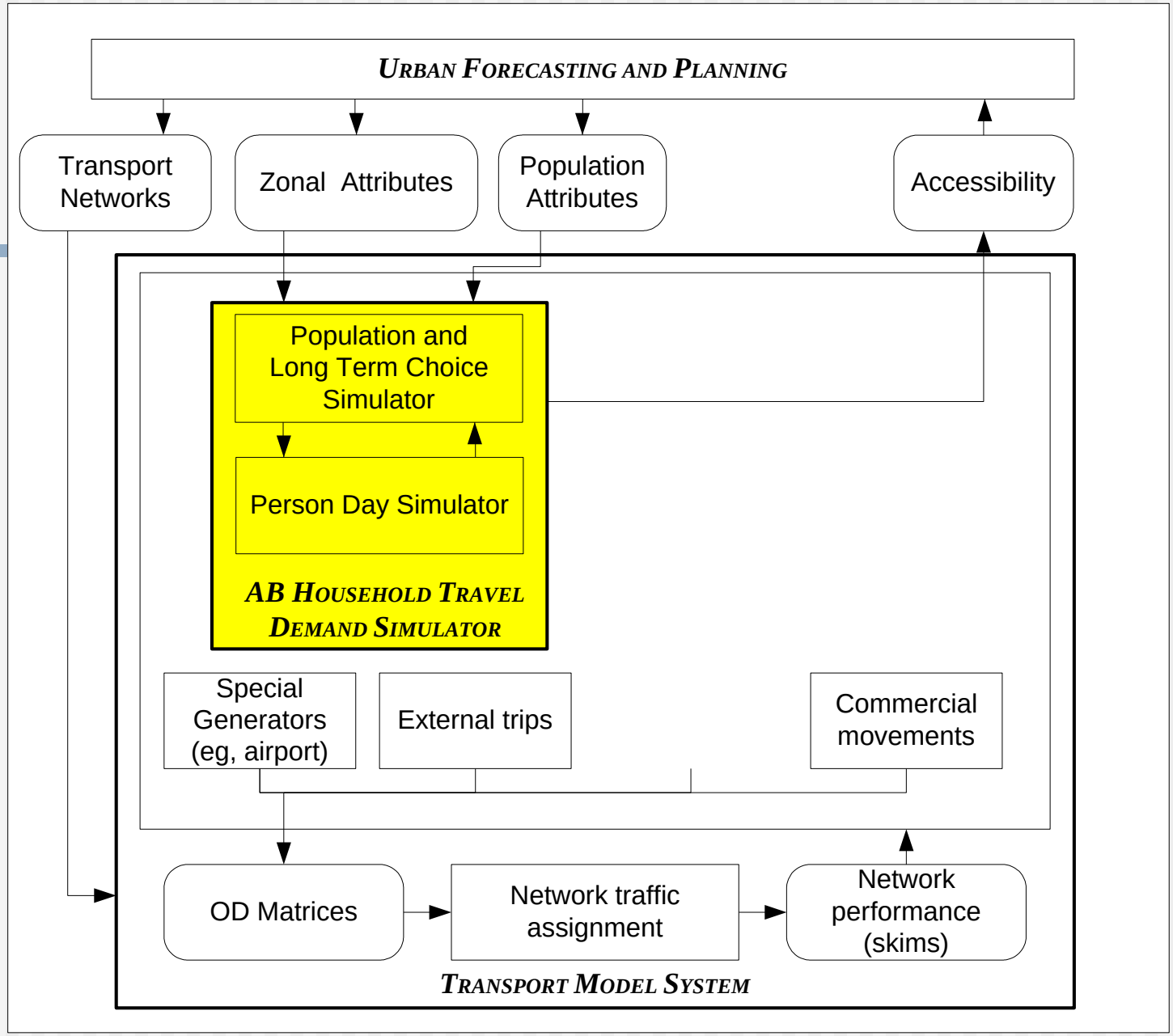
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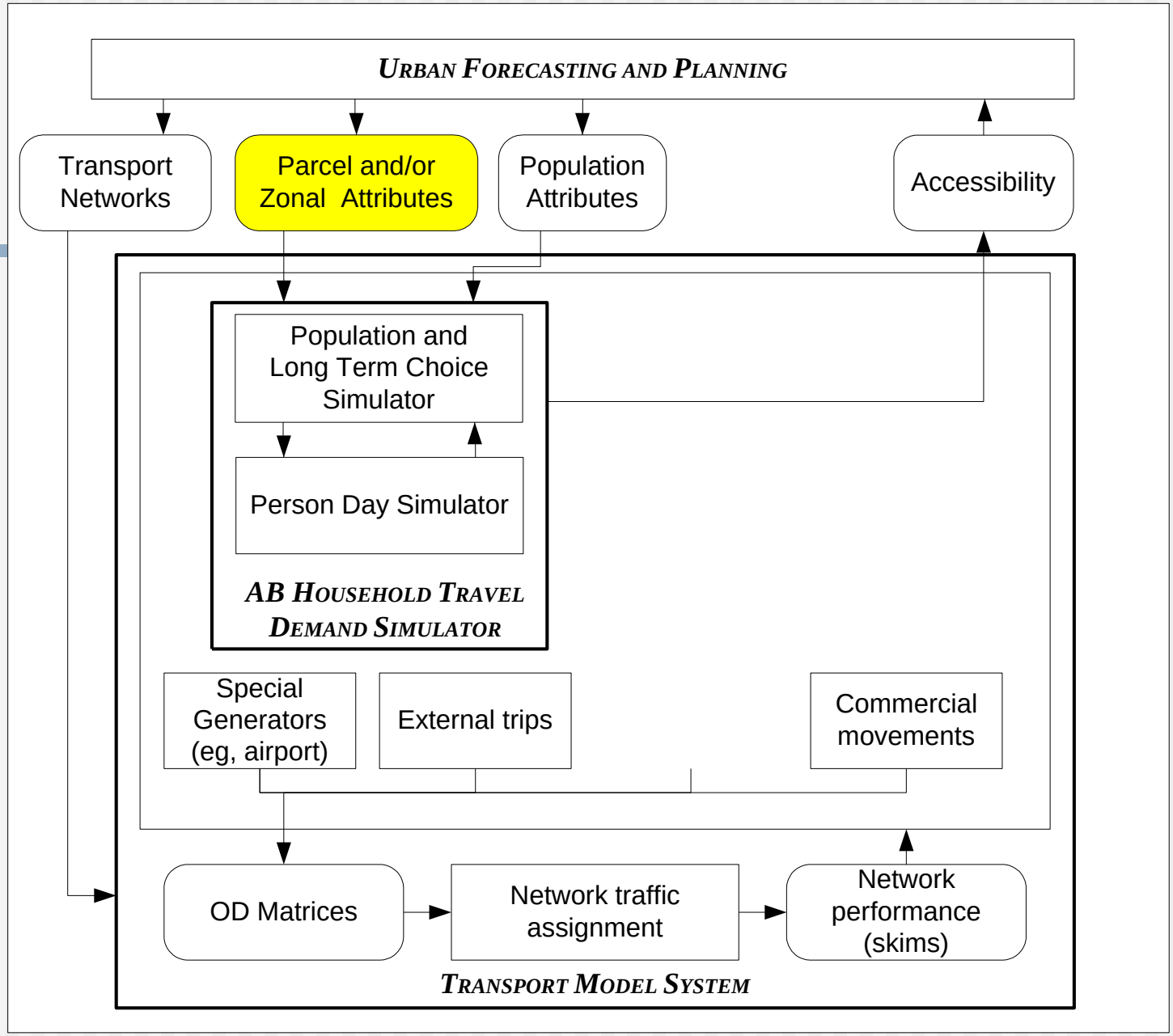
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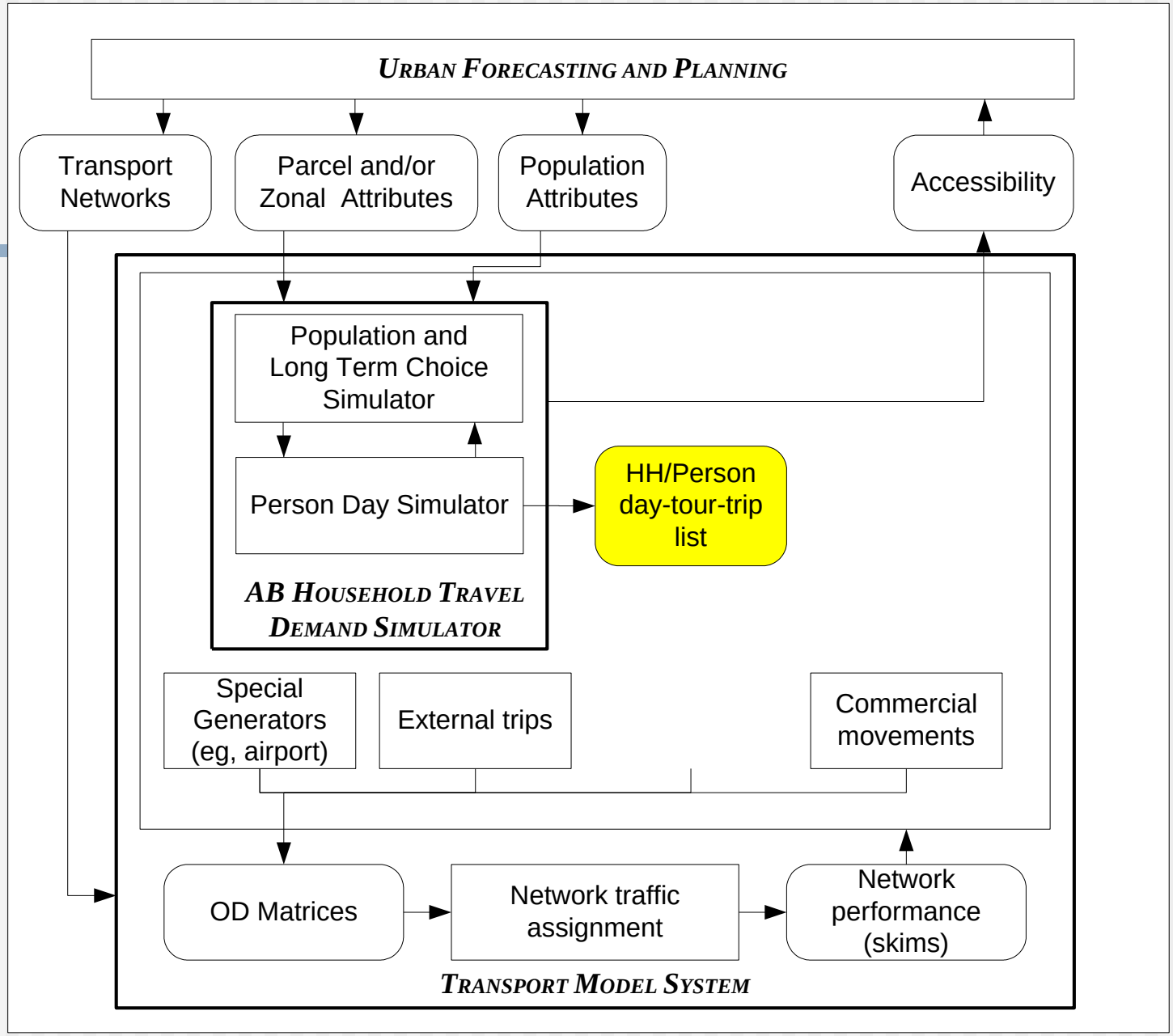
Parcel and/or Zonal Attributes
Population Attributes
Accessibility
Population and Long Term Choice Simulator
Person Day Simulator
AB HOUSEHOLD TRAVEL DEMAND SIMULATOR
Special Generators (eg, airport)
External trips
Commercial movements
OD Matrices
Network traffic assignment
Network performance (skims)
TRANSPORT MODEL SYSTEM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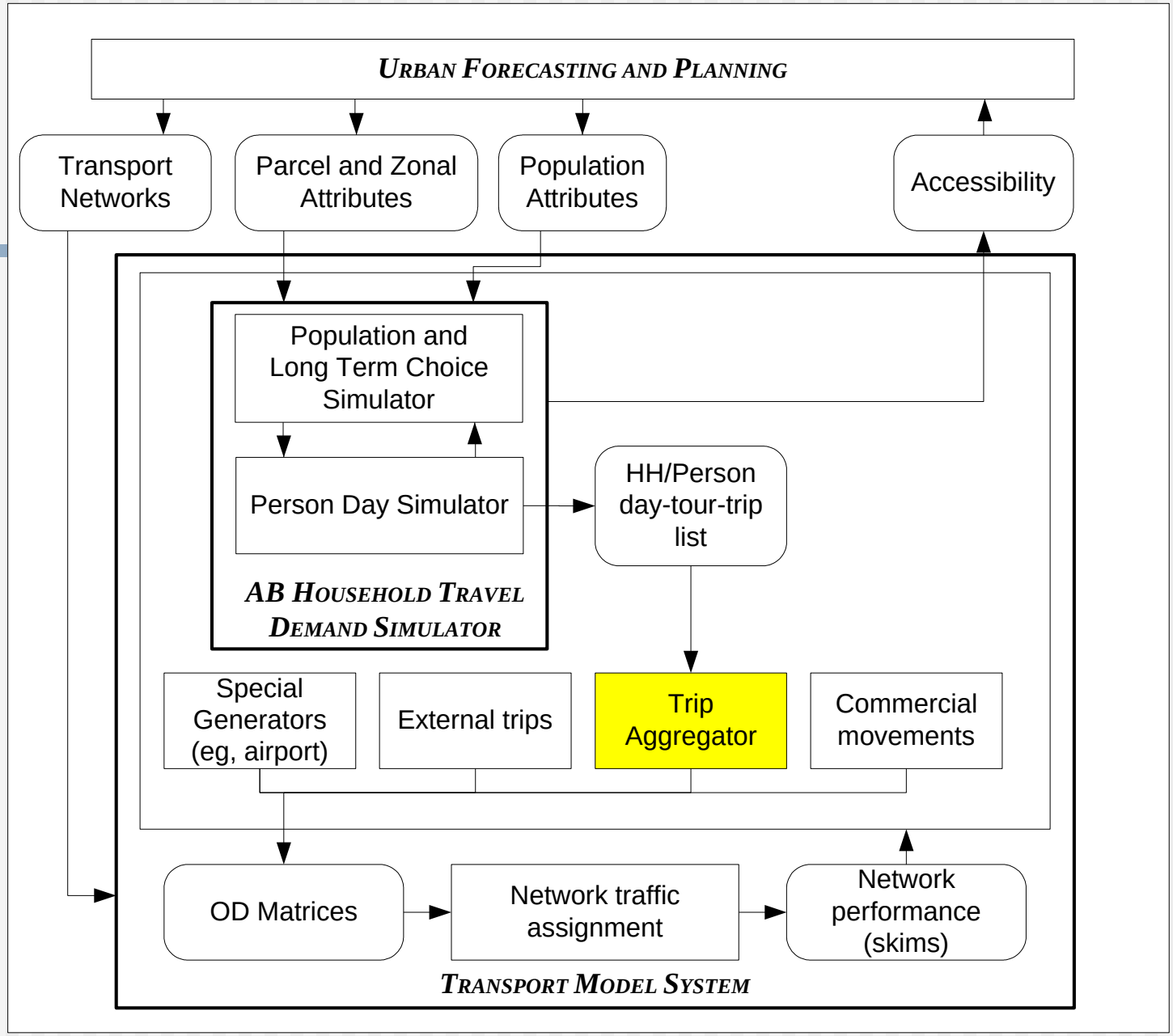
TRANSPORT MODEL SYSTEM

# HH/Person/Day/Tour/Trip List

| For each… | List includes… |
|---|---|
| Household | Location, size, vehicles, etc |
| Person | Age, gender, usual work & school locations, etc |
| Day | Number of tours and stops |
| Tour | Purpose, destination, timing, main mode, number of stops |
| Trip | Origin, destination, origin purpose, destination purpose, mode, departure time, travel time |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Commercial movements
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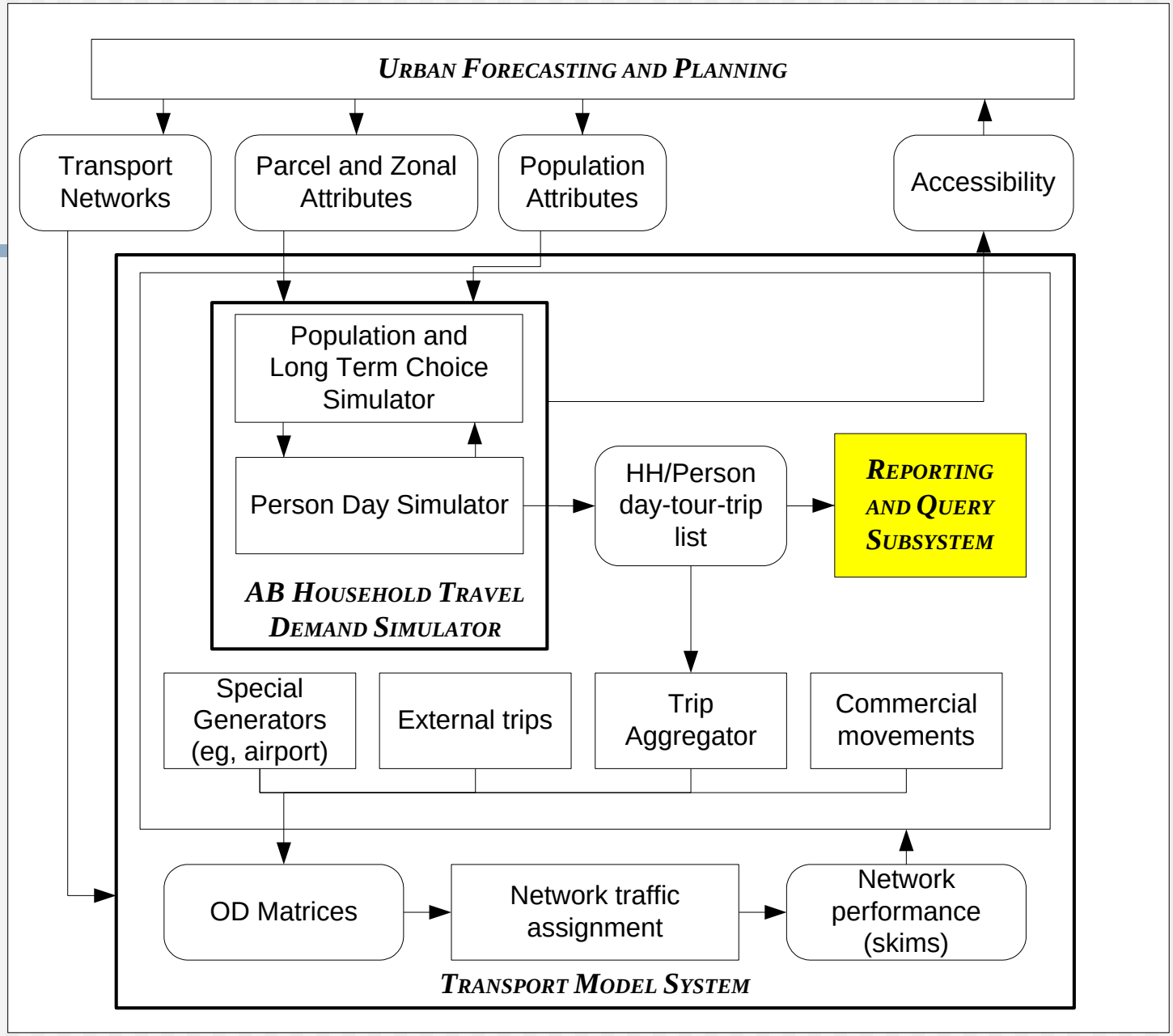
TRANSPORT MODEL SYSTEM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REPORTING AND QUERY SUBSYSTEM
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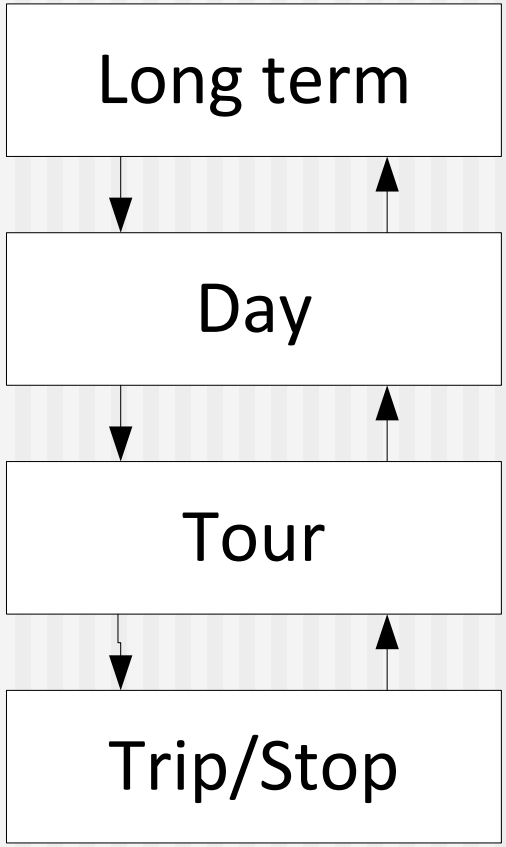
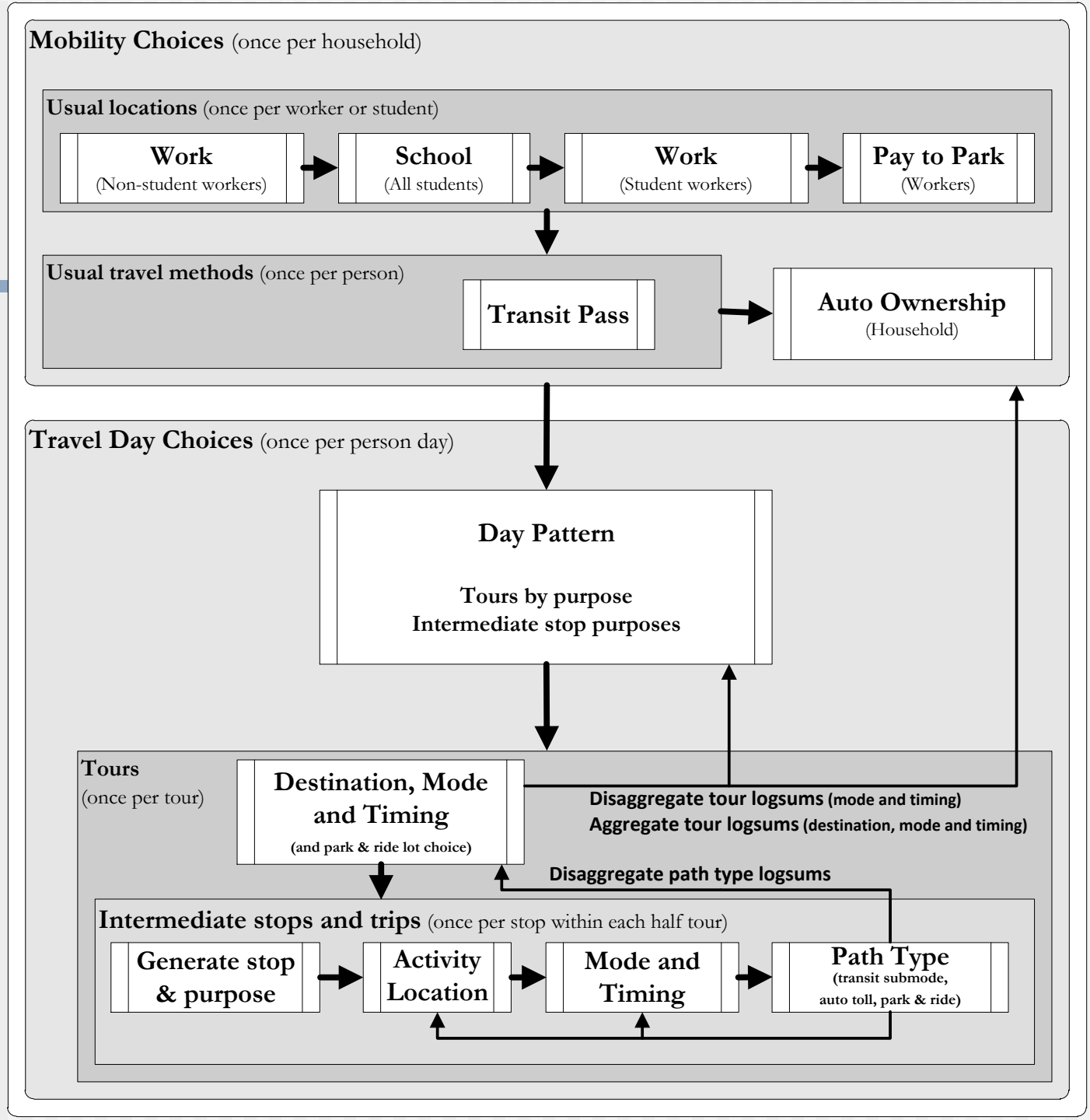
Commercial movements
OD Matrices
Network traffic assignment
Network performance (skims)
TRANSPORT MODEL SYSTEM

# AB Travel Demand Simulator
## Integrated System of Choice Models



# DaySim v1.7 Individual Simulation Flowchart



# Logit Choice Models

$$P_n(i) = \frac{\exp(\beta' X_{in})}{\sum_j \exp(\beta' X_{jn})}$$

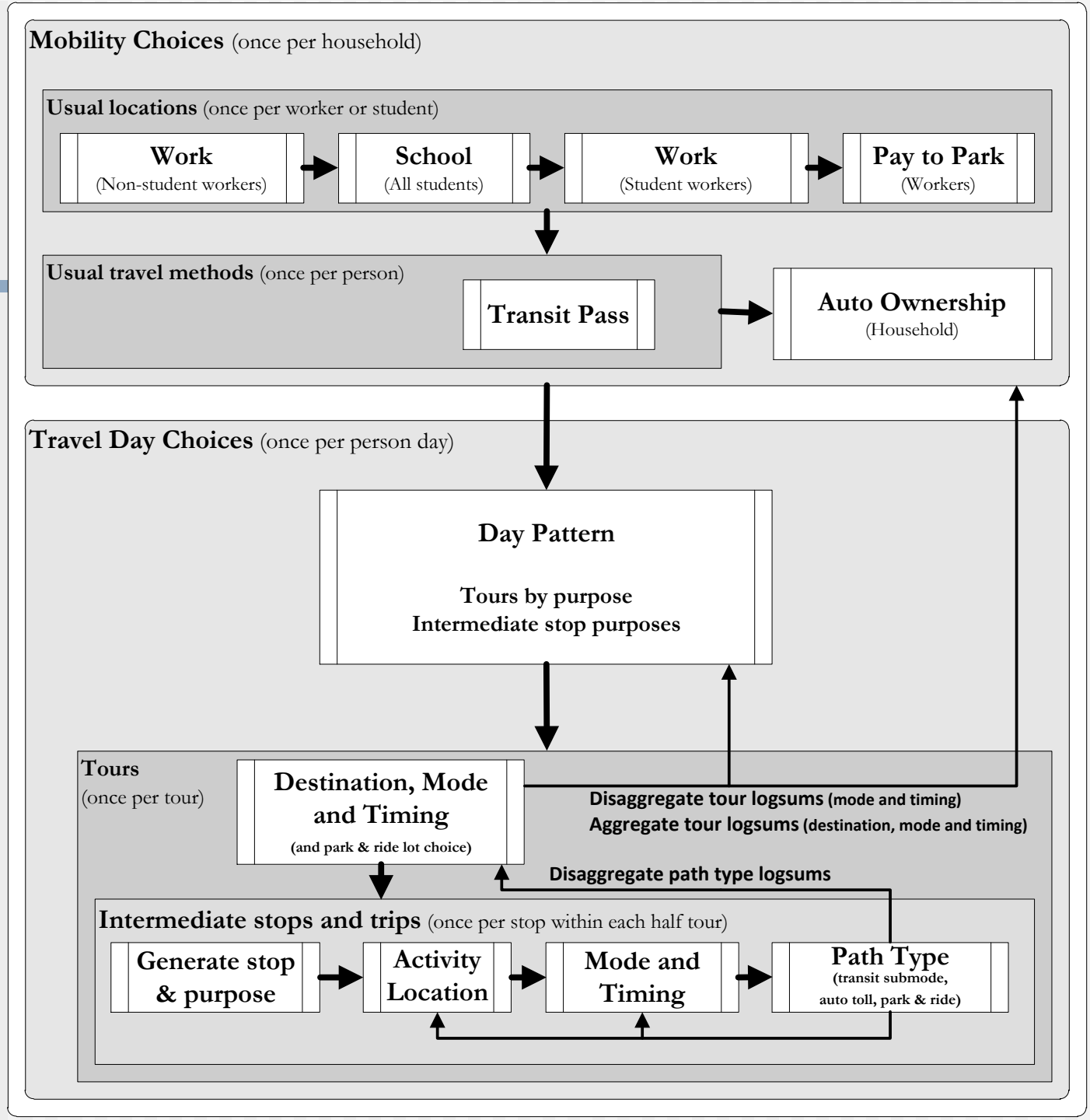
Where $i$ and $j$ index discrete alternatives

$P_n(i)$ is the probability that person $n$ chooses alternative $i$

$X_{in}$ is a vector of explanatory variables

$\beta$ is a vector of coefficients

# DaySim v1.7 Individual Simulation Flowchart

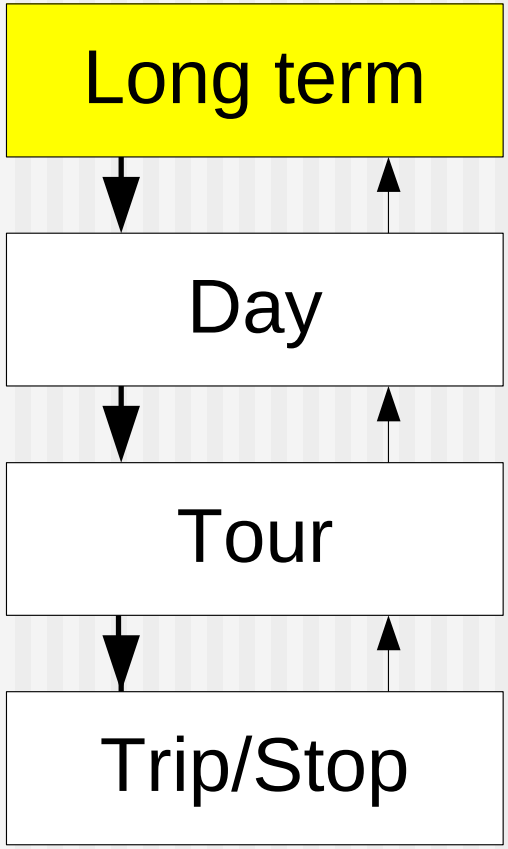


# AB Model Integration

- Downward (conditionality)
- Upward (accessibility)

# Downward Integration

## Lower models take upper outcomes as given



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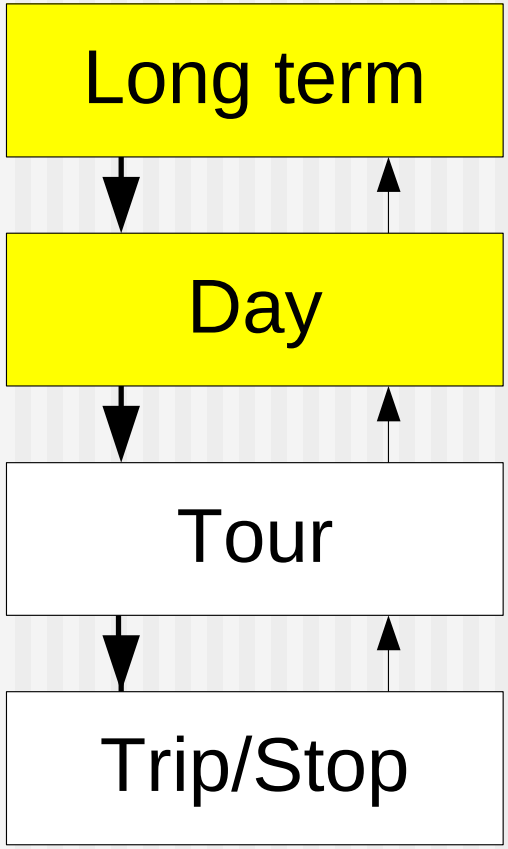

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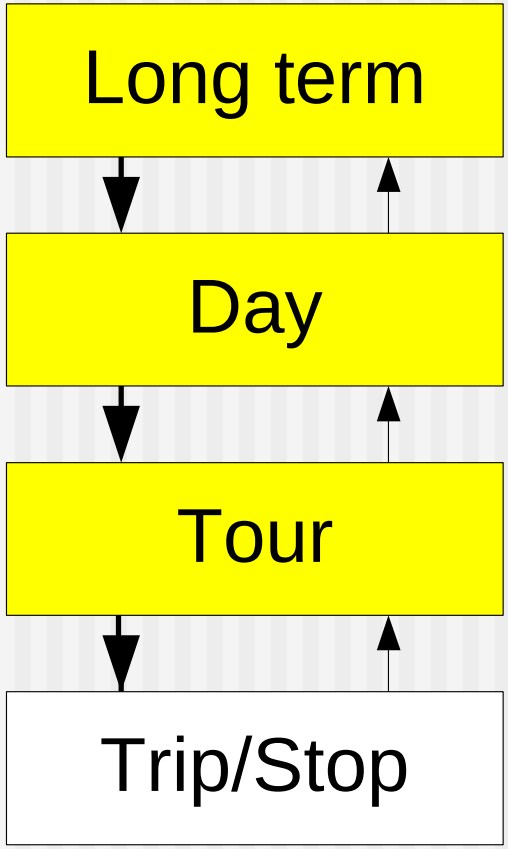

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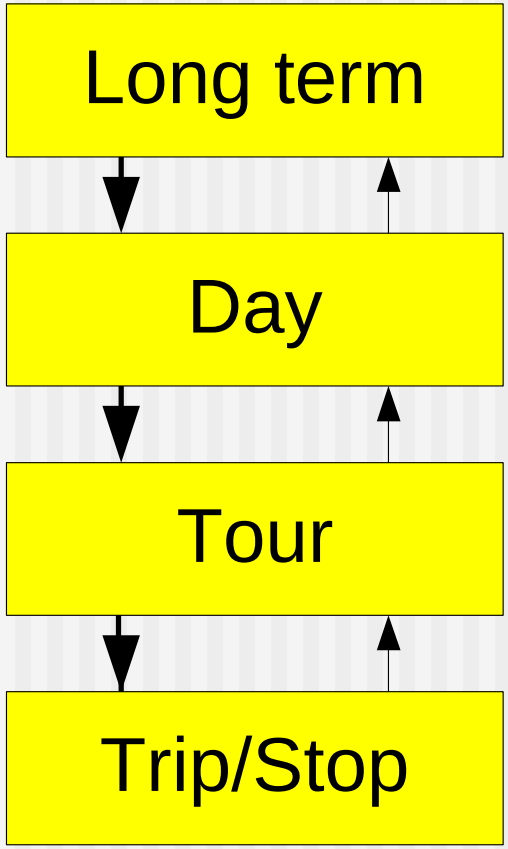
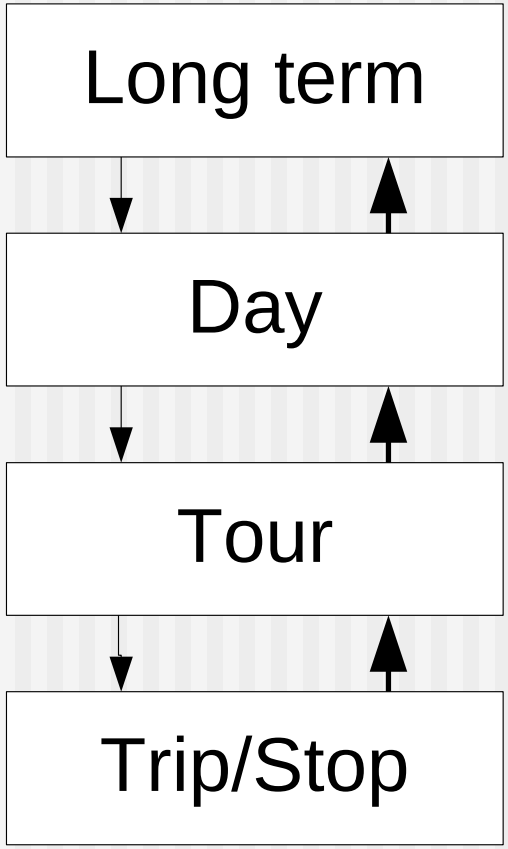


# Upward Integration

## Upper models should be sensitive to conditions affecting lower models



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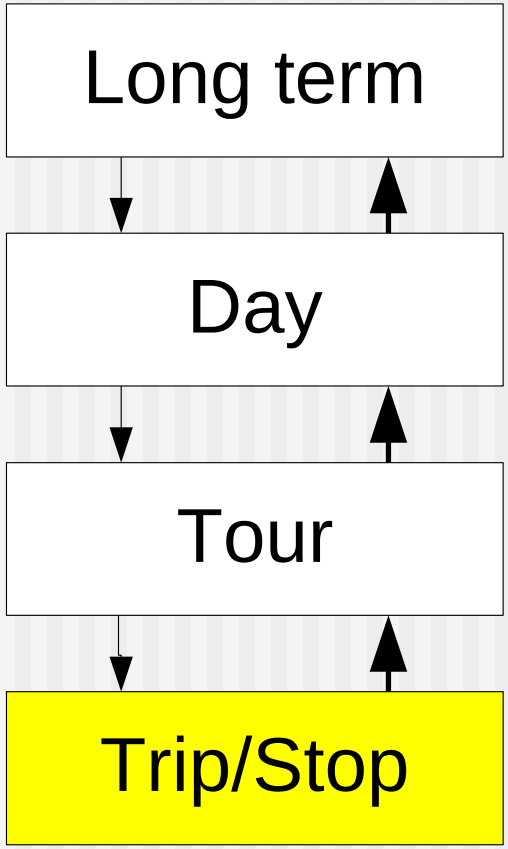

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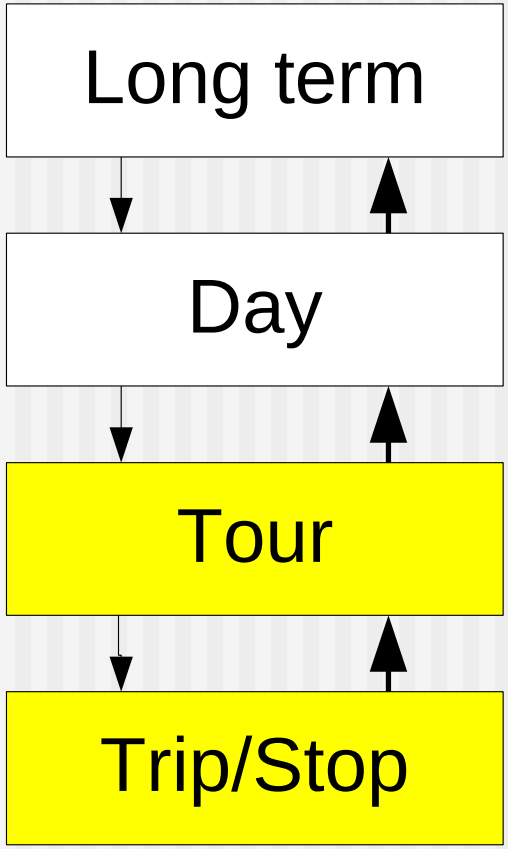

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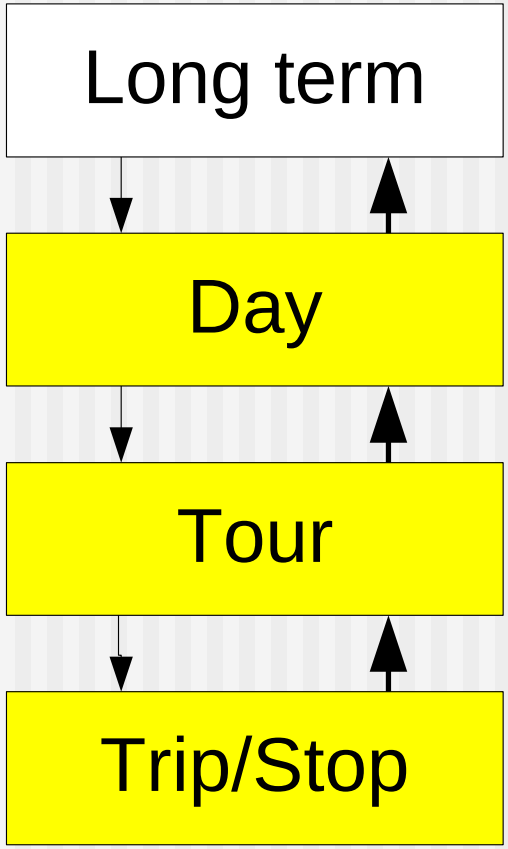

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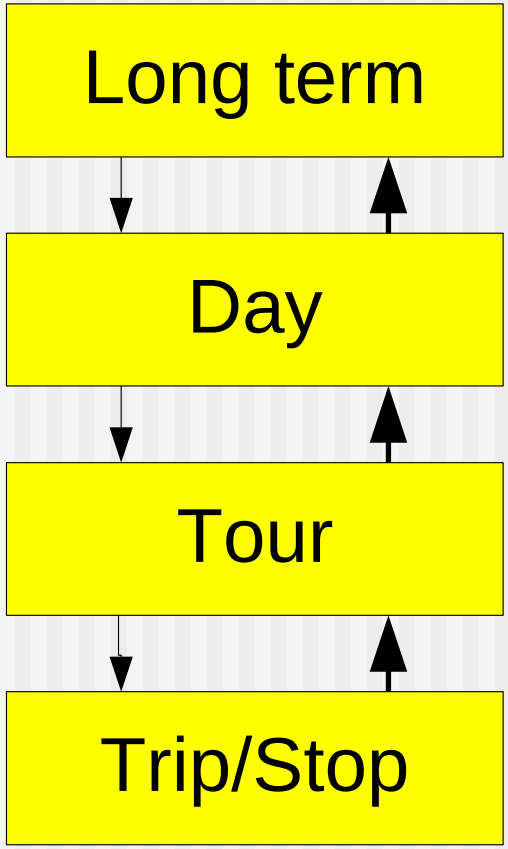


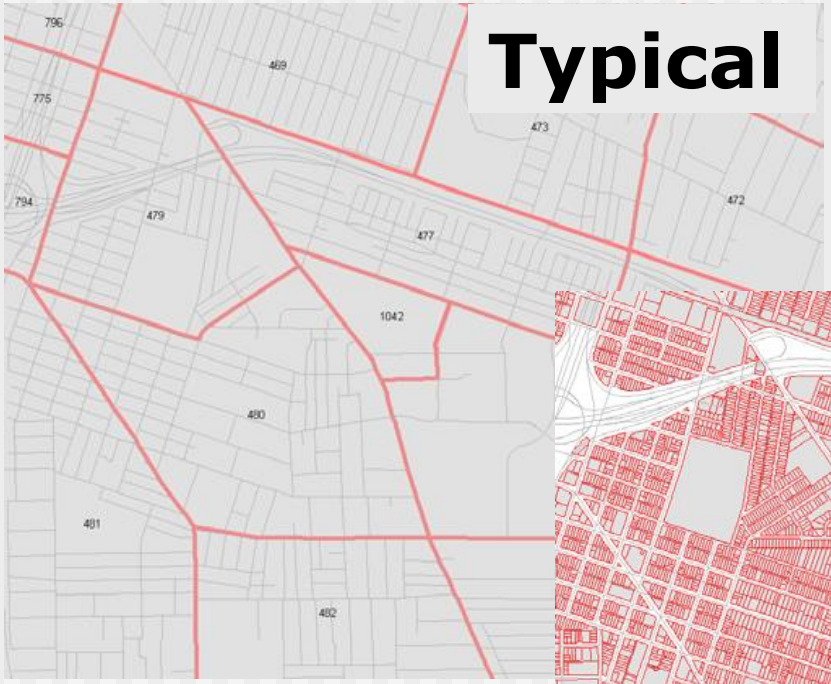
# Activity-Based Models
## 1993-2012

- Early history in the U.S.
- Basics of the "Activity-Based" model systems
- **Advanced features**

# Advanced Features

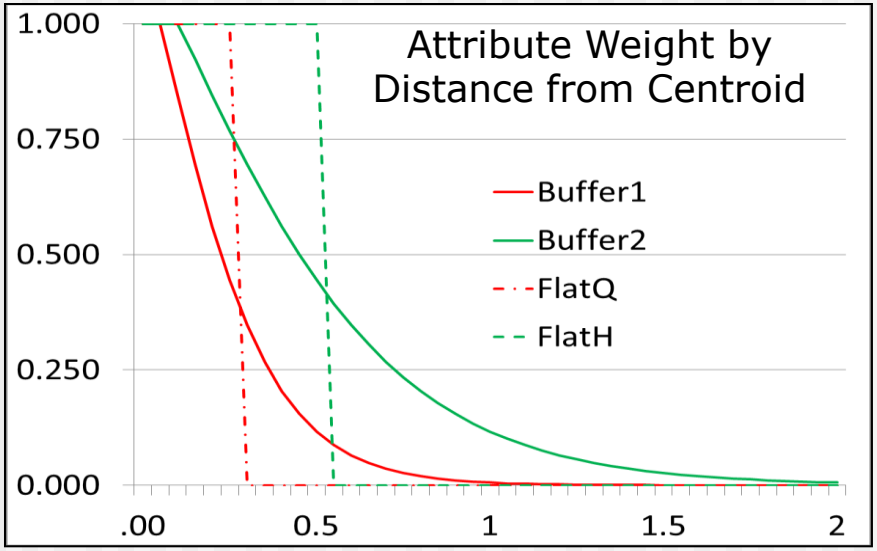
- **Fine spatial scale**
- Sensitivity to pricing
- Household behavior
- Vehicles and parking

# Disaggregating Location—750,000 parcels



# Parcel Data: Buffers

- Measure attributes in neighborhood of parcel centroid
  - ½ mi & ¼ mile "cliff" buffers (Classic)
  - Decay weighting function (Enhanced)
- Attributes buffered
  - Housing units
  - Employment by sector
  - Enrollment
  - Street intersections by type (dead end, 3-way, 4-way)



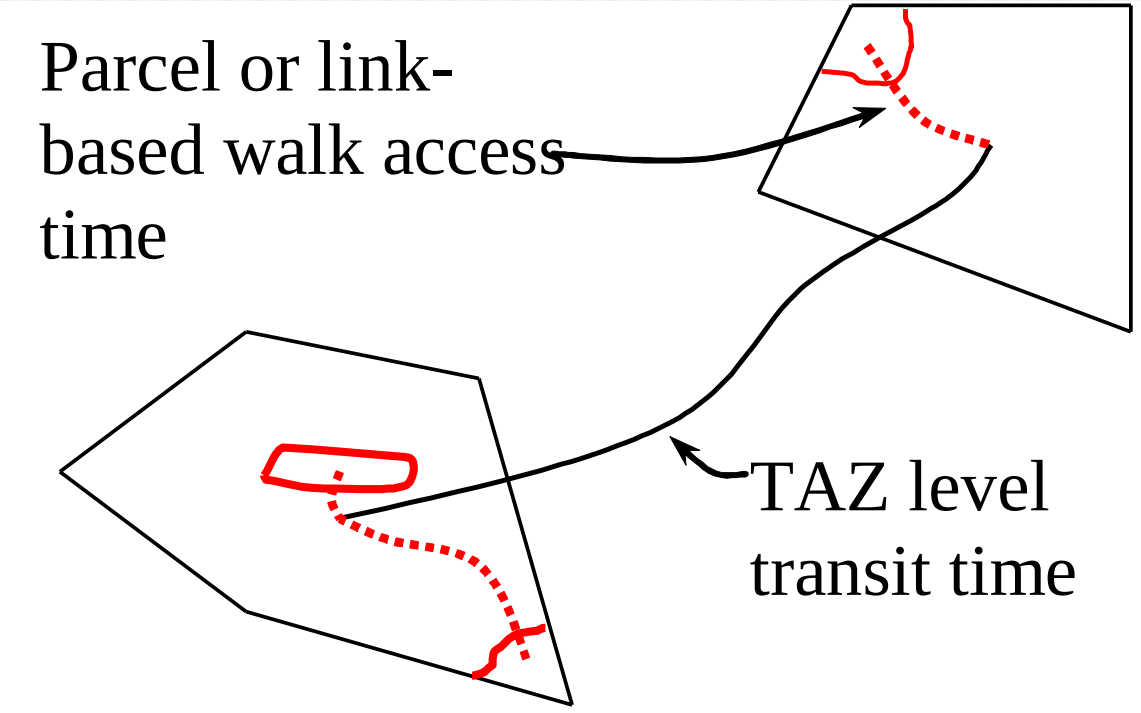
# Size and neighborhood effects in location choice

**Intermediate Stop Location Model**

**Escort purpose, Household with kids** (PSRC)

| Attribute | Parcel size effect relative to base | Neighborhood effect (coefficient) |
|---|---|---|
| total employment | 0.2563 | |
| K-12 enrollment | 1.0000 | 0.063840 |
| # households | Tiny | |
| indust.+agr+res.+constr employment | | -0.201894 |

# Fine spatial scale
## Improving measurement of impedance for transit trips…




Note: assumes person uses nearest transit stop

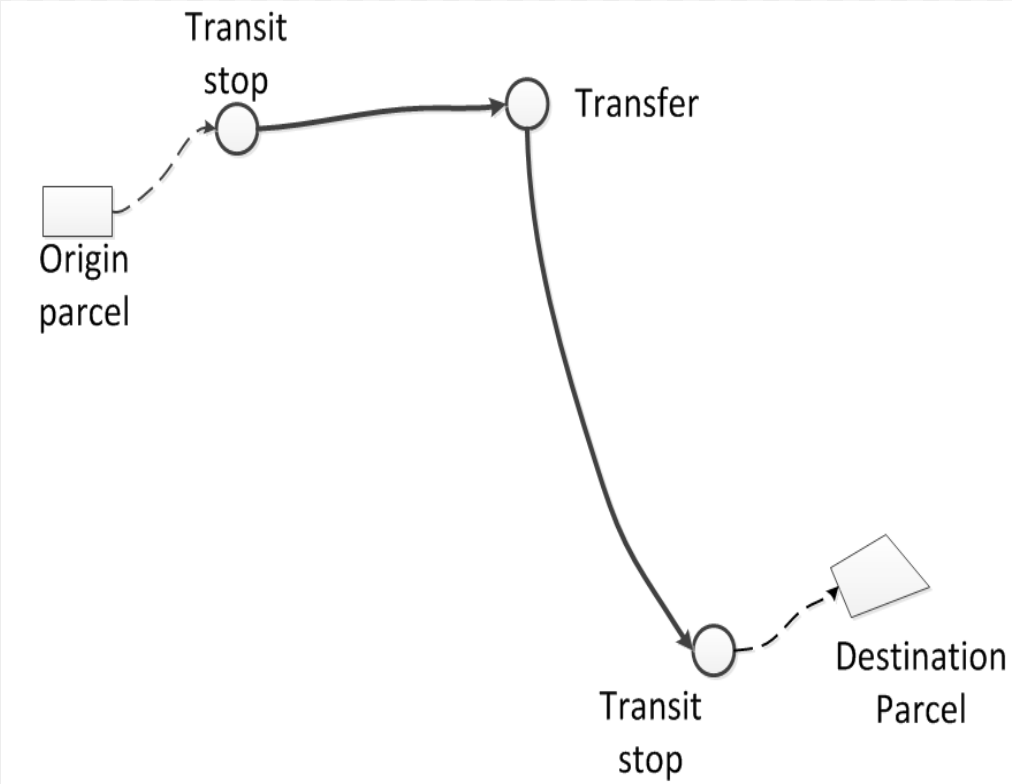
# …improves work mode choice estimation results (and prediction)

| | **TAZ-based** | | **Link-based** | |
|---|---|---|---|---|
| Log-likelihood | -4637 | | -4607 | |
| Values of time | $/hr | (T) | $/hr | (T) |
| Car- drive alone | 2.2 | (1.2) | 4.6 | (2.5) |
| Transit- in vehicle | 1.4 | (1.4) | 1.9 | (1.9) |
| Transit- wait | 5.9 | (3.5) | 5.3 | (3.3) |
| Transit- walk | 0.9 | (0.2) | **12.2** | **(6.1)** |

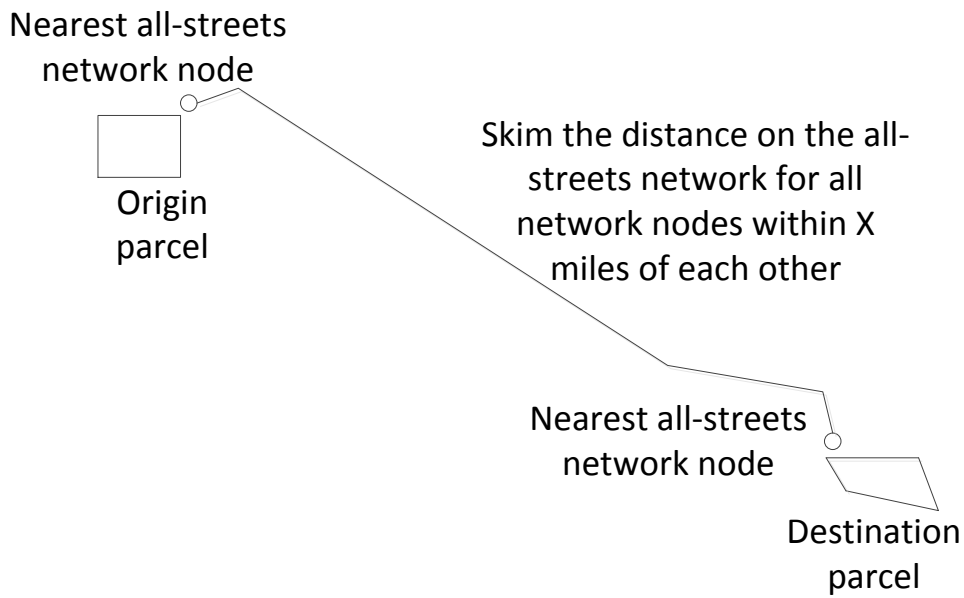
**From Portland Metro (Bowman, et al, 2001)**

# Further improvement
## (Philadelphia)

- Transit impedance from boarding stop to alighting stop
- Requires stop-to-stop transit skim capability
- AB model chooses stop pair with best total path impedance (including walk access time)



# Short distance calculations

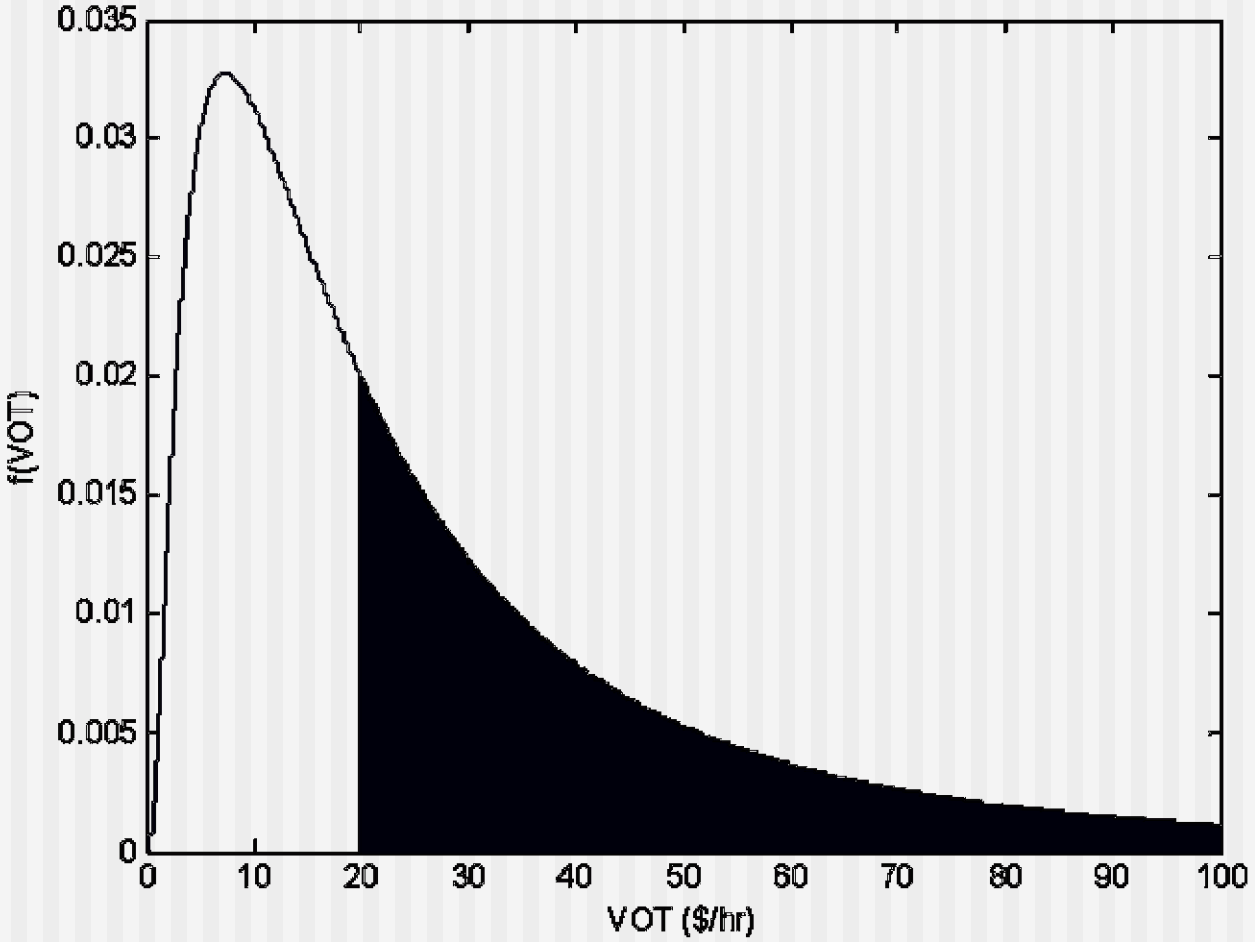



- Use for:
  - Walk access to transit
  - Distance on all short trips
  - Adjusting TAZ-based travel times by all modes

# Advanced Features

- Fine spatial scale
- **Sensitivity to pricing**
- Household behavior
- Vehicles and parking

# Shape of Log-Normal Distribution

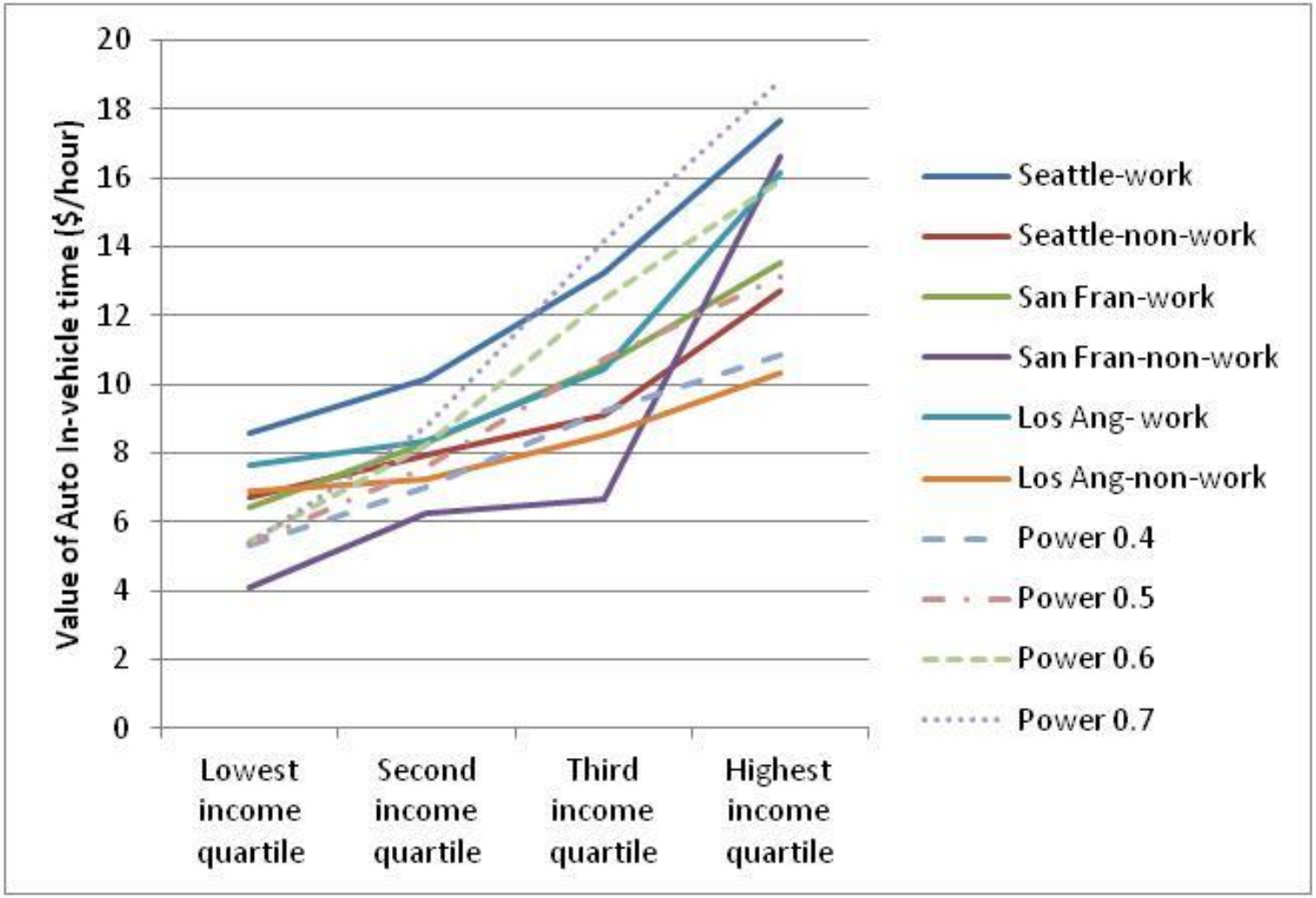


# Sensitivity to pricing via auto path type choice
(uses findings of SHRP 2 C04 and C10)

In AB model, for each auto trip simulate VOT-dependent binary choice between path with toll and path without toll

- VOT: lognormally distributed function of purpose & income
- Uses skimmed impedance matrices for each combination of:
  - Time period: 5 to 15 periods
  - Path type: (1) full network, (2) network excluding tolled links
  - VOT class: V1, V2, … VN
  - Occupancy: (1) SOV, (2) HOV 2 (3) HOV 3+ (if necessary)

# VOT variation with income – various C04 data sets



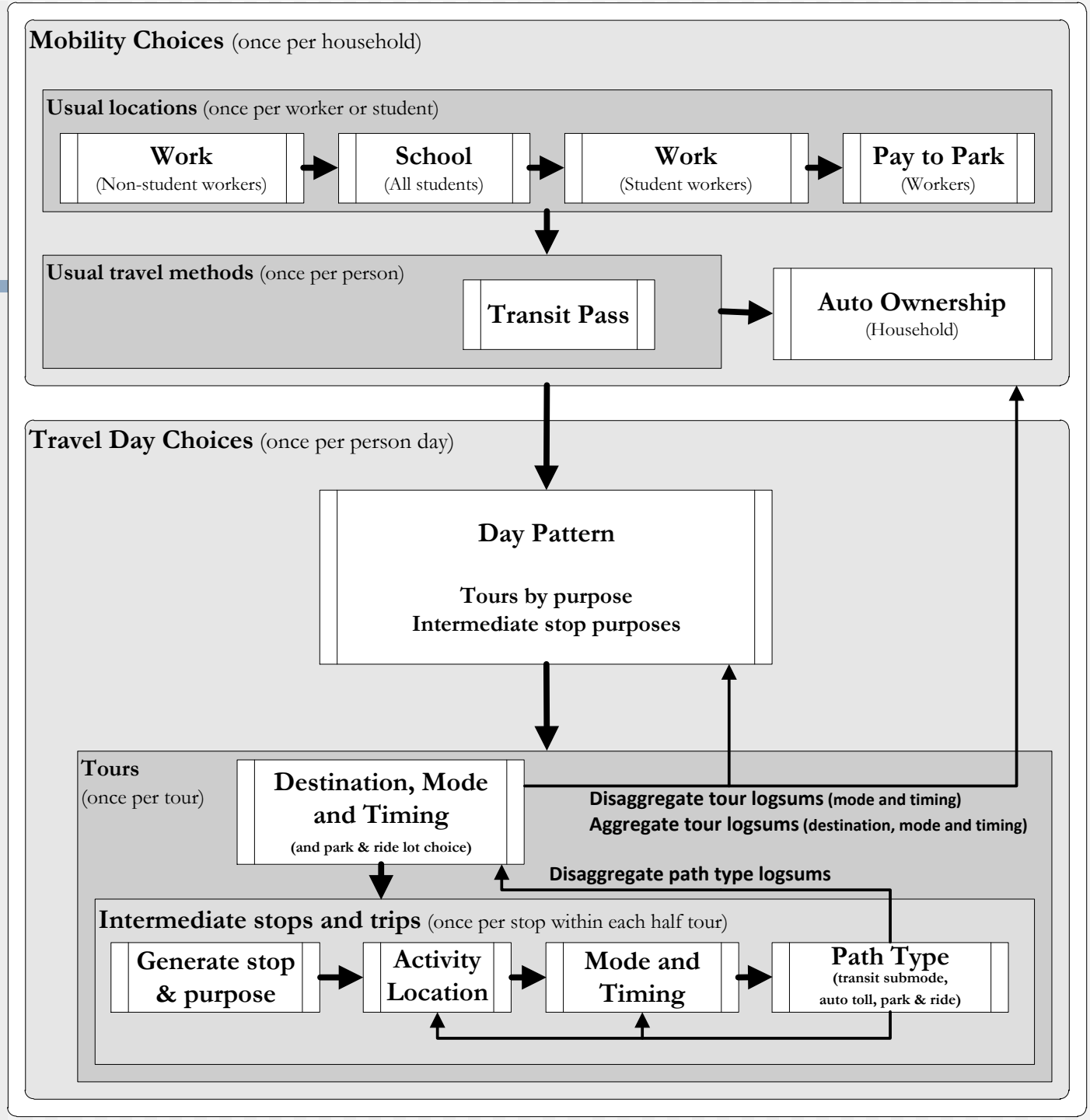
# Advanced Features

- Fine spatial scale
- Sensitivity to pricing
- **Household behavior**
- Vehicles and parking

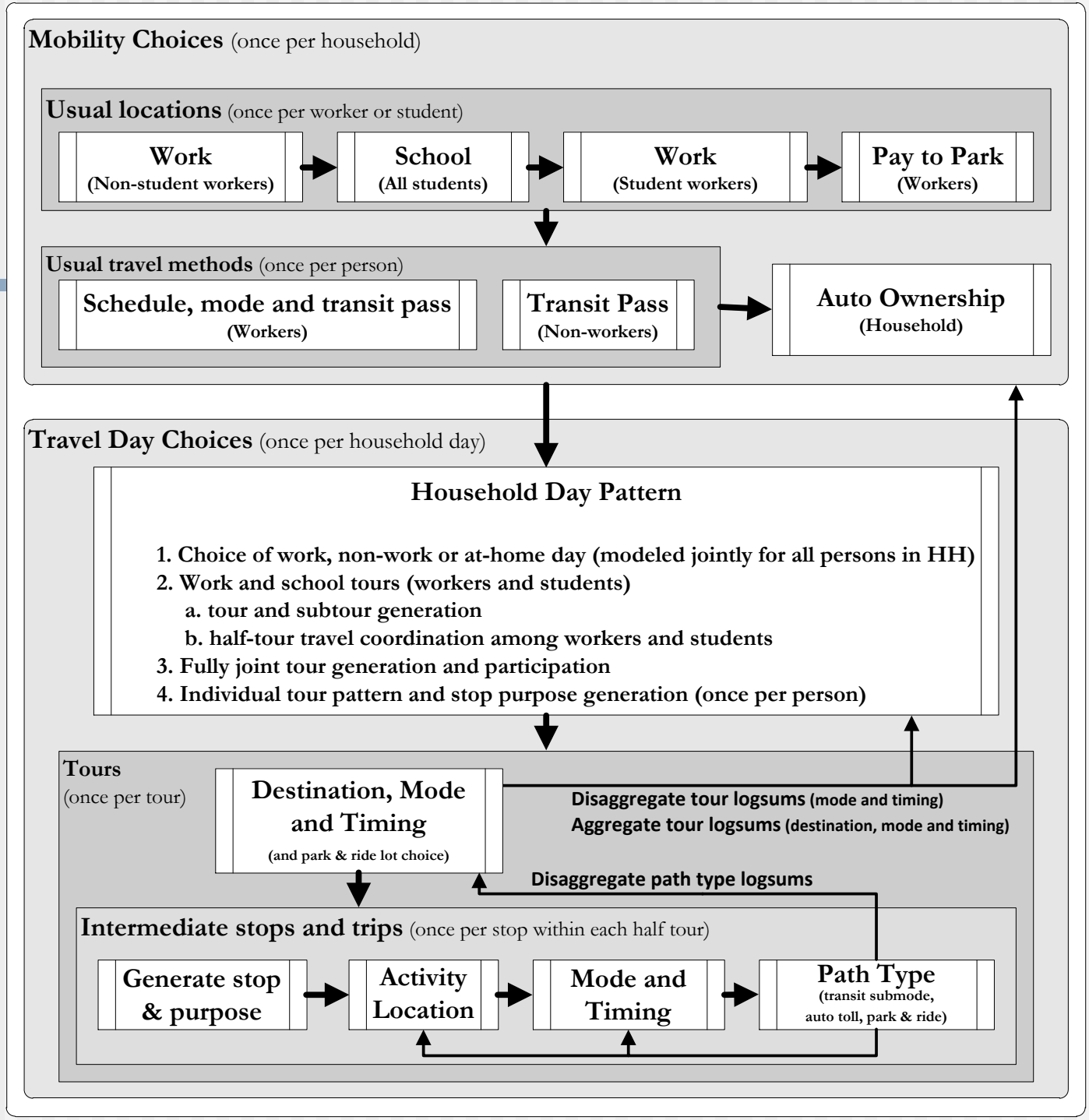
# Intra-household models

- Household day pattern
  - work, school, other or home for each member
- Joint tours
- Chauffeur half-tours—take passenger to/from school or work
  - on way to/from work
  - as a 'serve passenger' tour

# DaySim v1.7 Individual Simulation Flowchart



# DaySim v2.0 Household Simulation Flowchart



# Advanced Features

- Fine spatial scale
- Sensitivity to pricing
- Household behavior
- **Vehicles and parking**

# Park and ride lot location choice

- Lot utility depends on impedance from O to D via lot
- Simulator accounts for lot fill levels by time of day
- Lot is not available if it is full when trip would arrive.

# More vehicle model possibilities

- vehicle type choice
- vehicle usage
- vehicle itinerary accounting

# More possibilities
## In the queue and around the corner

- Effects of reliability
- Tour-based commercial movements
- Activity-based visitor models
- Integration with dynamic traffic assignment