CAMBRIDGE SYSTEMATICS

Think Forward

Aimsun Model Review Training

Day 1: DTA Overview

Caltrans On-Call Traffic Simulation Training

presented to

Caltrans District 7

Caltrans

presented by

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DTA Overview

What is DTA?

- DTA is NOT mesoscopic
- Best defined as Dynamic vs Static Assignment
- Key characteristics of DTA:
  - Origin-Destination travel demands are inputs
  - Route choice is sensitive to dynamic congestion conditions
  - Modeled travel times are time-dependent
    - Typically 5 or 15 minute resolution
  - Network is truly capacity constrained
    - Both for links and for turns
  - Excess demand creates queuing

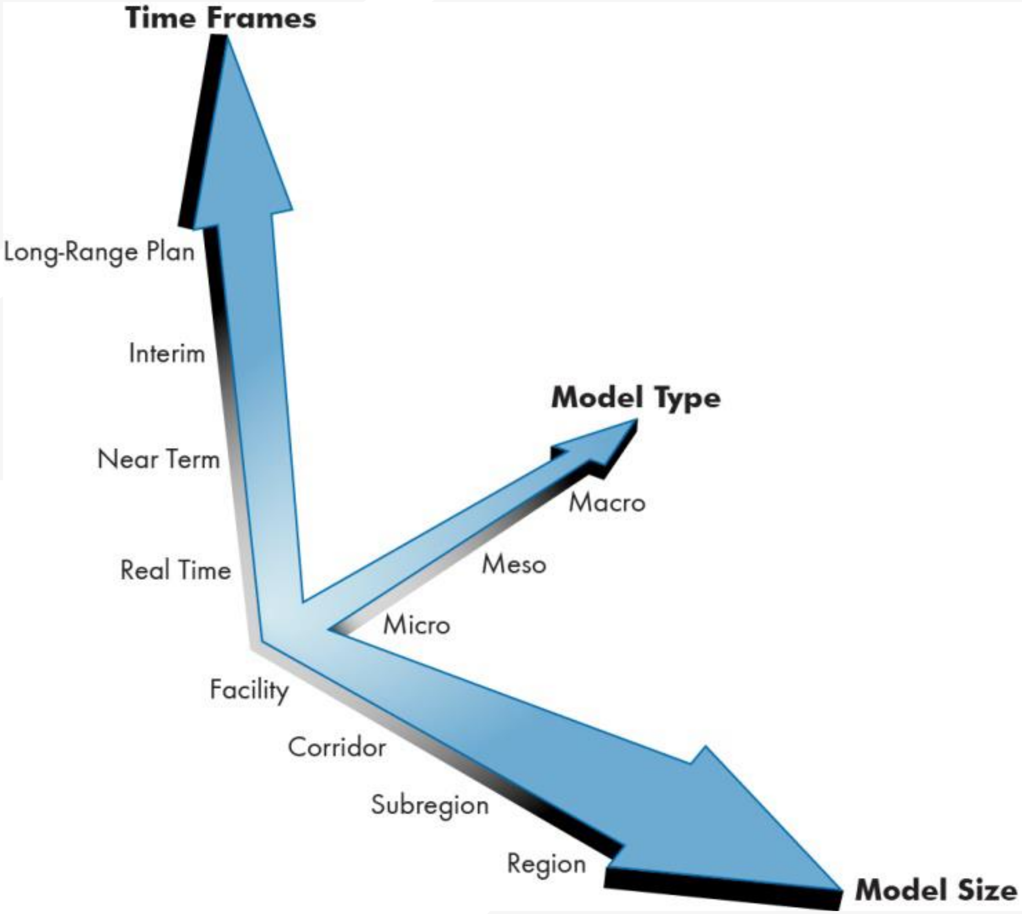
What is DTA?

- Well suited for evaluating operational strategies that are likely to induce a ***temporal or spatial pattern shift*** of traffic among different roadway facilities at a corridor and network-wide level
- Allows for more realistic estimation of travel behavior and congestion conditions from various demand and/or supply changes and interactions
- Suitable for analyses involving heavy levels of congestion, incidents, construction zones, ATDM strategies, ICM strategies, ITS, managed lanes, congestion pricing, etc.

What is DTA?

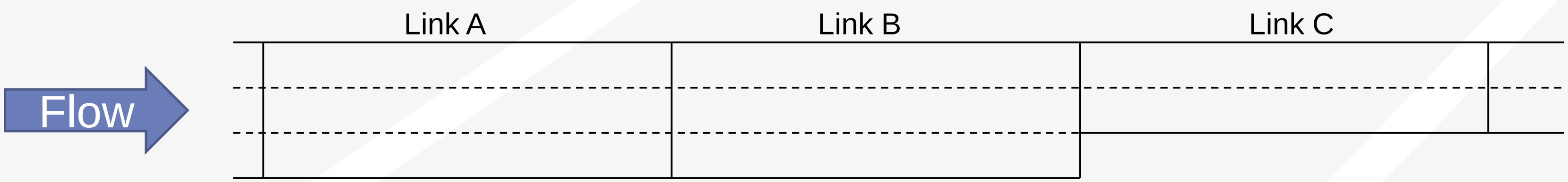
- May be incorporated into macroscopic, mesoscopic and/or microscopic simulation models
- Often involves a combination of model types representing Multi-Resolution Modeling (MRM)
- With updated information regarding congestion, network conditions, or other information received during the analysis period, simulated vehicles may consider:
  - choosing alternative routes
  - changing start times for a trip
  - changing modes for a trip

DTA Modeling Considerations



DTA vs STA: Modeling Congestion

- Simple Bottleneck:



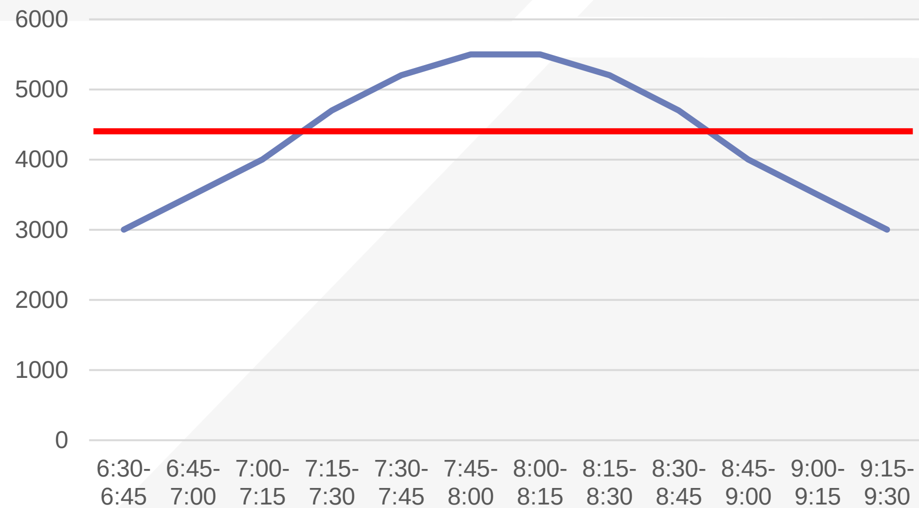
Lanes: 3
Capacity: 6000 veh/hr

Lanes: 3
Capacity: 6000 veh/hr

Lanes: 2
Capacity: 4000 veh/hr

- Demands:

Period	Flow Rate (v/hr)
6:30- 6:45	3000
6:45- 7:00	3500
7:00- 7:15	4000
7:15- 7:30	4700
7:30- 7:45	5200
7:45- 8:00	5500
8:00- 8:15	5500
8:15- 8:30	5200
8:30- 8:45	4700
8:45- 9:00	4000
9:00- 9:15	3500
9:15- 9:30	3000
Period Average	**4317**



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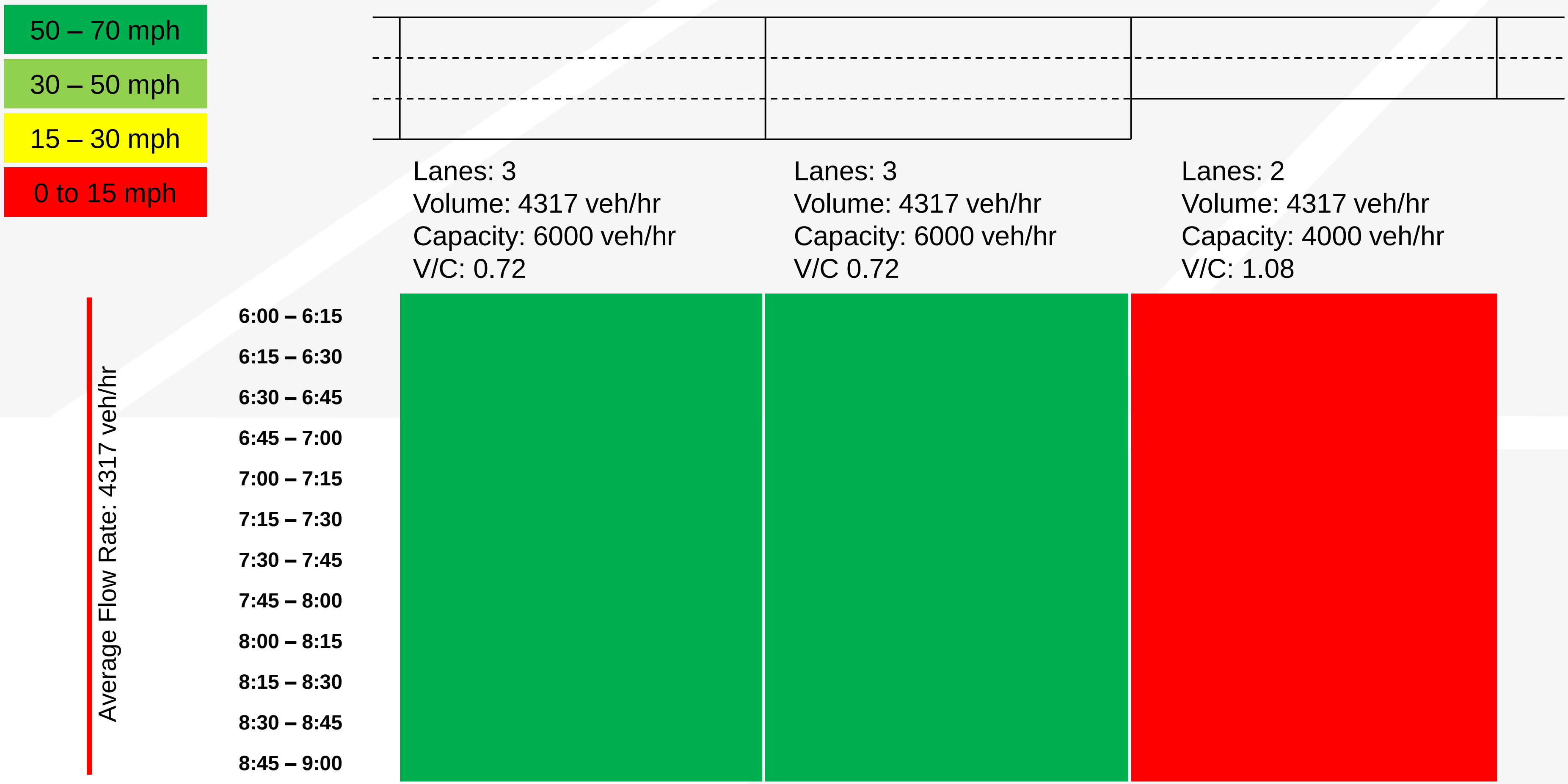
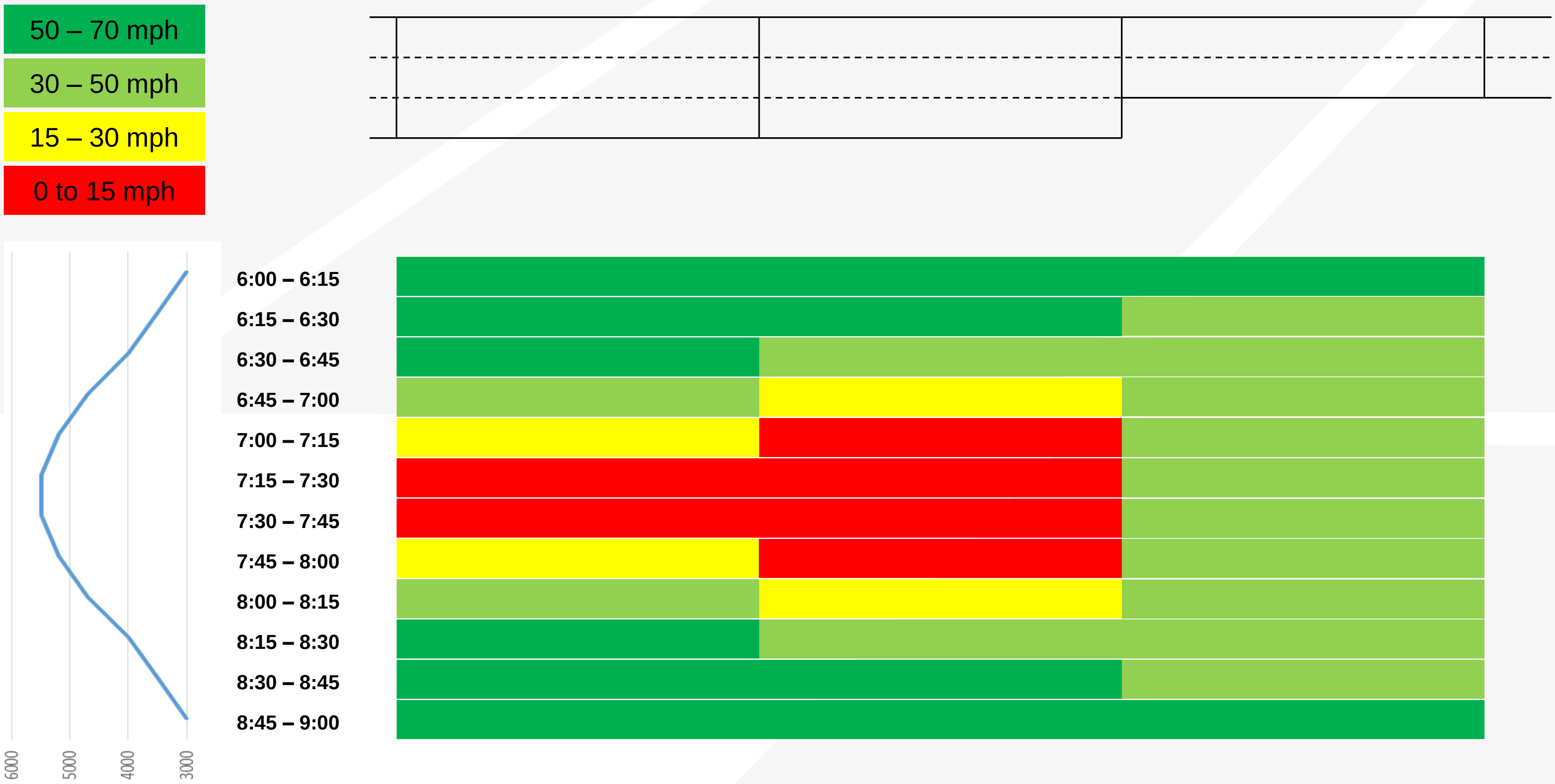
STA: Modeling Congestion

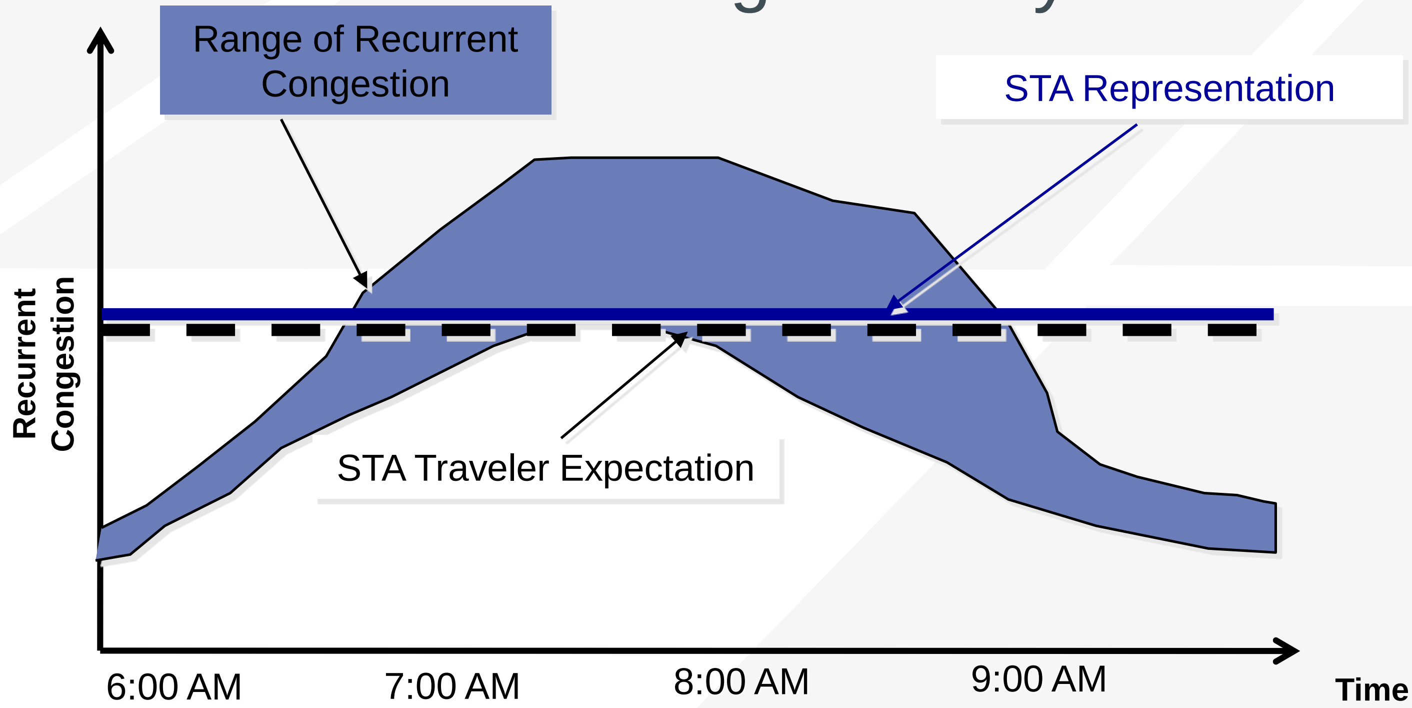


DTA: Modeling Congestion



STA Identifies Travel Patterns Inherently Consistent with Average Congestion

- Since congestion is represented over the period with an *average* value, traveler behavior is not sensitive to congestion dynamics



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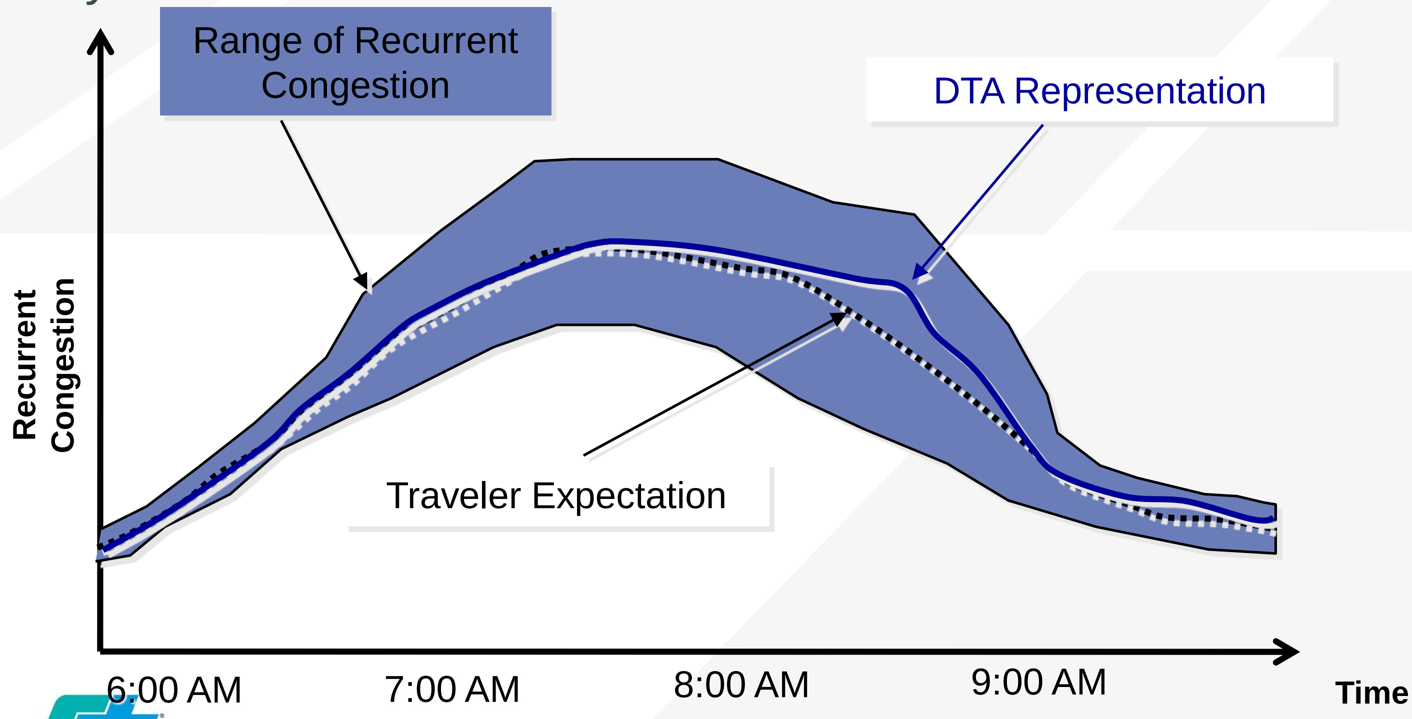
DTA Identifies Travel Patterns Inherently Consistent with Congestion Dynamics

- DTA is a technique that allows the analyst to:
  - Model long-term traveler adaptation to experienced (learned) congestion dynamics, AND
  - Accurately model within-day and with-in period congestion dynamics



Time Dependent Travel Times

- Instantaneous vs Experience Travel Times

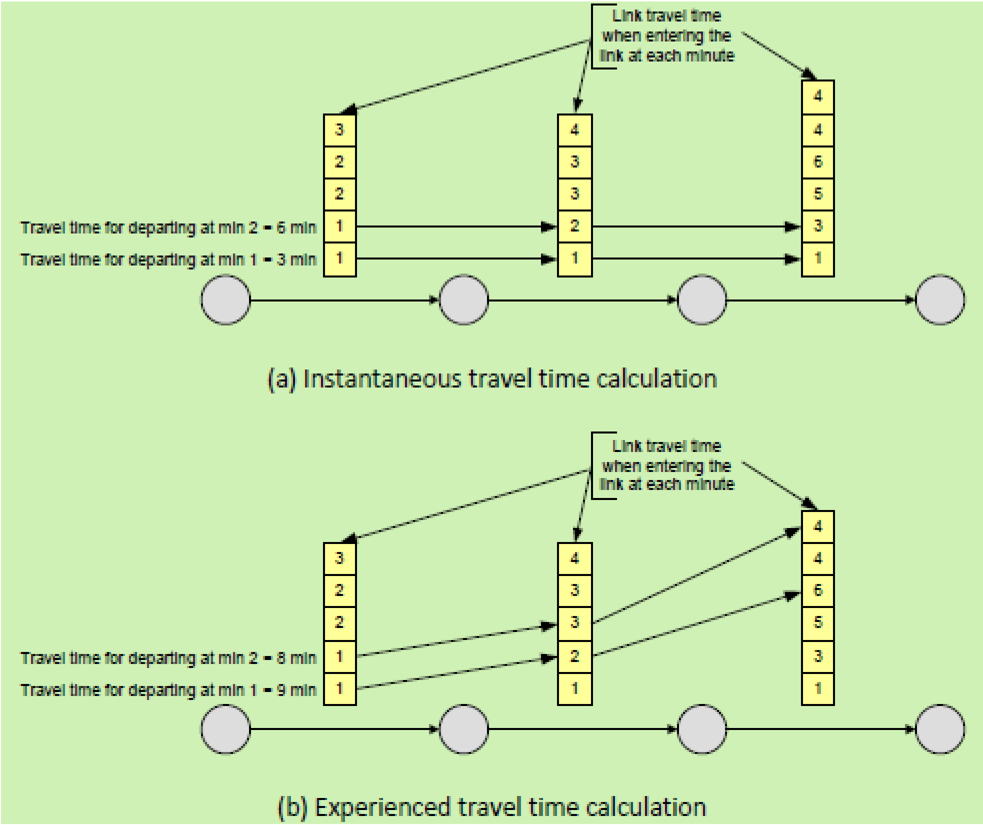


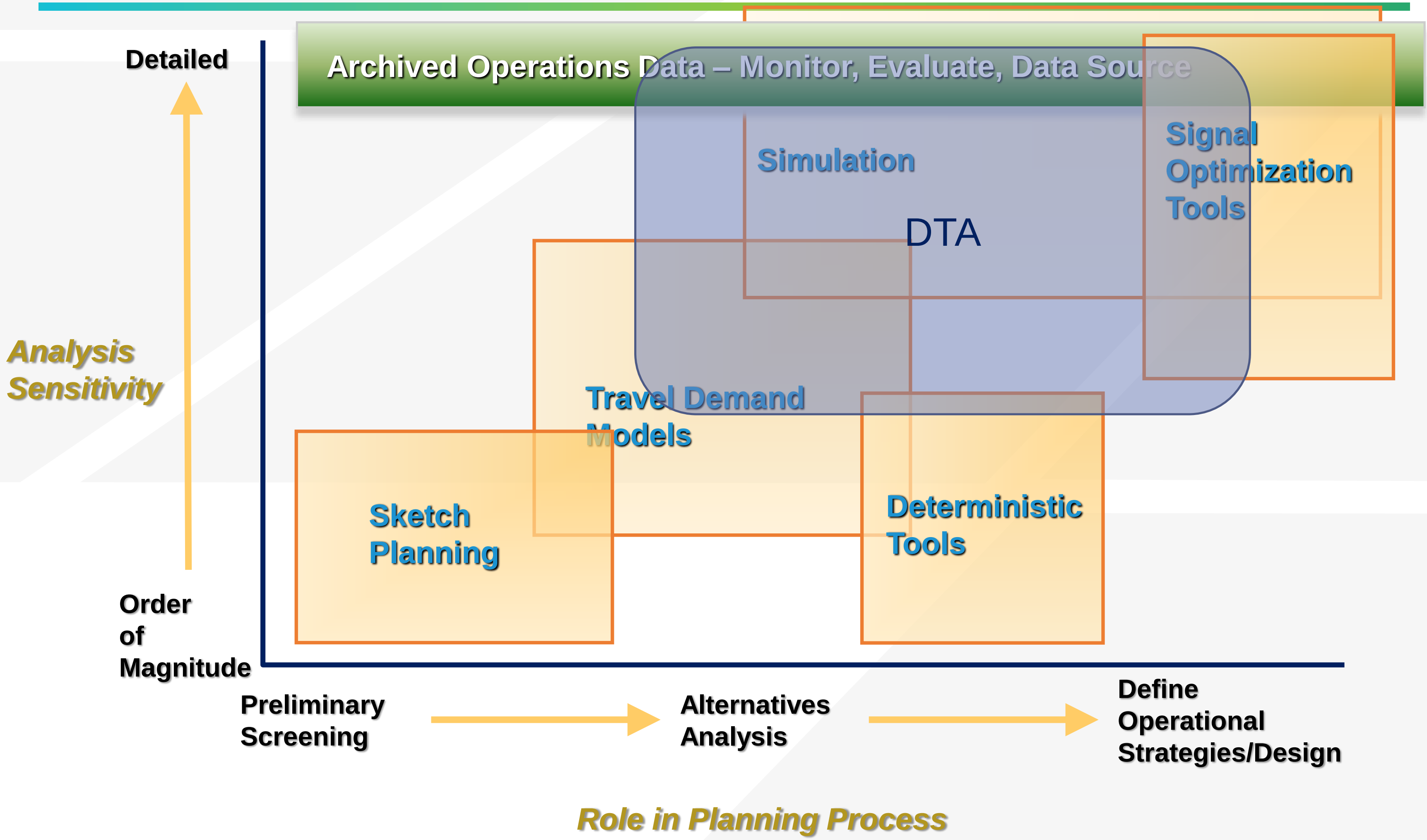
Figure 2.4: Experienced travel-time versus instantaneous travel-time determination

Source: DTA Primer, TRB

- Instantaneous:
  - » STA methods
- Experienced
  - » DTA model methods:

When to Use DTA?

DTA on the Analysis Spectrum:



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Criteria for Selecting a DTA Analysis Framework

Analysis Context:
Planning, Design, or Operations/Construction

1 Geographic Scope	2 Facility Type	3 Travel Mode	4 Management Strategy	5 Traveler Response	6 Performance Measures	7
What is your study area?	Which facility types do you want to include?	Which travel modes do you want to include?	Which management strategies should be analyzed?	Which traveler responses should be analyzed?	What performance measures are needed?	What operational characteristics are necessary?

• Isolated Location
• Segment
• Corridor/ Small Network
• Region
	• Isolated Intersection
	• Roundabout
	• Arterial
	• Highway
	• Freeway
	• HOV Lane
	• HOV Bypass Lane
	• Ramp
	• Auxiliary Lane
	• Reversible Lane
	• Truck Lane
	• Bus Lane
	• Toll Plaza
	• Light Rail Line
		• SOV
		• HOV (2, 3, 3+)
		• Bus
		• Rail
		• Truck
		• Motorcycle
		• Bicycle
		• Pedestrian
			• Freeway Mgmt
			• Arterial Intersections
			• Arterial Mgmt
			• Incident Mgmt
			• Emergency Mgmt
			• Work Zone
			• Spec Event
			• APTS
			• ATIS
			• Electronic Payment
			• RRX
			• CVO
			• AVCSS
			• Weather Mgmt
			• TDM
				• Route Diversion
				  - Pre-Trip
				  - En-Route
				• Mode Shift
				• Departure Time Choice
				• Destination Change
				• Induced/ Foregone Demand
					• LOS
					• Speed
					• Travel Time
					• Volume
					• Travel Distance
					• Ridership
					• AVO
					• v/c Ratio
					• Density
					• VMT/PMT
					• VHT/PHT
					• Delay
					• Queue Length
					• # Stops
					• Crashes/ Duration
					• TT Reliability
					• Emissions/ Fuel Consump
					• Noise
					• Mode Split
					• Benefit/Cost
						• Tool Capital Cost
						• Effort (Cost/ Training)
						• Ease of Use
						• Popular/Well-Trusted
						• Hardware Requirements
						• Data Requirements
						• Computer Run Time
						• Post-Processing
						• Documentation
						• User Support
						• Key Parameters User Definable
						• Default Values
						• Integration
						• Animation/ Presentation

Source: FHWA Traffic Analysis Toolbox Volume II

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Good Candidates for DTA Analysis

- Bottleneck removal studies
- Active Transportation and Demand Management (ATDM) strategies
- Integrated Corridor Management (ICM) strategies
- Intelligent Transportation Systems (ITS) strategies
- Operational strategies
- Demand management strategies
- Additional capacity in existing oversaturated conditions
- Downtown traffic management and street configurations

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Good Candidates for DTA Analysis

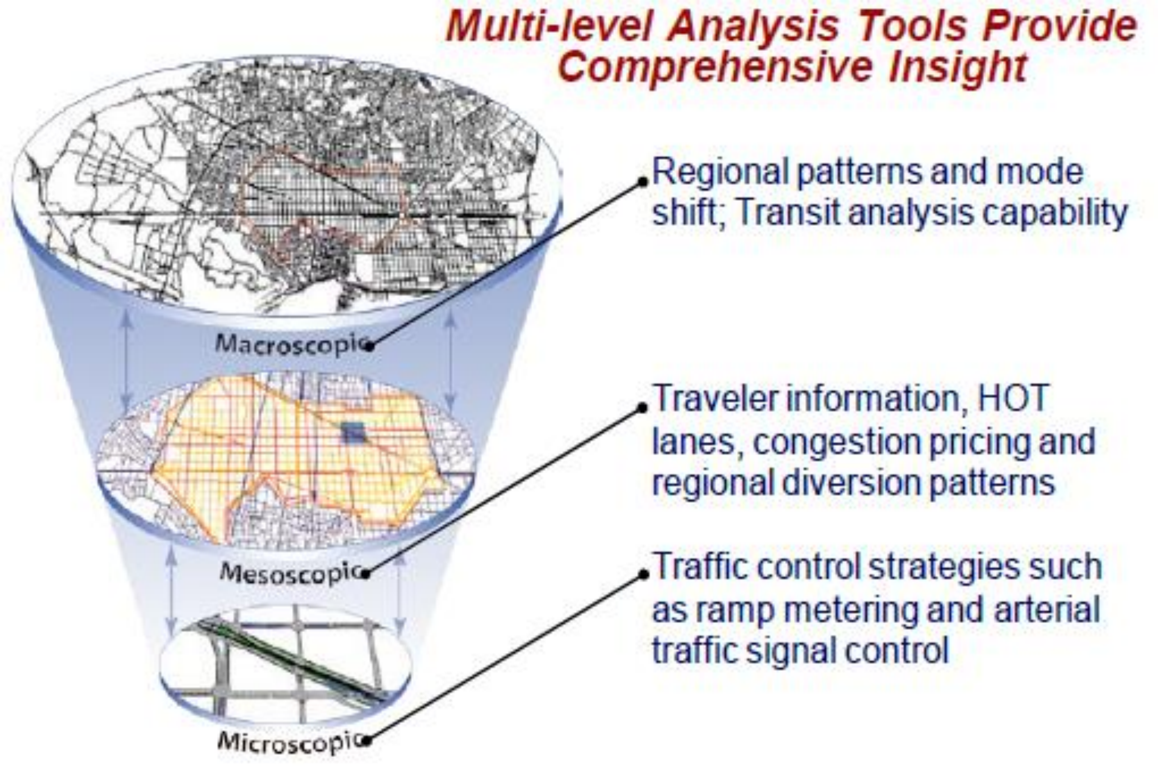
- Incident management response scenarios
- Evacuation or Emergency Management Modeling
- Special events
- Work zone impacts and construction diversion – short term
- Work zone impacts and construction diversion – long term
- Managed lanes
- Dynamic tolling or congestion pricing projects
- Linking ongoing traditional demand and microscopic modeling

DTA Flavors

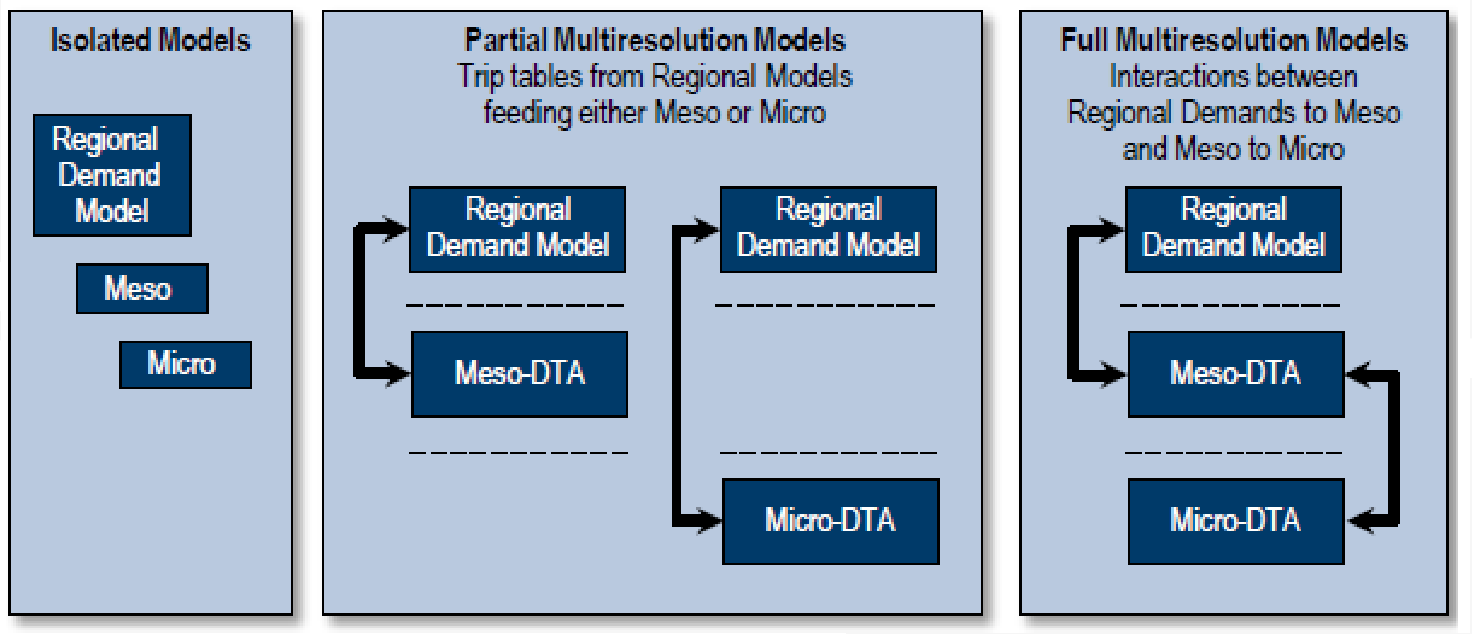
- Link Based Capacity
  - Can be less computationally intensive (somewhat)
  - Can be more regionally focused
- Lane Base Capacity
  - Can model special lanes
  - Can better model accidents and lane blockages
  - Can better model weave, merges, diverges

DTA in a MRM Framework

Multi-Resolution Modeling Framework



MRM Frameworks



MRM Framework Example: NYCDOT Manhattan Traffic Model

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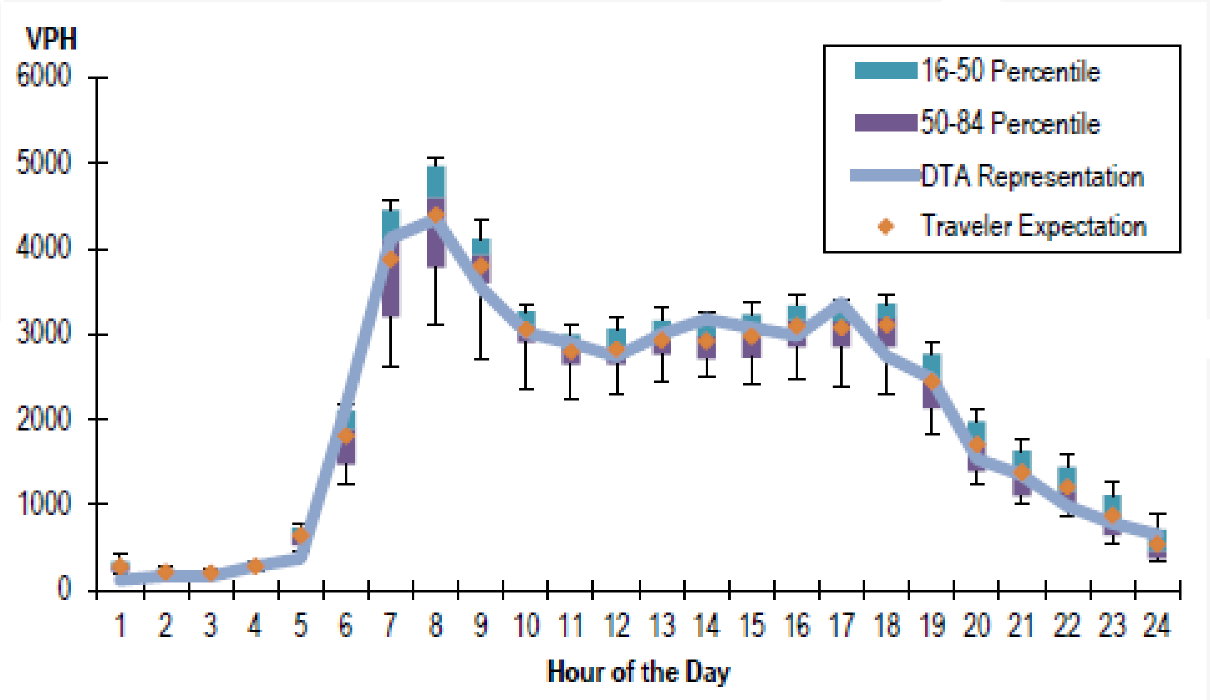
DTA Technical Discussions

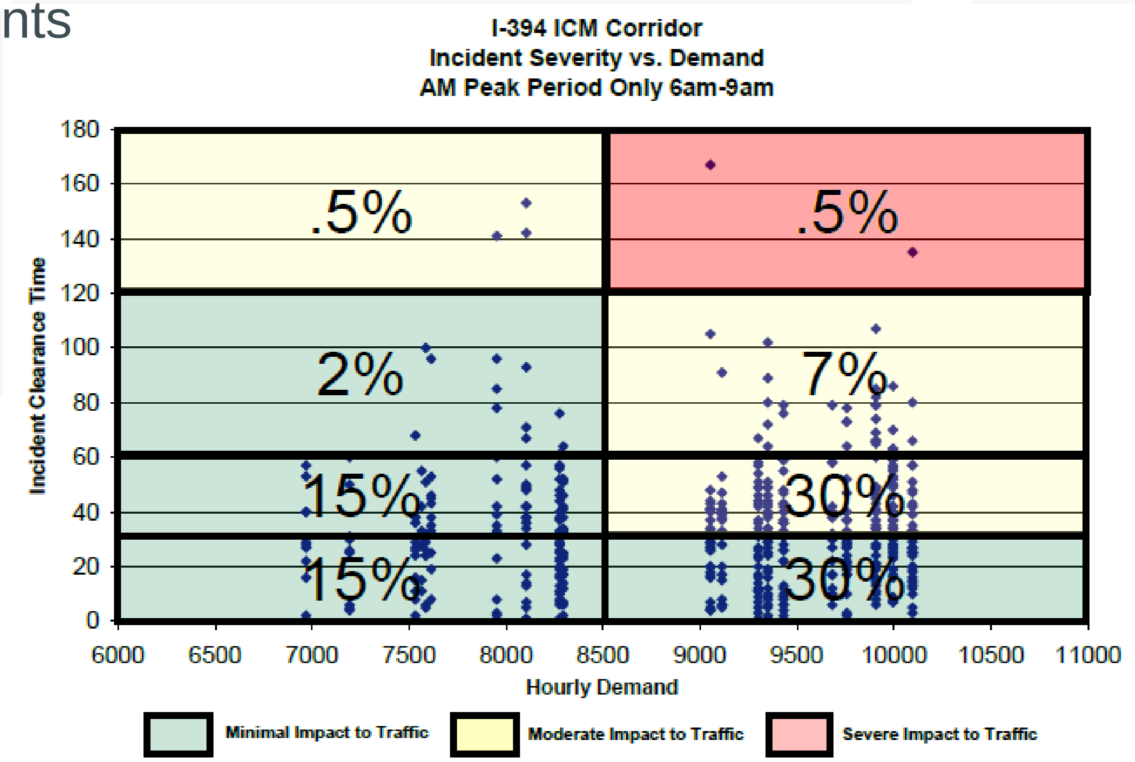
An Average Day Rarely Occurs: Demand

- Variations in traffic conditions (recurring congestion)
  - Day of week
  - Seasonal



An Average Day Rarely Occurs: Accidents

- Non-recurring Congestion
  - » Accidents & Incidents
    - Severity
    - Clearance Time
    - Blockages
  - » Special events
  - » Weather



Source: ICM Analysis, Modeling, and Simulation Guide, Traffic Analysis Toolbox Vol XIII

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DTA Equilibrium

- Wardrop's User-Equilibrium:
  - In a model network with many possible routes for ***each O-D pair***, all used routes have equal and lowest ***travel time (generalized cost)***. No user may lower their travel time (generalized costs) by unilaterally changing to a different route
- Time Dependent Dynamic User Equilibrium (DUE)
  - In a network with many O-D Zones and in a specific time period, for ***each O-D pair and departure time increment***, all used routes have equal and lowest ***experienced travel time (generalized costs)*** and no user may lower their experienced travel time (generalized cost) through unilateral action

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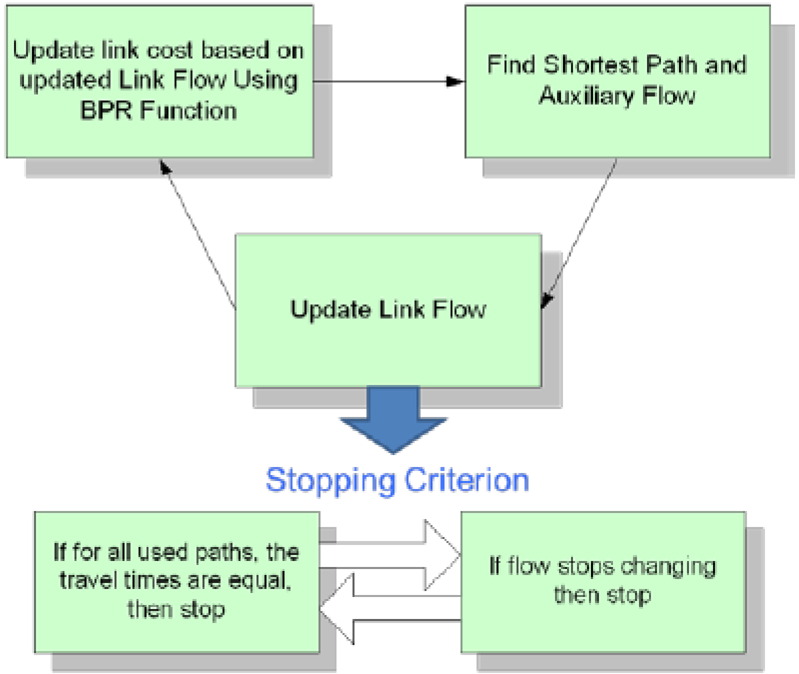
Static User Equilibrium (UE)

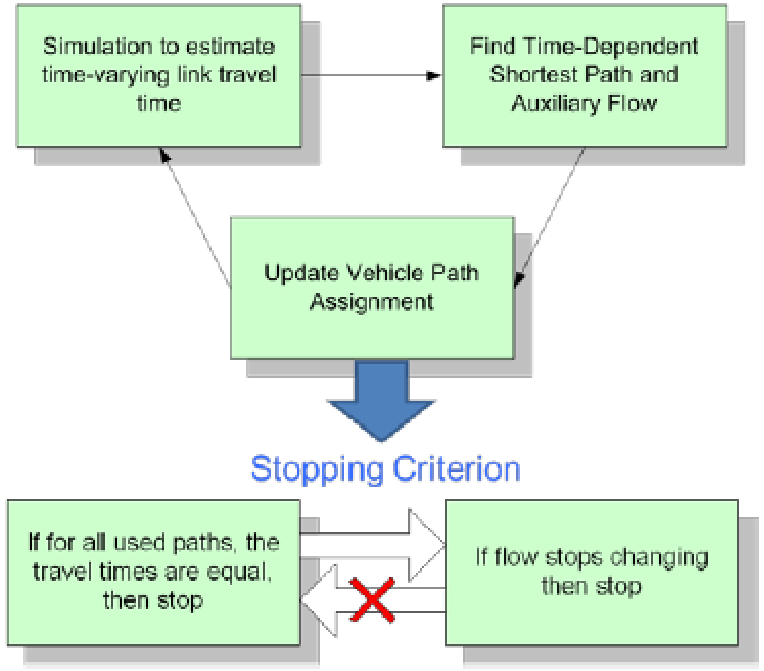
Figure 2.2 Static Traffic Assignment Algorithmic Structure



Source: DTA Primer, with permission from UA.

Dynamic User Equilibrium (DUE)

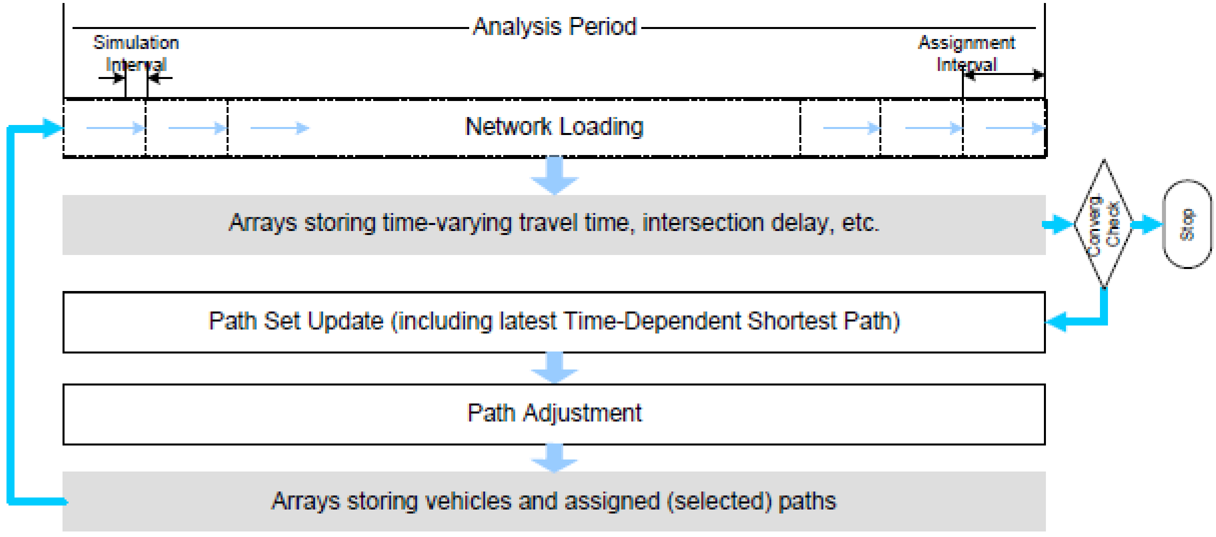
Figure 2.3 Dynamic Traffic Assignment Solution Algorithm Framework



Source: DTA Primer, with permission from UA.

Equilibrium DTA Algorithm

Figure 2.4 General DTA Algorithmic Procedure[a]



Source: DTA Primer, with permission from UA.

[a] Chiu, Bottom et al. 2011.

DUE Convergence Criteria

- Relative Gap (usually)
  - Calculated in a similar manner to SUE

$$rel_{gap} = \frac{\sum_t \sum_{i \in I} \left(\sum_{k \in K_i} f_k^t \tau_k^t \right) - \sum_t \sum_{i \in I} d_i^t u_i^t}{\sum_t \sum_{i \in I} d_i^t u_i^t}$$

Where

T = set of all departure time intervals

t = departure time interval, $t \in T$

I = set of all origin-destination trip pairs

i = origin-destination trip pair, $i \in I$

K_i = set of all used routes for origin-destination pair i

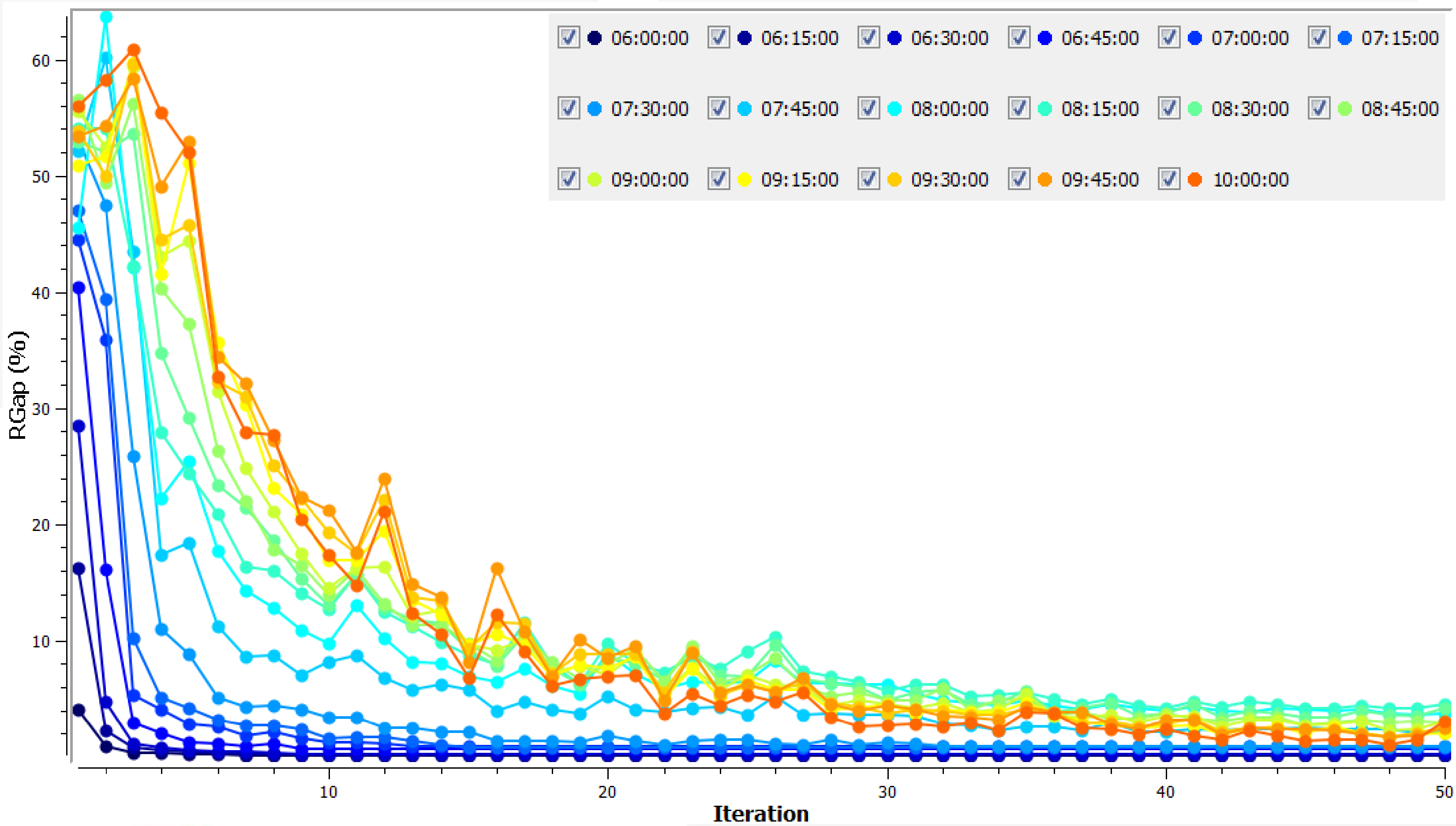
k = used route for origin-destination pair i, $k \in K_i$

f_k^t = flow from used route k at departure time interval t

τ_k^t = experienced travel time on used route k at departure time interval t

d_i^t = total flow from origin-destination pair i at departure time interval t

DUE Convergence Example



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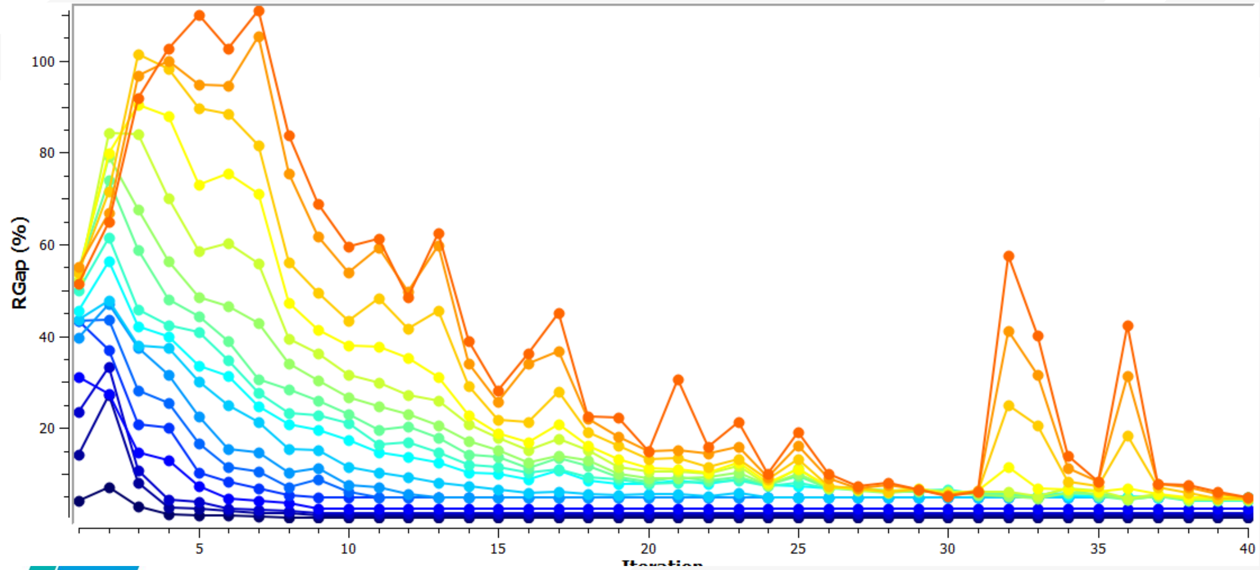
DUE Convergence Complexities

- Dynamic DUE Convergence in Theory
- Computational needs
- Earlier slices impacts convergence of later slices
- 

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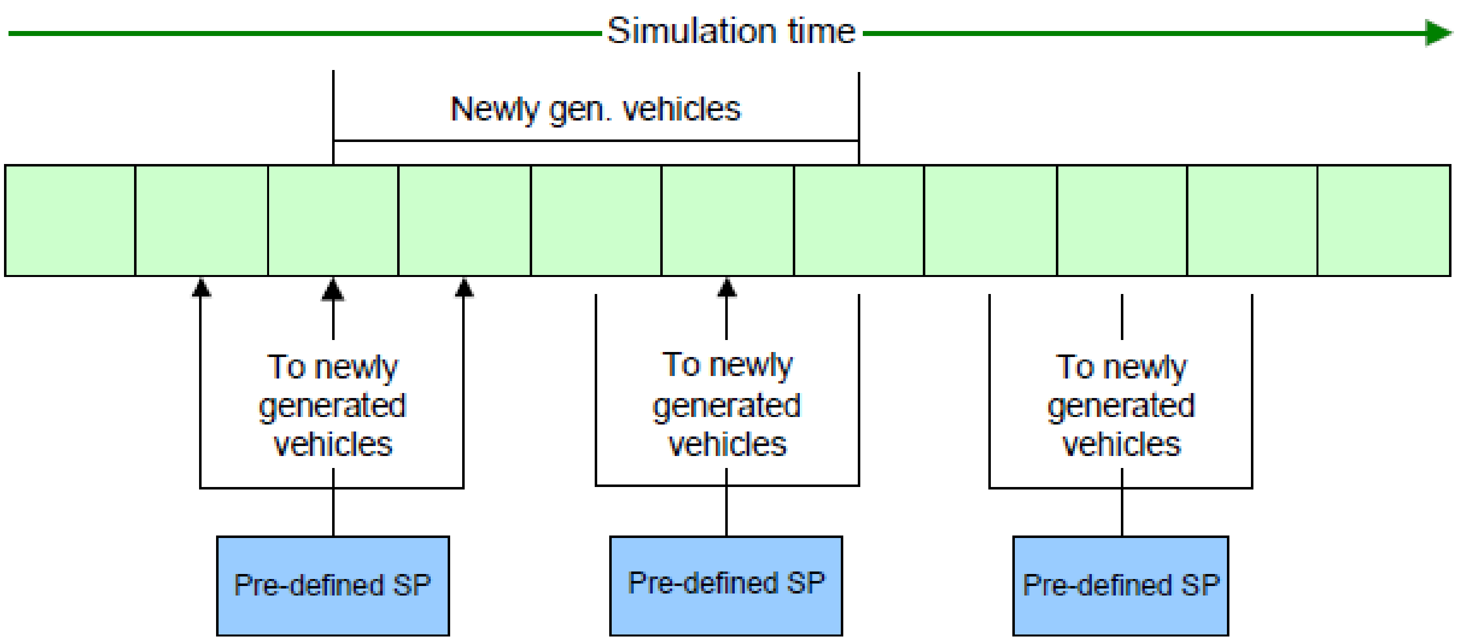
Equilibrium vs Non-Equilibrium DTA

- Equilibrium Appropriate
  - Recurring, long-term conditions
  - Drivers have chance to learn network-wide traffic patterns
  - Daily commute, long term work zones
  - Good wide-spread dissemination of real time travel information
- Non-equilibrium Approach
  - Short term or uncommon conditions
  - Lane or road closures, special events, short term work zones
  - Poor distribution of travel time information
  - Habitual drivers insensitive to congestion

Traditional One-Shot Simulation

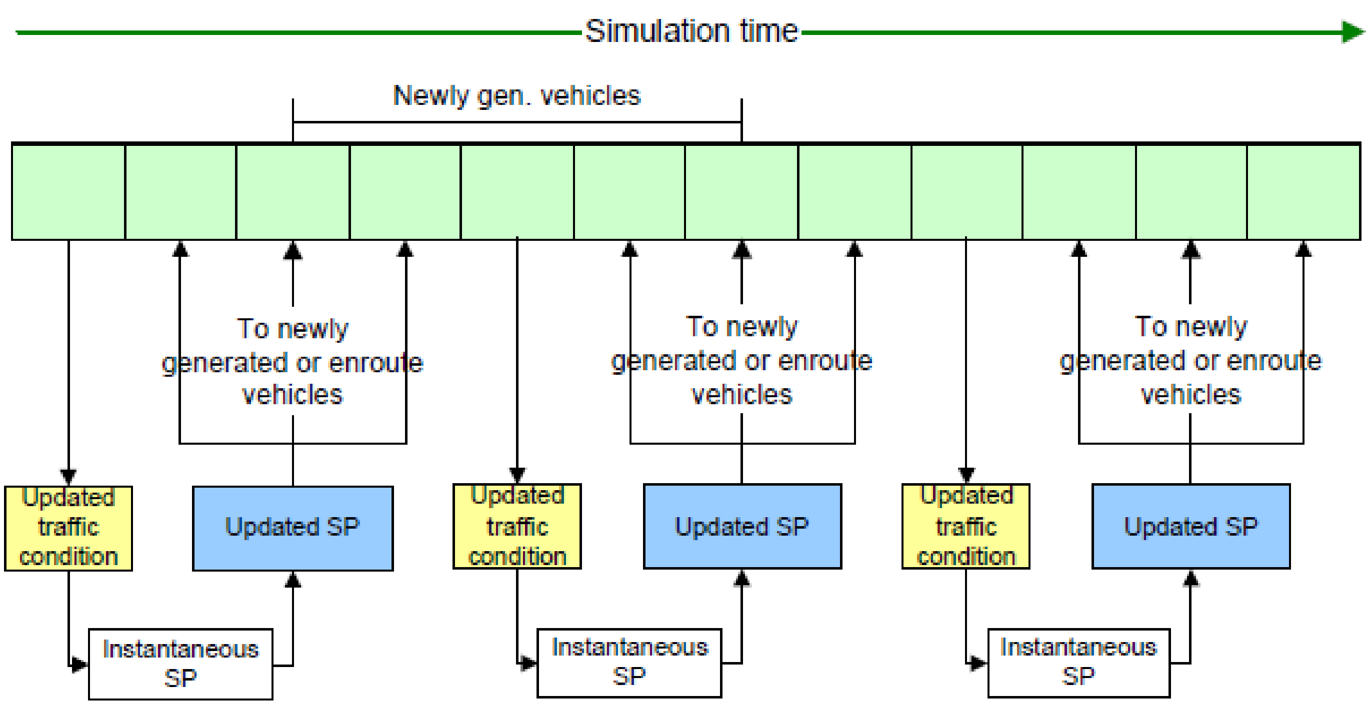
Figure 2.5 Static Assignment in a One-shot Simulation



Source: DTA Primer, with permission from UA.

Non-equilibrium DTA Simulation

Figure 2.6 Dynamic Assignment (with Feedback) in a One-shot Simulation

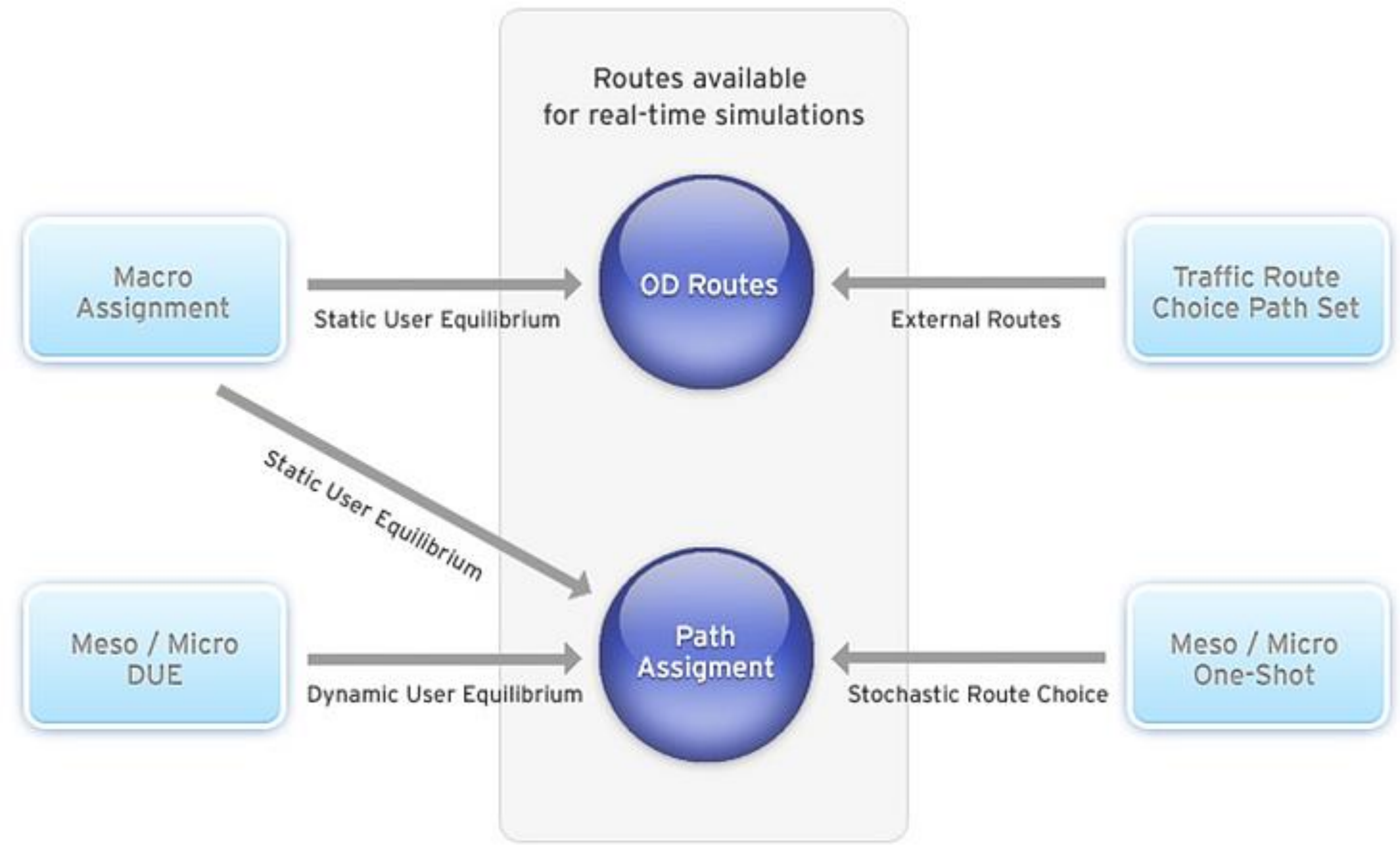


Source: DTA Primer, with permission from UA.

DTA Modeling with a Mixture of Equilibrium and Non-Equilibrium Methods

- Both methods can be used in a single model
- Apply a mixture of each –
  - DUE: Learned habitual path drivers
  - One-shot: Responsive to En-route travel time updates, ATIS feedback, DMS information, ATDM strategies, etc. for congestion or incidents
- Depending on platform:
  - 80 % DUE path based – don't deviate from habitual paths
  - 20 % initial DUE, updates periodically with SRC in a one-shot

Mixture of DUE and One-shot Simulation



Calibration Complexities

- Variables:
  - Route Choice
  - O-D Patterns
  - Behavior Parameters
  - Operation Performance
- Runtimes & Resources
- Gridlock

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