Integration of Dynamic Traffic Assignment and Diurnal Departure Curve Estimation in a Four-Step Framework

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Objectives

• Develop a simulation ready network for PSRC model
• Perform 24-hour continuous whole-system multi-class DTA simulation to estimate arrival time profiles
• Develop DUE based preferred arrival time estimation algorithm (DCE)
• Use preferred arrival time profiles to adjust departure times in a future year model
From Four-Step to ABM

Four Step
- Trip Generation
- Trip Distribution
- Modal Choice
- Time of Day
- Trip Assignment

ABM
- Activity Generator
- Activity Simulator
- Path Simulator

Static Vs. Dynamic

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PSRC Model Structure (Trip Based)
PSRC Model (continued)

- GIS based network
- 40,000 links
- 20,000 nodes
- 14,143 lane miles
- 5 time periods (am, md, pm, ev, ni)
- Departure time choice model
- 11 classes ($SOV_{nw}^{nw}$, $SOV_{1,2,3,4}^{w}$, $HOV_{2,3}^{2,3}$, $Truck_{lt,md,hv}^{lt,md,hv}$)
- 9.5 millions daily vehicle trips in 2006, 14 millions in 2040
# DTA Model Scale Comparison

<table>
<thead>
<tr>
<th>Model</th>
<th>Total Lane Miles</th>
<th>24 Hour Demand (mil)</th>
<th>Demand/Supply Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAMPO</td>
<td>11,461</td>
<td>4.6</td>
<td>400</td>
</tr>
<tr>
<td>SCAG</td>
<td>67,389</td>
<td>34.5</td>
<td>500</td>
</tr>
<tr>
<td>MAG</td>
<td>16,696</td>
<td>6.2</td>
<td>400</td>
</tr>
<tr>
<td>DRCOG</td>
<td>15,794</td>
<td>7.5</td>
<td>500</td>
</tr>
<tr>
<td>SACOG</td>
<td>9,594</td>
<td>5.2</td>
<td>550</td>
</tr>
<tr>
<td>PSRC</td>
<td>13,753</td>
<td>9.5</td>
<td>700</td>
</tr>
</tbody>
</table>
DTA Engine (DynusT)

- DUE Based with convergence assured
- Mesoscopic link based and demand model friendly
- Produces trajectory and perform subarea cuts
- Handles large network with long period simulation
- Handles multiclass demand with individual VOT
- Integrated transit simulation
- Multi-threaded
- Fully integrated with DynuStudio GUI
- Open source with on-going R&D
Diurnal Curves Example

Departure Curve

Normalized Factors

Minutes

Departure
Diurnal Curves Example

Departure & Arrival Curves

Normalized Factors

Minutes

Departure
Arrival
Diurnal Curves Example

![Graph showing departure, arrival, and volume curves over time. The x-axis represents minutes, ranging from 0 to 1350. The y-axis represents normalized factors, ranging from 0.000 to 0.035. The graph includes three curves: red for departure, green for arrival, and yellow for volume. The curves peak around the 450-minute mark, indicating peak activities.](image-url)
Diurnal Curves Example

**Departure & Arrival & Volume Curves**

- **Departure**
- **Arrival**
- **Volume**

**Average Trip Time & Delay Curves**

- **AvgTime**
- **AvgDelay**
Diurnal Curves Example

Cumulative Departure & Arrival Curves

- Departure
- Arrival

Minutes

Normalized Factors

0.000
0.200
0.400
0.600
0.800
1.000
1.200

0 150 300 450 600 750 900 1050 1200 1350
PSRC Diurnal Curves (Base Year)
PSRC Diurnal Curves (Base Year)

Arrival Curves by Trip Purpose

Vehicle Trips

Minutes

0 150 300 450 600 750 900 1050 1200 1350

0 5000 10000 15000 20000 25000 30000 35000 40000

COM
HBS
NHB
HBO
HBW
Future Year Diurnal Curves

• **Fixed Factor**
  - Assume the same departure time profile as base year
  - Issues:
    - Imply all trips will arrive late which is not reasonable for work trips
    - Cannot model peak spreading

• **Choice Model**
  - Trips can depart early or late in reacting to congestion in other time periods
  - Issues:
    - Model is estimated in base year condition that does not predict well for congested future year condition
    - Often produce counterintuitive arrival profiles
Existing PSRC TOD Choice Model

• Choice model formulation

\[ U_{ijkpm} = a_k + c_{1k}D_{ijk} + c_{2k}D_{ijk}SE + c_{3k}D_{ijk}SE^2 + c_{4k}D_{ijk}SL + c_{5k}D_{ijk}SL^2 + v_{ijpm} + d_{ijpm} \]

Where:
- \( i \) = Production zone
- \( j \) = Attraction zone
- \( k \) = Time interval
- \( p \) = Purpose (HBW, HBO, HBShop)
- \( m \) = Mode (SOV, HOV)
- \( D \) = Delays
- \( SE \) = Shift early factor
- \( SL \) = Shift late factor
- \( V \) = Socio-demographic variables
- \( d \) = Dummy variables
Diurnal Curve Estimation (DCE)
Relating Future Departure Curve to Base Arrival Curve

- Certain trips are departure constrained and certain are arrival constrained
- Estimation based on trip purposes with different scheduling weights

Future travel time for travelers departing following base departure curve.

Future travel time for travelers departing following estimated departure curve who anticipates arriving following base arrival curve.
Single-level Diurnal Curve Estimation Algorithmic Structure

DEC
- Departure Based TDSP
- Arrival Based TDSP
- Generalized Cost = TT + Schedule Delay
Bi-level Diurnal Curve Estimation
Algorithmic Structure

DCE
• Arrival Based TDSP
• Generalized Cost = TT+ Schedule Delay

Stop
Future Diurnal Curve Example

Fixed Factor

Future Vs. Base Year Diurnal Curves (Fixed Factors)
Future Diurnal Curve Example

Fixed Factor
Future Diurnal Curve Example

Fixed Factor

Future Vs. Base Diurnal Curves (Fixed Factor) - Cumulative
Future Diurnal Curve Example
Choice Model

PSRC HBW Diurnal Curves (Future Vs. Base)

- DEP Base
- ARR Base
- DEP Future
- ARR Future

Minutes
Normalized Factors
0.000
0.010
0.020
0.030
0.040
0.050
0.060
0
150
300
450
600
750
900
1050
1200
1350
Future Diurnal Curve Example
Choice Model

PSRC HBW Diurnal Curves (Future Vs. Base) - Cumulative

- DEP Base
- ARR Base
- DEP Future
- ARR Future
Future Diurnal Curve Example (DCE)

Diurnal Curves Before & After DCE

- Ini Departure
- Final Departure
- Ini Arrival
- Final Arrival

Vehicle Trips

Minutes

0 150 300 450 600 750 900 1050 1200 1350
Conclusions

- DTA can handle large-scale whole system networks
- DTA simulated diurnal curves provide new insights into congestion pattern
- DCE method is a powerful tool in modeling time-of-day and peak spreading issues
- More DCE tests by trip purpose are needed
- Large-scale DTA simulation is still time consuming. More efficient algorithm and implementation are desired.