Multi-Resolution Modeling with DTA
Existing Deployments

A Information Sharing Workshop for Dynamic Traffic Assignment

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Sponsored by:
Federal Highway Administration
Resource Center, Michigan Division
Michigan Department of Transportation

Lansing, Michigan
Wednesday, August 11, 2010
Who else are using DTA (Federal)?

- **FHWA - Integrated Corridor Management**
  - 2 out of 3 pioneering sites (Minneapolis and Dallas)
- **FHWA – Exploratory Advanced Research Program**
  - Integrating land-use, activity-based model and DTA
- **FHWA – Real-Time Traffic Estimation and Prediction**
  - TrEPS – for real-time ITS based active traffic management
Who else are using DTA (Federal)?

- TRB – Strategic Highway Research Program (SHRP2)
  - **C04** - Improving Our Understanding of How Highway Congestion and Pricing Affect Travel Demand
  - **C05** - Understanding the Contribution of Operations, Technology, and Design to Meeting Highway Capacity Needs
  - **C10** - Partnership to Develop an Integrated, Advanced Travel Demand Model and a Fine-Grained, Time Sensitive Network
  - **L04** - Incorporating Reliability Performance Measures in Operations and Planning Modeling Tools
  - **R11** - Strategic Approaches at the Corridor and Network Level to Minimize Disruption from the Renewal Process
Who else are using DTA (Federal)?

- EPA – Motor Vehicle Emission Simulators (MOVES)
  - “When fully implemented, MOVES will serve as the replacement for MOBILE6 and NONROAD for all official analyses associated with regulatory development, compliance with statutory requirements, and national/regional inventory projections.”
  - Official released Fall 2009
  - Tighter integration with regional traffic simulation models
Who else are using DTA (States)?

- IH corridor improvement (North Carolina)
- IH work zone planning (ELP, TX-2004)
- Florida turnpike system traffic and evacuation analysis (FDOT Turnpike)
- Downtown improvement (ELP, TX, 2004)
- ICM AMS modeling (Bay Area, CA, 2007)
Who else are using DTA (States)?

- Military deployment transportation improvement in Guam (PB, FHWA)
- Interstate highway corridor improvement (TTI, TxDOT, ELPMPO, Kittleson, ADOT)
- Value pricing (ORNL, FHWA; SRF, Mn/DOT, TTI, TxDOT, UA, CDOT/DRCOG)
- Evacuation operational planning (TTI, TxDOT, UA, ADOT; LSU, LDOT; Noblis, FHWA; Univ. of Toronto, Cornell Univ. Jackson State Univ., MDOT, Univ. of Missouri, MDOT)
- Integrated Corridor Management modeling (CS, FHWA, MAG, NCSU, NCDOT)
- Pilot studies (Portland Metro, DRCOG)
- Activity-based model integration (UA/CS, SHRP2 C10, FHWA EARp)
- Work zone impact management (SHRP2 R11)
Compatibility with Existing Modeling Framework

- Trip-based framework
  - Replace static assignment
  - Sub-area analysis in micro traffic models
  - Relative standard

Strategic Modeling

Mission-Driven Modeling
Capability Expansion not Replacement

- Multi-Resolution Modeling - Synergize existing model capabilities
  - Dynamic view of entire system
  - Rapid and consistent sub-area analyses
Compatibility with Existing Modeling Framework

• **Activity-Based Model**
  – Customization needed
  – Due to diversified ABM model structure

• Expanded opportunities for addressing both planning and operations issues

• SHRP2 C10 open source, completed in 2012 (DAYSIM-DynusT)
UrbanSim-OpenAMOS-MALTA/DynusT

- Evolutionary modeling, completed in 2011
What is Multi-Resolution Modeling (MRM)?

- Integrating macro, meso and micro traffic analysis tools with different levels of resolution and capabilities for the purpose of achieving a specific goal
  - Analyze network at both the system-wide and localized levels simultaneously

<table>
<thead>
<tr>
<th></th>
<th>Dynamic</th>
<th>Static</th>
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<tbody>
<tr>
<td></td>
<td>0.1-1 second</td>
<td>5-10 seconds</td>
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<tr>
<td>Intersections</td>
<td>Micro Sim</td>
<td></td>
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<tr>
<td>Corridor</td>
<td>Micro Sim</td>
<td>DTA</td>
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<tr>
<td>Regional</td>
<td>DTA</td>
<td>TDM</td>
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</table>
What is Multi-Resolution Modeling (MRM)?

- Addresses issues that may fall beyond the reach of both:
  - Macroscopic models: large scale but static
  - Microscopic models: dynamic but small-scale
  - DTA: dynamic and large-scale

- The scenarios of interest may result in shifts of network or corridor-wide traffic flow patterns
  - Significant change to roadway configuration
  - Certain corridor management strategies
• Many commercial packages allow us to perform microscopic analysis by extracting sub-area directly from TDM, why do we need DTA as the “middle man?”

• To answer this, let’s look at the following question:
Which of the following best explain v/c>1

1. It should not have happened in model as in real life volume cannot exceed capacity

2. “V” actually means demand assigned or wanting to use the facility. v/c > 0 means demand exceeds capacity and congestion would occur

3. V/C is just the output of the TDM. It does not mean much
Issue with Macro-Micro Integration

• OD flow arriving at boundary of sub-area is not constrained by roadway capacity outside the sub-area

• Consequences
  – Too much demand, sub-area over flooded
  – Hand-tweaking as calibration in baseline case
  – Min prediction power for future year cases
Macro-Meso-Micro

- Bridge macro and micro for a wide range of applications
Macro-Meso-Micro

• Bridge macro and micro for a wide range of applications
Capability Expansion not Replacement

- Multi-Resolution Modeling - Synergize existing model capabilities
  - Dynamic view of entire system
  - Rapid and consistent sub-area analyses
Why is MRM Important?

• Macro, meso and micro models are not mutually exclusive
• They are complimentary to one another and can accomplish optimal modeling capabilities
• Retain the best characteristics of each model
  – Incorporate multiple trip purposes
  – Realistic representation of regional traffic in baseline and future years
  – Provide realistic inputs to micro models
  – A wide range of visual representation of model outputs
A Recent MRM RFP (DVRPC)

• See RFQ
Network Conversion

TDM

Links
Nodes
Zones

DTA model
Network Conversion

• Convert the GIS layer of the travel demand model to mesoscopic format

• Disaggregate 24-hour matrix based upon car & truck
  – Home to work
  – Work to home
  – Home to private
  – Private to home
  – Thru
  – External local
  – Non-home based external local

• Multiply each matrix by corresponding hourly factor
Network Conversion

Multiply each matrix by hourly factor

H-W
W-H
H-P
P-H
THRU
EXLO
PEXLO

Summation of matrices gives you directional 1-hour matrix
Network Conversion

24 - one hour matrices
Network Conversion

• Network run to DUE
• Sub-area cut
  – Remove unneeded sections of network
  – Renumbering of new zones, nodes and links
  – Retain paths and flows that travel through the sub-area
Network Conversion

• Meso-Micro Converter
  – Developed by researchers from TTI and UA
  – Converts roadway network to Macro network
  – Retains network geometry
  – Converts all time-dependent paths and flows
  – Creates separate transportation systems (car, truck)
Network Conversion

- **Microscopic model**
  - Calibrate Micro model to reflect realistic roadway conditions
  - Perform detailed “fine-grained” analyses
    - Speed profile for individual lanes
    - Lane-changing behaviors
    - Vehicle interactions at merge areas
  - Create 3-D graphics for presentations
Calibration

- Traffic flow model
  - Traffic simulation in DynusT is based upon the Anisotropic Mesoscopic Simulation (AMS) model
  - Moves vehicle based upon speed-density (v-k) relationship
  - v-k relationship is derived from Greenshields equation
Calibration

- **Time-dependent OD**
  - Minimize the deviation between simulated and actual screen line counts & speed profile
  - Iterative process
  - Program solves linearized quadratic minimization problem
  - Results in updated OD matrices
Consistency

• Network
  – Lane configuration
  – Geometric design

• Paths and flows
  – Verify same origin/destination paths
  – Verify number of vehicles generated

• Speed profile
  – Perform field data collection to determine speed and vehicle counts
  – Obtain v-k curve from simulation output
  – Calibrate models with field data
Consistency

Greenshield's Equation

\[
(v - v_0) = (v_j - v_0) \left(1 - \frac{k}{k_j}\right)^\alpha
\]

\[
\Rightarrow \ln(v - v_0) = \ln(v_j - v_0) + \alpha \ln \left(1 - \frac{k}{k_j}\right)
\]

\[
\Rightarrow y = x_0 + \alpha x
\]
Consistency

Speed profile calibrated with field data
Case Study 1 – Truck Restricted Lanes (TTI)

• Analyze the effectiveness of restricting trucks from left-most fast lane on freeway
• 22-mile corridor of I-10 in El Paso, TX
• Analyze a.m. peak, p.m. peak, & mid-day
• Determine benefits
  – Speed on left-most lane
  – Acceleration/Deceleration patterns
  – Vehicle interactions at merge areas
  – Does grade play a significant role on truck speeds?
• How should we model this?
Case Study 1 – Truck Restricted Lanes (TTI)

• DTA model estimates region-wide truck and car trajectories (time-dependent paths and flows)
• Micro model gives detailed I-10 truck lane operations with truck trajectories
Case Study 1 – Truck Restricted Lanes (TTI)

- Simulate entire El Paso network to equilibrium conditions
- Use separate demand matrices for auto & truck
Case Study 1 – Truck Restricted Lanes (TTI)

- Sub-area cut of corridor was extracted
- Conversion tool was used to translate the roadway network, paths & flows to macro model
- Using macro models export capability, a microscopic simulation model was imported to microscopic format
Case Study 1 – Truck Restricted Lanes (TTI)
Case Study 1 – Truck Restricted Lanes (TTI)

• If modifications in the micro model change driver behavior (alters routes), changes must be reflected in DTA model and conversion process begins again.

• If no additional changes are needed, micro model development begins
Case Study 1 – Truck Restricted Lanes (TTI)

106 Origin/Destination links  -  1895 Routes created
GPS unit was used to input freeway grading information.
Case Study 1 – Truck Restricted Lanes (TTI)

Data provided by TxDOT Automatic Traffic Recorder Stations
## Case Study 1 – Truck Restricted Lanes (TTI)

<table>
<thead>
<tr>
<th>Truck Class</th>
<th>Relative Flow</th>
<th>Length (ft)</th>
<th>Width (ft)</th>
<th>Weight (lb)</th>
<th>Power (hp)</th>
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<td>Max.</td>
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Case Study 1 – Truck Restricted Lanes (TTI)

I-10 EB @ Sunland Park (7-11 am)

Speed profile calibrated with field data
Case Study 1

- Results showed that restricting trucks from left-most fast lane had slight improvement on speeds.
- Identified section of freeway where restrictions had adverse affect on freeway speeds.

![Graph showing speed comparison between left and right lanes](image-url)
Case Study 2

• Texas Department of Transportation looking at alleviating congestion at diamond interchange and surrounding arterials in El Paso, TX.
• Propose 7 different design alternatives for direct connects
• Two sets of designs are identical except for direct connect lane access
• Corridor has heavy truck usage
Case Study 2 – Freeway Improvements (TTI)

- TxDOT wants to know which alternative is most viable option?
- How does weaving at merge areas affect traffic on I-10?
- How does improved LOS due to new interchange attract traffic to I-10 in the future?
- Analyze both the localized traffic impact and regional traffic redistribution
- Which model should we use?
  - Travel demand model?
  - DTA model?
  - Microscopic model?
Case Study 2 – Freeway Improvements (TTI)
Case Study 2 – Freeway Improvements (TTI)

• DTA model was able to show shifts in traffic based upon each design alternative.
  – Queuing on arterials and frontage roads
  – Speed fluctuations during peak hours

• Micro model was able to identify “hot-spot” areas where direct connects merge

• Micro model was used to determine whether or not grade played a major role on trucks entering freeway.
Case Study 3 – Work Zone Mobility

- Construction sequencing for addition of freeway lane
  - TxDOT wants to widen section of I-10 in western portion of El Paso
  - Construction divided into 5 section areas
  - Determine optimal construction sequencing for TCP with moveable barriers
Case Study 3 – Work Zone Mobility
Case Study 3 – Work Zone Mobility

Determine optimal traffic flow in work zone during peak/non-peak hours using movable barriers
Case Study 3 – Work Zone Mobility

- DTA was able to evaluate effectiveness of TCPs
- Identify optimal construction sequencing of phases.
- Identify hotspots during peak and off-peak periods
- Evaluate possible mitigation strategies to help reduce congestion.
Case Study 3 – Work Zone Mobility

- Microscopic model was used to analyze areas of concern at a higher fidelity of resolution
  - Weave/merge areas
  - Optimize signal timings on adjacent arterials and feedback to DTA model
Case Study 4 - I-70 Zipper Lane Operational Planning

- 15-mile zipper Lane for I-70 EB during Sunday PM in ski season
- $20M capital, $9M O&M
MRM Modeling Process

- Planning decisions
  - Fatal flaw of MBS
  - Tolling traffic and revenue forecast
- Operational Decisions
  - Queue length (WB)
  - East and West terminal configuration
  - Interchange re-design
- Model initial setup
  - Existing I-70 corridor network from a prior study (PEIS)
- Model calibration and validation
  - Traffic data from CDOT
  - Trip origins and destinations
Model Initial Setup

1. Planning model

2. DTA model conversion

3. Subarea model
Model Calibration and Validation

- Calibration of simulation
  - Multiple traffic flow models for categories of grade along corridor

Model Calibration and Validation

Two-Stage Dynamic Calibration Framework

- Total Link Counts
- Speed Profile

- Discretize time horizon
- Calibration time interval

Stage 1
- OD Trips Calibration

Stage 2
- Departure Profile calibration

5/10/2010
Model Calibration and Validation

• OD calibration
  – Match total traffic counts within time period at different locations along corridor
Model Representative of Actual Traffic Condition

- **EB – Eisenhower Tunnel**
Scenario 1: Baseline (Existing Conditions)
Direction: EB Main Lanes
Scenario 2: Truck Allowed in EB Zipper Lane (No Toll)
Direction: WB Single Main Lane
Scenario 3: Truck Restricted from EB Zipper Lane (No Toll)

Direction: EB Zipper Lane
Analysis Scenarios/Strategies

• Scenarios presented

1. Baseline (existing conditions)
2. Truck Allowed in EB Zipper Lane – No Toll
3. Truck Restricted from EB Zipper Lane – No Toll
4. Truck Restricted from EB Zipper Lane – Congestion Responsive Toll on Zipper Lane
5. Truck Restricted from EB Zipper Lane – Congestion Responsive Toll on Zipper Lane & WB Truck Diverted
Questions?