Multi-Resolution Modeling for Operational Planning Projects

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Outline

• Introduction
• Model integration
• Concept
• Case studies
• Additional projects
• Q&A
City Council proposes ordinance to restrict trucks from using left lane on I-10 corridor

How does the ordinance affect the freeway and surrounding arterials?
Which type of model do I use?
Introduction

• Multi-resolution modeling (MRM) is used for variety of applications including operational planning projects
• Typically projects that are ready to let in 1-5 years
• Goal is to assist transportation agencies and practitioners in improved modeling and policy decision making using state-of-the-art tools
Introduction

- There are 3 levels of resolution in transportation modeling:
  - Macroscopic ➔
  - Mesoscopic ➔
  - Microscopic ➔
Introduction

• Macroscopic models are static
  – Typically used by planners for long-range forecasting
• Mesoscopic models are dynamic and large scale
  – Used by planners and engineers
• Microscopic models are dynamic but usually small scale
  – Typically used by engineers
Introduction

- Mesoscopic models provide region-wide estimation of traffic redistribution
  - Dynamic traffic assignment (DTA)
  - Determine how traffic shifts given various traffic conditions or network configurations
- Microscopic are able to analyze various localized areas in much higher detail
  - Individual vehicles
  - Merging areas
  - Multiple modes of traffic
Model Integration

• 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

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Why is Model Integration 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
  – Detailed interactions
Why is Model Integration Important?

- Why don’t we just convert from the travel demand model directly to micro model?
  - Travel demand model can give you a v/c ratio >1
  - This is not realistic
  - DTA model has capacity constraints on links
  - Will reroute excess flow to alternative routes based upon shortest experienced travel time
Why is Model Integration Important?

- **Static model** describes overall average.
- **Micro model** describes finer dynamic details.
- **Actual system dynamics**.
- **DTA** describes system structural pattern.

Diagram: Volume versus Time with a highlighted period of interest.
Why is Model Integration Important?

- **Under loading vehicles during peak hour**
- **Large effort to bring micro model closer to actual system dynamics**
- **Static model describes overall average**
- **Actual system dynamics**
- **Micro model starts from static model**
- **Over loading vehicles before and after peak hour**

**Graphical Representation:***
- **Volume** axis
- **Time** axis
- **Period of Interest**
- **Graph lines** indicating volume and time relationship

**Legend:**
- Blue line: Static model
- Orange line: Actual system dynamics
- Red line: Micro model

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**Key Points:**
- Importance of integrating micro models with static models to capture actual system dynamics.
- Challenges in matching micro model with actual system dynamics require significant effort.
- Static models provide an overall average, which is crucial for initial simulations.
- The period of interest is a critical time frame for dynamics analysis.
Concept

Understanding what you are trying to model

- Use DTA for travel demand modeling to understand the spatial and temporal distribution of traffic during peak periods (MTP)
- Sub – area analysis for detailed operations studies (TIP)

Which model resolution integration suits situation best?
Concept – Meso to Micro

- Used for operational planning where sub-area of DTA model is converted to microscopic
Which type of model do I use?
Case Study 1

• Truck restricted lanes
  – 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?

• Use MRM methodology
Case Study 1

- 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
Results showed that restricting trucks from the leftmost fast lane had slight improvement on speeds. Identified section of the freeway where restrictions had adverse effect on freeway speeds.
Case Study 2

- Texas Department of Transportation is constructing two direct connectors in El Paso, TX
- Construction is phased sequencing
- Want to use incentive/disincentive clauses to motivate contractors to stay on or ahead of schedule
- TTI to determine monetary values (road user costs)
Case Study 2

- Use multi-resolution modeling methods to derive specific measures-of-effectiveness to be used in developing deterministic road user cost model

\[ RUC = VOC + VDC \]

where:
- \( VOC \) = Vehicle Operating Cost
- \( VDC \) = Vehicle Delay Cost
Case Study 2
Case Study 2

Multi-Resolution Modeling Process

1. Regional Mesoscopic Model (DynusT)
   - DynusT Model Calibration
   - Construct Scenarios for Each Work Zone Phase
   - Run Assignment to Equilibrium Conditions

   - Sub-area Cut of Project Limits
   - Meso-Micro Model Conversion
   - VISSIM Microscopic Model

   - Model Calibration
     - Traffic Signals
     - Speed Profiles
     - Traffic Compositions
   - Simulation of Work Zone Scenarios
   - Model Output (MOEs)

2. Develop Deterministic Model
   - Calculate Final Road User Cost
Case Study 2

\[ f = \left( p_c (q_c^a + q_c^b) + p_t (q_t^a + q_t^b) \right) \]

where:

- \( p_c \): Price of fuel for cars
- \( p_t \): Price of fuel trucks
- \( q_c^a \): Total fuel consumed during AM time period for vehicle class c (cars)
- \( q_c^b \): Total fuel consumed during PM time period for vehicle class c (cars)
- \( q_t^a \): Total fuel consumed during AM time period for vehicle class t (trucks)
- \( q_t^b \): Total fuel consumed during PM time period for vehicle class t (trucks)
- Length of the work zone or detour
- Per mile operating costs for vehicle class c (cars)
- Per mile operating costs for vehicle class t (trucks)
- Directional volume during AM time period for vehicle class c (cars)
- Directional volume during PM time period for vehicle class c (cars)
- Directional volume during AM time period for vehicle class t (trucks)
- Directional volume during PM time period for vehicle class t (trucks)
\[ TN = \left[ (V_{AM}^c)(V_{PM}^c) + (V_{AM}^t)(V_{PM}^t) \right] + \left[ (D_{AM}^c)(V_{AM}^c) + (D_{PM}^t)(V_{PM}^t) \right] \]

where:

- \( V_{AM}^c \): Directional volume during AM time period for vehicle class c (cars)
- \( V_{PM}^c \): Directional volume during PM time period for vehicle class c (cars)
- \( V_{AM}^t \): Directional volume during AM time period for vehicle class t (trucks)
- \( V_{PM}^t \): Directional volume during PM time period for vehicle class t (trucks)
- \( D_{AM}^c \): Average delay during AM time period for vehicle class c (cars)
- \( D_{PM}^c \): Average delay during PM time period for vehicle class c (cars)
- \( D_{AM}^t \): Average delay during AM time period for vehicle class t (trucks)
- \( D_{PM}^t \): Average delay during PM time period for vehicle class t (trucks)
- \( V_{O}^c \): Implicit value-of-time for vehicle class c (cars)
- \( V_{O}^t \): Implicit value-of-time for vehicle class t (trucks)
Case Study 2

• The results from the MRM methodology provided a realistic foundation in determining an overall RUC for work zone construction sequencing

• Addresses key issues:
  – Diversion of vehicles around defined detour
  – Vehicles that opt to take alternative route outside boundary area
  – Time-dependency of daily traffic variations
Case Study 3

• Integrating the transportation system with a university campus master plan
  – UTEP enrollment has continued to increase each year
  – Campus planners have devised a master plan that will address this additional demand
  – However, they needed to know how construction projects will impact traffic and pedestrians in and around campus
Case Study 3

• Use simulation-based modeling to analyze the effects of future construction
  – Traffic control on Sun Bowl/University
  – Campus entrance realignment
  – New parking lots
  – Inner campus closure
Case Study 3

- First task was to collect a myriad of data around UTEP in the form of vehicle and pedestrian counts
- Develop a base simulation model of the entire campus and surrounding streets and parking lots
- Calibrate model based upon data collected
- Run a series of scenarios to determine impact
Case Study 3

- Traffic counts at all intersections around campus
- Pedestrians were also counted at same locations
- Necessary to populate model
Case Study 3

- Base microscopic model developed
- All parking lot capacity and number of spaces
- Pedestrians were included
- Model was run to equilibrium conditions
- A series of scenarios were then coded to determine impacts
Case Study 3

- New traffic control at Sun Bowl helps with congestion
- Simulation showed the need for additional parking garage behind academic building
- Model showed which inner lots filled up quickest after inner campus closure
Case Study 3
Case Study 3

- Mesoscopic model was used to determine traffic flow on exterior of campus
- Model showed proposed Paisano extension (tolled) was not attracting many vehicles
Case Study 4

- El Paso Transit Corridor Alternative Analysis
  - City of El Paso wants a comparative analysis of signal priority (TSM) versus bus rapid transit (BRT)
  - Simulate four large transit corridors in micro-simulation
  - Traffic impact due to dedicated bus lane
  - Travel time savings
Case Study 4

- Extremely large microscopic models
- Alameda corridor
  - 60 traffic signals
  - 80,000 vehicles generated
  - Simulated for 4 hours (morning peak)
Case Study 4

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Case Study 4

Total Travel Time [hrs]
All Vehicle Types

Montana No Build
Montana TSM
Montana TSM + BRT
Montana Full BRT
Montana WY out
No Build
Montana WY out
TSM
Montana WY out
TSM + BRT
Montana WY out
Full BRT
Case Study 4
Case Study 5

- 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 5

UNIT 1
1.51 mi.

UNIT 2
1.38 mi.

UNIT 3
1.01 mi.

UNIT 4
1.81 mi.

UNIT 5
0.61 mi.
Determine optimal traffic flow in work zone during peak/non-peak hours using movable barriers.
Case Study 5

- 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 5

- 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 6

- IH-10 Corridor Improvement Analysis
  - TxDOT is interested in improving traffic congestion in and around the IH-10/Zaragoza interchange
  - Looking at various routing alternatives for commuters
  - New interchanges at Pendale and/or Don Haskins
  - Reversing ramps in study area
Case Study 6

• Regional mesoscopic model was used to simulate future years
  – 2015
  – 2025
  – 2035
  – 2045
• Determine optimal time when additional construction projects are needed
• Determine most efficient construction sequencing to minimize congestion in work zone
Case Study 6

- The queue is also present at Esther Lama Dr (WB) on both AM and PM time periods
  - Graph shows the queue at Esther Lama Dr for both time periods

- The queue doesn’t appear to go past Esther Lama Dr on Zaragoza Rd (SB)
Case Study 6

VISSIM used to analyze effectiveness of Diverging Diamond Interchange
Additional Projects

• Analyzing New Truck Routing for the BOTA Port-of-Entry
• I-70 Mountain Corridor Winter Management Scenario Analysis
• Road safety audits
• Corridor hot-spot analysis
• Variable speed limits
Thank You

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