Health and Safety Moment

(A) Good Posture

(B) Bad Posture

SEATING POSITIONS

Less than 70°  90°  125° and over
Presentation Outline

- Need for Simulation
- Overview of 3 Tier Modeling Approach
- Simulation Tool Selection – A Project Based Approach
- Summary, Q/A
Need For Simulation

- Limitations of analytical approach – A deterministic approach
- Inability to analyze system / network effects
- Scale and complexity of the networks
- Applicability to unconventional network configurations
- Unlimited combination of events
- Ability to analyze multiple “what-if” scenarios
- Public outreach
- Why not?
Tier -1 Macroscopic Simulation

- Originally designed to estimate demand for major highway improvements included in regional long-range plans
- Large networks, limited detail
- Ability to complete all 4-steps in modeling process
- Allows for v/c greater than 1
- Travel time and speed determined by delay curves
- Demand matrix is unique for specific time periods and modes

OPERATIONAL OUTPUTS:
- ✔ Link Level Demand
- ✔ Origin Destination (OD) Matrix
Tier -3 Microscopic Simulation

- Designed to evaluate actual traffic operations
- Functions based on a number of behavioral models:
  - Car-following model
  - Lane-changing
  - Yielding
  - Gap acceptance models
  - Route choice models for DTA
- Best suited to evaluate operational and management strategies to address congestion
- Extremely detail oriented process

OPERATIONAL OUTPUTS:

✓ Speed
✓ Density
✓ Throughput (Volume)
✓ Post-Processing Data

✓ Queues
✓ Travel time
✓ Delay
✓ 2-D, 3-D Visualization
Microscopic Simulation - Video

Haverhill Rd Video
Need to Bridge the GAP

TIER 1 - MACRO

TIER 2 - MESO

TIER 3 - MICRO
Tier -2: Mesoscopic Simulation

- Best suited for larger networks – a balance between planning and operational models
- Individual vehicles with aggregate behavior - Cell Transmission technique
- Explicit treatment of interrupted flows
- Capture effects of capacity limitations & queue spillback
- Route choice based on Speed – Density relationship
- Dynamic Traffic Assignment (DTA) based on equilibrium assignment
- Time sliced demand matrix to replicate time varying demand
- Approaches microscopic with simple networks and macroscopic with complex networks

OPERATIONAL OUTPUTS:
- Speed
- Throughput (Volume)
- Travel time
- Delay

* Source: Centre for Traffic Research, Stockholm
Mesoscopic Simulation - Video

Mezzo Example Network

Source: Centre for Traffic Research, Stockholm
## Operational Merits and Demerits of Individual Modeling Approach

<table>
<thead>
<tr>
<th>Model</th>
<th>Merits</th>
<th>Demerits</th>
</tr>
</thead>
</table>
| **Macroscopic** | • Good planning tool to capture regional level impacts / benefits of traffic demand  
• Can complete 4-step modeling process  
• Generates demand data for meso and micro models, and sketch planning ITS tools  
• Extensive roadway and intersection detail not required | • Majority are static assignment  
• Cannot capture operational constraints                                                                                                                                 |
| **Mesoscopic** | • Computation efficiency for large networks  
• Operationally constrained results  
• Multiple vehicle types | • Vehicle interactions not considered  
• Lane by lane analysis not available                                                                                                                                 |
| **Microscopic** | • Operationally constrained results  
• Incorporates driver behavior  
• Multiple vehicle types, intersection controls  
• Excellent visual outputs for outreach  
• Interoperability with programs such as SSAM  
• Applicability to advanced traffic management system strategy  
• Efficient for moderate to heavy congested areas | • Detailed roadway and intersection characteristics  
• Complex network development                                                                                                                                 |
Simulation Tools – Applicability to 3 Tier Modeling

- Macro: AIMSUN, Cube Voyager, DynaSMART / DynaMIT
- Meso: Cube Avenue, Paramics, TransCAD, TransModeler
- Micro: CORSIM, SimTraffic, VISSIM, VISUM
Game Time

I have a complete tool box, which tool should I use?
Simulation Tool Selection – FHWA Criteria’s

- Geographic Scope
- Facility Type
- Travel Mode
- Management Strategy
- Travelers Response
- Performance Measures
- Tool / Cost-Effectiveness

Source: Traffic Analysis Toolbox, PUBLICATION NO. FHWA-HRT-04-039
# Simulation Tool Selection – Criteria’s

**Analysis Context:** Planning, Design, or Operations/Construction

<table>
<thead>
<tr>
<th><strong>#</strong></th>
<th>** Geographic Scope**</th>
<th><strong>Facility Type</strong></th>
<th><strong>Travel Mode</strong></th>
<th><strong>Management Strategy</strong></th>
<th><strong>Traveler Response</strong></th>
<th><strong>Performance Measures</strong></th>
<th><strong>Tool/Cost-Effectiveness</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1</strong></td>
<td>What is your study area?</td>
<td>Isolated Location, Segment, Corridor/Small Network, Region</td>
<td>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</td>
<td>SOV, HOV, (2, 3, 3+), Bus, Rail, Truck, Motorcycle, Bicycle, Pedestrian</td>
<td>Freeway Mgmt, Arterial Intersections, Arterial Mgmt, Incident Mgmt, Emergency Mgmt, Work Zone, Spec Event, APTS, ATIS, Electronic Payment, RRX, CVO, AVCSS, Weather Mgmt, TDM</td>
<td>Route Diversion - Pre-Trip, En-Route, Mode Shift, Departure Time Choice, Destination Change, Induced/Foregone Demand</td>
<td>LOS, Speed, Travel Time, Volume, Travel Distance, Ridership, AVO, v/c Ratio, Density, VMT/PMT, VHT/PHT, Delay, Queue Length, # Stops, Crashes/Dur, TT Reliability, Emissions/Fuel Consump, Noise, Mode Split, Benefit/Cost</td>
</tr>
</tbody>
</table>
Network Size - Breadth Assessment

Macroscopic

Mesoscopic

Macro

Micro
Project Complexity – Depth Assessment

- Breadth to Depth transition
- Level of detail
  - Intersection(s) / Interchange
  - Corridor
  - System / Network
- Tool selection based on depth
  - Static route?
  - Are there parallel routes – Need for dynamic route choice?
  - Is there need to model specific vehicle type?
  - What kind of traffic data do I have? OD – Turning movements
  - Any change in travel pattern? – New access points
  - Saturated versus low-moderate congestion?
Level - Intersection (s) / Interchange

Potential Projects:
- Turn lane improvements
- Interchange improvements – CFI, Diverging diamond, Signal to Loop
- Slip lane from/to Interstate ramps
- Merge / Diverge improvements
- Widening in sections – 2 to 4 lanes

Understanding the impacts:
- Localized effects
- Queuing, Delays, Crashes – Operational Issues
- Change in travel pattern - Insignificant

Our Approach:
- One level modeling – Microscopic simulation
- Tools: Synchro / Simtraffic, Corsim
An Example

Continuous Flow Intersection
Potential Projects:
- Collector Distributor System between 2-3 interchanges
- New interchange access
- “Reliever” / Local By-pass Projects
- Auxiliary lane between interchange

Understanding the impacts:
- Potential change in travel pattern
- Effects not local, spreads to competing / parallel routes
- Increase in demand due to added capacity
- Need for Dynamic Traffic Assignment (DTA) - Optional

Our Approach:
- Two level modeling – Macro-Micro
- Tools: Cube - Synchro - Corsim
- Visum - Synchro - Vissim
An Example

I-20 EB Collector Distributor
Level – System / Network

Potential Projects:
- Managed Lane Conversion (HOV to HOT)
- New Managed Lane System (HOT / TOL)
- Adaptive traffic control systems
- Corridor wide reversible lanes
- Downtown grid network

Understanding the impacts:
- Change in mode choice
- Significant change is traffic operations
- Change in travel pattern
- Multiple routes between each O-D pair
- Controlling routes via DTA – A necessity

Our Approach:
- Tri-level / Two level modeling –> Macro-Meso, Macro-Micro
- Tools: Visum - Vissim
  - Cube - Cube Avenue –> Cube-Vissim
An Example – Need for DTA

Path → Function (Cost, Time, Distance)
<table>
<thead>
<tr>
<th>Facility Type</th>
<th>Planning</th>
<th>Design / Operational</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arterial</td>
<td>MC, ME</td>
<td>MI</td>
</tr>
<tr>
<td>Freeway and Ramps</td>
<td>MC, ME</td>
<td>MI</td>
</tr>
<tr>
<td>Managed Lanes (HOV, HOT, TOL)</td>
<td>MC, ME</td>
<td>MI</td>
</tr>
<tr>
<td>Transit</td>
<td>MC, ME</td>
<td>MI</td>
</tr>
</tbody>
</table>
Performance Measures

- Critical Step: Develop project needs – Performance measure matrix
- High Level or Detailed measures
- Performance measures – Deal Breaker
- Assess ability of simulation tools to capture the performance measures directly or indirectly
## Advanced Traffic Management System Evaluation

<table>
<thead>
<tr>
<th>Management Strategy</th>
<th>Design / Operational</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ramp Metering</td>
<td>ME</td>
</tr>
<tr>
<td>Adaptive Traffic Control Systems</td>
<td>MI</td>
</tr>
<tr>
<td>Incident Management</td>
<td>MI</td>
</tr>
<tr>
<td>Changeable Message Signs</td>
<td>MI</td>
</tr>
<tr>
<td>Advanced Traveler Information Systems</td>
<td>MI</td>
</tr>
<tr>
<td>Commercial Vehicle Operations</td>
<td>MI</td>
</tr>
<tr>
<td>Railroad Crossings</td>
<td>MI</td>
</tr>
</tbody>
</table>
Commercial Vehicle Operations

Interstate Truck Weight Station
Special Studies

• Evacuation Modeling
• Planning for Special Events
  - Suitability of simulation models to large networks
  - High computational efficiency
  - Minimum details to produce reasonable estimates
  - Macro-Meso Model
• Toll and Revenue Studies
  - Alternative comparison to estimate demand – I vs. 2 Managed Lane, Type of Managed Lane
  - Sensitivity testing to tolling
  - Macro level detail to screen alternatives
• Planning for Work Zone
  - Need to capture effect of lost capacity
  - Extent of impact – Corridor or network level
  - Use of microscopic simulation to justify maintenance of traffic
• 14th Street Bridge Project
Integrate with Other Applications

• Does my project needs extend beyond traffic operational analysis?

• Our experience with using modeling tools for other applications
  ❖ ITS Concept Development – Planning Level
  ❖ Traffic Safety Analysis
IDAS – An application

- Output from macroscopic model fed to IDAS
- Estimate and compare the impact of non-recurring congestion between alternatives with and without ITS deployments
- Estimate planning level reduction in crashes by accident type due to ITS
- 3 out of 4 steps performed in IDAS to capture effect of ITS deployment on the system
- Useful tool to develop planning level ITS concepts as part of major investment studies
SSAM – An application

- SSAM – Surrogate Safety Assessment Module
- FHWA approved tool to perform safety analysis between alternatives
- A post processor to microscopic simulation tool
- Uses trajectory data from microscopic simulation tools (Vissim, Aimsun & Paramics)
- Uses surrogate measures technique to estimate “conflicts” from the trajectory data
- Reasonableness of conflict analysis closely tied to outputs from microscopic simulation
- Sound methodology to estimate conflicts for alternatives that are yet to be built
SSAM – An Application

Scenario -1

Scenario -2
Public Outreach

• Important step in most transportation projects

• Identify the level of detail to be presented to the public

• Convey information accurately, completely, and easy to comprehend

• Ability to develop 2D and 3D videos for ease of understanding

• Compatibility of simulation model with GIS 3D model development on major projects – revive 285 topend
Efficiency

• Cost-effectiveness
• Timeline
• Understand Client Needs
• Quality Matters
Cost – Effectiveness – Saving $$$$
In Summary....

• Imperative to understand three tier modeling approach
• Project based selection of simulation tools
• Uniqueness of each project
• No one “Tool” that can meet all project needs
• Model calibration to replicate real world scenarios
• Maximize the capability of simulation tools to integrate with other applications
• Maintain a balance between time, money, approach, innovation to strategically meet client needs
• Interpretation of the results from simulation tools defines successful application
Koushik.arunachalam@arcadis-us.com
Jody.Peace@arcadis-us.com
Three Tier Modeling Snapshot

Tier 1

Tier 2

Tier 3
Future Trend in Integrated Modeling
Meso-Micro

LARGE URBAN OR METROPOLITAN AREA
⇒ Mesoscopic Model

SUBAREA1 (Problem Network)
⇒ Detailed Microscopic Model

SUBAREA2 (Problem Network)
⇒ Detailed Microscopic Model

Origin i

Alternative Path

Meso

Congestion

Micro

Meso

Destination j
Why hybrid simulation?

- **Micro models:**
  - **Good** for small areas, with much detail, e.g. to study signal control in a number of intersections
  - **Not so good** for large areas. Difficult to calibrate, network coding takes a lot of effort and time, and simulations are slow.

- **Meso models:**
  - **Good** For large areas, less detail, e.g. an entire city. Easier to calibrate, takes less time to code network, routing over entire network, fast simulations.
  - **Not so good** for detailed studies, such as adaptive signal control, merging areas etc.
Comparison of Computational Time

The comparison of the three scenarios considering the computation time gives:

- **Micro**: 2595 seconds
- **Meso**: 259 seconds or 10%
- **Hybrid**: 331 seconds or 13%

The same comparison of the three scenarios, but considering the simulation time of 30 minutes instead of the 3 hours and 30 minutes:

- **Micro**: 247 seconds
- **Meso**: 45 seconds or 18%
- **Hybrid**: 64 seconds or 26%

The numerical results confirm the hybrid approach is able to take advantage of the microscopic simulator’s accuracy without sacrificing the computational benefits offered by the mesoscopic model.
Hybrid meso-micro simulation

- **Integrates** meso- and micro models to:
  - Simulate a small area (or multiple small areas) in detail with micro simulation
  - Simulate surrounding area with meso simulation
- Allows study of **local effects** of traffic operations, e.g. adaptive signal control with **micro**, and **network effects** with **meso**
- **Realistic inflows** into **micro** from buffer network in **meso**, incorporating queue propagation over meso-micro boundaries.
- Can capture **redistribution effects** of local changes, where traffic may avoid the micro area, or new traffic may be attracted to the micro area.
Hybrid framework

Common Module

Travel behavior
- Pre-trip
- En-Route
- Path generation

Database
- Network graph
- Travel times
- Paths
- OD flows

Route choices
Travel times

Meso Model
Vehicles,
Traffic conditions

Micro Model
Route choices
Travel times
Conceptual Architecture

- Static assignment
- Dynamic Assignment
  - One shot or iterative
- MACRO
- MESO
- MICRO
- Network data base
- OD Matrices
- Paths and path flows data base
### Popularity

<table>
<thead>
<tr>
<th>Type of Simulation</th>
<th>Number of Packages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microscopic</td>
<td>65</td>
</tr>
<tr>
<td>Mesoscopic</td>
<td>3</td>
</tr>
<tr>
<td>Macroscopic</td>
<td>16</td>
</tr>
</tbody>
</table>
Assignment in Mezzo

Loop 1

Routes
Travel Times
Network
Demand

Shortest Path algorithm

New Routes

Loop 2

Mezzo Simulation

New Travel times